WATER CONSERVATION / SUPPLY RECONNAISSANCE STUDY

Platte River Research Cooperative Agreement

Final Report

Prepared for

GOVERNANCE COMMITTEE OF THE COOPERATIVE
AGREEMENT FOR PLATTE RIVER RESEARCH

DECEMBER 1999

BOYLE
ENGINEERING CORPORATION

in association with
BBC Research & Consulting
Anderson Consulting Engineers

Platte River Water Conservation/ Supply Reconnaissance Study

Table of Contents

7. Water Budget Routing Model To Evaluate Flow Changes At Critical Habitat

8. Evaluation of Alternatives

Appendices

Tables and Figures

Figures

1. EXECUTIVE SUMMARY

A. Introduction

The Platte River Water Conservation/Supply Study (Study) was conducted in support of the Platte River Cooperative Agreement. Signed by the Department of the Interior and the states of Wyoming, Colorado and Nebraska in July 1997, the Cooperative Agreement (CA) addresses the wide-ranging needs of four threatened or endangered species in the central Platte River region in Nebraska. The U.S. Fish and Wildlife Service (FWS) developed recommendations for flows that it believes are needed at different times of the year for endangered species and other wildlife. In a cooperative approach with other federal, state, and local interests, the FWS agreed to an incremental approach with a goal of providing 130,000 to 150,000 acre-feet (ac-ft) per year of water over the next 10 to 13 years. The goal of this study was to identify and evaluate ways that 60,000 to 80,000 ac-ft of water could be provided on average. Three other projects, one in Colorado, Nebraska, and Wyoming, are to provide the other 70,000 ac-ft.

The Study is a reconnaissance level study. Evaluations were performed at a reconnaissance level of detail to distinguish major differences among alternatives and to provide a preliminary indication of the feasibility of each alternative. The Study is to be used as a tool for planning and screening purposes to compare alternatives and to help identify which alternatives are more likely to achieve the goals of the Program. The reconnaissance nature of this study should be taken into consideration during the formulation of the Water Action Plan, the next phase of the Cooperative Agreement process.

The Study was prepared by Boyle Engineering Corporation (Boyle) under contracts with each of the three states. Work began in July 1998 under the direction of the Water Management Committee (WMC). The WMC is comprised of the following entities and individuals:

Member	Association
Jon Altenhofen	Northern Colorado Water Conservancy District
Ann Bleed	Nebraska Department of Water Resources
Kurt Bucholz	Upper North Platte Valley Water Users Association
Mark Butler	U.S. Fish & Wildlife Service
Mike Drain	Central Nebraska Public Power & Irrigation District
Beth Goldowitz	Platte River Trust
Richard Holloway	Tri-Basin Natural Resources District
Frank Kwapnioski	Nebraska Public Power District
John Lawson	Bureau of Reclamation
Dan Luecke	Environmental Defense Fund
Becky Mathisen	Wyoming State Engineer's Office
Kent Miller	Twin Platte Natural Resources District
Mike Slifer	U.S. Geological Survey, WRD
Dick Stenzel	Colorado Division of Water Resources
Duane Woodward	Central Platte Natural Resources District

Boyle's work was completed with assistance from the following sub-consultants:

- Anderson Consulting Engineers performed the analysis of watershed management alternatives and assisted with the hydrologic and engineering analysis of several other types of alternatives.

- BBC Research & Consulting performed the analysis of all agricultural and municipal conservation measures, incentive based reductions in agricultural water use, and hydroelectric power interference options. The firm was also responsible for identifying and discussing potential third-party impacts of the alternatives.

- Jerry Kenny, Ph.D., P.E., of the firm Exponent provided an independent internal review of all Study work products through submission of the Draft Report on August 9, 1999.

B. Study Approach

The approach for conducting this Study included the following steps:

1. Develop screening criteria for evaluating alternatives.
2. Identify potential water conservation and supply measures for augmenting flows in the critical habitat and develop a long list of alternatives.
3. Review long list of water supply alternatives, then use screening criteria to develop a short list of alternatives. Identify project-specific and/or representative examples of the shortlisted alternatives.
4. Evaluate both general and project-specific shortlisted alternatives for effects on streamflows, costs, and other issues, and score the alternatives.

Screening Criteria

Criteria to compare and contrast alternatives were developed according to five major issues affecting the feasibility of potential projects that were previously identified by the WMC as follows:

1. Physical
2. Legal/Institutional
3. Social
4. Economic
5. Environmental

In addition, 31 sub-criteria were developed to capture the important aspects of the general criteria.

An initial screening shortened the long list of alternatives by identifying those alternatives that fail one or more of the five general screening criteria. The resulting short list of alternatives was then analyzed in greater detail.

Long List of Alternatives

The process of identifying the most suitable water conservation and supply measures included developing a long list of alternatives for the three regions in the Platte River study area (see Figure 1.1).

Boyle reviewed project notebooks provided by the three states and the Department of the Interior. Boyle also reviewed other information on the study area and other locations including, river basin planning reports, agency manuals, research papers, and conducted Internet searches to identify water conservation and supply alternatives for the three regions. Seventy-seven potential alternatives were identified in relation to all of the basin's water uses (see Table 1.1) and were subsequently reorganized and regrouped to reduce the overlap between the alternatives. Additional alternatives suggested by WMC members were noted and were included in the new list.

Scoping memoranda for the following seven categories of alternatives were developed:

1. Reservoirs
2. Water Conservation (Agricultural and Municipal)
3. Reuse
4. Incentive Based Reductions in Agricultural Water Use
5. Groundwater
6. Systems Integration and Management
7. Watershed Management

Water conservation was later divided into two sub-categories, which include Agricultural Conservation and Municipal Conservation. The scoping memoranda used for the initial screening included definitions of the alternatives, information regarding the volume of water likely to be produced, cost per unit volume of water, and past limitations/experiences based on information from existing studies.

Figure 1.1 – Platte River Study Area

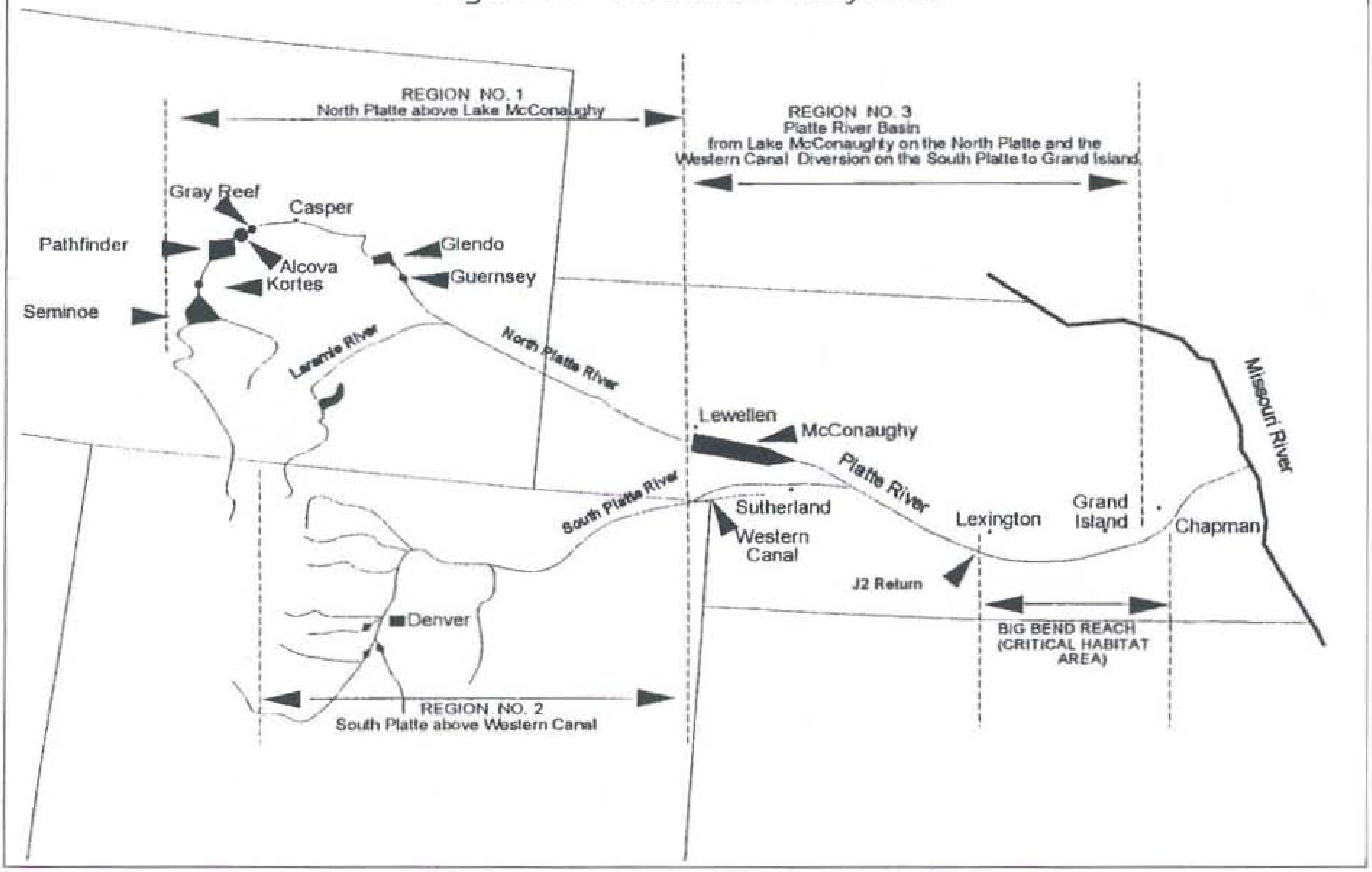


Table 1.1
Long List
Water Conservation and Supply Alternatives

Reservoirs

1 Build New Storage Facilities
2 Construct Equalizing Reservoirs
3 Enlarge/Dredge Existing Reservoirs
4 Evaporation Suppression
5 Reduce Reservoir Seepage Losses via Lining
6 Remove storage restrictions imposed by state and/or Federal agencies with responsibility for dam safety

Water Conservation

7 Change from Schedule-Based Irrigation to Demand-Based Irrigation
8 City Parks Metering
9 Computerized Irrigation System Scheduling
10 Conservation Cropping Patterns
11 Conservation Plumbing Ordinance
12 Conservation Pricing
13 Conservation Pricing – Increase Block Rates/Summer Surcharge
14 Conversion to Sprinkler Irrigation
15 Deficit Irrigation Practices
16 Financial Incentives for Municipal Conservation
17 Financing of Water Saving Equipment
18 Hydrologic Instrumentation
19 Irrigation Efficiency Improvements
20 Irrigation Monitoring for Municipal Greenways
21 Landscape Advisor
22 Landscape Audits
23 Landscape Irrigation System Improvements
24 Landscape Restrictions for New Homes
25 Local Downstream Control Method for Irrigation Canal Systems
26 Low Demand Plumbing Fixtures
27 Low Water Use Landscape Design
28 Microclimate Modification
29 Outdoor Watering Restrictions
30 Pressure Reduction
31 Prohibitions on New Connections
32 Public Sector Audits and Management
33 Reduce Municipal Distribution System Leakage
34 Rehabilitate/Improve Conveyance Channels
35 Repair/Improve Water Control Structures
36 Restrictions on Specific Uses
37 Soil Modification for Water Conservation
38 System Wide Use Reduction and Water Audit
39 Tax Incentives/Subsidies
40 Universal Metering
41 Use of Drip Irrigation
42 Use of Low Energy Precision Application
43 Use of Subsurface Drip Irrigation (SDI) Systems
44 Water Conservation Kits/Public Information/Demonstration Projects
45 Water Court Enforcement of Water Use Efficiency Goals
46 Water Use Consultations and Waste Minimization
47 Water Use Rationing

Reuse

48 Commercial/Industrial Water Recycling
49 Pump-Back Arrangement for Return Flows
50 Relocation of Return Flows
51 Sewage Effluent for Cooling
52 Water Reuse

Incentive Based Reductions in Agricultural Water Use

53 Acquisition and Dry-Up of Irrigated Lands
54 Drought Water Banking
55 Dry Year Leasing (Drought insurance)
56 Land Fallowing Program
57 Permanent Acquisition of Agricultural Water Supplies (not lands)
58 Temporary Leasing of Agricultural Water Supplies

Groundwater

59 Conjunctive Use
60 Additional Surface Water and/or Groundwater Reregulation Opportunities
61 Development of Non-Tributary Groundwater Sources/Deep Aquifer Pumping
62 Groundwater Allocation Management
63 Groundwater Recharge/Return Flow Project (similar to Tamarack)
64 Reduction of Groundwater Export (e.g. losses from Platte to Republican basin)

Systems Integration and Management

65 Changes in Points of Diversion
66 Effluent Exchange Agreements
67 Link Existing Water Supply Systems
68 Modification of Reservoir Filling Sequences
69 Modified Flow Release Rules
70 Transbasin Diversions/Imports
71 Transfer of Storage Decrees
72 Water Rights Transfers or Exchanges
73 Paying Power Interference Charges

Watershed Management

74 Forest Management
75 Phreatophyte Control
76 Snowpack Management via Vegetative Shading
77 Weather Modification

Short List of Alternatives

Alternatives (see Table 1.1) were reviewed in a two-step screening process. The first step used the general screening criteria to identify potential fatal flaws. Any alternatives on the long list receiving a score of zero on one or more of the general criteria were deferred from further evaluation at this time. The remaining alternatives formed the short list of alternatives presented in Table 1.2. The short list of alternatives was presented in November 1998.

Evaluate Shortlisted Alternatives

In the second step of the screening process, specific and/or representative examples of the shortlisted alternatives were identified (see Table 1.3) and evaluated with respect to the same pre-defined criteria. Draft evaluations were submitted to the WMC in May 1999. Projects were evaluated throughout the 19 reaches defined for the Platte River study area (see Figure 1.2). The effects on streamflows in the immediate area of each project as well as the critical habitat area, net reductions to target flow shortages, and costs were evaluated. Associated physical, legal/institutional, economic, social, and environmental issues were also addressed. Scores were assigned relative to associated physical, legal/institutional, social, economic, and environmental issues. Based upon these evaluations each project was assigned a composite score between zero and 25.

C. Summary

This Study identified and analyzed 190 specific and/or representative water supply projects with 61 additional variations on those projects. Of these, there are 15 projects capable of reducing shortages to target flows by an average of at least 10,000 ac-ft/yr if the resulting flows can be protected from downstream diversions. A number of these projects have variations of similar projects within the same reach or in other reaches. If the resulting flows cannot be protected from downstream diversions, these projects are capable of reducing shortages to target flows by an average of 0 to 38,000 ac-ft/yr. There are also an additional 20 projects capable of reducing shortages to target flows by 5,000 to 10,000 ac-ft/yr on average if the resulting flows can be protected from downstream diversions. If the resulting

Table 1.2
Short List
Water Conservation and Supply Alternatives

Category 1 - Reservoirs
- Construction of New Storage Facilities or Equalizing Reservoirs
- Enlarge Existing Reservoirs
- Remove Storage Restrictions
- Lining Smaller New or Existing Reservoirs and Gravel Pits

Category 2 - Water Conservation
- **Municipal**
  - Financial/Economic Incentives
    - Conservation Pricing
    - Financial Incentives for Municipal Conservation
    - Tax Incentives or Subsidies
    - Universal and City Parks Metering
  - End-user Technology Changes
    - Landscape Irrigation System Improvements
  - Regulatory Measures
    - Outdoor Water Restrictions
    - Restrictions on Specific Uses
- **Agricultural**
  - On-farm Changes in Irrigation Practices
    - Conservation Cropping Patterns
    - Deficit Irrigation Practices
    - Changes in Irrigation Techniques
  - Water District
    - Structural
      - Rehabilitate/improve Conveyance Channels
      - Repair/improve Water Control Structures
    - Non-structural
      - Conservation Pricing
      - Demand Based vs Schedule Based Irrigation

Category 3 – Reuse
- Relocation of Return Flows

Category 4 – Incentive Based Reductions in Agricultural Water Use
- Agricultural
  - Acquisition and Dry-up of Irrigated Lands
  - Permanent Acquisition of Agricultural Water Rights
  - Land Fallowing Programs
  - Temporary Leasing of Agricultural Water Supplies
  - Dry Year Leasing
  - Drought Water Banking

Category 5 - Groundwater
- Groundwater Recharge/return Flow Projects
- Groundwater Allocation Management and Transfer of Uses
- Reduction of Natural Groundwater Export from the Basin
- Additional Surface Water and/or Groundwater Reregulation Opportunities

Category 6 - Systems Integration and Management
- Modification to Reservoir Operations
  - Modification of Reservoir Filling Sequences
  - Modified Flow Release Rules
- Modification to Existing Water Rights
  - Change in Points of Diversion
  - Transfer of Storage Decrees
  - Water Rights Transfers or Exchanges
- Transbasin Diversion\Imports

Category 7 - Watershed Management
- Forest Management

Table 1.3

Specific and/or Representative Projects Evaluated

Category 1 - Reservoirs

- Construction of New Storage Facilities or Equalizing Reservoirs
  - Deer Creek Reservoir
  - Horse Creek Re-Regulating Reservoir
  - Grey Mountain Reservoir
  - 10,000 ac-ft Reservoir in middle of Reach 8
  - 50,000 ac-ft Reservoir in middle of Reach 8
  - 10,000 ac-ft Reservoir in middle of Reach 9
  - 50,000 ac-ft Reservoir in middle of Reach 9
  - 10,000 ac-ft Reservoir in bottom of Reach 9
  - 50,000 ac-ft Reservoir at bottom of Reach 9
  - Jeffrey Canyon Reservoir
  - Plum Creek Canyon Reservoir
  - Riverview Reservoir
- Enlarge Existing Reservoirs
  - Seminoe Dam Enlargement
  - Julesburg Reservoir Enlargement
  - Sutherland Reservoir Enlargement
- Remove Storage Restrictions
  - Kingsley Dam
- Lining Smaller New or Existing Reservoirs and Gravel Pits
  - 10,000 ac-ft Lined Reservoir in middle of Reach 8
  - 10,000 ac-ft Lined Reservoir in middle of Reach 9
  - 10,000 ac-ft Lined Reservoir at bottom of Reach 9
  - Sutherland Reservoir
- Reactivate Storage Lost to Sedimentation
  - Guernsey Reservoir

Category 2 - Water Conservation

- **Municipal** – Deferred from further evaluation at this time
  - Financial/Economic Incentives
    - Conservation Pricing
    - Financial Incentives for Municipal Conservation
    - Tax Incentives or Subsidies
    - Universal and City Parks Metering
  - End-user Technology Changes
    - Landscape Irrigation System Improvements
  - Regulatory Measures
    - Outdoor Water Restrictions
    - Restrictions on Specific Uses
- **Agricultural**
  - On-farm Changes in Irrigation
    - Conservation Cropping Patterns
      - Representative Projects in all 19 Reaches
    - Deficit Irrigation Practices
      - Representative Projects in all 19 Reaches
  - Changes in Irrigation Techniques
    - Presentative Projects in Reaches 17 through 19
  - Water District
    - Structural – Representative Projects in all 19 Reaches
      - Rehabilitate/improve Conveyance Channels
      - Repair/improve Water Control Structures
    - Non-structural
      - Conservation Pricing – Deferred from further evaluation at this time
      - Demand Based vs Schedule Based Irrigation – Deferred from further evaluation at this time

Category 3 – Reuse

- Relocation of Return Flows
  - Lost Creek-North Dry Creek Cutoff

Category 4 – Incentive Based Reductions in Agricultural Water Use

- Agricultural
  - Acquisition and Dry-up of Irrigated Lands
    - Representative Projects in all 19 Reaches
  - Permanent Acquisition of Agricultural Water Rights
    - Representative Projects in all 19 Reaches
  - Land Fallowing Programs
    - Representative Projects in all 19 Reaches
  - Temporary Leasing of Agricultural Water Supplies
    - Representative Projects in all 19 Reaches
  - Dry Year Leasing
    - Representative Projects in all 19 Reaches
  - Drought Water Banking
    - Representative Projects in all 19 Reaches

Table 1.3 (continued)

Specific and/or Representative Projects Evaluated

Category 5 – Groundwater

- Groundwater Recharge/return Flow Projects
  - Pratt-Ferris Groundwater Recharge Project
  - Beebe Draw Recharge Project
  - Badger-Beaver Recharge Project
  - Groundwater Pumping Recharge Projects
    - Middle of Reach 7 (SDF=60, 120 & 270 days)
    - Middle of Reach 8 (SDF=60, 120 & 270 days)
    - Middle of Reach 9 (SDF=60, 120 & 270 days)
    - Bottom of Reach 9 (SDF=60, 120 & 270 days)
    - Middle of Reach 10 (SDF=60, 120 & 270 days)
    - Middle of Reach 13 (SDF=60, 120 & 270 days)
  - Surface Water Diversion Recharge Projects
    - Middle of Reach 7 (SDF=300 days)
    - Middle of Reach 8 (SDF=300 days)
    - Middle of Reach 9 (SDF=300 days)
    - Middle of Reach 13 (SDF=300 days)
    - Gothenburg Canal-GW Recharge Project
    - Dawson Canal-GW Recharge Project
- Reduction of Natural Groundwater Export from the Basin
  - Pump up to 14,500 ac-ft from GW Mound to Platte
    - Reach 10
    - Reach 17
    - Reach 18
    - Reach 19
  - Pump up to 36,500 ac-ft from GW Mound to Platte
    - Reach 10
    - Reach 17
    - Reach 18
    - Reach 19
  - Pump up to 51,000 ac-ft from GW Mound to Platte
    - Reach 10
    - Reach 17
    - Reach 18
    - Reach 19
- Additional Surface Water and/or Groundwater Reregulation Opportunities
  - Pump up to 14,500 ac-ft from GW to Lands Previously Irrigated with Surface Water
    - Reach 17
    - Reach 18
    - Reach 19
  - Pump up to 51,000 ac-ft from GW to Lands Previously Irrigated with Surface Water
    - Reach 17
    - Reach 18
    - Reach 19

Category 6 – Systems Integration and Management

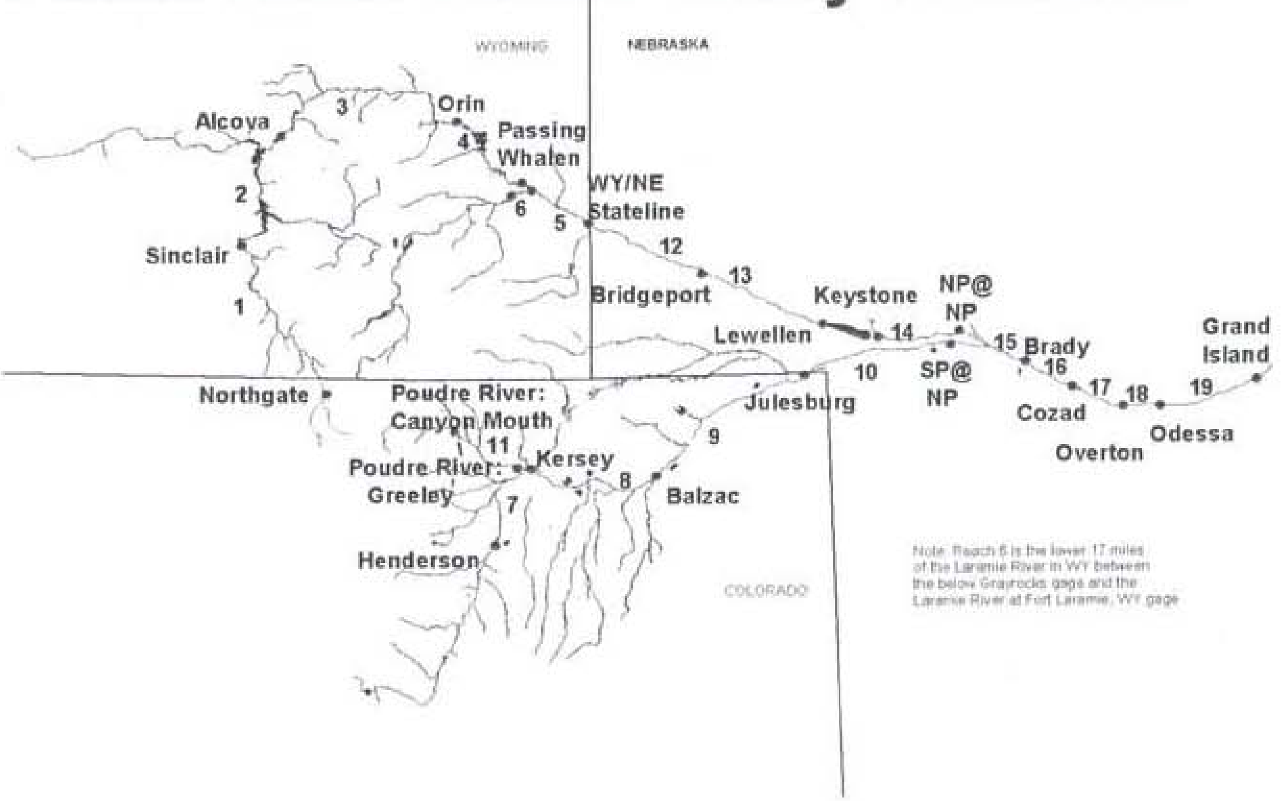
- Modification to Reservoir Operations
  - Glendo Reservoir
  - Chatfield Reservoir
  - B-1 Reservoir
- Modification to Existing Water Rights
  - La Prele Reservoir
  - Toltec Dam and Reservoir
  - Dodge Dam and Reservoir
  - Grayrocks Reservoir
- Transbasin Diversion\Imports
  - Middle Fork Powder River Transbasin Diversion
  - Cooper Creek Diversion
  - Wind River Transbasin Diversion
- Power Interface Charges

Category 7 - Watershed Management

- Forest Management
  - Regional Benchmark Yield, Water Yield, and USFS Selected Alternatives Scenarios
    - Upper South Platte River
    - Upper Cache La Poudre River
    - Upper North Platte River
    - Upper Laramie River

Figure 1.2

Platte River Basin Study Reaches



Note: Reach 6 is the lower 17 miles of the Laramie River in WY between the below Grayrocks gage and the Laramie River at Fort Laramie, WY gage

flows cannot be protected from downstream diversions, these projects are capable of reducing shortages to target flows by an average of 0 to 8,100 ac-ft/yr.

There are 15 specific and/or representative projects (or variations) for which the estimated unit costs are less than $1,000 per ac-ft of average shortage reduction. A number of these projects have variations of similar projects within the same reach or in other reaches. These same projects would be implemented at costs considerably more than $1,000 per ac-ft if Program water is not protected from downstream diversion.

Potential alternative scores ranged from zero to 25 based on five general criteria and 31 subcriteria. The scores for projects that were not deferred fell in the 14 to 19 range. Several of the groundwater projects earned scores at the upper end of this range and several of the incentive based reductions to agricultural water use, systems integration and management projects, and new reservoirs were at the lower end of the range.

Third party impacts associated with alternatives that were not deferred were identified and discussed. Third party impacts are primarily a result of hydrologic and economic impacts of an alternative. Third party hydrologic impacts are related primarily to changes affecting the timing and quantity of Platte River flows, which may affect existing downstream users or future water users. Third party economic impacts are related primarily to agricultural alternatives and focus on changes in the scale or nature of operations, changes in expenditure patterns, and changes in related industries.

Following the completion of this Study, an Action Plan will be prepared under the auspices of the Governance Committee of the Platte River Cooperative Agreement and through an Action Plan Committee. There are alternatives that, when combined, could yield 60,000 to 80,000 ac-ft of average annual reductions to target flow shortages. However, there are physical, legal/institutional, economic, social, and environmental issues that could constrain implementation and must be considered when preparing the Action Plan.

2. INTRODUCTION

A. Background and Perspective

The states of Nebraska, Wyoming and Colorado and the U.S. Department of the Interior entered into a partnership to address endangered species issues affecting water use in the Platte River Basin. This partnership is guided by the Cooperative Agreement for Platte River Research (June 1997). The driving force behind the Cooperative Agreement is that many water projects in the Platte River Basin are subject to reviews of federal government permits. Under the Endangered Species Act (ESA), federal agencies must ensure that the water projects they authorize, fund, or carry out do not jeopardize the continued existence of endangered and threatened species or result in the destruction or modification of habitat which has been determined to be critical. The Cooperative Agreement is a comprehensive approach to address ESA requirements that will eliminate the need for each individual water project to undergo a separate review of its impacts on endangered species.

The two main objectives of the Cooperative Agreement are as follows:

- Develop and implement a "recovery implementation program" (Recovery Program) to improve and conserve habitat for four threatened and endangered species that use the Platte River in Nebraska, which include the whooping crane, piping plover, least tern, and the pallid sturgeon.
- Enable existing and new water uses in the Platte River Basin to proceed without additional actions required (beyond the Recovery Program) for the four species under the Endangered Species Act.

The Recovery Program builds upon the Cooperative Agreement and lays out several activities and contributions from the three states and federal government that are to be conducted in specified increments. The objectives of the first phase of the proposed Recovery Program (10-13 years) are as follows:

- Reduce shortages to the U.S. Fish and Wildlife Service's (USFWS) target flows by 130,000 to 150,000 acre-feet per year (ac-ft/yr).
- Protect or restore 10,000 acres of habitat in the Central Platte River area within the critical habitat, which extends from near Lexington to Chapman, Nebraska.

The USFWS developed recommendations for flows in the critical habitat (at Grand Island, Nebraska) that it believes are needed for endangered species and other wildlife. The weighted average monthly species instream flow recommendations or target flows are summarized in Table 2.1. The recommendations vary season by season and year by year depending on whether wet, dry, or average conditions exist. The term, target flow shortages, refers to the degree that historic flows have been less than the target flows. The term, "reductions to target flow shortages" refers to the amount that the target flow shortages would be lessened in the future under the various types of alternatives considered in this report.

The USFWS also recommended pulse, or flushing flows for species in the critical habitat. Pulse flows are higher, natural flow events now occurring that the FWS would like to preserve. The FWS believes that pulse flows are needed between February 1 and March 31, and between May 1 and June 30 in some years to maintain wet meadows, the river channel, least tern and piping plover nesting habitat, and pallid sturgeon habitat. They include very high flow events (above 12,000 cubic feet per second (cfs) and in some cases above 16,000 cfs) that last a few days and more moderate flows of 3,000 to 3,600 cfs lasting for a week to a month. The recommended pulse flows from the USFWS are summarized in Table 2.1. Pulse flows are not addressed in the Cooperative Agreement or the scope of work for the Water Conservation/Supply Reconnaissance Study.

Under the first objective of the Recovery Program three water management projects are intended to reduce target flow shortages by approximately 70,000 ac-ft/yr. These three projects consist of the Tamarack Project in Colorado, the Pathfinder Modification Project in Wyoming, and an Environmental Account in Lake McConaughy in Nebraska. The study team was contracted to complete a Water Conservation/Supply Reconnaissance Study to identify and evaluate water supply and conservation alternatives to provide an additional 60,000 ac-ft/yr to 80,000 ac-ft/yr of average reductions to target flows shortages in the critical habitat.

An evaluation of the impacts of the Recovery Program is being conducted as required by the National Environmental Policy Act (NEPA) over the three-year Cooperative Agreement period. The Interior Department's Bureau of Reclamation and USFWS are preparing an Environmental Impact Statement (EIS), which addresses

TABLE 2.1
FWS (July 1997) Weighted Average Monthly Species Instream Flow Recommendations
(ac-ft)

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
WET	147600	101200	61500	61500	143000	167500	142800	170800	158700	73800	73800	65500	1367700
AVG	110700	83300	61500	61500	143000	167500	142800	150000	158700	73800	73800	65500	1292100
DRY	79900	56500	36900	36900	95800	114000	101200	67000	47600	49200	49200	41700	775900

FWS Recommended Pulse Flows for the Central Platte River

Dates	Pulse Flow	Duration
Feb. 1 - March 31	3,000 - 3,600 cfs	one week to a month
May 1 - June 30	3,000 - 3,600 cfs	one week to a month

Note: The FWS would also like to preserve very high flow events during these periods that are above 12,000 cfs and in some cases above 16,000 cfs that last a few days.

Pulse flow data based on The U.S. Fish and Wildlife Service's Instream Flow Recommendations for the Central Platte River, Brochure No. 4, published by the Governance Committee.

the effects of the proposed Recovery Program and other alternatives identified by the study team. The goal of the EIS is to evaluate the Recovery Program and other alternatives and provide a recommendation of the "preferred alternative" to the Secretary of the Interior. This EIS effort is separate and independent from the Water Conservation/ Supply Study. The two separate teams met periodically and shared basic data. Each team was free to utilize the shared data, gather additional data, perform independent analyses with differing methodologies, and develop their own results and conclusions.

B. Study Authorization and Schedule

The study team was authorized to conduct a Water Conservation/Supply Reconnaissance Study through three contracts executed between Boyle Engineering Corporation and the States of Colorado, Nebraska, and Wyoming. Work began in the summer of 1998. The study team's efforts were performed with guidance from the Water Management Committee (WMC) of the Governance Committee for Platte River Research.

A draft of the Final Report was submitted on the contractual due date of August 9, 1999. The initial due date of the Final Report (September 13, 1999) was delayed at the direction of the WMC to allow its members additional time to review the 800+ page document and to perform an independent peer review. This Final Report was submitted to the WMC on December 13, 1999 and reflects the team's best effort to address all comments received on the August 9, 1999 draft report.

C. Study Participants and Roles

The participants in this reconnaissance study include the:

- Study Team - comprised of engineering consultants with experience in river basin planning in all three states. Responsibilities of the team members are presented in the Acknowledgements section of this report.

- Water Management Committee – comprised of representatives of all three states, water users, federal agencies, and environmental groups. Individual members are listed in the Executive Summary. The WMC directed the basin-wide reconnaissance study of potential water conservation and supply projects conducted by the

Study Team. The WMC is also coordinating each state's means to track new water depletions or accretions to ensure mitigation of impacts on existing water users and proper crediting for water conservation projects. The WMC will also establish monitoring programs and protocols for verifying that water conservation/supply projects have the intended effects on instream flows.

- Governance Committee - comprised of the following 10 members: One member from the FWS; one member from the Bureau of Reclamation; one member from each of the three states (Colorado, Wyoming, and Nebraska); one water user member from Colorado, one user upstream of Lake McConaughy; one user downstream of Lake McConaughy; and two environmental organization members. The representative upstream of Lake McConaughy is selected by Wyoming water users and Nebraska water users upstream of Lake McConaughy with federal contracts for water in Wyoming reservoirs. The representative downstream of Lake McConaughy is selected by water users downstream of Lake McConaughy, water users upstream of Lake McConaughy who do not have federal contracts for water in Wyoming reservoirs, and water users downstream of the Western Canal diversion on the South Platte River. The Governance Committee oversees the implementation of the Cooperative Agreement and guides the development and implementation of the Recovery Program. The Governance Committee has three subcommittees, which include the Technical Committee, the Land Committee, and the Water Management Committee (presented above). The Technical Committee is developing the framework for habitat and species monitoring and research as well as a peer review process for scientific studies. The Land Committee is developing guidelines for land habitat management, leasing, and acquisition to determine ways to accomplish the habitat goals.

D. Study Approach

The Water Conservation/Supply Reconnaissance Study identifies and evaluates potential water conservation and supply projects that might, in various combinations, provide an additional 60,000 to 80,000 ac-ft/yr in average reductions to target flows shortages. The reconnaissance study was performed in the following manner:

- Identify a long list of water conservation and supply alternatives for the three regions in the Platte River study area.
- Conduct an initial screening of the long list of alternatives to identify any potential fatal flaws associated with an alternative and defer those alternatives from further evaluation at this time. Screening criteria include physical, legal and institutional, economic, social, and environmental issues.
- Develop a short list of alternatives based on the initial screening, which consists only of alternatives that were not deferred as part of the initial screening process.
- Identify specific and/or representative projects of the short-listed alternatives.
- Determine the local net hydrologic effects associated with a specified project.
- Develop a water budget spreadsheet to assist in determining effects on streamflows downstream of a specified project and the associated reductions to target flow shortages at the critical habitat.
- Evaluate the specific and/or representative projects with respect to the screening criteria. Evaluations include estimates of project costs and potential reductions to target flow shortages.
- Score each project based on the screening criteria and prepare lists of potential projects for future use in developing an Action Plan under the direction of the Governance Committee.

Many of the alternatives evaluated in this report are also being reviewed by the three states as sources of water to replace future depletions, to meet Cooperative Agreement commitments, and to meet Compact or Decree requirements. Partnership between the Recovery Program and the three states may occur on some alternatives, which could affect the costs, yields and net reductions to target flow shortages presented in this report.

E. Public Information Program

Public involvement in the Water Conservation/Supply Reconnaissance Study has been directed by the three states to facilitate public input.

The Governance Committee has also provided information to the public through direct mailings and the Internet through the Platte River website (www.platteriver.org). All Governance Committee meetings and subcommittee meetings have been open to the public. The general public has also been encouraged to provide input or obtain information by simply contacting the members of the committees.

3. GENERAL DESCRIPTION OF THE PLATTE RIVER STUDY AREA

Flows through the critical habitat area (extending from Lexington to Chapman, Nebraska) affect several threatened and endangered species, including the whooping crane, piping plover, and the least tern. The Platte River provides migratory bird habitat within the central flyway of North America. In addition to being federally designated critical migratory habitat for the whooping crane, the critical habitat in central Nebraska provides essential nesting habitat for the least tern, piping plover, and other migratory species. Habitat conditions within the channels have changed over the last 150 years. Consequently, much of the original open, braided river sections are now dominated by riparian woodlands and surrounded by croplands (U.S. Fish and Wildlife Service [USFWS], July 1997a).

The two main tributaries of the Platte River originate in the Rocky Mountains of Colorado. The North Platte's headwaters are located in Jackson County, Colorado; it then flows north into Wyoming. The South Platte originates southwest of Denver, Colorado in Park County and flows northeast through the Denver metropolitan area. The main stem of the Platte River is formed by the confluence of the North Platte and South Platte Rivers near North Platte, Nebraska. The Platte River then flows across Nebraska to its confluence with the Missouri River. The downstream end of the study area, however, coincides with the USGS gage at Grand Island, Nebraska near the downstream end of the critical habitat. The Platte is a meandering and braided river through central Nebraska in the critical habitat area.

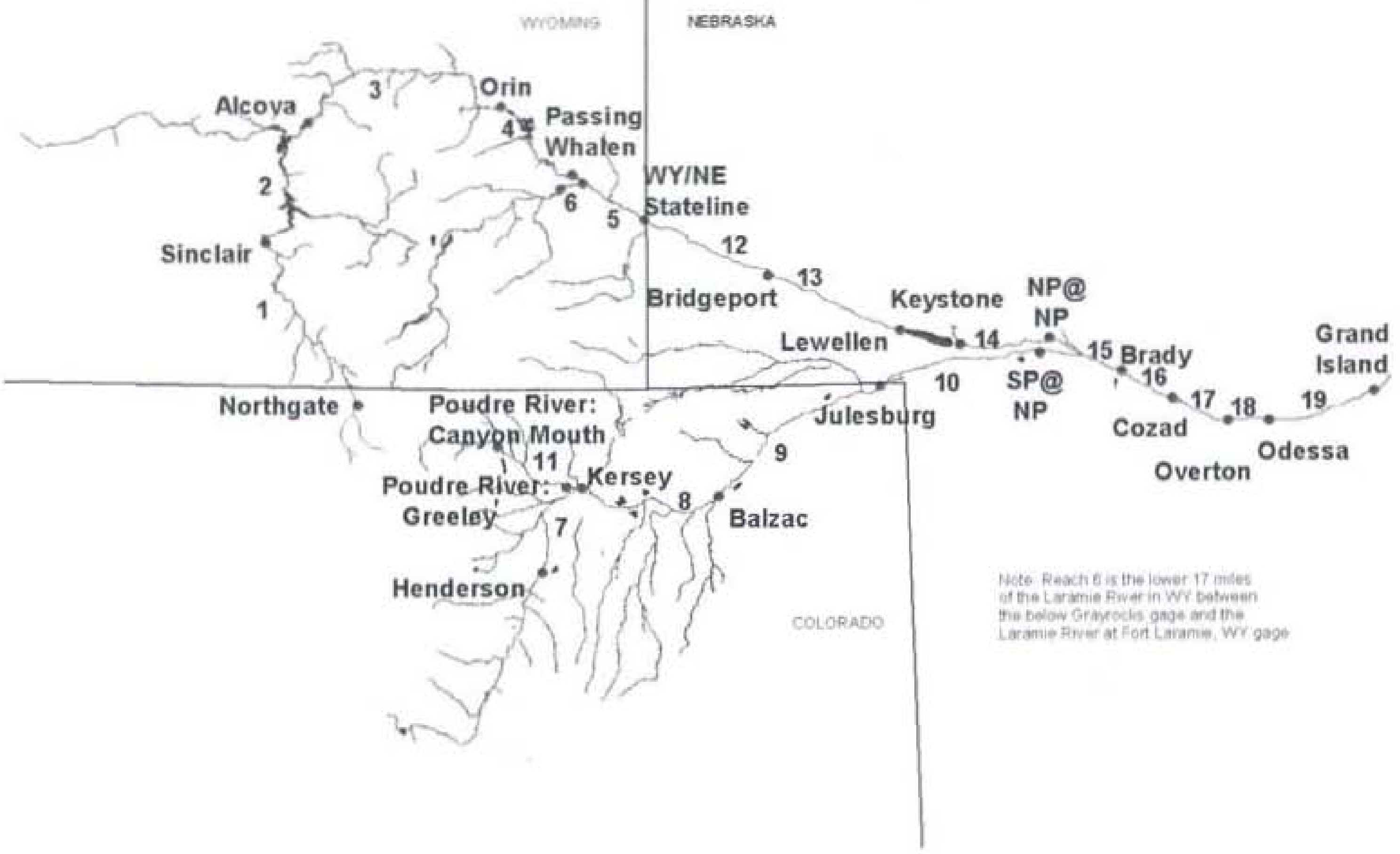
The total basin area above Grand Island, Nebraska is about 58,000 square miles. Average annual precipitation across the basin ranges from about 14-18 inches along Colorado's Front Range to approximately 24 inches at Grand Island, Nebraska. Snowmelt provides the majority of the flow in the North Platte and South Platte Rivers at the headwater areas. Flow in the South Platte basin is increased by transbasin diversions from west of the Continental Divide.

A. Study Regions

The Platte River Basin has been divided into three regions in the context of the Platte River Research Cooperative Agreement. Each region is subsequently divided into reaches, which are defined at the upstream and downstream ends by USGS streamflow gages. There are 19 Platte River study reaches, as shown in Figure 3.1. Region 1

Figure 3.1

Platte River Basin Study Reaches



Note: Reach 6 is the lower 17 miles of the Laramie River in WY between the below Grayrocks gage and the Laramie River at Fort Laramie, WY gage

extends from the headwaters of the North Platte River downstream to Lewellen, Nebraska, above Lake McConaughy. The majority of Region 1 is located in Wyoming. Region 1 is subdivided into eight reaches, including Reaches 1 through 6, 12, and 13.

Region 2 extends from the headwaters of the South Platte River downstream to Julesburg, Colorado. The majority of Region 2 is located in Colorado. Region 2 is subdivided into 4 reaches, including Reaches 7, 8, 9, and 11.

Region 3 consists of the South Platte River from Julesburg, Colorado and the North Platte River from Lewellen, Nebraska downstream to their confluence near North Platte, Nebraska. Region 3 continues from the confluence of the North and South Platte Rivers downstream to Grand Island, Nebraska. Region 3 does not include the Loup River basin. Region 3 is subdivided into seven Reaches, including Reaches 10 and 14 through 19.

Provided below are brief overviews of the existing water supply systems and uses within each region.

Region 1

North Platte River Basin Upstream of Lake McConaughy

Region 1 includes the North Platte River Basin above Lake McConaughy with a drainage area of about 28,600 square miles. Elevations in Region 1 range from 3,300 feet at Lake McConaughy to about 11,000 feet in the headwaters area in Colorado. Annual precipitation in the region varies from 20 to 40 inches at the headwaters to 9-16 inches in the lower reaches of the North Platte River above Lake McConaughy.

Within this region, water collected and conveyed by the North Platte River provides a source of supply to meet the needs of a variety of uses including agricultural, municipal, industrial, domestic, commercial, recreational, and environmental uses.

From a water budget perspective, the North Platte River Basin in Region 1 has both surface water and groundwater components. In addition to the main stem of the North Platte River, surface water flows from several major tributary streams including, but not limited to:

Horse Creek,
Laramie River,
Cottonwood Creek,
Horseshoe Creek,
La Bonte Creek,
La Prele Creek,
Deer Creek,
Casper Creek,
Poison Spider Creek,
Sweetwater River,
Medicine Bow River, and
Douglas Creek.

Several large storage reservoirs presently exist along the North Platte River in Wyoming. These reservoirs include Seminoe, Pathfinder, Alcova, Glendo, and Guernsey Reservoirs. In addition to these main stem facilities, surface water is diverted at several municipal intake structures and irrigation headgates. The major irrigation headgates are those associated with the Casper Canal, Interstate Canal, and Fort Laramie Canal.

Following are the principal reservoirs in Region 1 and their approximate storage capacity (League of Women Voters [LWV], 1997):

Reservoir Name	Approx. Storage Capacity (ac-ft)
Main Stem Reservoirs	
Guernsey Reservoir	46,000
Alcova Reservoir	184,000
Glendo Reservoir	789,000
Pathfinder Reservoir	1,016,000
Seminoe Reservoir	1,017,000
Tributary Reservoirs	
La Prele Reservoir	20,000
Toltec Reservoir	2,945
Wheatland No. 2 Reservoir	99,000
Grayrocks Reservoir	104,000

Note: Glendo Reservoir's capacity of 789,000 ac-ft includes an exclusive flood control space of 272,000 ac-ft.

Following are the principal canals in Region 1 and their approximate capacity (U.S. Department of the Interior [USDOI], 1981):

Canal Name	Approximate Capacity (cfs)
Casper Canal	1,200
Fort Laramie Canal	1,500
Interstate Canal	2,200

Note: A v-notched weir was installed in the Casper Canal, which limits the flow into the canal to approximately 600 cubic feet per second.

Groundwater is pumped at several locations adjacent to the North Platte River and its major tributaries. The majority of the groundwater wells serve as a source of water supply for individual irrigators, domestic users, and small municipalities. Large well fields, such as those associated with an irrigation district, do not exist within Wyoming. However, wells are clustered along the North Platte River downstream of the confluence with the Laramie River and adjacent to the Laramie River near Wheatland Flats.

Administration of the river is presently governed by the terms of the North Platte River Decree (October 8, 1945; Stipulation and Decree, October 1952). The Decree apportions natural flows of the mainstem from Whalen Dam downstream to the Wyoming-Nebraska state line as 75 percent to Nebraska and 25 percent to Wyoming from May 1 through September 30. In addition, the Decree specifically restricts the State of Wyoming from:

- Diverting or permitting the diversion of water from the North Platte River above Guernsey Reservoir and from the tributaries entering the North Platte River above Pathfinder Dam for the irrigation of more than a total of 168,000 acres of land in Wyoming during any one irrigation season; and
- Storing or permitting the storage of more than a total of 18,000 acre-feet of water for irrigation purposes from the North Platte River and its tributaries above Pathfinder Reservoir between October 1 of any year and September 30 of the following year.

The Decree also limits the State of Colorado from:

- Diverting from the North Platte River and its tributaries for the irrigation of more than a total of 135,000 acres of land in Jackson County, Colorado during any one irrigation season;
- Storing more than a total amount of 17,000 ac-ft of water for irrigation purposes from the North Platte River and its tributaries in

Jackson County, Colorado between October 1 of any given year and September 30 of the following year; and

- Exporting out of the basin of the North Platte River and its tributaries in Jackson County, Colorado to any other stream basin or basins more than 60,000 ac-ft of water in any period of ten consecutive years based on continuing progressive series beginning with October 1, 1945.

The conditions and restrictions of the Decree outlined above could impact potential water conservation and supply projects (i.e. new storage, or agricultural related alternatives) in Region 1. All water conservation and supply projects that are evaluated in Region 1 must comply with the provisions of the Decree outlined above.

Region 2

South Platte River Basin Upstream of the Western Canal Diversion

Region 2 includes the South Platte River above the Western Canal, which is just over the Nebraska-Colorado state line. The South Platte River originates in the mountains of central Colorado with a drainage area of about 19,020 square miles in the state of Colorado (Smith, et al., 1996). Elevations in Region 2 range from 3,450 feet at Julesburg, Colorado near the state line to 14,000 feet in the headwaters area. At the western margin of the basin, precipitation averages 40 inches annually, which includes snowfall in excess of 300 inches. In contrast, the annual precipitation on the plains in eastern Colorado ranges from 12 to 16 inches (Dennehy, et al.,1993).

Surface water and groundwater are used extensively throughout the region for irrigation, municipal, domestic, livestock, and industrial water supplies. In Region 2, downstream users depend on return flows to satisfy their needs to a large degree. Native water yield is estimated to be about 1.4 million acre-feet and transbasin imports are about 400,000 acre-feet, which is significantly less than the total diversions in Region 2. Colorado water law allows for multiple uses of water, which maximizes water use, but not to the detriment of downstream users.

Region 2 is a headwater system with surface water inflows influenced by interbasin transfers from west of the Continental Divide. Surface water flows from several major tributary streams including, but not limited to:

St. Vrain,
Upper South Platte,
Boulder Creek,
Clear Creek,
Big Thompson River, and
Cache La Poudre River.

Large reservoirs in the upper basin and the foothills of the Rocky Mountains provide flood control and storage water for municipalities along the Front Range of Colorado. There are approximately 370 reservoirs in the basin where capacity exceeds 500 acre-feet, and a collective storage capacity of approximately 2.2 million acre-feet (Smith, et al., 1996). The major irrigation headgates in the eastern plains are those associated with the following canals:

Canal Name	**Approx. Capacity (cfs)**	**Canal Name**	**Approx. Capacity (cfs)**
Sterling #1 Canal	200	Upper Platte & Beaver Canal	400
Harmony #1 Canal	350	Bijou Canal	600
Lower Platte & Beaver Canal	375	North Sterling Canal	745
Fort Morgan Canal	400	Riverside Canal	1000

These canals represent the largest diverters downstream of Kersey, Colorado. In addition to these canals, there are smaller canals including Farmers Ditch, Tremont Canal, and Springdale Ditch that hold senior rights. These ditches may call out the river during periods of low flow, therefore, they can control the river because of their seniority in the prior appropriation system.

Following are the principal storage reservoirs in Region 2 and in the headwaters area above Reach 7 and their approximate storage capacity (Dennehy, et al., 1993; Denver Water Department, 1997; Morrison-Knudsen Engineers, Inc., 1987):

Reservoir Name	Approx. Storage Capacity (ac-ft)
Main Stem Reservoirs	
Strontia Springs Reservoir	8,000
Chatfield Reservoir	11,000
Antero Reservoir	20,000
Spinney Mountain Reservoir	49,000
Cheesman Reservoir	79,000
Eleven Mile Reservoir	98,000
Tributary Reservoirs	
Julesburg Reservoir	27,000
Empire Reservoir	30,000
Barr Lake	32,000
Prewitt Reservoir	33,000
Jackson Lake	36,000
Standley Lake	42,000
Gross Reservoir	43,000
Wildcat Reservoir	64,000
Riverside Reservoir	65,000
North Sterling Reservoir	81,000
Cherry Creek Reservoir	92,800
Carter Lake	112,000
Horsetooth Reservoir	152,000

Groundwater is an important water resource in the South Platte River Basin. The Denver Basin aquifers and South Platte alluvial aquifer are the primary aquifers in the basin. Approximately 680,000 acre-feet of groundwater was withdrawn from the alluvial aquifer for irrigation in 1993 (Smith, et al.,1996).

Administration of the river is presently governed by the terms of the South Platte River Compact (April 27, 1923). The South Platte River Compact specifically restricts the State of Colorado from allowing diversions junior to June 14, 1897 in Water District 64, extending from Balzac, Colorado to the Colorado-Nebraska state line, when the gaged flow at Julesburg is less than 120 cfs, between April 1 and October 15 of each year.

Region 3

North Platte, South Platte, and Platte Rivers Downstream to Grand Island, Nebraska

Region 3 includes the Platte River drainage within the state of Nebraska, from the Western Canal diversion on the South Platte River and below Lake McConaughy on the North Platte River. For purposes of this study, the downstream end of Region 3 coincides with the USGS streamflow gage at Grand Island, Nebraska near the downstream end of the critical habitat. The total basin area of Region 3 is about 10,000 square miles. Elevations in the region range from 1,870 feet at Grand Island to 3,450 feet at Julesburg at the Colorado-Nebraska state line. Annual precipitation in Region 3 varies from about 18 inches at Lake McConaughy to 24 inches at Grand Island (USDOI, 1983).

Surface water uses within Region 3 include irrigation, power generation, and thermoelectric cooling. More than 200,000 acres of cropland are irrigated with Platte River water from Lake McConaughy (LWV, 1997). There are several coal and hydro-powered electric generating facilities within Region 3 that rely on Platte River water to power turbines or for cooling. Principal groundwater uses within Region 3 include irrigation and municipal supply. The majority of water use in this region occurs upstream of Kearney, in the middle of the Big Bend reach in central Nebraska.

The primary original source of water for the main stem Platte consists of the snowmelt that is delivered from the mountains in the headwater areas of the North Platte and South Platte River Basins. Water is reused numerous times enroute to the critical habitat through diversion of irrigation and hydropower return flows. Both the North Platte and South Platte Rivers have few large tributaries in Nebraska. Between North Platte and Kearney, groundwater seepage from irrigation practices and leaky canals on both sides of the river provide the main source of water for the river (LWV, 1997).

Principal hydrologic features within this region include Sutherland Reservoir, the Sutherland Supply Canal, the Korty Canal, the Tri-County Canal, and the Kearney Canal. Sutherland Reservoir and its supply canals are owned and operated by Nebraska Public Power District (Harza Engineering Company, 1993). Lake McConaughy, located above Reach 14, and the Tri-County Canal are owned and operated by the Central Nebraska Public Power and Irrigation District (CNPPID).

Following are the principal reservoirs and canals in Region 3 and their approximate storage and maximum canal diversion capacities (Harza Engineering Company, 1993; USDOI, 1981,1983; CNPPID, 1999d; Nebraska Department of Water Resources [DWR], 1999):

Reservoir Name	Approx. Storage Capacity (ac-ft)
Lake Maloney	18,000
Sutherland Reservoir	25,000
Johnson Reservoir	54,000
Lake McConaughy *	1,743,000

Note: * 1,743,000 ac-ft is the FERC License maximum storage level.

Canal Name	Approximate Capacity (cfs)
Keith-Lincoln Canal	100
North Platte Canal	350
Paxton-Hershey Canal	135
Suburban Canal	105
Cody-Dillon Canal	60
Thirty Mile Canal	325
Six Mile Canal	25
Cozad Canal	290
Orchard-Alfalfa Canal	85
Western Canal	250
Gothenburg Canal	340
Kearney Canal	400
Dawson County Canal	525
Korty Canal *	1,200
Sutherland Supply Canal *	2,000
Tri-County Canal *	2,250

Note: * The majority of diversions at the Korty and Sutherland Supply Canals, and Tri-County Canal are returned to the South Platte River at North Platte, and the Platte River, respectively.

Groundwater occurs in alluvial deposits, which form the valley bottom through much of the region, and in the underlying Ogallala aquifer.

Where these aquifers are in direct contact, they are often considered as a single aquifer. Groundwater storage, estimated at over 300 million ac-ft in the Platte River Basin in Nebraska, is a significant component of the hydrologic system.

4. MAJOR WATER USES

A. Introduction

Water conservation and supply alternatives to enhance instream flow use in the critical habitat area focus on the primary water uses within each region of the Platte River study area. The categories of water use in the basin that are being considered include domestic, commercial, industrial, mining, irrigation, livestock, thermoelectric cooling, and power generation. Major water uses in each region were evaluated to determine which categories within a region hold the most potential for water conservation and supply alternatives and focus the investigation on these categories.

The 1995 USGS Water Use Database was chosen to identify major water uses in each region because of the consistent methodology used across the three regions. The USGS water use database was considered to be a reasonable reference point from which to focus the investigation of alternatives.

The majority of water in each region is withdrawn for irrigation and power generation. There is also a considerable amount of water used for thermoelectric cooling in Regions 1 and 3, however, a very low percentage is consumed. Over 10 percent of the water used in Region 2 is for domestic purposes, which suggests a potential for municipal conservation alternatives in that region. In general, the USGS data suggests that the best opportunities for water conservation and supply alternatives include agricultural, municipal, and hydropower alternatives.

A more detailed discussion of the water uses in each region is provided in the following three sections.

B. Region 1

North Platte River Basin Upstream of Lake McConaughy

1995 USGS Water Use Data was relied on to determine the distribution of various water uses in Region 1. Power generation is the primary water diversion in Region 1, however, all power generation use is instream and only a small percentage is consumed. Irrigation is the next major water diversion in Region 1. The remaining water uses including commercial, domestic, thermoelectric cooling, industrial, mining, and livestock use constitute a small percentage of the overall water diversion and consumption in Region 1.

There are over 1 million irrigated acres in Region 1. The bulk of the irrigated acreage is located in the Kendrick Project, Wheatland Irrigation District, and the North Platte River valley from Whalen Dam downstream to Lake McConaughy. The primary irrigation districts consist of Goshen, Gering-Ft. Laramie, Pathfinder, Farmers, Northport, Casper-Alcova Irrigation District, and Wheatland Irrigation Districts.

The majority of irrigation water is provided by surface water withdrawals. Groundwater withdrawals for irrigation are used primarily to supplement surface water supplies. Almost half of the annual irrigation withdrawals return to the system as groundwater or surface water returns. Irrigation return flow patterns are primarily dependent upon irrigation application rates, the proximity of irrigated land to stream courses, and the underlying geology.

Surface water withdrawals for irrigation consist of natural flow and storage flow. Natural flow in the Guernsey Dam to the Tri-State canal reach of the North Platte River is split 75 percent to Nebraska and 25 percent to Wyoming from May 1 through September 30. Reclamation provides storage water to several irrigation districts in Nebraska and Wyoming under two major federal water resource development projects, which include the North Platte Project and the Glendo Unit of the Pick-Sloan Missouri Basin Program. The main features of the North Platte Project include several irrigation districts below Guernsey in Nebraska and Wyoming, the Interstate and Ft. Laramie Canals, the Northport Canal and two large mainstem reservoirs in Wyoming, which include Pathfinder and Guernsey. The primary purpose of the North Platte Project is to provide irrigation water to four large irrigation districts, which include Pathfinder, Goshen, Gering-Ft. Laramie, and Northport Irrigation Districts.

In addition to the North Platte Project, the Glendo Unit and the Kendrick Project also utilize waters of the North Platte River for irrigation and electric power generation. Major features of the Kendrick Project are Seminoe Dam and Powerplant, Alcova Dam and Powerplant, the Casper Canal and laterals, and the drainage and power distribution systems. The original project service area included 66,000 acres, however, due to drainage related problems the total reported irrigated lands in production during recent years are approximately 24,000 acres. The Glendo Unit consists of Glendo Dam, Reservoir, and Powerplant, Fremont Canyon Powerplant, and Gray Reef Dam and its reregulating reservoir. The unit supplies a maximum of 40,000 ac-ft of water annually from Glendo Reservoir for irrigation in Wyoming and Nebraska. The Glendo Unit and Kendrick Project work in conjunction with the North Platte Project and other units of the Pick-Sloan Missouri Basin Program.

Diversions for commercial, domestic, thermoelectric cooling, industrial, mining, and livestock use constitute a small percentage of the overall water diversion in Region 1. Livestock and mining water use is spread throughout the region with a significant portion supplied by groundwater withdrawals. The majority of livestock diversions are most likely held in local stock ponds and lost to evaporation. Major municipal uses include the cities of Laramie, Casper, and Douglas in Wyoming. Domestic use within the region relies primarily on groundwater withdrawals. Industrial water use is focused primarily along the North Platte River from Casper, Wyoming downstream to Scottsbluff, Nebraska. The majority of the industrial and commercial water supply is provided by surface water diversions. Thermoelectric power water use in the region is concentrated along the central North Platte River region near Casper and along the Lower Laramie River.

Power generation uses storage and natural flow water and occurs in Region 1 primarily at Seminoe, Fremont Canyon Powerplant located between Pathfinder and Alcova, Alcova, Grayrocks, Glendo, and Guernsey reservoirs. Consumptive use of power generation water use is generally very small.

C. Region 2

South Platte River Basin Upstream of the Western Canal Diversion

Surface water and groundwater are used extensively throughout the region for irrigation, municipal, domestic, livestock, and industrial water supplies. Irrigation is the primary water diversion in Region 2 with domestic use and power generation the next largest categories of water use. In Region 2, downstream users depend on return flows to satisfy their needs to a large degree. Native water yield plus transbasin imports are significantly less than the total diversions in Region 2. Colorado water law allows for multiple uses of water, which maximizes water use, but not to the detriment of downstream users.

According to USGS Water Use Data, approximately 950,000 acres of cropland were under irrigation in 1995 in Region 2. Irrigated acreage is spread throughout the region, on headwater tributaries and along the lower South Platte River. Irrigation water use relies predominantly on surface water withdrawals, releases from storage, and imported water from the Colorado-Big Thompson project. Irrigation return flow patterns are primarily dependent upon irrigation application rates, the proximity of irrigated land to stream courses, and the underlying geology. Livestock water use is spread throughout the region, relying on withdrawals from both groundwater and surface water sources.

The majority of domestic water use within the region is located in the upper South Platte River basin and the headwater tributaries including the St. Vrain River and Clear Creek. The major domestic user is Denver Water, serving the greater Denver metropolitan area. Over the last ten years, Denver Water had an average demand of approximately 253,000 ac-ft/yr. Other major domestic users in Colorado include the cities of Fort Collins, Greeley, Longmont, Boulder, Aurora, Thornton, Westminster, Northglenn, and Golden. Major domestic users downstream of Greeley include Fort Morgan and Sterling in Colorado, and Cheyenne, Wyoming. Domestic users in the lower basin rely predominantly on groundwater for their water supply. Consumptive use by municipalities is generally low in the winter with increased consumption in the spring and summer as a result of landscape irrigation.

Commercial and industrial water use is predominantly in the upper basin. Major commercial water users include two large beer producers, several computer manufacturers, and large food processing plants. Major industrial water users include a rubber company, a photographic products manufacturer, and several oil refineries. Return flows from commercial and industrial water use generally follow similar patterns with return flows to the stream typically within the same month that withdrawals are made.

Water use by mining operations include both hard rock mining along a southwest to northeast mineralized belt and sand and gravel operations in the foothills and the alluvial valley downstream of Denver, Colorado. Mining water supplies rely heavily on groundwater withdrawals.

Power generation facilities on the Big Thompson River are the major water users in this category, which are generally non-consumptive.

D. Region 3

North Platte, South Platte, and Platte Rivers Downstream to Grand Island, Nebraska

The majority of water use in this region occurs upstream of Kearney, in the middle of the Big Bend reach in central Nebraska. Power generation is the primary water diversion in Region 3. The next major water uses in Region 3 are irrigation and thermoelectric cooling.

Domestic water use within the region relies primarily on groundwater withdrawals. Major domestic uses include the cities of North Platte, Lexington, and Kearney. Commercial and industrial water use is spread throughout the region but constitutes a minor percentage of water use within the region. Return flows from municipal, commercial, and industrial water use generally follow similar patterns with return flows to the stream typically within the same month that withdrawals are made.

Mining water use within the region is concentrated on the Platte River downstream of North Platte, Nebraska. Production water for mining is used primarily for dust control (Nebraska Natural Resources Commission [NNRC], 1995). Thermoelectric cooling and power generation facilities use the majority of surface water and storage water in the region, but are generally non-consumptive.

Approximately 1.1 million acres of cropland were under irrigation in 1995. Irrigation water use relies predominantly on groundwater withdrawals, although more than 200,000 acres of cropland are irrigated with Platte River water from Lake McConaughy (LWV, 1997). Livestock water use is spread throughout the region, relying on withdrawals from both groundwater and surface water sources.

Irrigated acreage is spread throughout the region with irrigation use along the Western Canal on the South Platte, along the North Platte downstream of Lake McConaughy above the confluence with the

South Platte, in Dawson County on both sides of the Platte River downstream of Brady, and on the south side of the Platte River in Phelps County downstream of Lexington, Nebraska. Irrigation return flow patterns are primarily dependent upon irrigation application rates, the proximity of irrigated land to stream courses, and the underlying geology.

5. ASSUMPTIONS AND METHODOLOGY

The study team developed a multiple step process to identify and analyze water conservation and supply alternatives that can provide an additional 60,000 to 80,000 ac-ft/yr in average reductions to target flows shortages at the critical habitat. The process that was developed is comprehensive and thorough while maintaining an appropriate reconnaissance level of detail. This process is described below and illustrated schematically in Figure 5.1.

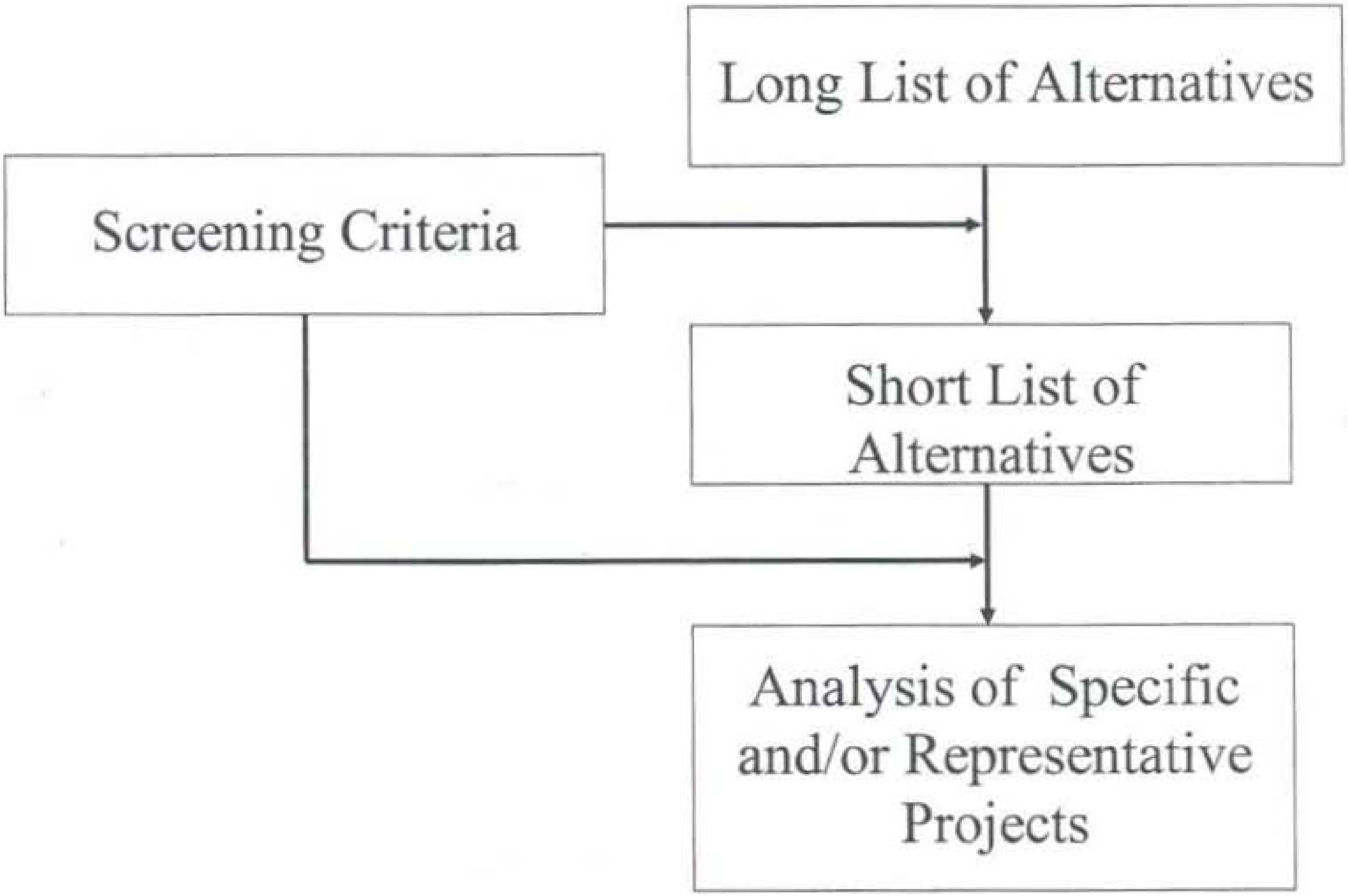
Water conservation and supply alternatives throughout the three regions were initially identified and a long list of alternatives developed based on documents provided by the three states and by DOI, reviews of other existing studies and reports, and discussions with WMC members. A screening process was initially applied to the long list of alternatives to focus the subsequent analysis on the most promising alternatives. A short list of alternatives was developed consisting of alternatives that were not deferred from further analysis during the initial screening process. Projects representative of the shortlisted alternatives were identified without bias to alternative type or geographic area. Net hydrologic effects and costs associated with the representative projects were estimated. These projects were evaluated with respect to the sub-criteria developed for the five categories of general screening criteria, which include physical, legal/institutional, economic, social, and environmental. Tabular scoring corresponding to the sub-criteria was provided for each project to compare and contrast the different alternatives. This report includes a comparison and summary of alternatives based on this analysis.

The general assumptions and methods described below provide the framework upon which the identification and analysis of alternatives was carried out. Detailed assumptions and methods are documented throughout Chapter 8 because proper explanation is possible only in the context of the technical definitions and engineering analysis of each alternative.

A. Identify Water Conservation and Supply Alternatives

A consistent approach was applied to identify water conservation/ supply alternatives in the three regions. The study team collected and reviewed existing information for each region to identify and assess potential water conservation/supply alternatives that could satisfy the goals of the Recovery Program. A long list of alternatives

FIGURE 5.1
ANALYSIS PROCESS



was compiled by reviewing information notebooks provided by Wyoming, Colorado, Nebraska, and the Department of the Interior, previous studies and reports, agency manuals, research papers, and other publications. Internet searches of state and federal agencies as well as university libraries were utilized to aid in identifying alternatives.

The comprehensiveness of the long list was evaluated in relation to the types of consumptive uses within each region. The long list was reviewed with the WMC and other entities. WMC involvement and approval to proceed was obtained throughout the evaluation process. Based on input from the WMC, the long list was reorganized based on the following seven categories of alternatives:

- Reservoirs
- Agricultural and Municipal Water Conservation
- Reuse
- Incentive Based Reductions in Agricultural Water Use
- Groundwater
- Systems Integration and Management
- Watershed Management.

Agricultural and Municipal Water Conservation were later evaluated separately to highlight the unique characteristics associated with the alternatives in this category.

To better define the alternatives within each category the study team assembled definitions of each alternative and developed a scoping memorandum outlining how each alternative would be evaluated.

B. Conduct an Initial Screening

An initial screening of the long list was completed to defer alternatives that were considered less likely to be included in the Recovery Program. The purpose of this step was to focus the evaluation and rapidly set aside alternatives are were not well-suited for the Recovery Program. In general, efforts were focused at every step of the evaluation process to concentrate on the more promising alternatives. The study team developed screening criteria to evaluate, compare, and contrast the alternatives. The general screening criteria categories consist of physical, legal/institutional, economic, social, and environmental. Sub-criteria were developed to capture important aspects of the general criteria.

Each alternative was reviewed in the context of failure to pass the general screening criteria. Fatal flaws were identified with respect to the general criteria based on low yield, high cost, and inconsistency with federal laws, decrees or interstate compacts. Alternatives that received a score of zero in the general screening criteria were deferred from further evaluation during this study. Alternatives that failed the initial screening process were not eliminated from the study, rather they were set aside and further analysis was not performed. Alternatives that did not fail the initial screening review comprise the short list of alternatives.

C. Identify Specific and/or Representative Projects

Specific and/or representative water conservation projects were identified for the short list of alternatives. To identify these projects the study team reviewed successful water conservation/supply measures that have been implemented in the Platte River Basin and other areas and the applicability of those measures to the individual regions identified in the Platte River study area. In addition, meetings were held with WMC representatives from each state and the USBR to help identify potential projects within each region.

D. Evaluate Net Hydrologic Effects and Cost

Data from existing studies, reports, and programs were used to the maximum extent possible to estimate project costs. Where studies were not available engineering judgement was applied to determine costs. The study team used standard, reconnaissance-level analysis techniques to conservatively estimate the net hydrologic effects associated with each project within the immediate area of the project. This analysis provides information on the location and timing of water before and after the project is instituted and how the change in timing relates to periods of excess and shortage in the immediate area of the project.

The methodologies used to identify net hydrologic effects varied according to site-specific conditions. In general, the net hydrologic effects within a reach were determined by applying a water budget approach for the area in the immediate vicinity of the alternative. The Blaney-Criddle method and SDF method were consistently used for all projects that required analyses of consumptive use and groundwater related impacts to the Platte River.

The study team reviewed a number of alternative methods for estimating evapotranspiration and evaluated the methods for use in this study. Based on the study team's recommendation the WMC concurred that the SCS Blaney-Criddle method is the most appropriate method with respect to this reconnaissance level study for evaluating evapotranspiration and consumptive irrigation requirement. A more detailed description of the SCS Blaney-Criddle method is provided in Appendix C.

The SDF method was used to evaluate groundwater related impacts to the Platte River. The study team reviewed policies and procedures used in each state and prepared a recommendation for the WMC. The SDF methodology was adopted by the WMC for the analysis of groundwater related impacts to the Platte River. The SDF method is intended primarily for use in analyzing "point" stresses, such as those produced by a well. The stream depletion factor (SDF) has units of days and is defined as the time from the beginning of steady pumping or recharge within which the volume of stream depletion or recharge is 28 percent of the volume pumped or recharged. A more detailed description of the SDF method is provided in Appendix B. The advantages of the SDF method are that it is commensurate with the level of analysis required for this reconnaissance level study and mapping of SDF values is available for most of the study area. The disadvantage of the SDF method is that is a simplified model, which relies on simplifications of a stream-aquifer system in order to achieve an analytical solution. These simplification include:

1) The aquifer is homogeneous, isotropic, and semi-infinite in areal extent and overlies a horizontal, impervious base;

2) The stream is infinitely long and penetrates the full depth of the aquifer as a straight-line boundary;

3) The transmissivity of the aquifer is constant in space and time, in which case drawdown of the water table due to pumping or mounding due to recharge is negligible compared to the saturated thickness of the aquifer;

4) Water is released instantaneously from aquifer storage;

5) Recharge occurs at a point-scale in the horizontal plane;

6) Both pumping wells and recharge basins fully penetrate the aquifer to its base and discharge at a constant rate;

7) The stream bed is in perfect hydraulic connection with the aquifer, in which case the streambed and aquifer hydraulic conductivities are the same, implying no additional flow resistance associated with deposition of fine sediments on the streambed;

8) The water surface elevation in the stream remains constant in space and time;

9) There is not diffuse recharge to the aquifer, so that the water table is initially horizontal; and

10) The temperature of the stream is constant and equal to the temperature of the water in the aquifer.

These assumptions are violated in the Platte River system to varying degrees depending on the groundwater alternative evaluated. The degree to which they are violated contributes to the level of uncertainty regarding the prediction of return flows using the SDF approach and the associated yields at the critical habitat. Although the SDF method is appropriate for this reconnaissance level study, there is a considerable level of uncertainty associated with alternatives that rely on the SDF method for prediction of return flows to the river.

In determining the local net hydrologic effects associated with a specific project it was assumed that diversions to recharge or storage are only made during periods of target flow excesses at the critical habitat. Likewise, releases for the benefit of the critical habitat are only made during periods of target flow shortages. The FWS recommendations for flows in the critical habitat, or target flows, vary season by season and year by year depending on whether wet, dry, or average conditions exist. The target flows used to determine shortages and excesses at the critical habitat do not include pulse flows. The FWS (July 1997) weighted average monthly species instream flow recommendations or target flows and shortages and excesses at Grand

Island with respect to the target flows are shown in Tables 5.1, 5.2, and 5.3. The FWS average monthly instream flow recommendations and target flow shortages and excesses at Grand Island are also provided in the WMC's Summary of Flow Conditions for the Platte River for the Historical 1975-1994 Water Year Period. As required by Milestone W14-1 of the Cooperative Agreement, the WMC was required to summarize the flow conditions in the associated habitats in central Nebraska and at the state lines for the historical water year period of 1975 through 1994. The WMC's Summary of Flow Conditions for the Platte River for the Historical 1975-1994 Water Year Period is provided in Appendix A.

E. Develop a Water Budget Spreadsheet

The study team developed a water budget spreadsheet based on stream reach definitions and loss factors provided by the WMC to assist in determining effects on streamflows downstream of each project and the associated reductions to target flow shortages at the critical habitat. A description of the monthly loss factors is provided in Appendix E. The water budget was utilized to evaluate and compare how new accretions and depletions to the system associated with each project affect streamflows down to and through the critical habitat. As the same spreadsheet was used for each alternative, no bias was introduced.

The WMC selected a historical hydrologic period of record (1975-1994) for use in the spreadsheet modeling. The justification for the time period selected is provided in Appendix D.

The net hydrologic effects associated with each project were routed downstream to the critical habitat to determine potential reductions to target flow shortages. Two routing scenarios were evaluated for each project. The first scenario assumes that additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. If there are no changes or improvements in reservoir operations, inflows just "skim" across the top and experience no evaporation losses or lag time. The water budget was used to evaluate the flow accretions and depletions at Grand Island as well as reductions to target flow shortages associated with each project.

TABLE 5.1
FWS (July 1997) Weighted Average Monthly Species Instream Flow Recommendations or Target Flows
(ac-ft)

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
WET	147600	101200	61500	61500	143000	167500	142800	170800	158700	73800	73800	65500	1367700
AVG	110700	83300	61500	61500	143000	167500	142800	150000	158700	73800	73800	65500	1292100
DRY	79900	56500	36900	36900	95800	114000	101200	67000	47600	49200	49200	41700	775900

TABLE 5.2
Grand Island Shortages With Respect to FWS Annual Species Target Flows for Wet, Average and Dry Years
(ac-ft)

Year Type	Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVG	1975	55070	34526	2686		69869	64736	51441	90825	50159	35590	51672	12059	518633
AVG	1976	66465	24316			33195	60809	44102	83615	139157	64489	72490	47022	635660
AVG	1977	64981	36887	925	5794	71119	74872	5345	38271	101037	63165	57307	18353	538056
AVG	1978	35776	29034	2214	14611	86392		35732	93447	139296	67362	63694	51917	639475
AVG	1979	74321	35473	1698	10604	93255	2118	40096	75636	36387		48654	45199	463441
WET	1980	122247	58379								50437	53813	36827	321703
DRY	1981	43650	16799			30683	31289	52581	21906	31014	12123		15810	255853
AVG	1982	61661	21370			39562	49999	83921	87590	118570	52287	49586	28598	593144
WET	1983	85613	16641											102254
WET	1984		8552									43526		52078
WET	1985							4889	24202	77271	30475	23747		160584
WET	1986	8380	12479											20859
WET	1987											29245		29245
WET	1988	43912					13999	28136	43164	128045	5380	25774	14890	303300
AVG	1989	48490	29318			49221	43672	98176	124856	100961		38974		533668
AVG	1990	55018	28657	16898		50342	43156	30615	44073	117880	64898	38425	49166	539128
DRY	1991	49829	8363			10273	38842	59029			41143	38895	26602	272976
DRY	1992	59635	4842			6564		25735	43780	13217	1230	20918	19916	195837
WET	1993	91020	49923			70226		44910	101460	93581		427		431547
AVG	1994					50790	1700	62860	98900	112630		42140	28360	397380
	Average	61629	25972	4884	10336	50884	38654	44505	69409	89943	40715	41135	30363	351241

TABLE 5.3
Grand Island Excesses With Respect to FWS Annual Species Target Flows for Wet, Average and Dry Years
(ac-ft)

Year Type	Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVG	1975				12920									12920
AVG	1976			35194	18216									53410
AVG	1977													0
AVG	1978						52388							52388
AVG	1979										26996			26996
WET	1980			61951	42513	21231	58140	146390	361226	190252				881703
DRY	1981			29883	34386							13271		77540
AVG	1982			20655	7921									28576
WET	1983			56913	78037	25139	23925	70562	318582	852573	590841	286835	325760	2629167
WET	1984	18615		147459	243161	263393	266047	446648	578555	382688	96257		132220	2575043
WET	1985	73180	211217	221760	114632	65463	114450						25402	826104
WET	1986			69607	109574	47691	7085	74251	32030	21308	12850	50147	141515	566058
WET	1987	88056	67752	96761	93469	3579	57525	78119	34311	73207	7590		31036	631405
WET	1988		15269	44120	51855	49516								160760
AVG	1989			14019	34401						368		27729	76517
AVG	1990				58599									58599
DRY	1991			6707	11556				12579	35121				65963
DRY	1992			22102	44145		27243							93490
WET	1993			11948	14923		107746				101089		27723	263429
AVG	1994	2900	26700	51000	27040						8200			115840
	Average	45683	80235	59339	58668	68002	79394	163194	222881	259192	105524	116751	101626	499795

F. Evaluate the Shortlisted Specific and/or Representative Projects with Respect to the Screening Criteria

Each of the alternatives was evaluated according to the previously defined screening criteria (see Section B.). Tabular scoring of the sub-criteria was prepared to compare and contrast the alternatives and evaluate their relative effectiveness. Each project received a composite or total score which could range between zero and twenty-five. Associated physical, legal/institutional, economic, social, and environmental issues were also addressed.

Scoring of each alternative was performed at a reconnaissance level of detail, defined as that level needed to distinguish major differences among alternatives and to provide a preliminary indication of the feasibility of each alternative. For each sub-criterion, the "more or less" approach was used to determine a numerical ranking between 0 and 5. A score of 3 is average; 5 is better than average; 1 is less than average; and a score of 0 represents a potential fatal flaw. Alternatives that received a score of zero for net reduction to target flow shortages, initial implementation and capital cost, average annual total cost per ac-ft of net reduction, or consistency with interstate compacts, federal laws and decrees were deferred from further evaluation in this study.

6. DEVELOPMENT OF WATER CONSERVATION/SUPPLY ALTERNATIVES

A. Introduction

To identify and develop the most suitable water conservation and supply measures to support the Platte River Recovery Program, the study team identified a long list of alternatives for the three regions in the Platte River study area. The long list of alternatives was reorganized and regrouped into seven categories. Scoping memoranda were developed for each category that included detailed definitions of the alternatives and outlined how each alternative was to be evaluated. These alternatives, shown in Table 1.1, were reviewed in a two-step screening process.

The first step, or initial screening process, used general screening criteria previously defined to identify potential fatal flaws. The general screening criteria that were used in the initial screening phase consist of physical, legal and institutional, social, economic, and environmental criteria. The initial screening was intended to identify alternatives that are not well suited for inclusion in the Recovery Program and do not warrant further investigation. Any alternatives on the long list receiving a score of zero on one or more of those criteria were deferred from further evaluation at this time.

The remaining alternatives formed the short list of alternatives, as shown in Table 1.2. Sub-criteria were developed which address the key aspects of the general criteria. Specific and/or representative examples of the shortlisted alternatives were identified and evaluated with respect to all sub-criteria. Each phase of the development of water conservation/supply alternatives is further described in the following sections.

B. Development of Long List of Alternatives

The study team reviewed notebooks provided by the three states and the Department of the Interior, river basin planning reports, agency manuals, and research papers, and conducted Internet searches to identify water conservation and supply alternatives for the three regions. Seventy-seven potential alternatives were identified in relation to all of the basin's water uses (see Table 6.1). The long list was comprehensive in that the alternatives identified are applicable to the types of consumptive uses in each region. The study team presented the long list of alternatives at an August 12, 1998, workshop.

To reduce the overlap between the alternatives the long list was reorganized and regrouped. In the process of regrouping the alternatives a memo was submitted to the WMC on September 21, 1998, which provides general information compiled from existing studies regarding the volume of water likely to be produced, cost per unit volume of water, and past limitations/experiences based on information from existing studies for each alternative. The reorganization of alternatives resulted in the development of seven categories of alternatives. The seven categories of alternatives are as follows:

1. Reservoirs
2. Water Conservation (Municipal and Agricultural)
3. Reuse
4. Incentive Based Reductions in Agricultural Water Use
5. Ground Water
6. System Integration and Management
7. Watershed Management

Scoping memoranda were developed and submitted to the WMC on November 4, 1998 for each of the seven categories of alternatives. These memos include detailed definitions of the alternatives and scope how each alternative will be evaluated. These memos include conceptual and operational definitions, which outline the simplifying assumptions that were used to define and analyze the alternatives. In addition, these memos provide information on data collection and the approach that was used to evaluate each of the screening criteria: physical, legal and institutional, economic, social and environmental. The scoping memoranda were used for the initial screening of alternatives to identify potential fatal flaws.

1. Development of Screening Criteria

The study team presented the following general screening criteria at a September 16, 1998 workshop:

1. Physical
2. Legal/Institutional
3. Social
4. Economic
5. Environmental

Sub-criteria were developed to capture the important aspects of the general criteria as they relate to the specific goals of the project. The sub-criteria are described in the next section. For each sub-criteria, the "more or less" approach was used to determine a numerical ranking between 0 and 5 as follows:

0 A zero represents a fatal flaw. The alternative fails the sub-criteria.

1 The alternative performs less favorable than average for the sub-criteria.

2 The alternative performs slightly less favorable than average for this sub-criteria.

3 The alternative performs about average for the sub-criteria.

4 The alternative performs slightly more favorable than average for the sub-criteria.

5 The alternative performs more favorable than average for the sub-criteria.

The average is defined for each sub-criteria under Section C. Sub-Criteria Scoring. For each sub-criteria, ranges or conditions were established for scores from 1 to 5.

During the Screening Workshop conducted September 16, 1998, these general criteria were discussed and the methods for screening outlined. If an alternative receives a zero ranking in any single sub-criteria, that zero ranking will be used to represent the entire general criteria. If there are no zero rankings, all sub-criteria rankings are considered of equal importance and are averaged to determine the general criteria score. The general criteria are considered to be of equal importance. Any alternatives on the long list that receive a score of zero on one or more of the general criteria were screened from further evaluation at this time.

The initial screening was carried out based on the preliminary information presented in scoping memoranda for all seven categories of alternatives on the long list. The initial screening shortened the long list of alternatives by identifying those alternatives that fail one or more of the general criteria. The result of the screening process is not to rank-order the alternatives, but to group them together with other alternatives that perform about the same overall. Alternatives that were removed from the long list were not removed from the study, only deferred from further analysis at this time. This allows more detailed examination of the alternatives most likely to satisfy the project goal for inclusion in the Recovery Program.

2. Development of Sub-Criteria

Sub-criteria capture the important aspects of the general criteria as they relate to the specific goals of the project. The sub-criteria are unique to avoid "double counting" within a general criteria.

Sub-criteria were developed that are both qualitative and quantitative. For instance, yield and cost sub-criteria are quantifiable; however, impacts to the environment require a more qualitative analysis. The scope of work limits the amount of detail that was generated for some sub-criteria. For example, although the Economic Criterion "Secondary Economic Impacts" can be quantified, the screening only occurred on a qualitative basis. The following sub-criteria were developed to analyze the general criteria.

Physical

- Net Reduction in Shortage to Target Flows

  What is the net reduction in shortage to target flows at the critical habitat?

- Sustainability

  Is the yield from the alternative sustainable over time?

- Scalability

  Can the alternative be increased or decreased to complement other alternatives?

- Technically Implementable

  Does the alternative require technology that has not been proven or has not been implemented at the proposed scale?

- Time to Yield Realization

Can the alternative deliver water to the critical habitat immediately following implementation or does it require a longer period of time for yield realization?

- Ability to Monitor and Measure

  Is the yield associated with the alternative easily quantified and distinguished from other sources of flow?

- Third Party Hydrologic Impacts

  What are the indirect and induced hydrologic impacts resulting from the direct hydrologic impacts of the alternative?

Legal/Institutional

- Ease of Permitting

  What is the potential for the alternative to gain support of regulatory agencies?

- Consistent with Interstate Compacts, Federal Laws and Decrees

  Is the alternative consistent with Interstate Compacts and Federal Laws and Decrees?

- Consistent with State Laws

  Does the alternative require a change in state water laws?

- Potential for Institutional Consensus

  Is the alternative likely to generate publicly stated opposition by an entity that has the ability to prevent implementation?

- Can be Mitigated

  Can undesirable impacts of an alternative be "made right"?

- Administrative Ease

  Is the alternative easy to administer and enforce?

- Consistent with Existing Contracts and Facility and Land Ownership

Does the alternative impact existing contracts or facility and land ownership?

Social

- Effects on Customs and Culture

  What are the effects of the alternative on traditional industries and community identity (may be partly measured in terms of any dislocative effects)?

- Equity of Impacts

  Does the alternative produce disparate gainers and losers? Will some identifiable groups be disproportionately affected – e.g. ethnic communities, low income residents, older or younger residents, or members of particular occupations? Are some geographic areas being disproportionately affected?

- Impacts on Community Organizations and Support Structures

  What are the effects on local groups, religious institutions and other organizations? What are the effects on housing and other community support structures.

- Effects on Community Sustainability

  Will the alternative change the capacity of the community to adapt to changing circumstances, or to maintain a critical mass needed to support services, businesses and infrastructure?

- Public Acceptability

  What is the potential for the public to accept the alternatives – separate from concerns regarding equity and other criteria?

Economic

- Initial Implementation and Capital Cost

  What are the up front costs to establish the alternative (measured in 1999 dollars)?

- Average Annual Total Cost per Acre-foot Delivered

  What is the average cost per acre-foot of water delivered to the critical habitat for the alternative over a 20-year period? Includes amortized capital and implementation costs, and ongoing OM&R costs.

- Direct Economic Impacts (includes direct third party economic impacts)

  What are the direct impacts of the alternative on business sales, employment and employee wages and wealth – e.g. property values (measured in dollars and jobs)?

- Secondary Economic Impacts (includes indirect third party economic impacts)

  What are the indirect and induced economic impacts from changes in sales and employee earnings resulting from the direct impacts and other third party economic impacts of the alternative (measured in dollars and jobs)?

- Fiscal Impacts

  What are the effects on revenues and expenditures of governmental entities resulting from the alternative (measured in dollars)?

- Effects on Economic Development Potential

  What effects does the alternative have on future growth potential, extending beyond the 20-year study horizon (qualitative assessment)?

Environmental

- Impacts to Wetlands

  What are the effects of the alternative on existing wetlands? Is there a potential to create new wetlands?

- Impacts to Habitat

  What are the effects of the alternative on existing habitat, other than wetlands-associated habitat (does not include the critical habitat)? Is there a potential to generate new habitat?

- Impacts to Water Quality

  What are the effects of the alternative on water quality (could be positive or negative)?

- Impacts to Prime and Unique Farmlands

  Does the alternative impact Prime and Unique Farmlands?

- Visual Impacts

  Does the alternative have associated visual impacts (could be positive or negative)?

- Impacts to Amenities

  What is the potential for an alternative to enhance or diminish recreational opportunities?

C. Sub-Criteria Scoring

For each sub-criterion, the "more or less" approach was used to determine a numerical ranking between 0 and 5. A score of 3 is average; 5 is better than average; 1 is less than average; and a score of 0 represents a fatal flaw. Some of the ranking criteria are quantitative while others are based on comparisons between alternatives.

For each sub-criteria, ranges or conditions were established for scores from 1 to 5. Alternatives were scored first by individuals based on the ranges or conditions established for the sub-criteria. Information obtained from knowledgeable parties in the Platte River Basin, including members of the WMC, was considered in scoring the alternatives. To ensure that alternatives were scored consistently across evaluators, the team then re-evaluated the scoring of all alternatives with respect to each sub-criteria. This was necessary for sub-criteria with more subjective scoring conditions. Adjustments were made if certain alternatives performed similarly with respect to a given sub-criteria yet received different scores.

The following ranges or conditions were established to score the sub-criteria under each general criteria.

Physical

All sub-criteria were scored based on the 'Yield at the Site' except the sub-criteria, Net Reduction in Shortages to Target Flows.

Net Reduction in Shortages to Target Flows

0	< 500 ac-ft/yr
1	500 to 2,500 ac-ft/yr
2	>2,500 to 5,000 ac-ft/yr
3	>5,000 to 7,500 ac-ft/yr
4	>7,500 to 10,000 ac-ft/yr
5	> 10,000 ac-ft/yr

Sustainability

1	Not sustainable, life span less than the term of the first increment of the Proposed Program (10 to 13 years)
2	Temporary arrangement, life span is difficult to extend beyond 10 to 13 years
3	Temporary arrangement, life span variable but has the potential to be extended beyond 10 to 13 years
4	Life span can easily be extended beyond 10 to 13 years, however infrastructure needs to be replaced or contract renewed
5	A permanent fixture, life span well beyond 10 to 13 years

Scalability

1 0 ac-ft/yr to 5,000 ac-ft/yr
2 0 ac-ft/yr to 10,000 ac-ft/yr
3 0 ac-ft/yr to 30,000 ac-ft/yr
4 0 ac-ft/yr to 60,000 ac-ft/yr
5 ≥ 60,000 ac-ft/yr

Technically Implementable – based on the scale evaluated

1 Cannot be implemented or not proven technology
2 Technology needed to implement is in experimental stages
3 Technically implementable, but not at scale proposed
4 Technically implementable at close to the scale proposed
5 Technically implementable at scale proposed

Time to Yield Realization

0 > 10 yrs
1 up to 10 yrs
2 up to 8 yrs
3 up to 6 yrs
4 up to 4 yrs
5 0 to 2 yrs

Ability to Monitor and Measure

1 Questionable and/or difficult
2 Engineering estimate with significant uncertainty
3 Engineering estimate with some uncertainty
4 Limited uncertainty
5 Uncontestable

Third Party Hydrologic Impacts

1 Very bad impact
2 Slightly less favorable than average impact
3 Neutral
4 Slightly more favorable than average impact
5 Good impact

Legal/Institutional

Ease of Permitting

1 Known to be difficult or has previously failed the permitting process
2 Known to have some opposition; permitting process not in place
3 General/routine permitting process
4 Portion of permit in place
5 No permitting required

Consistent with Interstate Compacts, Federal Laws & Decrees

0 Not consistent and cannot be circumvented
1 Clearly problematic
2 Problematic, however may be possible to overcome
3 Questionable
4 Some questions, however no major obstacles
5 Consistent

Consistent with State Laws

1 Clearly problematic
2 Problematic, however may be possible to overcome
3 Questionable; compliance with export statute an issue
4 Some questions, however no major obstacles
5 Consistent; export statutes are not an issue

Potential for Institutional Consensus

1 Strong objections publicly voiced
2 Specific objectors known
3 There will be objectors, do not know who specifically
4 Generally viewed favorably
5 Total consensus

Can be Mitigated

1 Bad impact that cannot be mitigated
2 Slightly less favorable than average impact; unknown whether impact can be mitigated
3 Neutral; unidentified impact or unknown impact which can be mitigated with a traditional solution
4 Known impacts that can be mitigated with a traditional solution
5 No undesirable impact

Administrative Ease

1-2 Administration not in place yet; new entity required. Closer to a 2 if existing entity could assume administration responsibility
3 Existing entities; new procedures required or existing procedures are cumbersome
4-5 Easy to operate/maintain – existing entities with existing procedures. Closer to a 4 if has to be administered on a monthly or annual basis. Closer to a 5 if no administration is required.

Consistent with Existing Contract, Facility & Land Ownership

1 Contract, facility or land ownership issues that are difficult to deal with
2 Contract, facility, or land ownership issues that may be difficult to deal with
3 Contract, facility, or land ownership issues that can be dealt with
4 Minimal contract, facility, or land ownership issues that are easily dealt with
5 Completely consistent

Social

Effects on Customs and Culture; Equity of Impacts; Impacts on Community Organizations and Support Structures; Effects on Community Sustainability; Public Acceptability

1 Major negative impacts
2 Modest but mostly negative impacts
3 Neutral or offsetting impacts
4 Modest but mostly positive impacts
5 Major positive impacts

Economic

Initial Implementation and Capital Cost

0 > $50 million
1 >$40 million to $50 million
2 >$30 million to $40 million
3 >$20 million to $30 million
4 >$10 million to $20 million
5 0 to $10 million

Average Annual Cost per Acre-Foot Reduction

0 > $3,000
1 > $2,500 to $3,000
2 > $2,000 to $2,500
3 > $1,500 to $2,000
4 > $1,000 to $1,500
5 $0 to $1,000

Direct Economic Impacts; Secondary Economic Impacts; and Fiscal Impacts

1 Major negative impacts
2 Modest but mostly negative impacts
3 Neutral or offsetting impacts
4 Modest but mostly positive impacts
5 Major positive impacts

Effects on Economic Development Potential

1 Irreversible negative effects
2 Negative effects that are difficult to mitigate
3 Reversible negative effects
4 Mostly positive effects and some reversible negative effects
5 Positive effects

Environmental

Impacts to Wetlands; Impacts to Habitat; Impacts to Water Quality; Visual Impacts; and Impacts to Amenities

1 Negative impacts
2 Slightly less favorable than average impacts
3 Neutral
4 Slightly more favorable than average impacts
5 Positive impacts

Impacts to Prime and Unique Farmlands

1 Major negative impacts
2 Less favorable than average impacts
3 Some impacts or potential impacts
4 Minimal impacts
5 No impact

An average of the sub-criteria scores under each major criteria (physical, legal and institutional, economic, social, and environmental) was determined. Each major criteria was weighted equally, therefore, the total score associated with each alternative is the sum of the average scores of the five main screening criteria. The total possible maximum score for an alternative is 25. The total scores are used to rank alternatives (see Chapter 8).

D. Initial Screening of Alternatives

An initial screening of the long list of alternatives was completed to defer evaluation of the alternatives that were deemed to be less likely candidates for inclusion in the Recovery Program. In each scoping memoranda the screening criteria were described in enough detail so 1) an alternative's performance can be analyzed, and 2) there is backup documentation to support the results of the criteria analysis. Based on an initial screening with the general criteria, a short list of alternatives was developed. Developing a short list allowed the remaining alternatives to be reviewed and analyzed in greater detail. Alternatives removed from the long list have not been dropped from consideration permanently, only deferred from further evaluation at this time.

Fatal flaws were identified with respect to the general criteria as follows:

- Physical. The alternative does not provide increased flow at the critical habitat in times of shortage and therefore does not provide at least 500 ac-ft of net reductions to target flow shortages. The alternative is not considered technically feasible at the scale required to produce increased flow at the critical habitat.
- Legal/Institutional. The alternative cannot be implemented under existing federal compacts and federal laws. Entities that have the ability to prohibit implementation have already expressed strong opposition. Alternatives that require adjudication and/or administrative permitting do not fail this criterion.
- Economic. The cost to implement the alternative is considered to be cost prohibitive. Alternatives will not be considered for further evaluation if the unit cost at the critical habitat exceeds $3,000/ac-ft or the implementation cost for an alternative exceeds $50 million.

Each alternative was reviewed in the context of failure to pass the general criteria. Failure to pass any one of the general criteria was considered justification for deferring the alternative from further analysis. Alternatives could also deferred if they violate the requirement of the Cooperative Agreement that projects be incentive based and reflect willing participation. This review was performed for each alternative in each of the three regions. This was necessary due to varying state water laws, state compact requirements, and physical limitations associated with routing water to the critical habitat. Alternatives that did not fail the above criteria based on the initial screening review comprise the short list of alternatives.

1. Initial Screening Results

Table 6.1 provides a summary of the initial screening. Alternatives that failed to pass the general criteria, as described above, for all three regions are highlighted, and a zero placed in the appropriate general criteria column. As shown, the alternatives were evaluated for potential implementation in each region.

TABLE 6.1
INITIAL SCREENING OF LONG LIST OF ALTERNATIVES

	Physical			Legal/Institutional			Economic			Social			Environmental		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Category 1 - Reservoirs															
Construction of new storage facilities or equalizing reservoirs															
Enlarge existing reservoirs															
Dredge existing reservoirs							0	0	0						
Reduce losses via evaporation suppression or lining large reservoirs	0	0	0												
Remove storage restrictions															
Category 2 - Water Conservation															
Municipal															
Financial/Economic Incentives															
Conservation pricing															
Financial incentives for municipal conservation															
Tax incentives/subsidies															
Universal metering															
City parks metering															
Municipal Education/Information	0	0	0												
Water use consultations Waste minimization/System wide use reduction and water audit Reduce municipal distribution system leakage	0	0	0												
Landscape audits	0	0	0												
Landscape advisor	0	0	0												
Public sector audits/management	0	0	0												
Irrigation monitoring for municipal greenways Low water use landscape design	0	0	0												
End-user Technology Changes															
Pressure reduction	0	0	0												
Low demand plumbing fixtures	0	0	0												
Landscape irrigation system improvements															
Regulatory measures															
Conservation plumbing ordinance				0	0	0	0	0	0						
Landscape restrictions on new homes				0	0	0	0	0	0						
Outdoor water restrictions															
Restrictions on specific uses															
Water use rationing				0	0	0	0	0	0						
Prohibitions on new connections				0	0	0	0	0	0						
Water court enforcement of efficiency goals				0	0	0	0	0	0						
Agricultural															
On-farm															
Change irrigation techniques	0	0													
Financing of water saving equipment	0	0													
Conversion to sprinkler irrigation	0	0													
Low Energy Precision Application	0	0													
Drip Irrigation	0	0													
Subsurface Drip Irrigation (SDI) Systems	0	0													
Improved management/information	0	0	0												
Hydrologic instrumentation	0	0	0												
Computerized system scheduling	0	0	0												
Local downstream control methods	0	0	0												
Change irrigation practices															
Conservation cropping patterns															
Deficit irrigation practices															
Other agricultural on-farm modifications	0	0	0												
Soil modification	0	0	0												
Microclimate modification	0	0	0												
Water District															
Structural															
Rehabilitate/improve conveyance channels															
Repair/improve water control structures															
Non-structural															
Conservation pricing															
Demand based irrigation vs schedule based															

Note: Water c ...vation Kits Public Information Demonstration projects is considered a component of all alternatives under municipal e information.

TABLE 6.1 (Cont.)
INITIAL SCREENING OF LONG LIST OF ALTERNATIVES

	Physical			Legal Institutional			Economic			Social			Environmental		
	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3	Region 1	Region 2	Region 3
Category 3 - Reuse															
Water reuse and commercial/industrial recycling	0	0	0				0	0	0						
Waste water effluent for cooling	0	0	0				0	0	0						
Pump-back arrangement for return flows				0	0	0									
Relocation of return flows	0	0													
Category 4 - Incentive Based Reductions in Agricultural Water Use															
Agricultural															
Acquisition and dry-up of irrigated lands Permanent acquisition of agricultural water rights Land fallowing programs Temporary leasing of agricultural water supplies Dry year leasing Drought water banking															
Non-agricultural															
Paying power interference charges															
Category 5 - Ground Water															
Ground water recharge/return flow project															
Development of non-tributary ground water sources							0	0	0						
Ground water allocation management															
Reduction of ground water export															
Additional surface water and/or groundwater reregulation opportunities															
Category 6 - Systems Integration and Management															
Changes in points of diversion															
Effluent exchange agreements	0	0	0				0	0	0						
Link existing municipal water supply systems	0	0	0				0	0	0						
Modification of reservoir filling sequences															
Modified flow release rules															
Transbasin diversions/imports					0	0									
Transfer of storage decrees															
Water rights transfers or exchanges															
Category 7 - Watershed Management															
Forest management			0												
Phreatophyte control	0	0	0				0	0	0						
Snowpack management via vegetative shading	0	0	0												
Weather modification	0	0	0												

Note: Water Conservation Kits/Public Information Demonstration projects is considered a component of all alternatives under municipal education information.

The following sections describes the alternatives that failed to pass one or more of the general criteria in any region and were excluded from the short list of alternatives.

Category 1 – Reservoirs

- Dredge Existing Reservoirs. This alternative has been eliminated from the short list for all three regions due to failure to pass the screening tests for the economic category.

  In the Cache la Poudre Basin Study, the cost of recovering lost storage capacity by dredging was found to exceed the cost of new reservoir storage by a factor of five or more (Harza Engineering Company, et al., 1990). In the St. Vrain Basin Study, R.W. Beck and Associates and Dames & Moore (1986) the estimated costs for dredging in 1985 ranged from $2,500-$3,500/ac-ft or higher, not including the costs of material disposal. These costs are likely to be double in present day dollars when material disposal is included.

  In addition to the prohibitive costs associated with dredging, the disposal of the dredged material presents environmental obstacles.

- Reduce Losses via Evaporation Suppression or Lining Large Existing Reservoirs. This alternative has been eliminated from the short list for all three regions due to failure to pass the screening test for the physical category.

  Evaporation suppression methods, including windbreaks, floating reservoir covers, and application of monomolecular films, are not considered technically feasible for large reservoirs (HDR Engineering, Inc., et al., May 1989a). Suppression of evaporation from existing reservoirs in the Cache la Poudre River Basin was not considered a viable means of enhancing water supply in the Basin (Harza Engineering Company, et al., 1990). Lining large existing reservoirs (greater than 10,000 ac-ft) is considered cost prohibitive (HDR Engineering, Inc. et al., May 1989a). However, lining new reservoirs, and smaller existing reservoirs or gravel pits in a reach was not screened out.

Category 2 – Water Conservation

- Municipal Education/Information. This alternative group has been eliminated from the short list for all three regions due to failure to pass the screening test for the physical category.

  Colorado's major municipalities have already enacted conservation programs, which include extensive education and information programs (Office of Water Conservation, 1997; ECI, 1994). The yield from public education and information programs has already been gained in most instances; therefore, additional effort in this area would not have a measurable effect on flow quantity or timing at the critical habitat. In addition, this alternative group requires a significantly longer time for yield realization (Rozaklis, 1997).

  Relatively little benefit toward the study's goals can be expected from municipal conservation measures in the Wyoming and Nebraska portions of the study areas because the total municipal use in these regions is small in comparison to the average annual project goal of 60,000 ac-ft at the critical habitat. Based on 1995 water consumption data from USGS, even if a combination of municipal conservation programs could achieve 20 percent reductions in consumptive use in all municipal systems within the study area in Wyoming and Nebraska, the reductions would be less than 3,600 ac-ft in Wyoming and 2,800 ac-ft in Nebraska (USGS, 1995).

- Municipal End-User Technology Changes. Two alternatives within this subcategory, which include pressure reduction and low demand plumbing fixtures, have not been included in the short list for all three regions due to failure to pass the screening test for the physical category. Pressure reduction will not reduce consumptive use of municipal customers. If the application rate for outdoor landscape irrigation is reduced, home and business owners are just as likely to respond by extending watering cycles. Pressure reduction could also lead to problems for many customers' sprinkler systems and coverage generating stiff public opposition to this measure. Low demand plumbing fixtures will not reduce consumptive use appreciably. Low demand plumbing fixtures can reduce municipal diversions but will also reduce return flows, producing no advantages from a basin-wide supply perspective.

- Municipal Regulatory Measures. Five of the seven alternatives in this alternatives group have not been included in the short list for all three regions due to the failure to pass the screening test for the physical yield and economic (cost per ac-ft of reductions to target flow shortages) categories. The five alternatives are water use rationing, prohibitions on new connections, water court enforcement of efficiency goals, landscape restrictions on new homes, and conservation plumbing ordinances.

  Possibilities for legal contention by special interests are likely and litigation will be costly. The two former alternatives may restrict economic growth with the latter requiring significant time for yield realization. The first three alternatives are also socially unpopular and are likely to only be feasible under drought conditions (AWWA, 1984). Public acceptance is unlikely (AWWA, 1984).

  Landscape restrictions on new homes are focused on reducing future water use for future water users. Future water users are outside the scope of the current study. Conservation plumbing ordinances also focus on future water users, which are outside the scope of the current study.

- Agricultural: Change Irrigation Techniques and Improved Management/Information. These alternative groups, which include financing of water saving equipment, conversion to sprinkler irrigation, low energy precision application, drip irrigation, subsurface drip irrigation systems, hydrologic instrumentation, computerized system scheduling, and local downstream control methods are all aimed primarily at increasing on-farm irrigation efficiency. These alternative groups have not been included in the short list for regions 1 and 2 due to failure to pass the screening criteria for the physical category. Changes in irrigation techniques were considered in Region 3 because, unlike the rest of the study area, a large portion of the return flows do not return to the river above the critical habitat.

  There is no simple, or universal, answer to improving on-farm efficiency. System conversion may be a valid alternative for improving water use and management where the existing irrigation system is poorly suited to the site conditions and the desired degree of efficiency cannot be obtained by improving the system design. No one irrigation method is adaptable to all conditions, and conversion from one method to another should not be based on such a premise (Nebraska Natural Resources Commission (NNRC), 1985).

Apart from the difficulty in identifying the applicability or potential savings from efficiency enhancing measures without a farm by farm analysis, the basic argument for de-prioritizing on-farm measures targeted at increasing irrigation efficiency is that, generally, these measures increase efficiency mainly by reducing return flows, not by reducing consumptive use (Allen, et al., 1995). While these types of efficiency gains are often of considerable benefit to farmers or irrigation districts, for example by allowing greater consumptive use from a specified diversion right, they generally do not reduce water use from a system-wide or basin perspective. In fact, the opposite may be the more likely result (Huffaker and Whittlesay, 1995). For example, the study by the Colorado Agricultural Water Conservation Task Force of Irrigation Water Conservation: Opportunities and Limitations in Colorado discussed potential concerns that conservation measures being adopted by farmers could have an adverse impact on streamflows (CWRRI, 1996).

Given that much of the study area is considered by farmers to be short of water supplies for agriculture, we believe the following would be the logical implications of efforts designed to increase on-farm irrigation efficiency. In the absence of additional measures, alternatives focused on providing incentives for improvements in on-farm irrigation efficiency are most likely to lead to increased consumptive use by participating farms as efficiency gains are used to overcome existing deficit irrigation circumstances, improve crop yields or bring more acreage under irrigation. To avoid this result, which is directly counterproductive to study objectives, the on-farm efficiency measures would have to be accompanied by onerous administrative structures and measuring efforts to reduce participating farmers' diversions by a corresponding percentage. These measures are likely to be difficult to monitor and enforce and might encounter stiff negative reaction from the agricultural communities in the three states.

Even if administrative restrictions on diversions could be successfully implemented in conjunction with incentives for improved on-farm efficiency, the net result would still be a zero net reduction in annual consumptive use. At best, there might be some benefit in terms of the timing of flows in the river. However, the cost of this benefit would be extraordinary in terms of a) direct costs for irrigation efficiency improvements, b) administrative cost and complexity, and c) potential third party hydrologic impacts.

Structural improvements or changes to water district systems, such as canal lining, offer comparable potential benefits by changing the timing that might result from increased on-farm efficiency with more favorable cost and administrative characteristics, therefore, these alternatives were not screened out. Other on-farm measures, which can actually reduce consumptive use through reductions in evaporation or transpiration (such as conservation cropping and deficit irrigation), were not screened out. Other agricultural on-farm modifications, which includes soil modification and microclimate modification, were not included in the short list for all three regions due to failure to pass the screening criteria for the physical category. This alternative group serves mainly to enhance soil moisture retention through land shaping or the use of windbreaks. Although there are secondary benefits (lower energy costs, increased yields), these alternatives would not significantly reduce consumptive use and may reduce return flows through additional moisture capture (NNRC, 1985; U.S. Congressional Office of Technology Assessment, 1983; Steppuhn and Waddington, 1996).

Category 3 – Reuse

- Water Reuse and Commercial/Industrial Recycling. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria primarily for the physical and economic categories. Municipal and industrial water use varies little over the year, when compared to agricultural water use. Therefore, there is essentially no lag time between diversion or pumping and return to the river. If less water is diverted or pumped during a time step, there is a corresponding decrease in river returns during the same time step. Therefore, there would be essentially no change in flow quantity or timing at the critical habitat.

  Municipalities place a high value on reuse or recycled water because this water represents a future water supply source, which can postpone water supply acquisition and development costs. Therefore, the value of the reuse alternative might best be estimated in terms of the cost of replacing potential reuse with an alternate supply in the city's portfolio. Reuse alternatives are considered cost prohibitive in the context of replacing potential reuse.

Direct costs related to wastewater cooling reuse alternatives can be very high. Direct up-front costs may include potential treatment facilities costs, distribution system costs, and pump station and storage reservoir costs, in addition to annual operational and maintenance costs. For example, Tucson, Arizona has initiated a metropolitan wastewater reuse program mandating that reclaimed wastewater be used for city landscape irrigation. The completed system will provide approximately 35,000 ac-ft/yr of reclaimed wastewater at a total capital development cost of about $63 million (Miller, 1991). In an effort to conserve Denver's water resources the Denver Water Nonpotable Reuse Project includes a water reclamation system that uses secondary effluent as a source of reclaimed water. The probable capital cost of the 30 million-gallon-per-day (MGD) project from the Schematic Design Report was greater than $5,000/ac-ft (Richard P. Arber Associates, 1999; Boyle Engineering Corporation, 1999). As shown by the above capital cost figures, reuse alternatives are considered cost prohibitive in the context of this study.

- Wastewater Effluent for Cooling. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for both the physical and economic categories. The need for industrial cooling water is relatively constant throughout the year, as is the availability of sewage effluent. Therefore, if less water were diverted for industrial cooling during a time step, there would be a corresponding decrease in river returns from municipal sewage. Therefore, there would be essentially no change in flow quantity or timing at the critical habitat.

Direct costs related to wastewater reuse alternatives can be very high. The city of Tampa, FL has remodeled an incinerator facility to use approximately 1 MGD of reclaimed wastewater for cooling-water make-up. The remodeling cost was $60 million and the project saved the Tampa water department over 1,000 ac-ft/yr of potable water (Miller, 1991). Due to the high capital costs typically associated with wastewater reuse systems, alternatives that involve wastewater effluent for cooling are considered cost prohibitive in the context of this study. In addition, the cooling effluent would require tertiary treatment before being released to the river. Cooling tower make-up water can also require treatment such as cold lime softening to protect from scale or the addition of biocides and biodispersents; therefore, there may be additional treatment costs involved.

- Pump-Back Arrangement for Return Flows. This alternative has been eliminated from the short list for all three regions due to failure to pass the screening criteria for the physical category. This alternative is similar to changes in irrigation techniques, some of which were also eliminated due to failure to pass the screening criteria for the physical category. Pump-back arrangements for return flows do not reduce consumptive use, they simply retime return flows. In the absence of additional measures, alternatives focused on providing incentives for improvements in on-farm irrigation efficiency are most likely to lead to increased consumptive use by participating farms as efficiency gains are used to overcome existing deficit irrigation circumstances, improve crop yields, or bring more acreage under irrigation. As a result, it is unlikely that pump-back arrangements would result in significant reductions to target flow shortages at the critical habitat.
- Relocation of Return Flows. This alternative has not been included in the short list for Regions 1 and 2 due to failure to pass the screening criteria for the physical category. Irrigation districts and municipal, industrial, and commercial entities in Regions 1 and 2 do not have return flows that enter the Platte River system below the critical habitat that could be physically relocated above the critical habitat. This option could potentially increase the flow to the critical habitat if return flows normally entering the river just downstream of the critical habitat were pumped and discharged above the critical habitat. Therefore, this alternative has been included in the short list for Region 3.

Category 4 – Incentive Based Reductions in Agricultural Water Use

- No alternatives were excluded.

Category 5 – Groundwater

- Development of Non-Tributary Groundwater Sources. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical category. Development of non-tributary groundwater sources is considered to be cost prohibitive. Reconnaissance level evaluations of groundwater development potential and development costs for non-tributary supplies in the Denver Basin performed in 1989 indicated costs of development in the range of $2,000 (lowest) to about $12,000 (average) per ac-ft of developed supply (Boyle Engineering Corporation, 1989). These costs did not include land acquisition costs, and generally involved development of wells and associated facilities in close proximity to the point of use. In the case of the present investigation, it may be necessary to convey water over long distances for alternatives relying on non-tributary supplies that are developed from outside of the Platte Basin. Independent analysis of the costs of developing non-tributary groundwater from adjacent basins results in minimum costs of about $2,000 per ac-ft of developed capacity. After including land acquisition costs and conveyance costs and accounted for losses enroute to the critical habitat, the average cost per ac-ft of reduction to target flow shortages will likely exceed $3,000. Another shortcoming of this alternative is its lack of long-term sustainability. In all three regions, non-tributary groundwater would be developed from basins that receive little or no recharge.

  Intermittent use of non-tributary groundwater sources, such as in response to infrequent drought events (say once in ten years) has also been rejected on economic grounds. In this instance, while the total capital costs of project development are substantially the same for this alternative, the average yield is reduced in proportion to the frequency of use.

- Groundwater Allocation Management. Groundwater allocation management refers to the use of agricultural water taxes or duties in order to reduce demand for groundwater. This alternative has been not been included in the short list because it violates the Cooperative Agreement, which requires programs to be incentive-based and reflect willing participation. This alternative is not an incentive based program and does not reflect willing participation which is required under the Recovery Program.

Category 6 – Systems Integration and Management

- Effluent Exchange Agreements. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical and economic categories. Municipalities place a high value on reusable effluent because this water represents a future water supply source, which can postpone water supply acquisition and development costs. Therefore, the value of the exchange potential might best be estimated in terms of the cost of replacing potential effluent exchange with an alternate supply in the city's portfolio. As shown for alternatives involving reuse opportunities under Category 3, alternatives involving effluent exchange agreements are considered cost prohibitive in the context of replacing potential reuse.

  Reuse of Windy Gap Project water is cited as a source of supply for the St. Vrain River basin in the St. Vrain Basin Reconnaissance Study (R.W. Beck and Associates and Dames & Moore, 1986). Under several plans analyzed in the study, effluent would be distributed directly or by exchange to irrigators from a small regulating reservoir at the wastewater treatment plant. The study estimated the capital cost of the effluent reservoir and pumping infrastructure at $17,900,000. Based on a firm yield of 6,600 ac-ft/yr of reusable water, the cost is $2,712/ac-ft. This does not include annual operational expenses such as energy costs related to pumping. Implementation of effluent exchange agreements that require structural elements such as reservoirs is considered cost prohibitive in the context of this study.

  In addition, similar to the water reuse alternatives, the availability of effluent is essentially the same year round, therefore, although an exchange agreement may have a positive effect on diverters upstream of the effluent return location, there would be essentially no change in the flow quantity at the critical habitat.

- Link Existing Municipal Water Supply Systems. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical and economic categories. This alternative would benefit municipalities by providing greater flexibility and redundancy in their supply systems, particularly in times of drought. Additional flexibility, redundancy, or possibly additional diversion points will not significantly change the flow quantity or timing at the critical habitat. This alternative may provide the opportunity to expand use within a water supply system as opposed to generating additional flows for the critical habitat.

Alternatives that expand delivery possibilities through system linking as described above generally require significant capital expenditures for conveyance facilities such as pipelines and reservoirs. Although linked water supply systems provide increased flexibility and potentially create reuse opportunities; they will not necessarily change the quantity of flow at the critical habitat. Municipalities place a high value on conserved water supplies because this water represents a future water supply source, which can postpone water supply acquisition and development costs. Therefore, the value of a linked water supply system alternative that generates reuse potential can be estimated in terms of the cost of replacing potential reuse with an alternate supply in the city's portfolio. As shown for alternatives involving effluent exchange agreements and reuse, the long-term capital cost of new supplies in the context of replacing potential reuse is considered cost prohibitive in the context of this study.

- Transbasin Diversions/Imports. This alternative has not been included in the short list for Regions 2 and 3 due to failure to pass the screening criteria for the legal/institutional category. The only feasible source of imported water within Region 2 in the time frames implied in the Cooperative Agreement is the Upper Colorado River Basin because of existing diversion facilities. The Colorado River Basin is also faced with endangered species listings, causing Colorado to embark on a conservation/supply study on the western slope similar to the Platte study. Therefore, it is unrealistic to look to that basin for additional imports to the Platte. This alternative is opposed by entities that have the ability to prohibit implementation. Both Wyoming and Colorado are prohibited from importing water from the Colorado River basin for delivery to the critical habitat due to Colorado River compact requirements. Transbasin diversions/imports from the Colorado River basin can only be used within the respective state; therefore, diversions to the critical habitat would be contrary to current compact conditions.

Nebraska statute restricts transbasin imports. It is generally considered better to use water within the basin of origin and current policy requires that the out-of-basin uses outweigh in-basin uses. In addition, there are interstate compact issues associated with the Republican and Blue Rivers. Nebraska is required to fulfil their compact obligations, which limit opportunities for transbasin diversions to the Platte River. Nebraska and Kansas are currently involved in litigation regarding the Republican River, which would essentially preclude transbasin diversions from the Republican River to the Platte River within the timeframe of the Cooperative Agreement.

Category 7 – Watershed Management

- Forest Management. Forest management involves timber harvest with the intent of increasing runoff for instream flow purposes consistent with the objectives of the cooperative agreement. This alternative has not been included in the short list for Region 3 due to failure to pass the screening criteria for the physical category. Region 3 does not have significant forested areas in the Platte basin available for clearing. This alternative could be reconsidered by the WMC or the Water Action Plan Committee during Action Plan preparation if it is felt that the Program should be credited with any reductions to target flow shortages from the vegetative management activities being conducted in the Critical Habitat. This type of application of the forest management concept would overlap with the Phreatophyte Control alternative discussed below because of the variety of vegetation currently being managed.

- Phreatophyte Control. This alternative refers to the retirement of the non-beneficial consumptive use from phreatophytes along river courses and ditches with the intent of transferring use for instream flow purposes. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical criteria.

  Consumptive use by phreatophyte species (cottonwoods, willows, salt cedars, etc.) has been estimated as approximately 1.65 ac-ft/acre (HDR Engineering Inc., et al., 1989a). Therefore, to retire 20,000 ac-ft of phreatophyte consumptive use in a region, over 12,000 acres would need to be cleared. Phreatophyte growth would need to be monitored and subsequent removal of secondary growth would likely be necessary to maintain the yield, as such, there would likely be annual maintenance costs associated with phreatophyte control.

Under current water law water rights cannot be established for water generated from phreatophyte control. At the scale required to generate 5,000 ac-ft at the critical habitat, this alternative would likely come under serious attack from conservation groups, making implementation unlikely. The aesthetic value, wildlife habitat, stream bank stabilization and water temperature reduction that phreatophytes provide would be lost through large-scale eradication efforts. Removal of phreatophytes from river courses and from along canals would have "limited effectiveness" (Harza Engineering Co., et al., 1987). Removal of phreatophytes may increase sedimentation due to reduction in stream bank stabilization. Institutional issues involving phreatophyte control are problematic as "water law principles would preclude claiming a water right as the result of watershed vegetation management" (USACOE, 1986).

- Snowpack Management via Vegetative Shading. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical category. Although this alternative has been shown to delay snow melt and the associated runoff on a scale of several acres, it would not be possible to implement on a large enough scale to effect the flow quantity or timing at the critical habitat.

- Weather Modification. This alternative has not been included in the short list for all three regions due to failure to pass the screening criteria for the physical category.

  Firm yields resulting from weather modification programs are uncertain and difficult to assess. Statements of an overall average increase in runoff are speculative and assume that modeling reflects cloud responses to cloud seeding (USACOE, 1986). Studies show that weather modification can have both positive and negative effects, and there is the potential it may have no effect (USACOE, 1986). Increase in snowpack and the associated runoff from cloud seeding programs reported in the available literature are based on small application areas and for time periods of generally less than ten years. Weather modification due to cloud seeding would be difficult to implement to definitively effect flow quantity at the critical habitat.

Other issues of concerns with respect to cloud seeding include potential water quality impacts on aquatic ecosystems and the timing of increased water yields.

E. Development of Short List of Alternatives

After conducting an initial screening based on the general screening criteria the long list was reduced to a short list, which consists of 35 alternatives. Water conservation and supply alternatives that did not fail the initial screening were included in the short list and are presented in Table 1.2. Three of the 35 alternatives, which include relocation of return flows, transbasin diversions, and forest management, do not apply to all three regions.

The resulting short list of alternatives was analyzed in greater detail to determine which of the alternatives was most promising in the context of this study. Specific and/or representative examples of the shortlisted alternatives were identified and evaluated with respect to the same previously identified criteria. Evaluation of the alternatives on the short list is described in Chapter 8.

7. WATER BUDGET ROUTING MODEL TO EVALUATE FLOW CHANGES AT CRITICAL HABITAT

A. Introduction

Potential reductions to target flow shortages in the critical habitat are a primary measure used to evaluate water conservation/supply alternatives for the Platte River Recovery Program. From the short list of alternatives, described in Chapter 6, the study team identified specific and/or representative projects throughout the Platte River study area. The effects on streamflows in the immediate area of each project, as well as the resulting effects in the critical habitat area were evaluated.

The net hydrologic effects at the alternative site were determined from existing studies and monthly models developed for the reconnaissance study. A water budget spreadsheet model was used to route the local net hydrologic effects to the critical habitat to determine the potential reductions to target flow shortages associated with an alternative. As the same water budget spreadsheet model was used to evaluate each alternative, no bias is introduced. The average reduction to target flow shortages during the study period was a sub-criterion used to evaluate, screen, and compare water conservation/supply alternatives.

The water budget is a predictive tool used to assess the relative magnitude and timing of additional water routed to the critical habitat for each alternative. The net hydrologic effects of each alternative are routed to the critical habitat with a water budget spreadsheet consisting of existing flow conditions and loss factors for the nineteen study reaches. The river loss factors attributed to seepage, diversion, and evaporation were developed by the WMC from historical records. A more detailed description of the development of the loss factors is provided in Appendix E.

The Platte River study area is represented as nineteen river reaches (see Figure 3.1) in the water budget. The upstream and downstream ends of each reach are defined by USGS streamflow gages (see Table 7.1).

The nineteen river reaches are represented by individual worksheets in the water budget spreadsheet (available on the World Wide Web at ftp://164.119.100.4/ pub/data/mad/w14-1). Continuity is maintained in the water budget, as the inflow to a downstream reach is equal to the outflow from the upstream reach. Baseline conditions within each reach were developed that represent current facilities and operations

Table 7.1
Platte River Reaches Defined for the Platte River Study Area

Reach Number	Reach Description	Reach Length Not Inundated by Reservoirs (miles)
Region 1 – North Platte River Upstream of Lake McConaughy		
1	Northgate, CO Gage to Sinclair, WY Gage	100
2	Sinclair, WY Gage to Alcova, WY Gage	40
3	Alcova, WY Gage to Orin, WY Gage	132
4	Orin, WY Gage to Passing Whalen Diversion Dam Gage	40
6	Laramie River: Below Grayrocks Reservoir Gage to Fort Laramie, WY Gage	17
5	Passing Whalen Diversion Dam Gage to WY-NE Stateline Gage	47
12	WY-NE Stateline Gage to Bridgeport, NE Gage	57.5
13	Bridgeport, NE Gage to Lewellen, NE Gage	60
Region 2 – South Platte River Upstream of Western Canal Diversion		
7	Henderson, CO Gage to Kersey, CO Gage	54.9
8	Kersey, CO Gage to Balzac, CO Gage	69.7
9	Balzac, CO Gage to Julesburg, CO Gage	97.6
11	Poudre River: Canyon Mouth Gage to Greeley, CO Gage	51.8
Region 3 – Platte River below Lake McConaughy and Western Canal		
10	Julesburg, CO Gage to South Platte at North Platte, NE Gage	85.6
14	Keystone Diversion Gage to North Platte at North Platte, NE Gage	51.5
15	North Platte at North Platte, NE Gage to Brady, NE Gage	23.8
16	Brady, NE Gage to Cozad, NE Gage	25.5
17	Cozad, NE Gage to Overton, NE Gage	28.1
18	Overton, NE Gage to Odessa, NE Gage	15.7
19	Odessa, NE Gage to Grand Island, NE Gage	56.2

for the defined hydrologic period. The twenty-year study period, 1975-1994, was chosen to judge the average net reduction in shortages to the target flows that would have occurred historically if an alternative had been implemented. The study period represents river flow conditions that are reflective of current development and includes representative wet years (1983-1984) and dry years (1988-1991). A more detailed description of the period chosen for this study is provided in Appendix D.

Baseline conditions reflect inflows and outflows from each reach, other inflows from tributaries and canals, diversions, and river surface evaporation (see Figure 7.1).

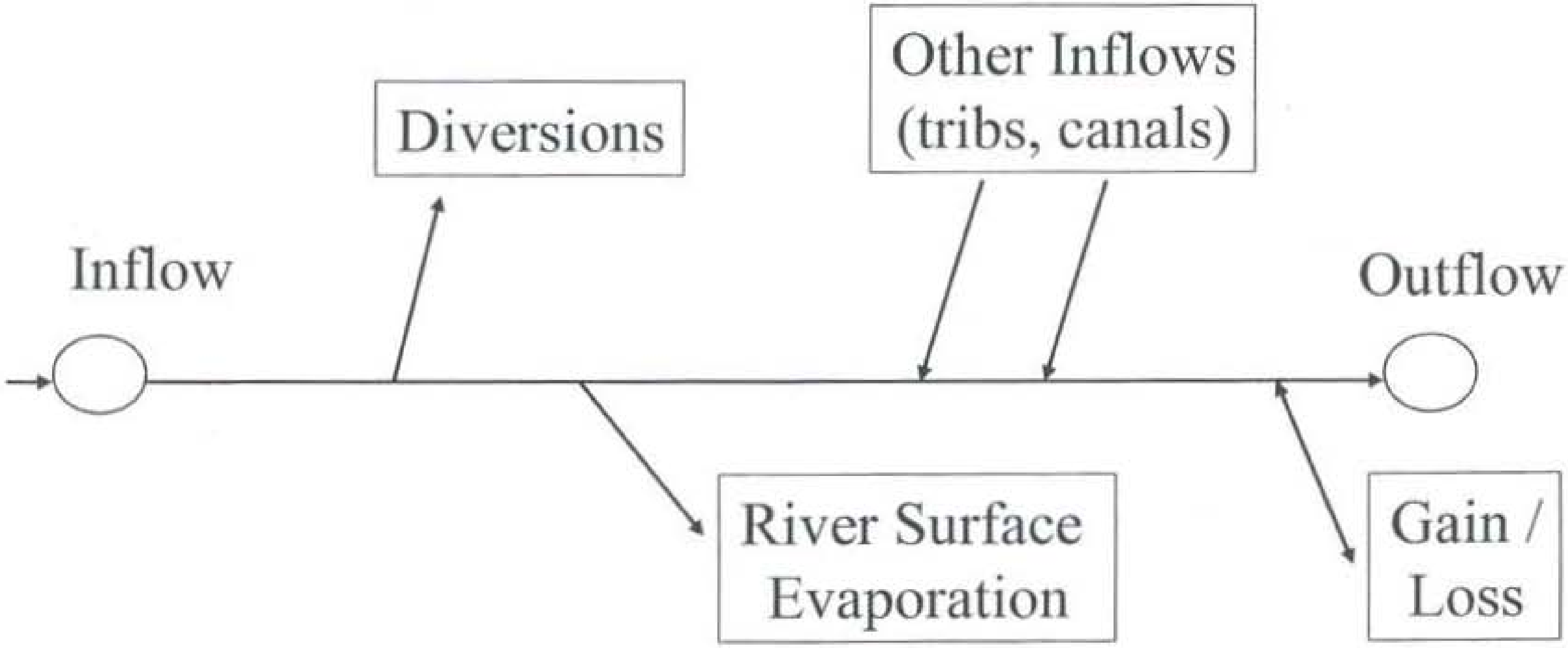
Diversion losses include the major diversion structures in each reach for which there are records. Specific structures included in the water budget spreadsheet are listed in Appendix E. Diversion losses are gross values rather than net values because they do not account for return flows to the river. However, the surface water returns from three hydropower diversion structures in Nebraska are represented in the water budget (see Reaches 10, 15 and 18 in Figure 7.2).

Evaporation losses are calculated from estimated river surface evaporation. River surface evaporation was calculated as a function of river channel width and length, and monthly pan evaporation values from weather stations along the Platte River. A water balance analysis between upstream and downstream gages was then carried out to determine the monthly gains and losses within a reach.

Seepage losses are calculated from the estimated gain/loss in the water balance analysis. Baseline return flows from diversions are accounted for in the gain/loss term. Seepage losses are zero during months when the river reach is gaining.

Based on this analysis, monthly loss factors were developed for evaporation, diversion, and seepage. Loss factors are expressed as a percent loss per mile within a given reach. Evaporation and seepage losses occur throughout the year. For some reaches diversion losses occur throughout the year, however, they are typically greatest during the irrigation season. Diversion losses are generally significantly greater than evaporation and seepage losses. The percentage loss due to evaporation, seepage, and diversions varies by month, therefore, the monthly distribution of water added to the system significantly impacts the reductions to target flow shortages.

Figure 7.1 Study Reach Representation in Water Budget Spreadsheet

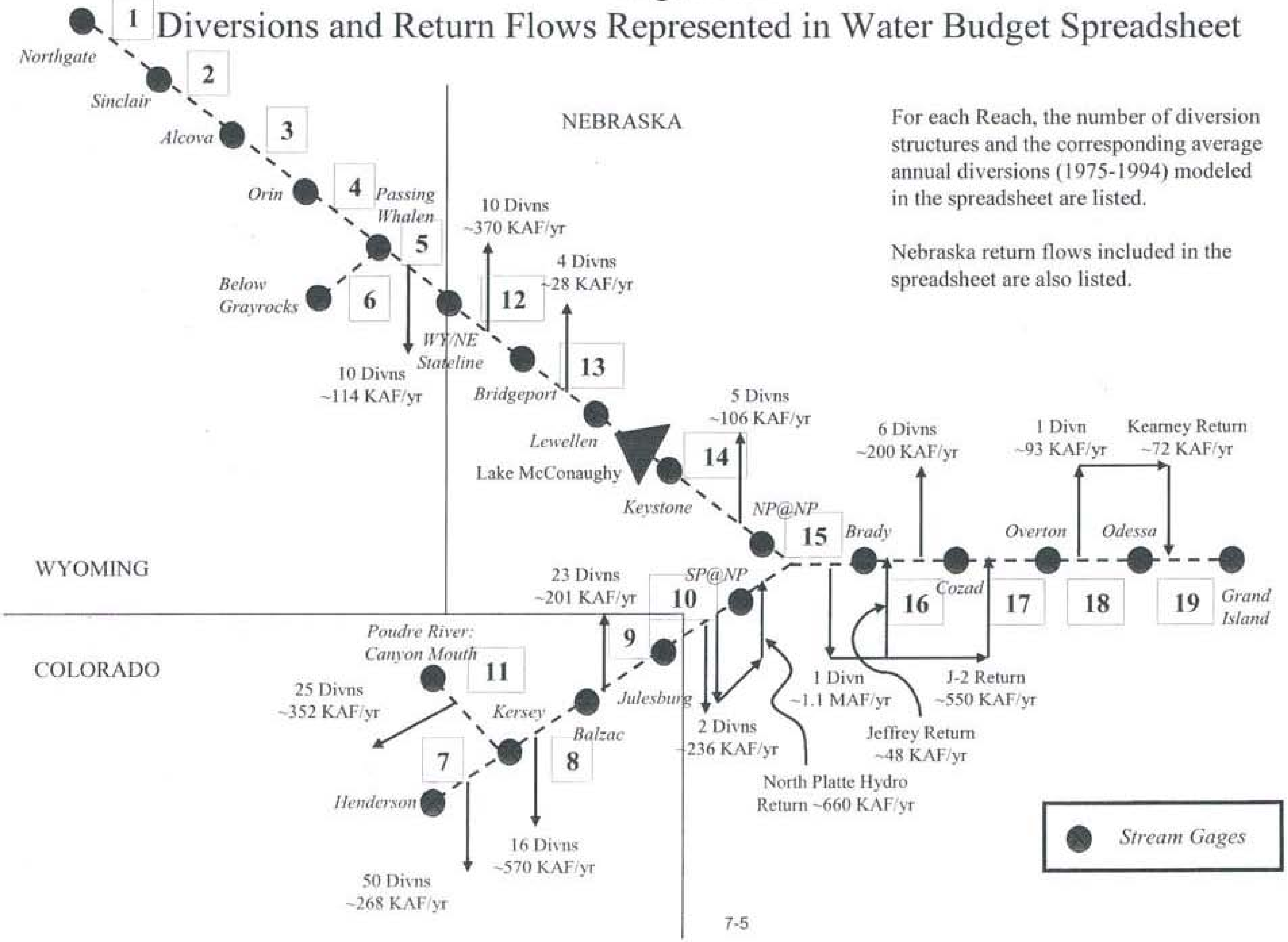


Gain/Loss = Outflows - Inflows
(Outflow + Evap + Diversions) - (Inflow + Other Inflows)

Total Inflows = Inflow + Other Inflows + Gain

Figure 7.2

Diversions and Return Flows Represented in Water Budget Spreadsheet



For each Reach, the number of diversion structures and the corresponding average annual diversions (1975-1994) modeled in the spreadsheet are listed.

Nebraska return flows included in the spreadsheet are also listed.

Percent loss factors can be applied to water contributions introduced at any point within a reach. The appropriate number of miles is multiplied by the percent loss factor per mile to reduce the water contribution as it moves downstream to the bottom of the reach. Total losses suffered enroute to the critical habitat generally increase the further upstream water is added to the system. As a result, additional water added to reaches in Regions 1 and 2 typically generates less reductions to target flow shortages than if the same amount of additional water is added to reaches in Region 3. Development of the monthly loss factors is covered in detail in Appendix E.

B. Assumptions

The water budget spreadsheet is based on the following assumptions. These assumptions are generally conservative with respect to the study, in that less water would be estimated to get to the critical habitat than might in reality.

- Monthly loss factors are prorated equally among all inflows. In other words, a contribution of water from a water conservation/supply alternative will experience the same loss or shrink as historic inflows to the reach.
- Additional water flowing through the system as a result of an alternative is subject to evaporation, seepage, and diversion losses for every mile of the respective river reaches through which the water is routed.
- Diversion losses can be turned off for each reach individually to simulate the protection of water from existing diversions.
- Diversion losses to additional water routed down to the critical habitat are assumed to be 100% consumptive.
- Surface return flow information from select diversions in Nebraska are modeled in the water budget spreadsheet (Korty diversion to NPPD return, Central Supply Canal to J-2 and Jeffrey returns, Kearney diversion to Kearney return).
- Flows added to any of the reaches are routed down to the critical habitat in the same month.

- Existing flow conditions and monthly loss factors are not affected by the introduction of additional water.
- Reservoir operations are not modeled, as such, water added to the system is assumed to 'skim' over reservoirs, suffering no losses.
- Loss factors have not been developed for all the tributaries and certain sections of the mainstem. The net hydrologic effects from alternatives on tributaries were conveyed to the upstream end of the nearest Platte River reach subject to no losses. The net hydrologic effects from alternatives located above Northgate, Colorado in Region 1, and Henderson, Colorado or Poudre River: Canyon Mouth in Region 2 were conveyed to the top of the most upstream reach subject to no losses.

C. Methodology

The net hydrologic effects define the changes to the flow regime associated with an alternative over the 1975-1994 study period in the vicinity of the alternative. Net hydrologic effects associated with the operations of alternatives were modeled on a monthly time step based on existing studies and conversations with representatives from the states of Wyoming, Colorado, and Nebraska. The specific methodologies and analytical techniques used to determine the local net hydrologic effects associated with each alternative are described in Chapter 8.

The 20-year time series of net hydrologic effects are input to the water budget at the alternative's location within the reach. The water budget conveys the additional water downstream to the bottom of the reach subject to evaporation, diversion, and seepage losses over the remaining miles in the reach. The net hydrologic effects at the bottom of the reach are then routed down to the critical habitat subject to appropriate loss factors in the intervening reaches. Diversion losses are not applied to additional water in reaches for which diversion losses have been turned off in the water budget spreadsheet.

Some alternatives can result in reductions to flows, as opposed to additional flows, in the vicinity of the alternative. Flow reductions can be caused by diversions from the river (a diversion to a reservoir or recharge), changes to return flow patterns, or changes to reservoir operations. Flow reductions are represented by negative numbers in tables of net hydrologic effects and reductions to target flow shortages. Flow reductions from an alternative are subject to evaporation, seepage, and diversion losses through downstream reaches even if additional flows from water conservation/supply alternatives are protected from existing diversions as they are routed downstream.

After the additional water is routed downstream to Grand Island, Nebraska (Reach 19), the additions and reductions to the streamflow at Grand Island are compared to historical target flow shortages and excesses to determine the average net reductions to target flow shortages associated with the alternative.

8.A. Introduction

8. EVALUATION OF ALTERNATIVES

A. Introduction

Project alternatives were formulated to meet the objective of providing additional water at Grand Island, Nebraska for endangered species. This additional supply of water is intended to reduce the target flow shortages identified in Chapter 2. Project alternatives that were not set aside in the initial screening, described in Chapter 6, are evaluated in this chapter.

The locations of projects evaluated throughout the Platte River Study area are depicted in Figure 8.A.1. The shortlisted alternatives were evaluated systematically to determine their comparative effectiveness in reducing target flow shortages in the critical habitat. Evaluations were performed at a reconnaissance level of detail, which is defined as that level needed to distinguish major differences among alternatives and to provide a preliminary indication of the feasibility of each alternative. The evaluations of the shortlisted alternatives consider the estimated amount of reduction to target flow shortages and cost, as well as environmental, social, and legal and institutional factors associated with each alternative. These factors, and the comparative scoring of the alternatives, are presented in sections 8.B through 8.I for the following categories of shortlisted alternatives:

- Reservoirs
- Agricultural Conservation
- Municipal and Industrial Conservation
- Reuse
- Incentive-Based Reductions in Agricultural Water Use
- Groundwater
- Systems Integration and Management
- Watershed Management

1. Yield Analysis

For this study, the yield of an alternative was defined as the average annual reduction in target flow shortage over the period 1975-1994. The analysis involved in determining the yield of each shortlisted alternative was carried out using the following standard approach:

Figure 8.A.1
Locations of Specific and/or Representative Projects Evaluated from the Short List of Alternatives

19 Reaches are defined between streamgages. Reach 6 is the lower 17 miles of the Laramie River in WY between the below Grayrocks gage and the Laramie River at Fort Laramie, WY gage.

Define the impacts. Define the area of immediate impact and the components of the local hydrological balance that will be impacted by the alternative.

Define the approach. Define the analytic approach and specific method of analysis necessary to evaluate the net hydrologic effect. For example, the analysis of a new reservoir would require a monthly operational spreadsheet; a ground water recharge alternative would require SDF analysis.

Perform the hydrologic analysis. Evaluate the yield of the alternative based on existing studies and conversations with representatives from the states of Wyoming, Colorado, and Nebraska. The specific methodologies and analytical techniques used to determine the local net hydrologic effects associated with each alternative are described in sections 8.B through 8.I. Some alternatives can result in reductions to flows, as opposed to additional flows, in the vicinity of the alternative. Flow reductions can be caused by diversions from the river, changes to return flow patterns, or changes to reservoir operations. Flow reductions are represented by negative numbers in tables of net hydrologic effects.

Analyses from existing studies were used where available. The SDF method, as discussed in Chapter 5 and Appendix B, was used to analyze groundwater related impacts to the Platte River. The SCS Blaney-Criddle method, as discussed in Appendix C, was used to analyze consumptive irrigation requirements associated with agricultural alternatives.

Route the hydrologic effects. Translate the local net hydrologic effects to the upstream end of the next downstream reach via the water budget spreadsheet. Route these effects to the critical habitat using the water budget spreadsheet to determine potential reductions to target flow shortages (see Chapter 7).

Two routing scenarios were evaluated for each alternative. The No Diversions scenario assumes additional flows can be protected from downstream diverters, in which case, additional flows are not reduced by diversions. The With Diversions scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions. For the latter scenario, diversions represented in the water budget spreadsheet are assumed to be 100% consumptive, with the exception of surface water return flows from the Korty, Tri-County, and Kearney Canals in Nebraska (see Chapter 7).

When routing water downstream, improvements or modifications to existing diversion structures that are necessary to bypass water downstream were considered in all three regions. Based on conversations with the Colorado Division 1 Water Resources Office, approximately 50 percent of the structures in Reaches 7, 8, and 9 in Colorado would need to be modified to bypass Program water downstream. These structures consist primarily of large sand dams that can divert the entire river. These structures do not have the ability to bypass specific amounts of water nor the ability to fine tune diversions through the use of spillways. Based on conversations with the State Engineer's Office in Wyoming, there are no diversion structures that would require improvements or modifications in Wyoming to bypass Program water downstream. Most of the gravity diversion structures have been replaced with pumps that can be regulated. Based on conversations with the Nebraska Department of Water Resources, there are no diversion structures in Nebraska that would require improvements or modifications to bypass water downstream. Although there are several sand dams along the North and Platte Rivers both above and below Lake McConaughy, these structures typically force water into side channels that run parallel to the river. The main headgate and measuring device for most canals are located on these side channels. Spillways are typically located at these measuring devices, therefore, the amount of water that is diverted to the canal and released back to the river can be fine tuned. In some cases the spill structure is also gate controlled. Although the sand dams across the mainstem do not have the ability to make low-flow releases, the diversions structures will not necessarily have to be improved due to the ability to fine tune diversions and releases back to the river as described above.

Independent Evaluation of Alternatives

Each alternative was analyzed independently of all other alternatives, that is, as though it was the only alternative implemented. Because some alternatives rely on the same source of water, the yield of two alternatives implemented simultaneously would generally be less than the sum of the yields of the individual alternatives. Furthermore, the analyses may overstate yields if participating districts or municipalities require a portion of the yield in return for their participation. Chapter 11 discusses the general compatibility of shortlisted alternatives. Refinements to this analysis, to determine the degree to which specific projects are compatible, must be addressed during the preparation of the Action Plan.

Operating Conditions That May Impact Yields

The yields of projects may be reduced if there are adverse impacts on downstream water rights that need to be offset or compensated. Water that another downstream water permit is entitled to divert may not be considered new program water in Nebraska with the exception of Lake McConaughy Environmental Account (EA) releases. An in depth evaluation of flows which are in excess of current downstream uses has not been completed for this reconnaissance level study. However, diversions to storage or diversions to groundwater recharge have been constrained to months of target flow excesses at the critical habitat. Yields associated with projects in regions 1 and 2 that could have impacts on downstream uses were estimated under both the No Diversions and With Diversions scenarios. However, because reservoir operations are not modeled, water added or subtracted from the system is assumed to "skim" over reservoirs suffering no losses. In which case, water that is retimed or removed from the system that was historically stored in Lake McConaughy is always passed through the reservoir under both the No Diversions and With Diversions scenarios. Therefore, with respect to Lake McConaughy, water generated as a result of an alternative has been considered by the Study Team as new water in Nebraska because the water budget spreadsheet does not account for diversions to the reservoir.

The Study Team and the WMC considered the possibility of developing a Lake McConaughy operations model. This was deferred in order to focus efforts on the creation of the water budget spreadsheet and with the understanding that more detailed analysis of reservoir operations might be accomplished for specific projects as part of the development of the Action Plan. Due to the absence of a Lake McConaughy operations model, impacts to Lake McConaughy are not specifically accounted for in this reconnaissance level study.

There are opportunities to reregulate all alternatives through the Lake McConaughy EA, which may increase reductions to target flow shortages. The difference between the annual delivery at Grand Island and the average annual reduction to target flow shortages represents the potential additional benefit of re-timing water generated by an alternative through the EA in Lake McConaughy. The annual delivery at Grand Island is equivalent to the net hydrologic effect at the habitat, which is provided in the yield and cost summary tables at the end of Chapter 8.B through 8.I.

As indicated in Section D of Attachment II of the Cooperative Agreement, "It is an operational goal to coordinate upstream conservation activities so as to increase storage in the Environmental Account." For example, for projects upstream of Lake McConaughy the EA could be used to reregulate additional water generated or retimed by the project. The EA could also be used to reregulate additional program water downstream of Lake McConaughy through an exchange. In that case users downstream of Lake McConaughy such as CNPPID and/or NPPD could use the additional water generated by an alternative in exchange for reduced releases, which would result in corresponding increases in the EA account. Projects located on the North Platte above Lake McConaughy can be easily reregulated through Lake McConaughy. South Platte and Platte River exchanges for projects downstream of Lake McConaughy are less certain because of minimum flow requirements and the requirement that water be of use to CNPPID and NPPD. The benefits associated with reregulation through Lake McConaughy were not considered in any yield analyses.

2. Cost Analysis

The cost analysis was carried out under the following standard approach:

Cost estimates for this reconnaissance-level report were derived primarily from information contained in a wide variety of planning, design, and construction reports. Information was also obtained from published cost indices and general references. Cost estimates for many alternatives were supported by discussions with parties having prior knowledge of the project in question, or other similar projects. Many references were not explicit regarding the methods used to estimate costs and whether those costs included provisions for unlisted cost components, engineering and administrative fees, and contingencies. In other cases it was not clear whether the estimated costs were related solely to direct construction expenditures or whether they also included financing expenses such as interest during construction, debt service, or bond issuance costs. An attempt was made to characterize the source and nature of the supporting cost information for each alternative so that the reader can make a determination of the reliability and level of detail contained in each estimate.

Some alternatives have relatively high initial construction costs but relatively low annual operation or administration costs. For other alternatives this situation is reversed. Therefore, a method was needed to compare disparate alternatives. Many reconnaissance level studies assume the following: 1) a consistent financing mechanism (such as the issuance of general obligation or revenue bonds) for the initial capital costs and 2) annual operation and administration costs funded from separate operating accounts, user fees or revenue sources. Because of the large river basin, multiple project participants, and widely varying project alternatives, this study used the following methodology as proposed by the Water Management Committee:

1. Previous cost estimates were reviewed and revised in an attempt to include all costs associated with incentive-based implementation of an alternative.

2. Cost estimates from previous studies were updated to 1998 cost levels using indices published in the *Engineering News Record.*

3. Annual operation, maintenance, and replacement costs for 20 years of use were estimated and an equivalent present value cost was computed using a six- percent discount rate.

4. The present value capital costs were added to the present value of the annual costs to obtain a Total Capitalized Cost. This value was used to compare alternatives on a consistent basis. For unit costs, that is, the cost per ac-ft of shortage reduction at the Critical Habitat, this Total Capitalized Cost was divided by the yield estimate as determined using the methods discussed in the above section.

The 20-year period used in the analysis was selected as a uniform and easily understood time period for the initial comparison of alternatives in this reconnaissance study. Some alternatives will have useful lives extending beyond 20 years. In these cases, no salvage value was included. This was deemed appropriate for this study because including salvage value would require the determination of whether that value would accrue to the Program or to others, including entities participating because of incentive-based programs. It was further felt that the 20-year period extended sufficiently beyond the first increment of the Cooperative Agreement (especially for alternatives that would not be implemented until late in the first increment) and the salvage value may not have a major impact on needed Program funding. If however, it was determined that an alternative requires significant replacement costs prior to 20 years of operation, provisions were included in the estimates to cover these costs.

It is also important to note that this Reconnaissance Study does not include economic analyses to determine the overall attractiveness of alternatives in the context of whether all benefits including primary, secondary, and third party benefits exceed costs. Nor does the Study include financial analyses to determine methods of funding the various alternatives. It is expected that alternatives receiving further evaluation in the Action Plan process or the programmatic EIS will include one or both of these types of evaluations. This Study attempts to only provide comparative reconnaissance level costs to implement alternatives.

At this point some of the alternatives were screened from further analysis based on the economic screening criteria identified in Chapter VI - project cost greater than $50 million; cost per acre-foot of average annual reduction to target flow shortages greater than $3,000.

3. Alternative Scoring

Alternatives included within each category were scored according to their respective physical, legal and institutional, economic, social, and environmental characteristics. The numerical scoring between 0 and 5 was defined as follows:

0 A zero represents a fatal flaw. The alternative fails the subcriterion.

1 The alternative performs less favorably than average for the subcriterion.

2 The alternative performs slightly less favorably than average for this subcriterion.

3 The alternative performs about average for the sub-criteria.

4 The alternative performs slightly more favorably than average for the subcriterion.

5 The alternative performs more favorably than average for the subcriterion.

A summary of the ranges or conditions established for scores from 0 to 5 for each sub-criterion is provided in Chapter 6. Alternatives that were scored zero in any of these subcriteria were set aside from further evaluation at this time and were not scored in any of the other subcriteria.

The final tables in sections 8.B through 8.I include the scores for the screening subcriteria, identified in Chapter 6, for both the No Diversions scenario and the With Diversions scenario. Scores for each sub-criterion are weighted equally; scores for the five general criteria are equal to the average of their respective subcriteria. The total score for the alternative is equal to the sum of the scores for the five general criteria. The scores provide the means to compare each of the alternatives.

4. Organization of Evaluation Sections

The following sections, 8.B through 8.I, are broken down into the following components:

Introduction. Provide background information for the development of the representative shortlisted projects analyzed in this category.

Conceptual Definition. Define the types of alternatives evaluated in this category.

Operational Definition. Define the evaluation methods and assumptions for the alternatives evaluated in this category.

Alternatives by Region

Description. Provide background information for the individual alternative.

Yield. Describe the methodology use to determine the local net hydrologic effects for the individual alternative. Present narrative and tabular results of the local net hydrologic effects and the reductions to target flow shortages at the critical habitat under the two routing scenarios.

Cost. Describe the development of capitalized costs for the individual alternative. Present the capitalized cost and cost per acre-foot of reductions to target flow shortages under the two routing scenarios.

Summary Yield. Summarize the local net hydrologic effects and reductions to target flow shortages of all alternatives evaluated within the category of shortlisted alternatives. Present a summary table of yields and costs for all alternatives.

Summary Cost. Summarize the total capitalized costs and costs per acre-foot of target flow shortage reductions for all alternatives evaluated within the category of shortlisted alternatives.

Associated Issues. Describe the physical, legal and institutional, economic, social, and environmental issues associated with each alternative as they relate to the scoring of the alternatives.

8.B. Reservoirs

Reservoirs

1. Introduction

This section examines the yields, costs and associated issues of various reservoir alternatives to reduce shortages to target flows at the critical habitat. A number of reservoir alternatives identified in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into four categories:

Constructing New Storage Facilities or Equalizing Reservoirs

Enlarge Existing Reservoirs

Remove Storage Restrictions Imposed by State and/or Federal Agencies with Responsibility for Dam Safety

Lining Smaller New or Existing Reservoirs and Gravel Pits

A brief description of each of the representative projects and how they might be implemented is provided below, followed by estimates of yields and cost for each project. Finally the evaluation of each project in terms of physical, legal and institutional, economic, social, and environmental effects is offered to conclude the reservoir alternatives evaluation.

2. Conceptual Definitions

Constructing New Storage Facilities or Equalizing Reservoirs. Constructing new storage facilities or equalizing reservoirs refers to the construction of new storage space. New storage facilities provide the opportunity to store excess flows for release during periods of target flow shortages at the critical habitat. Equalizing reservoirs provide the ability to regulate water deliveries to reduce overall system spills, capture water released for hydropower during the non-irrigation season, or reduce peak releases from an existing larger capacity reservoir. Equalizing reservoirs provide farmers with increased flexibility in terms of both the timing and amount of water delivered. The size of an equalizing reservoir is a function of the current variation in flow releases, which is dependent on the distance and travel times required for reservoir releases to reach irrigation districts. Equalizing reservoirs enable irrigators to utilize their storage releases more efficiently.

Enlarge Existing Reservoirs. Enlarging existing reservoirs involves structural modifications that increase storage capacity, such as increasing embankment height. The available water supply and the physical configuration of the reservoir to be enlarged limit the magnitude of the conserved water supply. Topographic and geological conditions, as well as permitting requirements can limit the ability to enlarge existing reservoirs.

Remove Storage Restrictions Imposed by State and/or Federal Agencies with Responsibility for Dam Safety. Removing storage restrictions refers to administrative restrictions that can be removed or altered to increase the amount of available storage. Storage restriction may be imposed, which limit the allowable storage in existing reservoirs to minimize the risk of dam failure for facilities with documented deficiencies. Structural corrections required to remove or reduce restrictions can and have been implemented throughout the Platte River system.

Lining Smaller New or Existing Reservoirs and Gravel Pits. The reduction of seepage losses can be attained through reservoir lining. Methods and materials used for reservoir lining include earth compaction, earth blankets, bentonite, cement, chemical additives, and flexible membranes.

3. Operational Definitions

For this reconnaissance level study, it is not possible to investigate every potential reservoir alternative within each region. As such, some limitations and basic assumptions have been applied to reservoir related alternatives. The following operational definitions describe the assumptions and methods that have been used to define the reservoir alternatives in the context of this study.

Constructing new storage facilities. The following simplifying assumptions were used to define and analyze the construction of new storage facilities:

- New storage facilities that have been evaluated are generally small and offstream to minimize environmental impacts.
- Only reaches where reservoir sites have been investigated in previous studies were assumed to have the potential for a new site. Where studies on specific reservoir sites are not available new storage was investigated on a general basis as opposed to identifying specific facilities.
- Historical monthly excess flows that are available for storage were determined using historical streamflows provided by the Water Management Committee.
- It was assumed that the monthly excess flow in each reach is available to store under a current priority.
- The minimum capacity of new storage reservoirs investigated in a reach was 10,000 ac-ft, unless site specific information indicated the potential for a smaller reservoir. The maximum capacity of new storage reservoirs investigated in a reach was 50,000 ac-ft, unless site specific information indicated the potential for a larger reservoir.
- The two capacity extremes were assumed to bracket all potential new reservoir alternatives within a reach.
- A simple area/capacity relationship was assumed for reservoir evaporation estimates unless site specific data were available.
- The recharge to the stream of seepage water from reservoirs was lagged with the aid of SDF analysis. A detailed description of the SDF method is provided in Chapter 5 and in Appendix B.

Constructing Equalizing Reservoirs. The following simplifying assumptions were used to define and analyze alternatives associated with the construction of equalizing reservoirs:

- Existing reservoirs that experience large spills or releases for hydropower during the non-irrigation season were identified through discussions with reservoir owners in the basin.

- Topographic mapping was reviewed to determine if there is an acceptable site for an equalizing reservoir downstream of these identified reservoirs.

- The equalizing reservoir was assumed to have a capacity large enough to store historical spills or non-irrigation season releases for hydropower.

- A simple area/capacity relationship was assumed for reservoir evaporation estimates unless site specific data were available.

Enlarging Existing Reservoirs. The following simplifying assumptions were used to define and analyze the enlargement of existing reservoir alternatives:

- Only reservoirs that have been identified for enlargement in previous studies were assumed to have enlargement potential.

- Enlarged capacity was based on previous studies.

- Historical monthly excess flows that are available for storage were determined using historical streamflows provided by the Water Management Committee.

- It was assumed that the monthly excess flows in each reach are available to store under a current priority.

- A simple area/capacity relationship was assumed for reservoir evaporation estimates unless site specific data were available.

- The recharge to the stream of seepage water from reservoirs was lagged with the aid of SDF analysis.

Remove Storage Restrictions Imposed by State and/or Federal Agencies with Responsibility for Dam Safety. Reinforcement and protection of the upstream face of Kingsley Dam is the sole alternative identified at this time for removal of storage restrictions. The following simplifying assumption was used to define and analyze the removal of storage restrictions alternative:

- Additional reinforcement and protection of the upstream face of the dam could provide additional storage while having relatively little impact on current evaporation and seepage losses from the reservoir.

Lining smaller new or existing reservoirs and gravel pits. The following simplifying assumptions were used to define and analyze the lining of smaller new or existing reservoirs and gravel pits:

- Lining was investigated on a general basis where studies on reducing seepage at specific reservoir sites were not available. New storage facilities that have been evaluated are generally small and offstream to minimize environmental impacts.
- Historical monthly excess flows that are available for storage were determined using historical streamflows provided by the Water Management Committee.
- It was assumed that the monthly excess flow in each reach is available to store under a current priority.
- A simple area/capacity relationship was assumed for reservoir evaporation estimates unless site specific data were available.
- The recharge to the stream of seepage water from reservoirs was lagged with the aid of SDF analysis.

4. Alternatives

Region 1

Deer Creek Reservoir (Constructing New Storage Facilities)

The State of Wyoming, through the Water Development Commission, initially evaluated the Deer Creek project to provide a reliable municipal water supply for the City of Casper and other communities, and provide for future growth and needed insurance against future potential water rights regulation. In addition, the State of Wyoming and the municipalities wanted to ensure that the lack of water did not inhibit the opportunity for future growth. The U.S. Army Corps of Engineers (Corps) completed a Final Environmental Impact Statement (FEIS) in September 1987 for regulatory permits to evaluate the expected impacts of the proposed project. The FEIS was relied on for the evaluation of Deer Creek Reservoir as a potential alternative to reduce target flow shortages at the critical habitat.

The proposed Deer Creek Reservoir would be located on Deer Creek, a right bank tributary of the North Platte River near the town of Glenrock, Wyoming. Based on the FEIS the Deer Creek project would consist of Deer Creek Dam and Reservoir, spillway, outlet works, recreational facilities, access roads, utilities, stream gaging stations, and telemetry equipment. The proposed dam would be a roller compacted concrete dam approximately 900 feet long and 280 feet high. This reservoir would capture surplus water from Deer Creek during high runoff and would have an active storage of approximately 66,000 ac-ft. For the purpose of the FEIS study, water available for storage was defined as excess-to-ownership. Deer Creek Reservoir would provide a firm yield of 6,400 ac-ft for municipal and industrial uses. The FEIS showed a capital cost for the Deer Creek project of $52 million. Annual operation, maintenance, and replacement costs were estimated at $35,000.

There is no need for Deer Creek Reservoir for the City of Casper if the Pathfinder Modification Project is implemented. The capacity of Pathfinder Reservoir will be increased 54,000 ac-ft under the Pathfinder Modification Project, of which, 20,000 ac-ft will be retained by the State of Wyoming to provide the same basic municipal water supply benefits as the Deer Creek Dam and Reservoir. The parties to the Nebraska v. Wyoming lawsuit agreed to a stipulation titled, "Amendment of the 1953 Order to Provide for the Modification of Pathfinder Reservoir", which specifies that upon completion of the Pathfinder Modification Project, Wyoming will release the 404 permit and water rights for the Deer Creek Project.

With respect to this study, Deer Creek Reservoir is not feasible based on a project cost of $52 million in 1987. Alternatives will not be evaluated further if the implementation cost for an alternative or combination of alternatives exceeds $50 million. However, the size of the reservoir could be scaled back to reduce the cost in order to meet the economic screening criteria for a feasible project within this study. The project cost in 1987 was updated to a 1998 cost of approximately $70 million. Costs are not linearly related to reservoir size. It was assumed that reducing the reservoir size just over 50 percent to 30,000 ac-ft would reduce the cost approximately 30 percent to $50 million.

Due to the uncertainty related to the costs associated with a reduced reservoir, a reservoir size of 10,000 ac-ft was also evaluated to bracket the potential reductions to target flows associated with different Deer Creek Reservoir sizes.

Yield

For the FEIS Deer Creek Reservoir was analyzed in the context of meeting municipal demands, in which case, the estimated yield of 6,400 ac-ft is the firm yield as opposed to the average yield. The average yield of Deer Creek Reservoir has, therefore, been analyzed with respect to providing flows to reduce target flow shortages at the critical habitat.

The hydrology studies presented in Deer Creek Project Feasibility Study Calculation Book 3 of 4 Feasibility Report Reservoir Yield Studies (R.W. Beck & Associates, 1984) were used to reevaluate Deer Creek Reservoir storage capacities of 10,000 ac-ft and 30,000 ac-ft with respect to this study. The study team developed a simplified reservoir operations model to evaluate the yield of the reservoir. The following operating rules and assumptions were used in the analysis.

- The reservoir was assumed to be empty at the beginning of the study period.
- Storable flows were considered to be the amount available at the dam site after downstream Deer Creek rights were satisfied and after water was bypassed to fulfill prior rights downstream on the North Platte River in Wyoming (USACOE, 1987). Storable flows were obtained from the Deer Creek Project Feasibility Report Reservoir Yield Studies (R.W. Beck & Associates, 1984).
- Storable flow data is available for 1941 through 1980. The study period for this project is 1975 through 1994. Therefore, for the period from 1981 through 1994 average monthly storable flows from the 1941-80 study period were used.
- The reservoir was operated under the one-fill criteria with maximum fill capacities of 10,000 ac-ft and 30,000 ac-ft.

- Diversions to storage were only made during months of excess flows at the critical habitat. Between October and April water from Deer Creek typically accrues to one of the storage ownerships below Alcova under the senior storage rights of the Glendo Ownership, Guernsey Ownership, and the Inland Lakes Ownership. During that period water from Deer Creek that is not stored in Glendo, Guernsey or the Inland Lakes is typically stored in Lake McConaughy. Diversions to storage would reduce the accruals to the storage ownerships below Alcova and possibly Nebraska's contributions to the Environmental Account in Lake McConaughy.
- Releases from the reservoir were made during months of target flow shortages at the critical habitat.
- Monthly evaporation was based on estimates of monthly evaporation for different capacities determined in the FEIS study.

Tables 8.B.1 and 8.B.2 show the local net hydrologic effects of the 10,000 ac-ft and 30,000 ac-ft reservoir alternatives, respectively, through the 20-year study period. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Deer Creek Reservoir is located approximately in the middle of Reach 3. Monthly diversions to storage (flow reductions) and releases (flow additions) from Deer Creek Reservoir were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions. Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 4, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.3 through 8.B.6 show the reductions to target flow shortages at the critical habitat for a 10,000 ac-ft reservoir and a 30,000 ac-ft reservoir. The average annual reductions to target flow shortages with downstream diversion losses and without downstream diversion losses for a 10,000 ac-ft reservoir are 405 ac-ft and 1,406 ac-ft, respectively.

Table 8.B.1
10,000 ac-ft Deer Creek Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-1507	50	50	50	50	50	50	50	50	-1107
1976	50	50	-973	-837	50	50	50	50	50	50	50	50	-1310
1977	50	50	50	50	50	50	50	50	50	50	50	50	600
1978	50	50	50	50	50	-821	50	50	50	50	50	50	-271
1979	50	50	50	50	50	50	50	50	50	0	50	50	550
1980	50	50	-849	-874	-833	-973	-2111	0	0	275	275	275	-4715
1981	275	275	-840	-848	275	275	275	275	275	275	0	275	787
1982	275	275	-601	-576	275	275	275	275	275	275	275	275	1573
1983	275	275	-601	-576	-512	-873	-3589	-3847	-2	0	0	0	-9450
1984	-167	325	-601	-195	-80	-80	-80	-80	-80	0	325	0	-713
1985	-167	-558	-80	-80	-80	-80	325	325	325	325	325	0	580
1986	325	325	-601	-576	-512	-873	-753	-80	-80	0	0	0	-2825
1987	-167	-233	-80	-80	-80	-80	-80	-80	-80	0	325	0	-635
1988	325	-627	-503	-80	-80	325	325	325	325	325	325	325	1310
1989	325	325	-601	-576	325	325	325	325	325	0	325	0	1423
1990	325	325	325	-576	325	325	325	325	325	325	325	325	2999
1991	325	325	-601	-576	500	500	0	-8823	0	500	500	500	-6850
1992	500	500	-601	-576	500	-873	500	500	500	500	500	500	2450
1993	500	500	-601	-576	500	-873	500	500	500	0	500	0	1450
1994	-167	-627	-601	-576	500	500	500	500	500	0	500	0	1029
Average	152	83	-413	-477	64	-140	-151	-466	168	150	238	136	-656

Table 8.B.2
30,000 ac-ft Deer Creek Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-1507	50	50	50	50	50	50	50	50	-1107
1976	50	50	-973	-837	50	50	50	50	50	50	50	50	-1310
1977	50	50	50	50	50	50	50	50	50	50	50	50	600
1978	50	50	50	50	50	-821	50	50	50	50	50	50	-271
1979	50	50	50	50	50	50	50	50	50	0	50	50	550
1980	50	50	-849	-874	-833	-973	-2111	0	0	275	275	275	-4715
1981	275	275	-840	-848	275	275	275	275	275	275	0	275	787
1982	275	275	-601	-576	275	275	275	275	275	275	275	275	1573
1983	275	275	-601	-576	-512	-873	-3589	-10775	-1177	0	0	0	-17553
1984	-167	850	-601	-576	-512	-873	-3589	-8080	-197	0	850	0	-12895
1985	-167	-627	-601	-576	-455	-197	850	850	850	850	850	0	1627
1986	850	850	-601	-576	-512	-873	-3589	-2557	-197	0	0	0	-7205
1987	-167	-627	-388	-197	-197	-197	-197	-197	-197	0	850	0	-1514
1988	850	-627	-601	-576	-512	850	850	850	850	850	850	850	4484
1989	850	850	-601	-576	850	850	850	850	850	0	850	0	5623
1990	850	850	850	-576	850	850	850	850	850	850	850	850	8774
1991	850	850	-601	-576	850	850	850	-10775	-1177	600	600	600	-7079
1992	600	600	-601	-576	600	-873	600	600	600	600	600	600	3350
1993	600	600	-601	-576	600	-873	600	600	600	0	600	0	2150
1994	-167	-627	-601	-576	600	600	600	600	600	0	600	600	2229
Average	293	201	-433	-551	81	-90	-311	-1319	153	239	415	229	-1095

Table 8.B.3
10,000 ac-ft Deer Creek Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	34	36	16	1	2	0	0	1	90
1976	4	24	0	0	37	35	5	1	0	0	0	0	107
1977	7	23	27	26	31	33	7	1	0	0	0	1	157
1978	23	25	28	32	42	0	3	2	0	0	0	0	157
1979	8	21	31	30	25	37	3	1	1	0	0	0	156
1980	3	21	0	0	0	0	0	0	0	0	1	3	28
1981	22	119	0	0	175	178	6	1	0	2	0	2	504
1982	26	176	0	0	214	194	6	2	2	1	1	4	626
1983	39	155	0	0	0	0	0	0	0	0	0	0	194
1984	0	217	0	0	0	0	0	0	0	0	5	0	222
1985	0	0	0	0	0	0	73	9	9	1	1	0	93
1986	42	182	0	0	0	0	0	0	0	0	0	0	224
1987	0	0	0	0	0	0	0	0	0	0	3	0	3
1988	164	0	0	0	0	248	54	32	3	2	1	8	513
1989	30	176	0	0	234	232	9	1	2	0	1	0	684
1990	144	180	183	0	223	222	23	19	1	0	2	3	999
1991	19	224	0	0	368	324	0	0	0	0	0	4	940
1992	30	285	0	0	389	0	6	6	3	4	1	3	727
1993	278	312	0	0	259	0	7	6	12	0	7	0	880
1994	0	0	0	0	348	416	20	7	3	0	1	8	804
Average	42	107	13	4	119	98	12	4	2	1	1	2	405

Table 8.B.4
10,000 ac-ft Deer Creek Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	44	46	46	44	44	43	31	40	338
1976	32	36	0	0	45	45	42	44	34	17	6	20	321
1977	40	37	37	39	44	48	40	44	42	26	31	41	468
1978	41	40	39	34	46	0	44	43	41	15	23	20	386
1979	30	37	42	40	37	48	45	44	33	0	35	26	416
1980	32	40	0	0	0	0	0	0	0	191	194	149	606
1981	195	193	0	0	219	240	227	245	172	148	0	148	1788
1982	215	261	0	0	265	243	233	244	233	227	239	186	2345
1983	260	221	0	0	0	0	0	0	0	0	0	0	481
1984	0	304	0	0	0	0	0	0	0	0	204	0	508
1985	0	0	0	0	0	0	295	292	282	284	288	0	1441
1986	309	278	0	0	0	0	0	0	0	0	0	0	587
1987	0	0	0	0	0	0	0	0	0	0	219	0	219
1988	240	0	0	0	0	298	269	267	253	242	247	246	2062
1989	257	311	0	0	300	283	275	255	279	0	234	0	2193
1990	291	283	255	0	305	308	287	287	214	146	261	175	2812
1991	201	250	0	0	466	455	0	0	0	156	193	221	1942
1992	285	454	0	0	478	0	435	349	424	368	286	317	3396
1993	399	431	0	0	307	0	455	443	434	0	427	0	2896
1994	0	0	0	0	396	474	444	428	409	0	429	326	2906
Average	141	159	19	6	148	124	157	152	145	93	167	96	1406

Table 8.B.5

30,000 ac-ft Deer Creek Reservoir

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	34	36	16	1	2	0	0	1	90
1976	4	24	0	0	37	35	5	1	0	0	0	0	107
1977	7	23	27	26	31	33	7	1	0	0	0	1	157
1978	23	25	28	32	42	0	3	2	0	0	0	0	157
1979	8	21	31	30	25	37	3	1	1	0	0	0	156
1980	3	21	0	0	0	0	0	0	0	0	1	3	28
1981	22	119	0	0	175	178	6	1	0	2	0	2	504
1982	26	176	0	0	214	194	6	2	2	1	1	4	626
1983	39	155	0	0	0	0	0	0	0	0	0	0	194
1984	0	568	0	0	0	0	0	0	0	0	14	0	582
1985	0	0	0	0	0	0	190	24	23	3	4	0	244
1986	109	477	0	0	0	0	0	0	0	0	0	0	586
1987	0	0	0	0	0	0	0	0	0	0	8	0	8
1988	430	0	0	0	0	649	142	82	9	5	4	20	1341
1989	78	460	0	0	611	606	22	3	6	0	2	0	1789
1990	376	472	478	0	582	581	61	49	2	0	4	7	2613
1991	49	587	0	0	625	551	7	0	0	0	0	5	1825
1992	36	343	0	0	467	0	8	7	3	5	2	4	873
1993	333	374	0	0	311	0	8	7	14	0	9	0	1056
1994	0	0	0	0	417	499	24	9	4	0	1	9	965
Average	77	192	28	4	179	170	25	9	3	1	2	3	695

Table 8.B.6

30,000 ac-ft Deer Creek Reservoir

Reductions to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	44	46	46	44	44	43	31	40	338
1976	32	36	0	0	45	45	42	44	34	17	6	20	321
1977	40	37	37	39	44	48	40	44	42	26	31	41	468
1978	41	40	39	34	46	0	44	43	41	15	23	20	386
1979	30	37	42	40	37	48	45	44	33	0	35	26	416
1980	32	40	0	0	0	0	0	0	0	191	194	149	606
1981	195	193	0	0	219	240	227	245	172	148	0	148	1788
1982	215	261	0	0	265	243	233	244	233	227	239	186	2345
1983	260	221	0	0	0	0	0	0	0	0	0	0	481
1984	0	795	0	0	0	0	0	0	0	0	533	0	1328
1985	0	0	0	0	0	0	772	764	737	742	754	0	3768
1986	808	727	0	0	0	0	0	0	0	0	0	0	1535
1987	0	0	0	0	0	0	0	0	0	0	574	0	574
1988	627	0	0	0	0	780	705	699	661	633	645	643	5392
1989	673	813	0	0	785	739	719	668	729	0	611	0	5737
1990	762	739	666	0	799	804	750	751	560	381	683	459	7355
1991	526	653	0	0	792	773	671	0	0	188	231	266	4099
1992	342	545	0	0	573	0	522	419	508	442	344	380	4076
1993	479	517	0	0	369	0	546	531	521	0	427	0	3390
1994	0	0	0	0	476	569	533	513	491	0	515	391	3487
Average	253	283	39	6	225	217	295	253	240	153	294	138	2395

The average annual reductions to target flow shortages with downstream diversion losses and without downstream diversion losses for a 30,000 ac-ft reservoir are 695 ac-ft and 2,395 ac-ft, respectively. Different release schedules were analyzed to determine whether the reductions to target flow shortages could be increased. Consolidating releases to fewer months each year increased reductions, however, not significantly.

Cost

Using the FEIS cost for a 66,000 ac-ft reservoir, updated to 1998 dollars, as a reference point, a 10,000 ac-ft Deer Creek Reservoir might be expected to cost between $10 and $15 million. Similarly, a 30,000 ac-ft reservoir might cost between $40 and $50 million. Costs associated with the dam foundation, and permitting and legal fees were not assumed to decrease linearly with reductions in the reservoir size.

The cost per ac-ft of target flow reductions at the critical habitat for a 10,000 ac-ft reservoir would be approximately $30,860 assuming releases cannot be protected from downstream diversions and $9,000 assuming diversions can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat for a 30,000 ac-ft reservoir would be approximately $64,750 assuming releases cannot be protected from downstream diversions and $18,790 assuming diversions can be protected from downstream diversions. The cost per ac-ft of target flow reductions exceeds the economic screening criteria upper limits; therefore, this alternative has been deferred from further evaluation at this time. As such, the associated issues for Deer Creek Reservoir have not been addressed.

Horse Creek Re-Regulating Reservoir (Constructing New Equalizing Reservoirs)

The Horse Creek Re-Regulating Reservoir is proposed for construction on Horse Creek near the Wyoming-Nebraska state line in Goshen County, Wyoming. The purpose of the reservoir is to store and re-regulate excess flows (operational waste) and storm flows originating from the Fort Laramie Canal.

The canal began operating in 1925 after it was completed by the USBR. It originates at Whalen Dam and continues in a southeasterly direction through Goshen County before leaving Wyoming at a point approximately 7 miles south of Lyman, Nebraska. Goshen Irrigation District (GID) spills water into Horse Creek to be subsequently diverted into the South Horse Creek Lateral and the Lawrence Canal. Water in excess of these demands (waste) is conveyed to the North Platte River via Horse Creek. The re-regulating reservoir would store this waste during the irrigation season for later release when shortages occur at the critical habitat.

In 1986, HDR Infrastructure, Inc. studied the feasibility of a reservoir to re-regulate the operational waste of the GID (Horse Creek Reservoir Level II Study, Final Report, November 1986). Lidstone & Anderson, Inc. (LA) conducted a more detailed investigation in 1993 that resulted in the recommendation of several smaller reservoir alternatives (Goshen Irrigation District Horse Creek Re-Regulating Reservoir Level II Study, December 1993). While the alternatives recommended in the LA report were large enough to re-regulate waste on a short-term basis, none provided the storage necessary to mitigate flow shortages at the critical habitat. Of those alternatives recommended in the HDR report, the Upper Bureau Dam site provided the greatest amount of storage for the lowest cost; consequently, the 11,000 ac-ft Upper Bureau Dam Site was selected for evaluation in this study.

Yield

To evaluate the potential yield of the re-regulating reservoir, the study team developed a simplified reservoir operations model. The assumptions, methods, and data sources for the model are presented below.

- The reservoir was assumed to be empty at the beginning of the study period.
- Monthly waste quantities for the evaluation period were obtained from the HDR and LA reports. These data represent water that would have been conveyed to the North Platte River after downstream diversions have been satisfied.
- During months of excess flows at the critical habitat, the waste was stored in the reservoir.
- Stored water was released only during months of shortage. The volume released was equal to the lesser of the total stored

volume or the shortage at the critical habitat. In most cases, the shortage at the critical habitat greatly exceeded the total stored volume. Therefore, the reservoir typically empties in the first month that a shortage occurs at the critical habitat.

- Evaporative losses were computed using mean monthly evaporation data presented in the HDR report and the water surface area extracted from the HDR stage-area curve.

Table 8.B.7 shows the local net hydrologic effects of the Horse Creek Re-Regulating Reservoir alternative through the 20-year study period. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Annual impacts approximately 5 miles east of the Wyoming-Nebraska State line, where Horse Creek joins the North Platte River, range from a reduction in flows of 5,238 ac-ft to a gain in flow of 11,000 ac-ft. The annual effects of the re-regulating reservoir are highly sensitive to the time that waste water is stored in relation to when it is released.

Monthly diversions to storage (flow reductions) and releases (flow additions) from Horse Creek Re-Regulating Reservoir were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions.

The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 12, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.8 and 8.B.9 show the reductions to target flow shortages at the critical habitat for Horse Creek Re-Regulating Reservoir. The average annual reductions to target flow shortages with downstream diversion losses were estimated to be 1,112 ac-ft. The average annual reductions to target flow shortages without downstream diversion losses were estimated to be 1,699 ac-ft. Reductions in critical habitat target flows shortages are limited primarily to the month of October given the assumed operations criteria.

Table 8.B.7
Horse Creek Re-Regulating Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	-1834	0	0	-1834
1980	1775	0	0	0	0	0	0	-3738	-1856	0	0	0	-3819
1981	5210	0	0	0	0	0	0	0	0	0	-2122	0	3088
1982	2093	0	0	0	0	0	0	0	0	0	0	0	2093
1983	0	0	0	0	0	0	0	0	-740	-660	-950	-3540	-5890
1984	0	5755	0	0	0	0	0	-1156	-5238	-3370	0	-1610	-5619
1985	0	0	0	0	0	0	4889	0	0	0	0	-1384	3505
1986	5847	0	0	0	0	0	0	-4532	-4844	-1975	-34	0	-5538
1987	0	0	0	0	0	0	0	-1365	0	0	0	0	-1365
1988	11000	0	0	0	0	0	0	0	0	0	0	0	11000
1989	0	0	0	0	0	0	0	0	0	-494	0	-46	-540
1990	521	0	0	0	0	0	0	0	0	0	0	0	521
1991	0	0	0	0	0	0	0	0	-624	0	0	0	-624
1992	571	0	0	0	0	0	0	0	0	0	0	0	571
1993	0	0	0	0	0	0	0	0	0	-3168	0	-632	-3800
1994	0	0	0	0	3534	0	0	0	0	-3168	0	0	366
Average	1351	288	0	0	177	0	244	-540	-665	-733	-155	-361	-394

Table 8.B.8
Horse Creek Re-Regulating Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	486	0	0	0	0	0	0	0	0	0	0	0	486
1981	1833	0	0	0	0	0	0	0	0	0	0	0	1833
1982	1003	0	0	0	0	0	0	0	0	0	0	0	1003
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	3869	0	0	0	0	0	0	0	0	0	0	3869
1985	0	0	0	0	0	0	2299	0	0	0	0	0	2299
1986	4282	0	0	0	0	0	0	0	0	0	0	0	4282
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	5650	0	0	0	0	0	0	0	0	0	0	0	5650
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	236	0	0	0	0	0	0	0	0	0	0	0	236
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	107	0	0	0	0	0	0	0	0	0	0	0	107
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	2472	0	0	0	0	0	0	0	2472
Average	680	193	0	0	124	0	115	0	0	0	0	0	1112

Table 8.B.9
Horse Creek Re-Regulating Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	1170	0	0	0	0	0	0	0	0	0	0	0	1170
1981	3745	0	0	0	0	0	0	0	0	0	0	0	3745
1982	1657	0	0	0	0	0	0	0	0	0	0	0	1657
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	5422	0	0	0	0	0	0	0	0	0	0	5422
1985	0	0	0	0	0	0	4507	0	0	0	0	0	4507
1986	5615	0	0	0	0	0	0	0	0	0	0	0	5615
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	8241	0	0	0	0	0	0	0	0	0	0	0	8241
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	477	0	0	0	0	0	0	0	0	0	0	0	477
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	333	0	0	0	0	0	0	0	0	0	0	0	333
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	2817	0	0	0	0	0	0	0	2817
Average	1062	271	0	0	141	0	225	0	0	0	0	0	1699

The study team also evaluated an alternative reservoir operations scenario in which waste was stored in every month of the irrigation season, even in months when shortages occur at the critical habitat. This scenario increases reductions to target flow shortages in the winter months at the expense of the reductions to target flow shortages in the summer months. The average annual reductions to target flow shortages for this scenario were estimated to be 1,997 ac-ft with downstream diversion losses and 3,814 ac-ft without downstream diversion losses. Tables showing net hydrologic effects and reductions to target flow shortages for this scenario are provided in Appendix F.

Cost

The 1986 HDR report estimated the cost to construct this reservoir to be $12.7 million. Adjusting this value for inflation, the estimated cost becomes $17.5 million in 1998 dollars. The cost per ac-ft at the critical habitat with downstream diversions is approximately $15,740 for the first operations scenario and $8,760 for the second operations scenario. The cost per ac-ft at the critical habitat without downstream diversions is approximately $10,300 for the first operations scenario and $4,590 for the second operations scenario. The cost per ac-ft of target flow reductions exceeds the economic screening criteria upper limits; therefore, this alternative has been deferred from further evaluation at this time. As such, the associated issues for Horse Creek Re-Regulating Reservoir have not been addressed.

Seminoe Reservoir (Enlarge Existing Reservoirs)

Seminoe Reservoir (Seminoe) is a reservoir of the USBR's Kendrick Project, which stores North Platte River water for irrigation and power generation. Seminoe has a total storage capacity of 1,017,300 ac-ft and is located on the North Platte River about 72 miles southwest of Casper. The average annual inflow is approximately 1,070,000 ac-ft and the average annual pool is 500,000 ac-ft with about 13,000 surface acres (U.S. Army Corps of Engineers, September 1987).

Numerous studies have been prepared on Seminoe Dam modifications. In October 1991, USBR completed an appraisal level study that analyzed the additional yield associated with raising the dam height. The study evaluated two increases in dam height: 18 feet and 35 feet. The study concluded that raising the dam 18 feet from elevation 6357 to 6375 feet would increase the reservoir storage capacity by 415,000 ac-ft at an estimated cost of $38.15 million. USBR analyzed the new elevation with and without Deer Creek Dam and Reservoir being in place to determine the firm annual yield for municipal and industrial use. The firm annual yield without Deer Creek Dam and Reservoir was estimated to be 7,300 ac-ft. Raising the dam 35 feet would result in additional reservoir storage capacity of 909,000 ac-ft at an estimated cost of $62.5 million. The cost of raising the dam 35 feet exceeds the economic screening criteria of $50 million, therefore, that alternative has been deferred from further evaluation at this time. However, enlarging Seminoe Reservoir by 18 feet is within the Project budget and may provide an opportunity to establish an environmental account. An environmental account in Seminoe Reservoir could provide an opportunity to re-regulate flows in the North Platte River.

An additional opportunity to enlarge the storage capacity of Seminoe Reservoir may be the reactivation of storage space lost to sedimentation. However, USBR has not recently studied reactivation of storage space lost to sedimentation at Seminoe Reservoir nor are any such studies anticipated at this time. A report titled A History of the Seminoe Reservoir Resurvey, Kendrick Project, Wyoming, dated November 1975, concluded, "the sediment accumulation in Seminoe Reservoir was not determined because of the irreconcilability of the 1972 survey data with previous surveys." This alternative has been deferred from further evaluation at this time due to lack of data regarding current sediment build-up in Seminoe Reservoir and the significant costs that would be associated with dredging the reservoir. The only alternative that has been evaluated for Seminoe Reservoir is raising the dam height 18 feet.

Yield

USBR evaluated enlarging Seminoe Reservoir in the context of meeting municipal and industrial demands, in which case, the estimated annual yield of 7,300 ac-ft is the firm yield as opposed to the average yield. To estimate average yield of a Seminoe Reservoir enlargement the study team completed a simple reservoir operation study based on historical conditions for 1975-1983.

To analyze the enlargement of Seminoe Reservoir, the USBR obtained a copy of the State of Wyoming's North Platte River Simulation

Model (NPRSM) and modified the model to simulate operation of the enlarged Seminoe Reservoir. The difference in the end-of-month contents at the current storage capacity and the enlarged capacity and the monthly municipal and industrial demands are provided in USBR's study. The study team estimated monthly evaporation and diversions from storage from average monthly municipal releases and end-of-month storage contents. The period of record for USBR's Seminoe Reservoir enlargement evaluation extended from 1951 through 1983. This time span included the critical period, June 1952 through June 1971, during which no water was stored in the enlarged storage account. The study period used for USBR's analysis had to be extended to 1994 to cover the study period for this project. Due to several below average Seminoe Reservoir inflow years in this period, it was assumed no accruals to the enlarged space occurred from 1984 through 1994. There may have been an ability to divert water to storage in 1984 because that was a wet year; however the late 1980's and early 1990's were fairly dry years, in which case, storage in a Seminoe Reservoir enlargement would have been highly unlikely.

Other assumptions used to evaluate the reservoir are described below.

- The reservoir was assumed to be empty at the beginning of the study period.
- Water was diverted to storage only during months of excess flows at the critical habitat.
- Releases were made only during months of target flow shortages at the critical habitat.
- Monthly evaporation was based on estimates of monthly evaporation for different capacities determined in the USBR study.

Table 8.B.10 shows the local net hydrologic effects of the Seminoe enlargement alternative through the 20-year study period. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Seminoe Reservoir is located approximately in the middle of Reach 2. Monthly diversions to storage (flow reductions) and releases (flow additions) from Seminoe Reservoir were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The

Table 8.B.10
Seminoe Reservoir Enlargement
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	-7783	1300	-6483
1982	1300	1300	-6117	-5839	1300	1300	1300	1300	1300	1300	1300	1300	1044
1983	1300	1300	-717	-1139	0	-1450	-12189	0	0	0	0	0	-12894
1984	0	1300	0	0	0	0	0	0	-86306	-1600	1300	0	-85306
1985	0	0	0	0	0	0	1300	1300	1300	1300	1300	0	6500
1986	1300	1300	0	0	0	0	0	0	0	0	0	0	2600
1987	0	0	0	0	0	0	0	0	0	0	1300	0	1300
1988	1300	0	0	0	0	1300	1300	1300	1300	1300	1300	1300	10400
1989	1300	1300	0	0	1300	1300	1300	1300	1300	0	1300	0	10400
1990	1300	1300	1300	0	1300	1300	1300	1300	1300	1300	1300	1300	14300
1991	1300	1300	0	0	1300	1300	1300	0	0	1300	1300	1300	10400
1992	1300	1300	0	0	1300	0	1300	1300	1300	1300	0	0	9100
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	520	520	-277	-349	325	252	-154	390	-3925	310	131	325	-1932

first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by downstream diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by downstream diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 3, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.11 and 8.B.12 show the reductions to target flow shortages at the critical habitat. The average annual reductions to target flow shortages with and without downstream diversion losses are 968 ac-ft and 3,314 ac-ft, respectively.

Cost

The estimated cost for raising the dam an additional 18 feet was $38.15 million in 1991. This cost was updated to a 1998 cost of approximately $46.7 million. The cost per ac-ft of average annual target flow reductions at the critical habitat with downstream diversion losses and without downstream diversion losses is approximately $48,240 and $14,090, respectively. The cost per ac-ft of target flow reductions exceed the economic screening criteria upper limits, therefore, this alternative has been deferred from further evaluation at this time. As such, the associated issues for enlarging Seminoe Reservoir have not been addressed.

Guernsey Reservoir: Reactivate Storage Lost to Sedimentation

The USBR completed Guernsey Reservoir in 1927. Before the reservoir was built, sediment from the basin below Pathfinder Reservoir was conveyed downstream as well as into the canals of the North Platte Project. Between the time the dam was completed (1927) and 1957, an estimated 29,000 ac-ft of sediment had accumulated within its pool, thereby reducing the reservoir storage from 73,810 ac-ft to 44,800 ac-ft.

The reservoir pool level is lowered annually to facilitate the silt run. The silt run was initiated in 1959 to mitigate impacts to the Fort Laramie and Interstate Canals. Sediment-free discharge reportedly caused bank erosion and increased seepage losses as previously

Table 8.B.11

Seminoe Reservoir Enlargement

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	8	8
1982	120	823	0	0	1006	909	29	10	8	3	4	20	2933
1983	185	727	0	0	0	0	0	0	0	0	0	0	912
1984	0	862	0	0	0	0	0	0	0	0	22	0	884
1985	0	0	0	0	0	0	290	36	35	4	6	0	370
1986	166	726	0	0	0	0	0	0	0	0	0	0	892
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	649	0	0	0	0	990	215	125	13	7	5	31	2034
1989	117	698	0	0	932	919	34	5	9	0	3	0	2717
1990	564	714	729	0	884	881	92	73	3	0	6	10	3957
1991	73	889	0	0	949	834	10	0	0	1	1	11	2768
1992	76	740	0	0	1003	0	16	14	7	10	0	0	1865
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	97	309	36	0	239	227	34	13	4	1	3	4	968

Table 8.B.12

Seminoe Reservoir Enlargement

Reductions to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	687	687
1982	1008	1218	0	0	1245	1135	1087	1147	1076	1053	1112	869	10951
1983	1217	1040	0	0	0	0	0	0	0	0	0	0	2257
1984	0	1208	0	0	0	0	0	0	0	0	806	0	2014
1985	0	0	0	0	0	0	1173	1160	1096	1122	1128	0	5679
1986	1225	1107	0	0	0	0	0	0	0	0	0	0	2332
1987	0	0	0	0	0	0	0	0	0	0	853	0	853
1988	946	0	0	0	0	1190	1068	1059	946	917	947	970	8043
1989	1014	1235	0	0	1197	1120	1087	1007	1096	0	879	0	8635
1990	1142	1118	1016	0	1213	1220	1132	1132	833	540	1032	682	11059
1991	787	989	0	0	1202	1170	1019	0	0	397	485	568	6616
1992	726	1177	0	0	1232	0	1108	866	1089	946	0	0	7143
1993	0	0	0	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	403	455	51	0	304	292	384	318	307	249	362	189	3314

deposited sediment was removed from the banks and canal (U.S. Bureau of Reclamation (USBR), 1983). Flushing of sediments has been shown to have reduced seepage losses by approximately 30 ac-ft per mile per year (USBR, 1963). This translates to approximately 10,000 ac-ft of water conserved within the Fort Laramie and Interstate Canals (Lidstone & Anderson, Inc., 1993a).

Operation of the silt run increased reservoir storage 812 ac-ft during the period from 1957 when the silt run started, through 1982 (Lidstone & Anderson, Inc., 1993a). This represents an average of approximately 32.5 ac-ft of storage capacity reactivated per year. Extrapolating to 1999, an additional 550 ac-ft of sediment may have been removed, leaving over 27,000 ac-ft of storage that could be reactivated for use in an environmental account to mitigate target flow shortages at the critical habitat.

Reactivation of this storage volume, or a portion of it, would require either dredging, raising Guernsey Dam, or excavating using conventional truck and shovel. The first two methods were deferred during the scoping process of this investigation. Dam modification alternatives were evaluated only if feasibility studies had been completed, and none has been executed for Guernsey Reservoir.

Guernsey Reservoir operations offer a relatively unique opportunity to reactivate storage using dryland truck and shovel excavation methods. Because the reservoir pool is annually lowered to facilitate the sediment flushing, conventional dryland excavation techniques could conceivably be used to remove accumulated sediments, thereby reactivating lost storage capacity.

The cost of implementing this alternative would include the costs of excavating sediment accumulated in the reservoir, transporting and disposing of materials, both engineering and environmental analysis, and compensating third parties for project impacts. Based on earthwork costs of approximately $5/cubic yard, and assuming reactivation of 5,000 ac-ft of storage (8.06 million cubic yards), the cost to excavate and transport the sediment is likely to exceed $40 million. Sediment disposal and environmental costs would represent additional costs. Consequently, a conservatively low cost to reactivate 5,000 ac-ft of storage becomes $8,000 per ac-ft even in a best case scenario where the 5,000 ac-ft of capacity yields 5,000 ac-ft of water in storage.

This alternative has been deferred from further evaluation at this time because it fails to meet the economic screening criteria. As such, the associated issues for reactivating storage lost to sedimentation in Guernsey Reservoir have not been addressed.

Region 2

Constructing New Storage Facilities on the South Platte River (including Lining Gravel Pits)

Various water storage projects on the South Platte have been identified to maximize use of water resource systems and return flows in the lower South Platte River basin. The study team relied on existing studies and conversations with the Northern Colorado Water Conservancy District, the Colorado Water Conservation Board, and the Colorado State Engineer's Office to evaluate storage alternatives to meet target flow shortages at the critical habitat. The study reaches on the South Platte downstream of the Cache la Poudre confluence are assumed to have the potential for a new off-channel site. The potential of new storage units on the mainstem of the South Platte to reduce target flow shortages at the critical habitat were investigated in a general manner and analyzed as described below.

- Three storage alternatives were analyzed.
- Capacities of 10,000 ac-ft and 50,000 ac-ft were investigated in Reaches 8 and 9. A storage site at the bottom of Reach 9 was also analyzed as the most downstream location in the State of Colorado. These two capacities are assumed to bracket all potential new reservoir alternatives within these reaches.
- Gravel pits in Region 2 are concentrated in the upper reaches of the region. To represent lining of gravel pits/new storage, a design capacity of a new 10,000 ac-ft reservoir with zero seepage was analyzed in Reaches 8 and 9.

- It is assumed that monthly excess flows in each reach above compact requirements plus recharge are available to store under a current priority.

- Reservoir storage was operated to fill to maximum capacity with available supply. Excess capacity in existing canals is assumed to be available for Program use. Capacity problems that may exist could be overcome by enlarging existing canals. Coordination of canal operations with existing owners may require financial compensation or shares of reservoir yield from Program operations.

Yield

To evaluate the yield of new storage alternatives in Reaches 8 (Kersey to Balzac) and 9 (Balzac to Julesburg), the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- Storable flow was determined as flow in excess of 180 cfs at the Nebraska-Colorado state line in months when flow at the critical habitat exceeded the target flow. According to the Division 1 Water Resources Office, Compact obligations as well as in-state water rights are typically satisfied when State line flows are 180 cfs or greater. State line flows were adjusted to account for the depletions/additions to historic Julesburg gage flows from Colorado's proposed Tamarack Plan.

- The reservoir was assumed to be empty at the beginning of the study period.

- The reservoir was operated to fill to maximum capacity with available supply during months of excess flows at the critical habitat. Based on historical diversions for storage on the South Platte, reservoir storage was possible throughout the winter.

- Monthly evaporation amounts for new storage facilities were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship based on an average reservoir depth of 40 feet was used.

- Releases from the reservoir were made during months of target flow shortages at the critical habitat.
- A seepage rate of 8 percent of monthly storage volume was developed in the Riverside Water Study (W.W.Wheeler and Associates, 1979) for an off-channel reservoir. This rate of seepage was used for all reservoir alternatives except the lining of gravel pits. Seepage water was returned to the river based on a generic Stream Depletion Factor (SDF) of 100 days, based on SDF factors listed for reservoirs in existing studies. Return flows were routed back to the river using the SDF model SDF View.

For the storage alternatives analyzed in Reaches 8 and 9, the reduction to target flow shortages improves as the reservoirs are sited closer to the Colorado-Nebraska state line. Due to the large number of scenarios that were evaluated, the local net hydrologic effects through the 20-year study period are presented in Tables 8.B.13 and 8.B.14 for a 10,000 ac-ft reservoir and 50,000 ac-ft reservoir, respectively, located at the bottom of Reach 9. Negative values indicate months when water goes into storage; positive values indicate months when water is released. Tables showing monthly net hydrologic effects for the other reservoir projects are provided in Appendix F.

Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) from reservoir alternatives were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at each alternative site; at the top of the downstream reach, with and without diversions; and at the critical habitat, with and without diversions for the storage units analyzed. Again, due to the large number of scenarios that were evaluated, the reductions to target flow shortages at the critical habitat, with and without diversions, are presented in Tables 8.B.15 through 8.B.18 for a 10,000 ac-ft reservoir and a 50,000 ac-ft reservoir located at the bottom of Reach 9. Tables showing monthly net reductions to target

Table 8.B.13
10,000 ac-ft Reservoir at Bottom of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9254	183	99	62	42	31	25	20	-284
1976	17	14	-9988	58	8680	271	156	103	75	58	47	39	-472
1977	33	29	25	22	20	18	16	15	14	13	12	11	226
1978	10	10	9	9	8	-9992	9205	190	105	67	48	37	-294
1979	30	25	22	19	17	15	14	13	12	-9989	9184	185	-455
1980	105	68	-9951	86	-543	-404	-366	-362	-348	8801	437	282	-2197
1981	205	160	-9871	156	8766	343	219	160	126	104	89	78	534
1982	69	62	-9944	98	8729	306	189	135	104	85	73	64	-31
1983	57	51	-9954	90	-543	-401	-359	-338	-327	-321	-337	-312	-12695
1984	-277	8998	-9514	382	-323	-233	-226	-228	-251	565	8170	-9495	-2430
1985	409	-334	-213	-189	-173	-165	5475	3790	439	323	260	-9783	-161
1986	8622	1068	-9742	250	-410	-285	-276	-272	-256	556	561	-1846	-2029
1987	-110	-218	-169	-156	-151	-153	-149	-190	-198	615	8215	-9452	-2116
1988	9602	-9509	416	-292	-182	9062	534	381	297	247	214	189	10957
1989	170	155	-9858	179	8805	377	256	199	165	144	129	-9883	-9163
1990	9316	280	191	-9850	9379	295	199	154	129	112	101	92	10398
1991	86	80	-6632	-3190	8928	301	194	145	-9883	9251	273	180	-267
1992	136	112	-9903	134	6871	-7778	9296	359	237	177	144	121	-94
1993	107	95	-9914	127	8763	-9668	9420	342	226	168	137	-9884	-10080
1994	157	-521	-346	-306	8984	450	299	225	180	151	132	116	9522
Average	1437	31	-5267	-1119	4244	-873	1710	244	-456	558	1396	-2462	-557

Table 8.B.14
50,000 ac-ft Reservoir at Bottom of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-12920	11956	237	127	80	55	41	32	26	-367
1976	21	18	-23785	-18090	33863	4316	606	386	270	203	161	131	-1900
1977	111	95	82	73	64	58	52	47	43	40	37	34	735
1978	32	30	28	26	25	-20887	19254	404	226	146	107	83	-527
1979	68	57	49	44	39	36	32	30	28	-11124	10253	219	-270
1980	128	87	-23736	-23636	-3574	-2338	-2066	-1986	-1881	43888	2085	1324	-11705
1981	949	730	-23217	-23200	31787	11836	1099	763	580	469	396	341	2533
1982	301	269	-17847	-7615	23236	806	518	384	307	259	226	201	1045
1983	182	166	-23648	-23546	-3504	-2295	-2006	-1845	-1763	-1713	-1778	-1640	-63388
1984	-1456	11156	-13652	-230	-1158	-1040	-1043	-1083	-1218	2850	40867	-21265	12729
1985	-22686	-1547	-1358	-1100	-974	-909	7752	27054	11466	1933	1471	-22612	-1510
1986	9518	13721	-22560	-22713	-2818	-1680	-1558	-1486	-1380	2699	2739	-9286	-34804
1987	-602	-1133	-885	-816	-626	-958	-762	-977	-1016	3050	32284	-17759	9800
1988	28392	-13133	-20762	-11737	-737	16526	28538	2236	1616	1283	1084	942	34248
1989	839	759	-13326	-23094	34806	1360	963	773	661	588	536	-15225	-10358
1990	14935	715	560	-23317	22459	839	611	502	438	396	367	343	18846
1991	324	307	-6414	-11243	10768	6183	570	436	-23436	22100	732	509	836
1992	405	347	-20387	-23419	7448	-15840	27380	17734	1424	974	747	607	-2582
1993	517	454	-11544	-14498	24536	-22900	22530	919	640	500	422	-23432	-21856
1994	-2438	-22935	-2273	-2027	44579	1984	1279	939	740	614	530	466	21459
Average	1477	-492	-11234	-12153	11609	-1233	5194	2266	-610	3460	4665	-5300	-2352

Table 8.B.15
10,000 ac-ft Reservoir at Bottom of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4912	142	52	17	14	2	1	6	5146
1976	7	7	0	0	5789	178	91	30	7	1	0	5	6115
1977	14	12	12	10	11	8	7	4	2	0	1	5	87
1978	4	4	5	5	5	0	5594	33	5	1	1	4	5662
1979	8	10	12	10	5	8	6	3	4	0	293	29	388
1980	21	15	0	0	0	0	0	0	0	122	23	54	235
1981	61	50	0	0	5550	213	58	18	4	10	0	15	5980
1982	25	32	0	0	6707	209	64	14	5	2	2	14	7075
1983	40	27	0	0	0	0	0	0	0	0	0	0	67
1984	0	5417	0	0	0	0	0	0	0	0	505	0	5922
1985	0	0	0	0	0	0	3474	1530	127	22	23	0	5177
1986	5485	570	0	0	0	0	0	0	0	0	0	0	6055
1987	0	0	0	0	0	0	0	0	0	0	758	0	758
1988	4248	0	0	0	0	6259	268	187	29	26	19	58	11093
1989	54	65	0	0	5813	239	76	21	22	0	8	0	6297
1990	3568	134	90	0	5111	158	119	49	10	1	7	8	9256
1991	30	41	0	0	4679	163	40	0	0	115	5	17	5089
1992	27	51	0	0	4174	0	4373	45	31	22	10	12	8745
1993	53	52	0	0	3983	0	4018	65	40	0	28	0	8238
1994	0	0	0	0	5800	334	123	59	21	0	7	41	6385
Average	682	324	6	1	2627	396	918	104	16	16	85	13	5189

Table 8.B.16
10,000 ac-ft Reservoir at Bottom of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8265	173	94	57	40	28	16	16	8690
1976	11	10	0	0	7958	252	140	96	54	21	5	16	8563
1977	27	21	19	17	18	17	14	14	13	7	7	9	184
1978	9	8	7	6	8	0	8719	177	90	21	22	15	9082
1979	18	19	18	15	11	15	13	12	8	0	6713	102	6944
1980	70	55	0	0	0	0	0	0	0	6373	316	156	6971
1981	149	114	0	0	7162	313	203	152	92	58	0	43	8285
1982	55	60	0	0	8593	280	174	125	96	75	65	44	9565
1983	54	41	0	0	0	0	0	0	0	0	0	0	96
1984	0	8552	0	0	0	0	0	0	0	0	4666	0	13218
1985	0	0	0	0	0	0	4889	3614	411	294	241	0	9450
1986	8380	927	0	0	0	0	0	0	0	0	0	0	9307
1987	0	0	0	0	0	0	0	0	0	0	5811	0	5811
1988	7277	0	0	0	0	8494	473	330	260	201	173	147	17354
1989	139	151	0	0	8283	338	234	168	153	0	101	0	9567
1990	8770	250	154	0	9024	289	190	147	115	57	85	54	19134
1991	56	63	0	0	8519	284	164	0	0	3131	112	83	12413
1992	80	104	0	0	6564	0	8789	285	218	136	87	81	16344
1993	88	84	0	0	5493	0	9047	319	208	0	129	0	15368
1994	0	0	0	0	7258	441	284	205	160	0	117	78	8544
Average	1259	523	10	2	3858	545	1671	285	96	520	933	42	9745

Table 8.B.17
50,000 ac-ft Reservoir at Bottom of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	6346	184	67	22	18	2	2	8	6649
1976	9	9	0	0	22586	2832	355	112	24	4	1	17	25950
1977	48	39	40	34	36	27	23	14	6	1	2	14	285
1978	13	13	14	15	16	0	11702	69	10	3	3	10	11868
1979	17	23	28	24	13	19	14	6	10	0	327	34	515
1980	26	19	0	0	0	0	0	0	0	610	108	255	1018
1981	282	229	0	0	20127	7352	292	88	20	44	0	64	28499
1982	109	141	0	0	17855	551	175	40	13	6	8	45	18944
1983	130	87	0	0	0	0	0	0	0	0	0	0	217
1984	0	6715	0	0	0	0	0	0	0	0	2528	0	9244
1985	0	0	0	0	0	0	4889	10920	3325	130	132	0	19396
1986	6055	7318	0	0	0	0	0	0	0	0	0	0	13374
1987	0	0	0	0	0	0	0	0	0	0	2977	0	2977
1988	12560	0	0	0	0	11415	14313	1095	158	133	97	291	40063
1989	265	321	0	0	22979	862	284	82	88	0	31	0	24913
1990	5720	342	264	0	12239	451	364	160	35	5	27	29	19636
1991	112	158	0	0	5644	3346	117	0	0	274	12	47	9710
1992	80	159	0	0	4524	0	12880	2200	188	120	53	59	20264
1993	258	245	0	0	11152	0	9609	176	113	0	85	0	21638
1994	0	0	0	0	28779	1473	524	245	88	0	28	166	31301
Average	1284	791	17	4	7615	1426	2780	762	205	67	321	52	15323

Table 8.B.18
50,000 ac-ft Reservoir at Bottom of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	10678	224	122	74	51	36	21	21	11227
1976	14	13	0	0	31047	4025	544	358	194	73	19	53	36340
1977	91	70	61	57	58	56	44	45	40	22	23	29	597
1978	27	24	22	18	23	0	18239	375	194	45	49	34	19051
1979	41	43	42	35	27	35	31	28	19	0	7494	120	7915
1980	86	71	0	0	0	0	0	0	0	31781	1510	734	34182
1981	689	522	0	0	25970	10778	1018	721	423	262	0	189	40572
1982	241	260	0	0	22874	737	477	356	283	227	202	139	25796
1983	175	135	0	0	0	0	0	0	0	0	0	0	311
1984	0	8552	0	0	0	0	0	0	0	0	23341	0	31893
1985	0	0	0	0	0	0	4889	24202	10741	1760	1367	0	42959
1986	8380	11910	0	0	0	0	0	0	0	0	0	0	20290
1987	0	0	0	0	0	0	0	0	0	0	22836	0	22836
1988	21515	0	0	0	0	13999	25281	1936	1416	1043	878	736	66805
1989	687	742	0	0	32743	1217	881	653	611	0	422	0	37957
1990	14060	638	453	0	21609	822	583	478	391	200	307	199	39739
1991	210	241	0	0	10273	5829	481	0	0	7480	301	236	25052
1992	239	320	0	0	6564	0	25735	14070	1309	751	453	407	49848
1993	429	401	0	0	15380	0	21637	858	589	0	396	0	39690
1994	0	0	0	0	36016	1700	1213	858	658	0	472	312	41230
Average	2344	1197	29	5	10663	1971	5059	2251	846	2184	3005	160	29714

flow shortages for the other reservoir projects are provided in Appendix F.

The average annual reductions to target flow shortages with and without downstream diversion losses for a 10,000 ac-ft reservoir at the bottom of Reach 9 are 5,189 ac-ft and 9,745 ac-ft, respectively. The average annual reductions to target flow shortages with and without downstream diversion for a 50,000 ac-ft reservoir at the bottom of Reach 9 are 15,323 ac-ft and 29,714 ac-ft, respectively.

Cost

The primary direct costs of new storage facilities in Region 2 are associated with land acquisition, excavation and site development, dam construction, delivery fees for use of existing canals, and annual operations and maintenance costs. Project costs will vary based on site-specific conditions. The cost estimates provided herein can be refined based on site-specific feasibility studies and communication with canal owners.

Building project costs of $800/ac-ft were adopted based on existing studies (Tuttle Applegate, Inc., 1998; Sear-Brown Group, 1997). The cost estimate for PVC lining of smaller storage units is based on a $0.25/sq. ft. estimate from the 1993 Water Utilization Study for the Sutherland Project (Harza Engineering Co.), updated to a 1998 cost of $0.28/sq. ft. The additional costs associated with installing and operating pumps to deliver water from lined gravel pits is not included in the lining of new storage reservoirs analyzed. The present value of annual operations and maintenance costs, are set equal to 5% of total capital costs.

Delivery fees in the Lower South Platte River region vary but can run as high as $5 per ac-ft. For this analysis it was assumed the project would pay a delivery fee of $5 per ac-ft delivered. Annual operations and maintenance costs and delivery fees have been amortized over 20 years at a discount rate of 6 percent.

There are several large sand dams located in the Lower South Platte River region in Colorado that would need to be replaced in order for additional water generated from reservoir alternatives to be protected downstream to the critical habitat. Based on input from the Division 1 Water Resources Office, approximately half of these would need to be modified to be able to pass water downstream. The Division 1 Water

Resources Office also indicated that the average cost for replacing an existing sand dam is $300,000. If additional water is to be protected from diversions to the Colorado-Nebraska state line, an additional $6,000,000 and $3,600,000 would need to be added to the cost of all reservoir projects in the middle of Reaches 8 and 9, respectively.

If sand dams are modified to bypass flows, then more than one alternative could be located above the sand dams without incurring the additional cost of sand dam replacement. The sand dams would only be modified once, therefore, the total cost to replace these dams would be incurred by all projects implemented in Colorado under the Program, as opposed to each individual project. Therefore, the cost per ac-ft for scenarios without diversion losses could be lower in the Action Plan if more than one alternative is selected in Region 2 that requires sand dam modifications.

Total project costs and costs per ac-ft of target flow reduction are tabulated in Table 8.B.37 for all the structural and routing scenarios included in this alternative. Representative project costs for a 10,000 ac-ft reservoir in Region 2 would be approximately $8.4 million. Delivery fees are approximately $68,500 per year. Total costs for a 10,000 ac-ft reservoir, with annual costs amortized over the 20-year study period at a discount rate of 6 percent, would be approximately $9.2 million. Assuming additional water is not protected from downstream diversions, the cost per ac-ft of target flow reductions at the critical habitat for 10,000 ac-ft reservoirs in the middle of Reaches 8 and 9 would be $3,320 and $2,000, respectively. Assuming additional water is protected from downstream diversions, the cost per ac-ft of target flow reductions of $1,610 and $1,340 for these two storage units. For a 10,000 ac-ft reservoir at the bottom of Reach 9, the cost per ac-ft of target flow reductions, with and without diversions, would be $1,770 and $940, respectively.

Representative project costs for a lined 10,000 ac-ft reservoir in Region 2 would be approximately $11.6 million. Delivery fees are approximately $59,220 per year. Total costs for a lined 10,000 ac-ft reservoir, with annual costs amortized over the 20-year study period at a discount rate of 6 percent, would be approximately $12.3 million. Assuming additional water is not protected from downstream diversions, the cost per ac-ft of target flow reductions at the critical habitat for 10,000 ac-ft lined reservoirs in the middle of Reaches 8 and 9 would be $4,240 and $2,580, respectively. Assuming additional water is protected from downstream diversions, the cost per ac-ft of target flow reductions of $1,910 and $1,640 for these two storage units. For a 10,000 ac-ft lined reservoir at the bottom of Reach 9, the cost per ac-ft of target flow reductions, with and without diversions, would be $2,300 and $1,250, respectively.

Representative project costs for a 50,000 ac-ft reservoir in Region 2 would be approximately $42 million. Delivery fees are approximately $222,000 to $230,000 per year. Total costs for a 50,000 ac-ft reservoir, with annual costs amortized over the 20-year study period at a discount rate of 6 percent, would be approximately $44.6 million. Assuming additional water is not protected from downstream diversions, the cost per ac-ft of target flow reductions at the critical habitat for 50,000 ac-ft reservoirs in the middle of Reaches 8 and 9 would be $5,680 and $3,430, respectively. Assuming additional water is protected from downstream diversions, the cost per ac-ft of target flow reductions of $2,590 and $1,700 for these two storage units. For a 50,000 ac-ft reservoir at the bottom of Reach 9, the cost per ac-ft of target flow reductions, with and without diversions, would be $2,910 and $1,500, respectively.

Grey Mountain Reservoir (Constructing New Storage Facilities)

The Cache la Poudre River is the largest tributary to the South Platte River Basin in Colorado. In 1987, Harza Engineering, through the Colorado Water Resources and Power Authority, evaluated seven alternative storage plans for water supply and hydroelectric power in the Cache la Poudre River basin (Harza Engineering Company, et al., 1987; 1990). Grey Mountain Reservoir, the most favorable alternative identified in the original Basin Study, was further evaluated based on technical and economic performance, as well as probable environmental effects and mitigation/enhancement opportunities (Harza Engineering, Cache la Poudre Study Extension, 1990).

The proposed Grey Mountain Reservoir would be located on the Cache la Poudre River, approximately two miles below the confluence with the North Fork Cache la Poudre River. Based on the Cache la Poudre Study Extension, the Grey Mountain project would consist of Grey Mountain Dam and Reservoir, spillway, outlet works, conventional hydropower facilities, access roads, and conveyance facilities to irrigation users. The proposed dam would be a concrete arch dam approximately 1580 feet long and 415 feet high. This reservoir would capture surplus water from the Cache la Poudre River during high runoff and transbasin imports and would have an active storage of approximately 185,000 ac-ft.

With respect to this study, the study team assumed that only South Platte storable flows were available for storage in Grey Mountain Reservoir. Operational analyses carried out by Hydrosphere Resource Consultants (1999) showed that a 195,000 ac-ft Grey Mountain Reservoir could yield 16,000 ac-ft/yr if only native water is utilized for storage.

The Cache la Poudre Study Extension estimated a 1988 capital cost for the Grey Mountain project, less the cost of hydropower facilities, of $187 million. The cost per ac-ft of yield from storing only native flows is approximately $15,300 based on a 1998 project cost of approximately $245 million. The total project cost and cost per ac-ft of target flow reductions exceed the economic screening criteria upper limits, therefore, this alternative has been deferred from further evaluation at this time. As such, the associated issues for Grey Mountain Reservoir have not been addressed.

Julesburg Reservoir (Enlarge Existing Reservoirs)

The Julesburg Irrigation District (the District) owns and operates Julesburg Reservoir, an off-channel reservoir filled by Harmony Ditch, which diverts water from the South Platte River near the town of Proctor, Colorado. Located in Reach 9, approximately 2.5 miles north of the South Platte River and southwest of Cottonwood Creek, Julesburg Reservoir has an operating capacity of approximately 22,700 ac-ft.

Five earthen embankment dams are constructed to create the reservoir. Seepage is a recognized characteristic of Julesburg Reservoir. From the time construction was completed, the dam leaked considerably, resulting in failure of one of the dams in 1910. Storage restrictions have been placed on Julesburg Reservoir by Dam Safety because of seepage concerns. Investigating alternatives to enhance current supply and overcome storage restrictions on the reservoir, the Julesburg Irrigation District developed a feasibility study for rehabilitating the existing embankment dams to store additional water (W.W. Wheeler, 1998).

The study team relied on this feasibility study to evaluate the potential of reservoir enlargement alternatives to mitigate target flow shortages at the critical habitat. Four enlargement alternatives presented in the feasibility study produced a range of 5,300 ac-ft to 21,900 ac-ft of additional storage in Julesburg Reservoir. All four incorporated rehabilitation of existing dams and construction of one or more new dams to increase storage capacity.

Yield

To evaluate the yield of an enlarged Julesburg Reservoir, the study team developed a simplified reservoir operations model. The following operating rules were used to analyze two enlargement alternatives (5,300 ac-ft and 21,900 ac-ft).

- Storable flow was determined as flow in excess of 180 cfs at the Nebraska-Colorado state line, in months when flow at the critical habitat exceeded target flow. According to the Division 1 Water Resources Office, Compact obligations as well as in-state water rights are typically satisfied when State line flows are 180 cfs or greater. State line flows were adjusted to account for the depletions/additions to historic Julesburg gage flows from Colorado's proposed Tamarack Plan.

- The enlarged storage volume was assumed to be empty at the beginning of the study period.

- The increased reservoir storage was operated under the one-fill criteria to fill the enlarged capacity once per year with available supply during months of excess flows at the critical habitat.

- Available ditch capacity was based on a total capacity of 350 cfs less historical diversions. Based on the historical record of diversions through the Harmony Canal, reservoir storage was possible throughout the winter.

- Monthly evaporation amounts for new storage facilities were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship based on a surface area of approximately 1,400 acres was used.

- Releases from the reservoir were made during months of target flow shortages at the critical habitat.
- Seepage from the reservoir was estimated as 8 percent of storage volume per month. Seepage water was returned to the river based on a Stream Depletion Factor (SDF) of 750 days, extrapolated from available SDF mapping from the Missouri Basin States Association Report. Return flows were routed back to the river using the SDF model SDF View.

Tables 8.B.19 and 8.B.20 show the local net hydrologic effects of enlargements of 5,300 ac-ft and 21,900 ac-ft, respectively, through the 20-year study period. The average annual effect is -516 ac-ft and –3,140 ac-ft for enlargements of 5,300 ac-ft and 21,900 ac-ft, respectively. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Releases from Julesburg Reservoir are discharged into the Highline Canal. The flow additions and reductions from this alternative were assumed to occur 20 miles above the Julesburg stream gage in Reach 9.

Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) from the reservoir enlargement alternatives were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

The summary table in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 10, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.21 through 8.B.24 show the reductions to target flow shortages at the critical habitat for a 5,300 ac-ft enlargement and a 21,900 ac-ft enlargement. The average annual reductions to target flow shortages with downstream diversion losses and without downstream diversion losses for a 5,300 ac-ft enlargement

Table 8.B.19
5,300 ac-ft Julesburg Reservoir Enlargement
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-5300	4866	2	10	15	16	16	15	14	-348
1976	12	11	-5290	10	4467	19	30	36	36	34	32	29	-574
1977	27	25	23	21	20	18	17	16	15	14	13	12	220
1978	12	11	11	10	10	-5291	4800	10	18	23	24	23	-342
1979	22	20	19	17	16	15	14	13	13	-5288	4781	13	-345
1980	20	24	-5275	24	24	32	44	57	68	2751	84	88	-2059
1981	87	83	-5223	71	4527	71	79	81	78	74	69	64	59
1982	60	56	-5248	49	4519	54	64	67	66	63	59	56	-136
1983	52	49	-5254	44	43	50	61	73	84	93	99	104	-4502
1984	-3015	4777	-2067	114	114	113	111	110	109	107	1096	103	1672
1985	-5200	96	92	96	104	113	3224	128	132	129	123	115	-847
1986	108	101	-5205	89	86	90	99	109	118	125	130	133	-4016
1987	-3005	-60	-292	-258	-255	-258	-161	168	175	180	3249	186	-332
1988	186	-5120	170	161	160	3917	170	173	170	162	153	143	444
1989	135	127	-5180	114	4582	113	121	122	119	114	108	103	576
1990	98	93	89	-5215	4946	80	85	87	86	83	79	76	585
1991	73	70	-5233	65	4522	71	81	85	84	81	78	74	50
1992	71	67	-5236	62	4516	68	78	82	81	78	75	71	12
1993	68	64	-5239	59	4540	65	75	79	79	76	72	69	6
1994	-2835	-2338	60	63	3988	84	94	97	94	90	85	80	-437
Average	-651	-92	-2714	-485	2290	-29	455	80	82	-50	521	78	-516

Table 8.B.20
21,900 ac-ft Julesburg Reservoir Enlargement
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-12920	11862	2	10	15	16	16	15	14	-972
1976	12	19	-21466	-305	18526	81	85	92	92	87	81	75	-2621
1977	69	66	85	124	147	149	142	133	122	113	104	96	1349
1978	89	83	77	80	112	-10845	10059	131	123	114	108	109	240
1979	107	102	96	92	102	136	156	157	151	-11008	10166	123	382
1980	115	107	-21418	-277	105	117	154	174	175	11235	169	172	-9175
1981	176	179	-21340	-201	18630	173	215	267	289	284	271	263	-795
1982	257	247	-9921	-7703	16041	190	182	194	231	248	245	236	446
1983	232	230	-21297	-168	200	188	177	171	185	223	240	238	-19383
1984	-12656	8778	-8788	227	227	225	223	220	227	278	8927	361	-1751
1985	-20323	352	-878	320	304	290	5165	7519	251	245	271	315	-6171
1986	334	338	-21185	-50	324	315	301	285	268	252	247	281	-18290
1987	-12632	-463	-1425	-1308	-1329	-1374	-1024	317	311	303	12967	298	-5359
1988	343	-14871	-6204	431	426	14416	2152	399	390	381	372	361	-1404
1989	363	414	-13575	-7440	19509	421	411	400	382	362	342	322	1911
1990	305	297	318	-21192	20076	311	306	303	295	283	270	257	1827
1991	245	237	-6457	-11270	10577	5730	291	279	-3364	3508	253	241	270
1992	230	220	-13099	-8371	6816	270	10539	262	260	260	254	244	-2115
1993	233	222	-11737	-9747	19470	255	274	272	264	261	260	254	280
1994	-2657	-7820	-10728	210	17725	217	256	275	273	265	262	261	-1460
Average	-2258	-563	-9447	-3973	7992	563	1504	593	47	385	1791	226	-3140

Table 8.B.21
5,300 ac-ft Julesburg Reservoir Enlargement
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2572	1	5	4	5	1	1	4	2591
1976	5	6	0	0	2961	12	15	9	3	0	0	3	3013
1977	10	10	11	10	11	9	7	4	2	0	1	4	79
1978	4	5	5	6	6	0	2422	1	1	0	0	2	2453
1979	5	7	10	9	5	8	6	3	5	0	137	2	194
1980	4	5	0	0	0	0	0	0	0	32	3	14	58
1981	22	24	0	0	2797	42	19	8	2	6	0	10	2930
1982	19	25	0	0	3440	34	18	6	3	1	2	11	3558
1983	32	25	0	0	0	0	0	0	0	0	0	0	57
1984	0	2850	0	0	0	0	0	0	0	0	60	0	2911
1985	0	0	0	0	0	0	1779	50	35	7	9	0	1879
1986	67	54	0	0	0	0	0	0	0	0	0	0	120
1987	0	0	0	0	0	0	0	0	0	0	246	0	246
1988	74	0	0	0	0	2641	80	81	15	14	11	36	2951
1989	37	47	0	0	2930	69	31	11	13	0	5	0	3143
1990	32	38	37	0	2658	42	49	23	6	1	5	5	2896
1991	22	32	0	0	2298	36	15	0	0	1	1	6	2411
1992	12	26	0	0	2740	0	35	8	10	8	5	6	2850
1993	32	33	0	0	2012	0	31	13	12	0	12	0	2145
1994	0	0	0	0	2485	59	34	21	9	0	4	23	2634
Average	19	159	3	1	1346	148	227	12	6	4	25	6	1956

Table 8.B.22
5,300 ac-ft Julesburg Reservoir Enlargement
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4343	2	9	14	15	14	10	11	4418
1976	8	8	0	0	4091	17	27	33	26	12	4	12	4238
1977	22	18	17	16	18	18	14	15	14	8	8	11	178
1978	10	9	8	7	9	0	4531	9	15	7	11	9	4626
1979	13	15	16	14	11	15	13	13	9	0	3486	7	3611
1980	13	20	0	0	0	0	0	0	0	1985	61	49	2127
1981	63	59	0	0	3696	65	73	76	57	41	0	35	4165
1982	48	54	0	0	4446	49	58	62	61	55	53	38	4924
1983	50	40	0	0	0	0	0	0	0	0	0	0	90
1984	0	4544	0	0	0	0	0	0	0	0	617	0	5161
1985	0	0	0	0	0	0	3041	121	121	117	114	0	3514
1986	105	87	0	0	0	0	0	0	0	0	0	0	193
1987	0	0	0	0	0	0	0	0	0	0	2292	0	2292
1988	140	0	0	0	0	3667	150	149	148	131	123	112	4621
1989	110	124	0	0	4310	101	110	103	109	0	85	0	5053
1990	92	83	72	0	4757	78	81	83	76	42	66	44	5472
1991	47	55	0	0	4311	67	68	0	0	27	32	34	4642
1992	42	62	0	0	4407	0	73	65	74	60	45	47	4876
1993	56	57	0	0	2845	0	72	74	72	0	67	0	3243
1994	0	0	0	0	3221	82	89	88	83	0	75	53	3693
Average	41	262	6	2	2023	208	421	45	44	125	357	23	3557

Table 8.B.23
21,900 ac-ft Julesburg Reservoir Enlargement
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	6269	1	5	4	5	1	1	4	6288
1976	5	9	0	0	12277	53	43	22	7	1	0	8	12426
1977	27	27	42	58	81	70	60	34	14	2	4	33	452
1978	32	37	38	44	73	0	5076	19	5	2	2	11	5338
1979	23	36	50	48	33	69	63	31	55	0	290	17	714
1980	21	23	0	0	0	0	0	0	0	129	7	28	208
1981	44	52	0	0	11510	101	52	28	9	22	0	40	11858
1982	81	112	0	0	12211	120	52	17	9	5	7	45	12659
1983	143	117	0	0	0	0	0	0	0	0	0	0	260
1984	0	5239	0	0	0	0	0	0	0	0	491	0	5729
1985	0	0	0	0	0	0	2849	2918	66	14	20	0	5867
1986	206	179	0	0	0	0	0	0	0	0	0	0	384
1987	0	0	0	0	0	0	0	0	0	0	982	0	982
1988	137	0	0	0	0	9718	1008	186	35	32	27	92	11234
1989	99	152	0	0	12474	257	107	35	42	0	16	0	13183
1990	100	120	133	0	10790	163	177	81	19	3	16	18	11621
1991	75	110	0	0	5374	2940	53	0	0	35	3	20	8610
1992	39	85	0	0	4135	0	4693	26	31	28	16	22	9076
1993	111	114	0	0	8631	0	112	44	39	0	42	0	9094
1994	0	0	0	0	11042	152	93	59	26	0	11	75	11458
Average	57	321	13	8	4745	682	722	175	18	14	97	21	6872

Table 8.B.24
21,900 ac-ft Julesburg Reservoir Enlargement
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	10588	2	9	14	15	14	10	11	10663
1976	8	14	0	0	16966	76	76	85	66	31	9	30	17360
1977	56	49	63	97	133	145	120	125	113	62	66	82	1110
1978	75	68	61	56	106	0	9496	121	105	35	50	44	10216
1979	65	77	82	74	70	134	147	147	105	0	7413	67	8380
1980	76	87	0	0	0	0	0	0	0	8106	122	95	8486
1981	127	128	0	0	15211	157	198	252	210	158	0	145	16587
1982	205	239	0	0	15782	174	167	179	212	216	218	163	17556
1983	223	187	0	0	0	0	0	0	0	0	0	0	410
1984	0	8350	0	0	0	0	0	0	0	0	5027	0	13377
1985	0	0	0	0	0	0	4872	7116	231	222	251	0	12692
1986	325	291	0	0	0	0	0	0	0	0	0	0	616
1987	0	0	0	0	0	0	0	0	0	0	9148	0	9148
1988	259	0	0	0	0	13497	1901	344	341	309	301	281	17233
1989	296	404	0	0	18351	377	375	337	352	0	269	0	20760
1990	286	264	257	0	19306	305	291	289	263	142	225	149	21777
1991	158	186	0	0	10084	5394	245	0	0	1184	104	112	17466
1992	136	202	0	0	6564	0	9935	208	238	200	154	163	17799
1993	192	196	0	0	12203	0	262	253	242	0	243	0	13592
1994	0	0	0	0	14316	213	242	250	242	0	233	174	15670
Average	124	537	23	11	6984	1024	1417	486	137	534	1192	76	12545

are 1,956 ac-ft and 3,557 ac-ft, respectively. The average annual reductions to target flow shortages with downstream diversion losses and without downstream diversion losses for a 21,900 ac-ft enlargement are 6,872 ac-ft and 12,545 ac-ft, respectively.

Cost

The direct cost associated with this alternative is the cost associated with excavation and site development, rehabilitation/repair of embankment dams, outlet works and structures, and construction of county roads and bridges. Delivery fees for use of existing canals may be necessary to divert water for Program purposes.

The feasibility study estimates costs for the 5,300 ac-ft enlargement at approximately $12.5 million in 1998 dollars, corresponding to $2,375/ac-ft of additional storage. The cost estimate for the 21,900 ac-ft enlargement is approximately $23 million in 1998 dollars, corresponding to $1,048/ac-ft of additional storage.

Delivery fees in the Lower South Platte River region vary but can run as high as $5 per ac-ft. For this analysis it was assumed the project would pay a delivery fee of $5 per ac-ft delivered. Annual operations and maintenance costs and delivery fees have been amortized over 20 years at a discount rate of 6 percent.

Delivery costs for the 5,300 ac-ft enlargement would amount to approximately $25,000/yr. Delivery costs for the 21,900 ac-ft enlargement would amount to approximately $95,000/yr. Total project costs, including annual costs amortized over 20 years at a 6% discount rate, would be $12.8 million for the 5,300 ac-ft enlargement alternative and $24.1 million for the 21,900 ac-ft enlargement alternative.

The cost per ac-ft of target flow reductions at the critical habitat for the 5,300 ac-ft enlargement would be approximately $6,540 assuming releases cannot be protected from downstream diversions and $3,600 assuming diversions can be protected from downstream diversions. The cost per ac-ft of target flow reductions for the 5,300 ac-ft enlargement exceeds the economic screening criteria upper limits and has been deferred from further evaluation at this time.

The cost per ac-ft of target flow reductions at the critical habitat for the 21,900 ac-ft enlargement would be approximately $3,510 assuming releases cannot be protected from downstream diversions and $1,920 assuming diversions can be protected from downstream diversions. The cost per ac-ft of target flow reductions for the 21,900 ac-ft enlargement with diversions exceeds the economic screening criteria upper limits and has been deferred from further evaluation at this time. As such, the associated issues for only the 21,900 ac-ft enlargement without diversions have been addressed.

Region 3

Riverview #2 Reservoir (Constructing New Storage Facilities)

The State of Nebraska initially evaluated storage alternatives in the South Platte valley near the Colorado-Nebraska state line in the late 1800's for irrigation supply. Construction of the Perkins County Canal, sometimes known as the South Divide Canal, was started near Ovid, Colorado in anticipation of water resources development along the divide between the South Platte River and Republican River basins and was not completed. There is no evidence of the canal east of Julesburg. Use of the Perkins County Canal for diversions from the South Platte River was revisited by the Twin Platte Natural Resources District in the early 1980's for use in a groundwater recharge project. Application for a permit for the storage and release of water was turned down by the Nebraska Department of Water Resources, as the plan did not follow the original alignment in Nebraska of the Perkins County Canal. In October 1982 the USBR completed a subappraisal-level cost estimate for dams and main supply canals to divert and store South Platte River water.

The study team relied on the reservoir information from the South Platte Divide Project report (USBR, 1982) and conversations with Twin Platte Natural Resources District personnel (1999) to evaluate the Riverview #2 (Riverview) Reservoir as a potential alternative to reduce target flow shortages at the critical habitat.

The dam analyzed for this alternative would be a 70 feet high embankment with a top length of approximately 4400 feet. The dam would be located 4 miles south of the city of Brule in Keith County, Nebraska. Riverview Reservoir would be situated on the south side of the Western Canal and would be used to capture Platte River flows beyond that required for mainstem instream flows. Diversions would be conveyed through the Western Canal and lifted approximately 70 feet to fill Riverview Reservoir.

The Riverview Reservoir alternative analyzed for this study would have an active storage capacity of 9,562 ac-ft.

Yield

To evaluate the yield of Riverview Reservoir, the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- Storable flows were considered to be the amount available at Julesburg, Colorado less Western Canal and Korty Canal diversions, which are the only diversions in Reach 10 upstream of the confluence of the North Platte and South Platte rivers.
- The reservoir was assumed to be empty at the beginning of the study period.
- The reservoir was operated to fill to maximum capacity with available supply during winter months of excess flows at the critical habitat. Available supply was considered to be limited by the available canal capacity beyond historical Western Canal diversions.
- Water was released from the reservoir during months of target flow shortages at the critical habitat.
- Monthly evaporation amounts for Riverview Reservoir were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship based on a surface area of approximately 391 acres was used.

Seepage from the reservoir was estimated as 8 percent of the storage volume per month. Seepage water was returned to the river in the same month for this on-canal reservoir.

Table 8.B.25 shows the local net hydrologic effects of the Riverview Reservoir alternative, through the 20-year study period. The average annual effect of Riverview Reservoir is –4,221 ac-ft. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Table 8.B.25
Riverview Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-5069	4653	0	0	0	0	1	1	2	-411
1976	2	3	-2764	-6792	8566	4	4	4	5	6	7	9	-946
1977	10	10	11	12	12	12	12	12	12	12	12	12	140
1978	12	12	11	11	11	11	11	10	10	10	10	9	127
1979	9	9	9	9	8	8	8	8	8	8	7	7	98
1980	7	7	-426	-9122	-427	-9123	-427	-9123	-426	19867	11	16	-9165
1981	22	31	-4368	-4879	8292	63	69	73	77	80	83	84	-373
1982	86	86	-2245	-2459	4386	85	84	83	82	81	80	79	428
1983	78	77	-9486	75	-9488	72	-9491	70	-9065	100	-4686	-4720	-46463
1984	-4674	8649	-9453	122	-9424	155	-9388	192	-9350	232	33544	-1932	-1326
1985	-7061	-1888	-7016	-1844	-6976	-1809	5299	15861	430	438	447	-2917	-7036
1986	3540	467	-9092	471	-9092	467	-9099	459	-9108	450	80	-8570	-39028
1987	-100	-8566	-92	-8554	-77	-8536	-55	-8511	-27	536	29798	-8977	-13161
1988	12573	-1445	-4611	-3662	-4574	14609	695	702	705	706	705	703	17107
1989	698	692	-8878	676	8730	656	645	634	624	613	604	-3300	2394
1990	4131	575	564	-9007	9320	535	525	516	507	499	491	483	9141
1991	476	468	-6247	-2403	8713	437	430	423	-9145	9026	406	401	2983
1992	396	391	-7477	-1317	6942	-9189	10408	364	360	357	355	353	1942
1993	350	348	-9217	343	8409	-9227	9047	328	325	323	321	-9243	-7891
1994	318	-9154	222	-9158	22613	308	307	308	311	314	318	321	7026
Average	544	-461	-4028	-3127	2530	-1023	-46	121	-1683	1683	3130	-1859	-4221

Riverview Reservoir is located south of the Western Canal in Reach 10. The flow additions and reductions from this alternative were assumed to occur 20 miles below the Julesburg gage. Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 15, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.26 and 8.B.27 show the reductions to target flow shortages at the critical habitat. The average annual reduction to target flow shortages with downstream diversion losses is 5,800 ac-ft. The average annual reduction to target flow shortages without downstream diversion losses is 11,821 ac-ft.

Cost

The primary direct costs of this alternative are associated with land acquisition, excavation and site development, construction of the Riverview Dam, lift station and pipeline, rehabilitation of the Western Canal headgate, delivery fees for use of the Western Canal, and annual pumping and operations and maintenance costs. The initial estimate for this alternative was developed from the USBR South Canal Divide Project report.

A construction cost estimate of $15.5 million from the 1982 USBR report of the dam was updated to a 1998 cost of $24 million. A pump station capable of delivering 160 cfs would cost approximately $5.5 million. Rehabilitation of the headgate to enable year-round diversions would cost approximately $300,000.

Delivery fees in the Lower South Platte River region vary but can run as high as $5 per ac-ft. For this analysis it was assumed the project would pay a delivery fee of $5 per ac-ft delivered. Annual operations and maintenance costs and delivery fees have been amortized over 20 years at a discount rate of 6 percent.

Table 8.B.26
Riverview Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2638	0	0	0	0	0	0	1	2639
1976	1	1	0	0	5906	2	2	1	0	0	0	1	5916
1977	4	4	6	6	7	6	6	4	2	0	1	5	51
1978	5	5	6	7	8	0	6	2	1	0	0	1	41
1979	3	4	5	5	3	5	4	2	3	0	0	1	34
1980	2	2	0	0	0	0	0	0	0	293	1	3	300
1981	7	11	0	0	5296	40	20	10	3	8	0	17	5411
1982	35	48	0	0	3401	59	30	9	4	2	3	20	3611
1983	52	41	0	0	0	0	0	0	0	0	0	0	93
1984	0	5368	0	0	0	0	0	0	0	0	2320	0	7688
1985	0	0	0	0	0	0	3432	6942	132	32	43	0	10581
1986	2352	253	0	0	0	0	0	0	0	0	0	0	2605
1987	0	0	0	0	0	0	0	0	0	0	3016	0	3016
1988	5893	0	0	0	0	10410	360	353	74	82	69	236	17477
1989	242	314	0	0	5913	432	203	73	91	0	39	0	7307
1990	1692	288	281	0	5424	309	326	179	45	7	42	47	8639
1991	176	261	0	0	5039	250	96	0	0	124	8	43	5997
1992	79	190	0	0	4527	0	5185	48	53	48	28	37	10195
1993	193	196	0	0	3970	0	4268	67	64	0	68	0	8826
1994	0	0	0	0	14943	237	137	86	39	0	17	118	15579
Average	537	349	15	1	2854	588	704	389	26	30	283	27	5800

Table 8.B.27
Riverview Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4158	0	0	0	0	1	1	2	4161
1976	2	2	0	0	7860	3	3	4	4	2	1	3	7884
1977	8	8	8	9	11	12	10	12	11	7	8	10	114
1978	10	10	9	8	10	0	10	10	9	3	4	4	86
1979	6	7	7	7	6	8	8	7	5	0	5	4	70
1980	5	6	0	0	0	0	0	0	0	14493	8	9	14521
1981	16	22	0	0	6779	58	64	69	56	45	0	47	7156
1982	69	84	0	0	4321	78	77	77	76	71	72	55	4980
1983	76	63	0	0	0	0	0	0	0	0	0	0	139
1984	0	8242	0	0	0	0	0	0	0	0	19806	0	28048
1985	0	0	0	0	0	0	4889	15162	404	402	417	0	21274
1986	3457	406	0	0	0	0	0	0	0	0	0	0	3863
1987	0	0	0	0	0	0	0	0	0	0	21245	0	21245
1988	9569	0	0	0	0	13709	618	610	621	578	576	552	26832
1989	574	677	0	0	8216	588	592	538	579	0	479	0	12243
1990	3903	513	456	0	8973	525	503	494	456	254	414	283	16775
1991	309	368	0	0	8321	413	364	0	0	3080	169	187	13211
1992	235	361	0	0	6564	0	9868	291	332	277	216	237	18380
1993	291	308	0	0	5274	0	8708	308	301	0	303	0	15493
1994	0	0	0	0	18281	302	292	283	279	0	286	217	19939
Average	926	554	24	1	3939	785	1300	893	157	961	2201	81	11821

The initial estimate for this alternative, including engineering and contingency costs, is approximately $34.1 million. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $2,880 assuming releases can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $5,880 assuming releases cannot be protected from downstream diversions. Accordingly, the associated issues for only the scenario where releases can be protected from downstream diversions have been addressed.

Plum Creek Basin Reservoirs (Constructing New Storage Facilities)

The State of Nebraska initially evaluated a reservoir site on the mainstem of Plum Creek in the 1930's before Keystone Dam (now known as Kingsley Dam) was constructed on the North Platte River; the reservoir was to provide a reliable irrigation and hydropower water supply. In May 1989 USBR completed a Planning Report/Draft Environmental Statement for a storage unit on Plum Creek with associated recharge facilities in the Prairie Bend area to maintain species habitat, recharge ground water, and augment wildlife habitat.

The proposed Plum Creek Reservoir would be located on Plum Creek, a right bank tributary of the Platte River near the town of Smithfield, Nebraska. The Plum Creek project would consist of Plum Creek Dam and Reservoir, spillway, outlet works, access roads, and inlet and outlet canal structures. The proposed Plum Creek reservoir would have an active storage of approximately 252,000 ac-ft. Based on preliminary analysis this reservoir, as conceived, was defined a high-risk, significant hazard dam, primarily due to its inability to pass a probable maximum flood of approximately 180,000 ac-ft.

With respect to this study, a 252,000 ac-ft reservoir would not be feasible based on a project cost of approximately $173 million in 1985. However, the location and the size of the reservoir, or the size of the reservoir and spillway, could be modified to reduce the risk and costs associated with the structure. The study team relied on the USBR Planning Report and conversations with CNPPID personnel to evaluate storage alternatives in the Plum Creek Basin. The potential for new storage units in the Plum Creek basin to reduce target flow shortages at the critical habitat were investigated in a general manner and analyzed as described below.

- Two storage alternatives were analyzed.
- Off-channel storage of 4,800 ac-ft and mainstem storage of 30,000 ac-ft was investigated.
- Streamflow data on Plum Creek was not available for the period of record analyzed in the reconnaissance study (1975-1994). Reservoirs in the Plum Creek basin would capture Platte River water beyond that required for irrigation deliveries and mainstem instream flows. Diversions from the J-2 forebay, below Philips Lake, would be conveyed via a pipeline to fill reservoirs in the Plum Creek basin.
- Hydropower return flows diverted for storage in Plum Creek basin reservoirs would reduce the flows available to the J-2 Hydropower plant

30,000 ac-ft Plum Creek Reservoir

Due to concerns with seepage from Elwood and Johnson Reservoirs in the immediate area, structural measures to reduce seepage would be necessary for new storage facilities in the basin. Seepage drains and associated cutoff structures downstream of the reservoir would be used to mitigate potential flooding of neighboring lands.

The dam analyzed for this alternative would be a 53 foot high embankment dam with a top length of approximately 3000 feet. The dam would be located on Plum Creek, southeast of the J-2 power plant, near the town of Smithfield, Nebraska. Plum Creek Reservoir would capture Platte River water beyond that required for irrigation deliveries and mainstem instream flows. Diversions from the J-2 forebay, below Phillips Lake, would be conveyed to fill Plum Creek Reservoir via a pipeline approximately 2 miles long. For a smaller reservoir to handle the probable maximum flood, the spillway on Plum Creek Dam could consist of a two-stage spillway with a lower spillway capable of passing a 100-year flood and an auxiliary fuse plug dike designed to breach and wash out when overtopped by the probable maximum flood.

Yield

To evaluate the yield of the Plum Creek Reservoir alternative, the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- Philips Lake is filled via returns from the J-1 Hydropower plant. J-1 Hydropower returns feed the J-2 Hydropower plant. Monthly hydropower returns, over the 1975-1994 study period, from J-2 are roughly 95%-100% of the hydropower returns from J-1.

  Storable flows were considered to be the amount available below J-1 less Phelps County Canal deliveries during months when Platte River flows at Grand Island, Nebraska exceeded USFWS target flows. Storable flows were determined from monthly time series of J-1 returns and Phelps County Canal diversions provided by CNPPID.

- The reservoir was assumed to be empty at the beginning of the study period.

- The reservoir was operated to fill to maximum capacity with available supply during months of excess flows at the critical habitat.

- Water was released from the reservoir during months of target flow shortages at the critical habitat.

- Monthly evaporation amounts for Plum Creek Reservoir were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship, from the USBR report, based on a surface area of approximately 1,689 acres was used.

- A seepage rate was developed in the 1989 Draft Report (USBR) for a mainstem reservoir based on site geology and seepage estimates from existing reservoirs (Sherman and Elwood). This rate of seepage (0.516 ac-ft/ac surface area) was used for monthly seepage with the Plum Creek Reservoir alternative analyzed in this study. Seepage water was returned to the river in the same month for this on-stream reservoir.

Table 8.B.28 shows the local net hydrologic effects of the Plum Creek Reservoir alternative through the 20-year study period. The average annual effect of the Plum Creek Reservoir alternative is –1,326 ac-ft. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Plum Creek Reservoir is located in the lower end of Reach 17. The flow additions and reductions from this alternative were assumed to occur 6 miles above the Overton gage in Reach 17. Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) from the Plum Creek Reservoir alternative was routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative sites; at the top of Reach 18, with and without diversions; and at the critical habitat, with and without diversions. Table 8.B.29 and 8.B.30 show the reductions to target flow shortages at the critical habitat for the Plum Creek Reservoir alternative. The average annual reduction to target flow shortages with and without downstream diversion losses is 24,837 ac-ft and 25,571 ac-ft, respectively.

Cost

The primary direct costs of this alternative are associated with land acquisition, excavation and site development, construction of the Plum Creek Dam and spillway, excavation, bedding, pipeline and seepage drains, and annual operations and maintenance costs.

The project cost for a 252,000 ac-ft reservoir from the USBR Planning Report was updated to a 1998 cost of approximately $248 million. Project costs for the 30,000 ac-ft Plum Creek reservoir were developed based on a unit storage cost from the USBR Planning Report of approximately $982/ac-ft. This cost is assumed to cover land acquisition, environmental, and permitting costs as the cost estimate includes the following cost items: 10% unlisted items, 20% contingency, 30% indirect costs, 5% mobilization, 1% archaeological,

Table 8.B.28
30,000 ac-ft Plum Creek Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-12920	12867	0	0	0	0	0	0	0	-53
1976	0	0	-23801	-5508	29127	0	0	0	0	0	0	0	-181
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-23801	23458	0	0	0	0	0	-342
1979	0	0	0	0	0	0	0	0	0	-23801	23375	0	-426
1980	0	0	-23801	-5508	98	-127	-195	-437	-522	27820	0	0	-2672
1981	0	0	-23801	-5508	29127	0	0	0	0	0	-13271	13073	-379
1982	0	0	-20655	-7321	27808	0	0	0	0	0	0	0	-168
1983	0	0	-23801	-5508	98	-127	-195	-306	-516	25	-1187	-629	-32147
1984	-509	9393	-10015	231	-83	-121	-196	-364	-514	-602	27995	-23801	1413
1985	-5508	-53	-136	-85	-73	-122	5730	22306	0	0	0	-23801	-1742
1986	9071	12901	-23755	-3950	49	-126	-196	-447	-543	-676	-659	-502	-8832
1987	-340	-443	-123	-86	-73	-122	-196	-513	-514	-715	27720	-23801	796
1988	23561	-15269	-14287	368	-87	14842	13769	0	0	0	0	0	22896
1989	0	0	-14019	-15574	29435	0	0	0	0	-368	361	-23801	-23966
1990	23497	0	0	-23801	23702	0	0	0	0	0	0	0	23399
1991	0	0	-6707	-11361	10797	7131	0	-12579	-17056	28592	0	0	-1182
1992	0	0	-22102	-7256	7415	-7602	26584	2141	0	0	0	0	-819
1993	0	0	-11948	-14576	26384	-23801	23524	0	0	-23801	1118	-7096	-30195
1994	-147	-351	-126	-86	28962	0	0	0	0	-8200	8027	0	28079
Average	2481	309	-10954	-5922	11278	-1699	4604	490	-983	-86	3674	-4518	-1326

Table 8.B.29
30,000 ac-ft Plum Creek Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	11607	0	0	0	0	0	0	0	11607
1976	0	0	0	0	26972	0	0	0	0	0	0	0	26972
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	22578	0	0	0	0	0	22578
1979	0	0	0	0	0	0	0	0	0	0	16598	0	16598
1980	0	0	0	0	0	0	0	0	0	19365	0	0	19365
1981	0	0	0	0	24065	0	0	0	0	0	0	7541	31607
1982	0	0	0	0	27684	0	0	0	0	0	0	0	27684
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8552	0	0	0	0	0	0	0	0	17319	0	25871
1985	0	0	0	0	0	0	4889	20989	0	0	0	0	25878
1986	8380	11410	0	0	0	0	0	0	0	0	0	0	19790
1987	0	0	0	0	0	0	0	0	0	0	19699	0	19699
1988	18420	0	0	0	0	13958	11780	0	0	0	0	0	44158
1989	0	0	0	0	27937	0	0	0	0	0	281	0	28218
1990	22446	0	0	0	23042	0	0	0	0	0	0	0	45489
1991	0	0	0	0	10273	6846	0	0	0	9224	0	0	26343
1992	0	0	0	0	6564	0	25660	1717	0	0	0	0	33942
1993	0	0	0	0	17158	0	23221	0	0	0	427	0	40806
1994	0	0	0	0	23623	0	0	0	0	0	6524	0	30146
Average	2462	998	0	0	9946	1040	4406	1135	0	1429	3042	377	24837

Table 8.B.30
30,000 ac-ft Plum Creek Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	11607	0	0	0	0	0	0	0	11607
1976	0	0	0	0	26972	0	0	0	0	0	0	0	26972
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	23112	0	0	0	0	0	23112
1979	0	0	0	0	0	0	0	0	0	0	17682	0	17682
1980	0	0	0	0	0	0	0	0	0	25468	0	0	25468
1981	0	0	0	0	24065	0	0	0	0	0	0	7614	31680
1982	0	0	0	0	27684	0	0	0	0	0	0	0	27684
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8552	0	0	0	0	0	0	0	0	18620	0	27172
1985	0	0	0	0	0	0	4889	21928	0	0	0	0	26817
1986	8380	11305	0	0	0	0	0	0	0	0	0	0	19685
1987	0	0	0	0	0	0	0	0	0	0	20665	0	20665
1988	18476	0	0	0	0	13999	12603	0	0	0	0	0	45078
1989	0	0	0	0	27937	0	0	0	0	0	297	0	28235
1990	22974	0	0	0	23042	0	0	0	0	0	0	0	46016
1991	0	0	0	0	10273	6846	0	0	0	10289	0	0	27407
1992	0	0	0	0	6564	0	25735	1811	0	0	0	0	34110
1993	0	0	0	0	17158	0	23221	0	0	0	427	0	40806
1994	0	0	0	0	23623	0	0	0	0	0	7594	0	31216
Average	2492	993	0	0	9946	1042	4478	1187	0	1788	3264	381	25571

and 0.5% pre-investigation. Costs for spillway development would be approximately $5 million, based on similar projects in the state of Colorado. Installing a pipeline from one of the southeast fingers of Philips Lake to Plum Creek Reservoir would require excavation and installation of bedding material and pipeline. Total installation costs for 11,100 feet of 36-inch pipeline would be approximately $6.1 million. Estimated costs for seepage drains and associated cutoffs would be approximately $2 million. Annual operating and maintenance costs have been amortized over 20 years assuming a 6 percent discount rate. The initial estimate for the Plum Creek Reservoir alternative, including engineering and contingency costs, is approximately $44.1 million.

Assuming a project cost of $44.1 million, the cost per ac-ft of target flow reductions at the critical habitat would be approximately $1,720 assuming releases can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $1,780 assuming releases cannot be protected from downstream diversions.

4,800 ac-ft J-2 Re-Regulating Reservoir (Constructing New Storage Facilities)

A smaller off-channel reservoir in the Plum Creek basin would not be required to pass the probable maximum flood on Plum Creek and would cause less seepage problems than mainstem storage units. The J-2 Re-Regulating Reservoir alternative analyzed for this study would have an active storage capacity of 4,800 ac-ft. The study team relied on the USBR Planning Report and conversations with CNPPID personnel to evaluate J-2 Re-Regulating Reservoir as a potential alternative to meet target flow shortages at the critical habitat.

The dam analyzed for this alternative would be a 45 foot high embankment dam with a top length of approximately 1000 feet. The dam would be located on a left bank tributary of Plum Creek, southeast of the CNPPID J-2 power plant, near the town of Lexington, Nebraska. J-2 Re-Regulating Reservoir would capture Platte River water beyond that required for irrigation deliveries and mainstem instream flows. Diversions from the J-2 forebay, below Phillips Lake, would be conveyed to fill J-2 Re-Regulating Reservoir via a pipeline approximately 1 mile long.

Yield

To evaluate the yield of J-2 Re-Regulating Reservoir, the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- Philips Lake is filled via returns from the J-1 Hydropower plant. J-1 Hydropower returns feed the J-2 Hydropower plant. Monthly hydropower returns, over the 1975-1994 study period, from J-2 are roughly 95%-100% of the hydropower returns from J-1.

  Storable flows were considered to be the amount available below J-1 less Phelps County Canal deliveries during months when Platte River flows at Grand Island, Nebraska exceeded USFWS target flows. Storable flows were determined from monthly time series of J-1 returns and Phelps County Canal diversions provided by CNPPID.

- The reservoir was operated to fill to maximum capacity with available supply during months of excess flows at the critical habitat.

- Water was released from the reservoir during months of target flow shortages at the critical habitat.

- Monthly evaporation amounts for J-2 Re-Regulating Reservoir were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship based on a surface area of approximately 200 acres was used.

- A seepage rate was developed in the 1989 Draft Report (USBR) for a mainstem reservoir based on site geology and seepage estimates from existing reservoirs (Sherman and Elwood). This rate of seepage (0.516 ac-ft/ac surface area) was used for monthly seepage for the J-2 Re-Regulating Reservoir alternative analyzed in this study. Seepage water was returned to the river based on an SDF of 3,000 days, based on SDF mapping from the Missouri Basin States Association Report. Return flows were routed back to the river using the SDF model SDF View.

- Table 8.B.31 shows the local net hydrologic effects of the J-2 Re-Regulating Reservoir alternative, through the 20-year study period. The average annual effect of J-2 Re-Regulating Reservoir is -429 ac-ft. Negative values indicate months when water goes into storage; positive values indicate months when water is released. J-2 Re-Regulating Reservoir is located in the lower end of Reach 17. The flow additions and reductions from this alternative were assumed to occur 6 miles above the Overton gage in Reach 17. Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) from J-2 Re-Regulating Reservoir were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 18, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.32 and 8.B.33 show the reductions to target flow shortages at the critical habitat for J-2 Re-Regulating Reservoir. The average annual reduction to target flow shortages without downstream diversion losses is 5,306 ac-ft. The average annual reduction to target flow shortages with downstream diversion losses is 5,156 ac-ft.

Cost

The primary direct costs of this alternative are associated with land acquisition, excavation and site development, construction of the J-2 Re-Regulating Dam, excavation, bedding, pipeline and seepage drains, and annual operations and maintenance costs. The initial estimate for this alternative was developed from different sources as no J-2 Re-Regulating project studies were available.

Based on an average cost of $403 per acre for grazing land (University of Nebraska, Lincoln, 1999) acquisition of about 200 acres would cost approximately $81,000. Construction of the dam, spillway, and outlet

Table 8.B.31
4,800 ac-ft J-2 Re-Regulating Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-4800	4681	0	0	0	0	0	0	1	-118
1976	1	1	-4799	1	4571	1	1	1	1	2	2	2	-216
1977	2	2	3	3	3	3	3	3	3	3	3	3	31
1978	3	3	3	3	2	-4798	4646	2	2	2	2	2	-127
1979	2	3	3	3	3	3	3	3	3	-4797	4634	3	-137
1980	3	3	-4798	3	-111	-113	-122	-150	-160	4439	4	5	-999
1981	5	6	-4793	7	4578	8	9	9	9	10	-4790	4652	-289
1982	10	10	-4790	11	4581	11	11	11	11	11	11	11	-101
1983	11	11	-4789	11	-102	-105	-114	-127	-152	-143	-174	-168	-5841
1984	-150	4568	-4787	14	-99	-101	-109	-128	-145	-155	4476	-4781	-1397
1985	20	-115	-96	-90	-88	-93	4538	24	25	25	26	-4774	-597
1986	4693	27	-4773	27	-86	-89	-98	-128	-139	-155	-153	-134	-1009
1987	-115	-126	-89	-84	-82	-87	-95	-132	-132	-155	4456	-4767	-1407
1988	4693	-4766	34	-80	-76	4594	35	36	36	36	36	36	4614
1989	36	36	-4764	36	4606	35	35	34	34	-335	388	-4767	-4627
1990	4682	32	32	-4769	4712	30	30	30	29	29	29	29	4894
1991	28	28	-4773	27	4597	26	26	-4774	25	4450	25	25	-288
1992	25	25	-4775	25	4595	-4775	4666	25	25	25	25	25	-91
1993	25	25	-4775	25	4595	-4776	4678	24	24	-4776	451	-572	-5053
1994	-116	-119	-93	-88	4597	24	25	25	26	-4774	4646	27	4180
Average	693	-17	-2641	-486	2274	-510	908	-261	-24	-313	705	-757	-429

Table 8.B.32
4,800 ac-ft J-2 Re-Regulating Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4223	0	0	0	0	0	0	0	4223
1976	0	1	0	0	4233	1	1	1	1	1	0	1	4239
1977	2	2	2	2	2	3	2	3	2	1	2	2	25
1978	2	2	2	2	2	0	4472	2	2	1	1	1	4489
1979	1	2	2	2	2	3	3	3	2	0	3291	2	3311
1980	2	2	0	0	0	0	0	0	0	3090	3	3	3099
1981	4	4	0	0	3783	8	8	8	7	6	0	2684	6511
1982	8	10	0	0	4560	10	10	10	10	9	9	8	4644
1983	11	9	0	0	0	0	0	0	0	0	0	0	21
1984	0	4390	0	0	0	0	0	0	0	0	2769	0	7159
1985	0	0	0	0	0	0	4299	23	23	21	23	0	4389
1986	4600	24	0	0	0	0	0	0	0	0	0	0	4624
1987	0	0	0	0	0	0	0	0	0	0	3166	0	3166
1988	3669	0	0	0	0	4320	30	32	30	29	30	29	8170
1989	30	36	0	0	4371	32	32	29	31	0	302	0	4863
1990	4473	29	26	0	4580	30	29	29	26	15	23	16	9275
1991	20	22	0	0	4437	25	22	0	0	1436	10	12	5984
1992	15	23	0	0	4537	0	4504	20	21	19	15	17	9171
1993	21	22	0	0	2988	0	4618	23	22	0	427	0	8122
1994	0	0	0	0	3750	24	24	24	23	0	3776	19	7640
Average	643	229	2	0	2073	223	903	10	10	231	692	140	5156

Table 8.B.33
4,800 ac-ft J-2 Re-Regulating Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4223	0	0	0	0	0	0	0	4223
1976	0	1	0	0	4233	1	1	1	1	1	0	1	4240
1977	2	2	2	2	2	3	2	3	3	2	2	2	26
1978	2	2	2	2	2	0	4578	2	2	1	1	1	4596
1979	2	2	2	2	2	3	3	3	2	0	3505	1	3526
1980	2	2	0	0	0	0	0	0	0	4064	3	3	4074
1981	4	4	0	0	3783	8	8	9	7	6	0	2710	6538
1982	9	10	0	0	4560	10	10	10	10	10	10	8	4649
1983	11	9	0	0	0	0	0	0	0	0	0	0	21
1984	0	4395	0	0	0	0	0	0	0	0	2977	0	7372
1985	0	0	0	0	0	0	4473	24	24	24	25	0	4571
1986	4662	24	0	0	0	0	0	0	0	0	0	0	4685
1987	0	0	0	0	0	0	0	0	0	0	3322	0	3322
1988	3680	0	0	0	0	4363	32	32	33	31	31	30	8232
1989	31	36	0	0	4371	32	33	30	32	0	319	0	4885
1990	4578	29	26	0	4580	30	30	29	28	17	25	18	9390
1991	21	22	0	0	4437	25	23	0	0	1601	11	12	6153
1992	15	23	0	0	4537	0	4570	21	23	20	16	17	9243
1993	21	22	0	0	2988	0	4618	23	23	0	427	0	8123
1994	0	0	0	0	3750	24	24	24	24	0	4396	19	8261
Average	652	229	2	0	2073	225	920	11	11	289	754	141	5306

works would cost approximately $3 million dollars, based on similar projects done in the State of Colorado. Installing a pipeline from one of the southeast fingers of Philips Lake to Plum Creek Reservoir would require excavation and installation of bedding material and pipeline. Total installation costs for 5,000 feet of 36-inch pipeline would be approximately $4 million. Annual operating and maintenance costs were amortized over 20 years assuming a 6 percent discount rate. The initial estimate for the unlined storage alternative, including engineering and contingency costs, is approximately $9 million.

Assuming a project cost of $9 million, the cost per ac-ft of target flow reductions at the critical habitat would be approximately $1,700 assuming releases can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $1,750 assuming releases cannot be protected from downstream diversions.

Jeffrey Canyon Reservoir (Constructing New Storage Facilities)

The Central Nebraska Public Power and Irrigation District (CNPPID) is considering a Jeffrey Canyon storage project to provide secondary storage for Platte River water. The study team relied on information from a meeting with Nebraska representatives of the Water Management Committee in Holdrege, Nebraska on February 2, 1999 and conversations with CNPPID personnel to evaluate Jeffrey Canyon Reservoir as a potential alternative to meet target flow shortages at the critical habitat.

The dam analyzed for this alternative would be a 30 foot high embankment with a top length of approximately 1200 feet. The dam would be located in Jeffrey Canyon, a right bank tributary of the Platte River near the town of Brady, Nebraska. Jeffrey Canyon Reservoir would be situated to the southeast of Jeffrey Reservoir and would be used to capture Platte River water beyond that required for mainstem instream flows. Diversions from the Jeffrey Reservoir, would be conveyed to fill Jeffrey Reservoir via a pipeline approximately 1 ¼ mile long. Releases from Jeffrey Canyon Reservoir would enter the Platte River downstream of Brady, Nebraska.

The Jeffrey Canyon Reservoir alternative analyzed for this study would have an active storage capacity of 6,000 ac-ft. Diverting storage water from the Jeffrey power plant forebay would reduce the flows available for hydropower generation.

Yield

To evaluate the yield of Jeffrey Canyon Reservoir, the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- The bulk of returns from the Jeffrey Hydropower plant flow down the central supply canal and through the J-1 and J-2 Hydropower plants. Storable flows were considered to be the amount available at the J-2 return during months when Platte River flows at Grand Island, Nebraska exceeded USFWS target flows.
- The reservoir was assumed to be empty at the beginning of the study period.
- The reservoir was operated to fill to a maximum capacity of 6,000 ac-ft with available supply during months of excess flows at the critical habitat.
- Water was released from the reservoir during months of target flow shortages at the critical habitat.
- Monthly evaporation amounts for Jeffrey Canyon Reservoir were based on the reservoir surface area corresponding to the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship was used based on a surface area of approximately 290 acres.
- Site-specific seepage estimates were not available for this site. A general seepage rate of 8 percent, based on a South Platte storage site, was used for the Jeffrey Canyon Reservoir site. Seepage water was returned to the river with an SDF factor of 6,000 days, based on SDF mapping from the Missouri Basin States Association Report. Return flows were routed back to the river using the SDF model SDF View.

Table 8.B.34 shows the local net hydrologic effects of the Jeffrey Canyon Reservoir alternative, through the 20-year study period. The average annual effect of Jeffrey Canyon Reservoir is -1,603 ac-ft. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Jeffrey Canyon Reservoir is located in the upper part of Reach 16. The flow additions from this alternative were assumed to occur 5 miles below the Brady stream gage in Reach 16. Water diverted for storage in Jeffrey Canyon Reservoir would otherwise enter the river at the J-2 return. Flow reductions from this alternative were assumed to occur at the J-2 return, 6 miles above the Overton stream gage in Reach 17. Monthly diversions to storage (flow reductions) and releases and seepage returns (flow additions) from Jeffrey Canyon Reservoir were routed from Reaches 16 and 17, respectively, downstream using the water budget spreadsheet. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Table 8.B.37 in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 17, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.B.35 and 8.B.36 show the reductions to target flow shortages at the critical habitat for Jeffrey Canyon Reservoir. The average annual reduction to target flow shortages without downstream diversion losses is 6,112 ac-ft. The average annual reduction to target flow shortages with downstream diversion losses is 4,994 ac-ft.

Cost

The primary direct costs of this alternative are associated with land acquisition, excavation and site development, construction of the Jeffrey Canyon Dam, feeder canal, pipeline, and annual operations and maintenance costs. Based on an average cost of $200 per acre for grazing land (University of Nebraska, Lincoln, 1999) acquisition of about 290 acres would cost approximately $57,800. Construction of the dam, spillway, and outlet works would cost approximately $3 million dollars, based on similar work done in the State of Colorado.

Table 8.B.34
Jeffrey Canyon Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-6000	5499	0	0	0	0	0	0	0	-501
1976	0	0	-6000	1	5048	1	1	1	1	2	2	2	-941
1977	2	3	3	3	4	4	4	5	5	5	5	6	49
1978	6	6	6	6	6	-5994	5453	6	6	6	6	6	-479
1979	7	7	7	7	7	7	7	7	7	-5993	5436	8	-488
1980	8	8	-5992	8	-485	-452	-467	-504	-516	4912	8	9	-3465
1981	9	10	-5990	11	5059	13	14	15	16	17	-5982	5462	-1347
1982	20	21	-5979	22	5070	24	24	25	25	26	26	27	-670
1983	28	28	-5972	29	-463	-430	-445	-461	-493	-449	-553	-508	-9690
1984	-489	5094	-5967	33	-459	-425	-439	-464	-485	-497	4974	-5958	-5082
1985	43	-480	-413	-410	-406	-412	4941	157	55	57	59	-5940	-2749
1986	5539	63	-5935	66	-425	-391	-405	-443	-455	-475	-471	-445	-3777
1987	-420	-437	-384	-380	-377	-384	-394	-443	-440	-471	4977	-5914	-5067
1988	5555	-5912	90	-404	-360	5156	95	96	98	99	100	101	4714
1989	102	103	-5896	105	5153	107	107	107	108	-260	440	-5892	-5716
1990	5562	108	107	-5893	5606	107	106	106	106	105	105	104	6229
1991	104	103	-5897	102	5149	101	101	-5900	99	4950	98	98	-892
1992	97	97	-5904	96	5142	-5905	5537	94	94	94	94	93	-372
1993	93	93	-5907	93	5140	-5907	5553	92	92	-5908	519	-907	-6956
1994	-375	-408	-371	-367	5172	91	91	91	91	-5909	5503	92	3700
Average	795	-75	-3320	-644	2454	-735	994	-371	-79	-484	767	-978	-1675

Table 8.B.35
Jeffrey Canyon Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4933	0	0	0	0	0	0	0	4933
1976	0	0	0	0	4653	1	1	1	0	0	0	0	4656
1977	2	2	2	3	3	4	4	4	2	1	1	3	29
1978	5	5	5	4	6	0	5167	4	1	1	1	1	5200
1979	4	5	6	5	5	7	6	3	4	0	946	2	993
1980	5	6	0	0	0	0	0	0	0	791	2	2	807
1981	7	7	0	0	4154	12	6	6	3	4	0	2070	6269
1982	16	20	0	0	5019	22	21	11	8	5	5	9	5135
1983	27	23	0	0	0	0	0	0	0	0	0	0	50
1984	0	4873	0	0	0	0	0	0	0	0	1138	0	6011
1985	0	0	0	0	0	0	4095	104	21	13	14	0	4248
1986	5093	56	0	0	0	0	0	0	0	0	0	0	5148
1987	0	0	0	0	0	0	0	0	0	0	1029	0	1029
1988	4081	0	0	0	0	4821	72	74	26	34	21	31	9160
1989	41	101	0	0	4868	96	75	25	37	0	101	0	5343
1990	5176	97	87	0	5420	105	94	70	26	13	26	20	11135
1991	70	82	0	0	4942	96	72	0	0	400	9	21	5693
1992	57	90	0	0	5051	0	4492	29	26	20	23	22	9810
1993	77	83	0	0	3253	0	4856	50	31	0	154	0	8504
1994	0	0	0	0	4198	88	69	43	24	0	1255	42	5719
Average	733	272	5	1	2325	263	952	21	10	64	236	111	4994

Table 8.B.36
Jeffrey Canyon Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4933	0	0	0	0	0	0	0	4933
1976	0	0	0	0	4653	1	1	1	1	1	0	1	4659
1977	2	2	2	3	3	4	4	5	5	3	4	5	41
1978	5	5	5	4	6	0	5294	6	6	2	3	3	5338
1979	4	5	6	5	5	7	7	7	5	0	4059	4	4114
1980	5	6	0	0	0	0	0	0	0	3831	6	5	3854
1981	7	7	0	0	4154	12	13	14	12	10	0	3135	7364
1982	16	20	0	0	5019	22	23	24	24	23	24	19	5214
1983	27	23	0	0	0	0	0	0	0	0	0	0	50
1984	0	4878	0	0	0	0	0	0	0	0	3268	0	8146
1985	0	0	0	0	0	0	4800	152	53	54	56	0	5115
1986	5457	55	0	0	0	0	0	0	0	0	0	0	5512
1987	0	0	0	0	0	0	0	0	0	0	3662	0	3662
1988	4306	0	0	0	0	4869	86	85	88	84	84	81	9683
1989	85	102	0	0	4868	96	101	93	102	0	358	0	5805
1990	5353	97	87	0	5420	105	103	103	98	56	91	63	11577
1991	76	82	0	0	4942	96	87	0	0	1746	42	47	7118
1992	59	90	0	0	5051	0	5334	78	88	74	58	64	10896
1993	79	83	0	0	3253	0	5416	88	87	0	427	0	9433
1994	0	0	0	0	4198	90	88	85	84	0	5126	64	9736
Average	774	273	5	1	2325	265	1068	37	33	294	863	175	6112

Installing a pipeline from the southeast finger of Jeffrey Reservoir to Jeffrey Canyon Reservoir would require excavation and installation of bedding material and pipeline. Total installation costs for 6,400 feet of 36-inch pipeline would be approximately $5.2 million. Annual operating and maintenance costs were amortized over 20 years assuming a 6 percent discount rate. The initial estimate for the Jeffrey Canyon project, including engineering and contingency costs, is approximately $13.9 million.

Assuming a project cost of $13.9 million, the cost per ac-ft of target flow reductions at the critical habitat would be approximately $2,270 assuming releases can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $2,780 assuming releases cannot be protected from downstream diversions.

Lake McConaughy Reservoir (Remove Storage Restrictions)

Kingsley Dam, completed in 1941, impounds Lake McConaughy for CNPPID Tri-County Supply Canal and Nebraska Public Power District's Sutherland Project. Kingsley Dam was constructed to impound 1,984,000 ac-ft at elevation 3270 feet. Maximum storage levels in Lake McConaughy Reservoir are currently limited to elevation 3265 feet (1,743,000 ac-ft) due to concerns regarding wave erosion on the upstream face of Kingsley Dam. The upstream face of Kingsley Dam is subject to wave surges from westerly winds sweeping across Lake McConaughy during extended storms.

CNPPID refined a cost estimate on Kingsley Dam slope protection replacement cost that reflects the current understanding of size and amounts of riprap placement necessary for the project (CNPPID, 1999a).

Project costs were estimated between $130 million and $170 million. The total project cost exceeds the economic screening criteria upper limits, therefore, this alternative has been deferred from further evaluation at this time. As such, the associated issues for Lake McConaughy Reservoir were not addressed.

Sutherland Reservoir (Construction of New Storage Facilities, Enlarge Existing Reservoirs)

Sutherland Reservoir, located south of the South Platte River near Sutherland, Nebraska, was originally constructed in the mid-1930's. From the time construction was completed, the dam leaked considerably, resulting in reductions in storage from a design capacity of 180,000 ac-ft to the current capacity of approximately 65,000 ac-ft. In 1993, Harza Engineering evaluated alternatives to reduce seepage from Sutherland Project facilities and to provide additional storage for the project (Harza Engineering Company, 1993).

Two options for reducing seepage from Sutherland Reservoir are to control seepage through the reservoir bottom by lining or to control horizontal flow away from the reservoir by constructing a vertical cut-off at the reservoir's perimeter. With respect to this study, seepage reduction at Sutherland Reservoir would not be feasible based on a project cost of between $100 million and $500 million dollars in 1993.

Increasing storage capacity for the Sutherland Project was investigated by Harza Engineering Company via enlargement of Sutherland Reservoir, and construction of a separate storage facility. Three different alternatives were analyzed to increase the storage capacity of Sutherland Reservoir between 18,000 and 78,750 ac-ft. Corresponding project costs, in 1998 dollars, ranged from $115 million to $166 million. The total project costs exceed the economic screening criteria upper limits, therefore, this alternative has been deferred from further evaluation at this time.

A potential site for an additional storage reservoir is located about two and one-half miles east of Sutherland Reservoir. Construction of a Sutherland East Reservoir would require lining or an impermeable cut-off to avoid the high seepage rates seen in the nearby storage units. Construction of new partially lined reservoirs of 7,500 ac-ft and 12,500 ac-ft were analyzed in the Harza study, at estimated project costs of $20 million and $25 million dollars, respectively.

Operations modeling was performed in the Harza study to determine the yield of Sutherland Project facilities under current operating criteria and with the seepage reduction alternatives described above. The alternative including the construction of Sutherland East Reservoir was determined to have a minor impact on safe yield to Sutherland

Project operations. Operating data and flow time series from the 1993 study were not available. Due to the uncertainty related to the reductions to target flow shortages with Sutherland East Reservoir, this alternative has been deferred from further evaluation at this time. As such, the associated issues for Sutherland Reservoir have not been discussed.

5. Yield Summary

Table 8.B.37 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of the downstream reach, with and without diversions; and at the critical habitat, with and without diversions.

Each of the alternatives for reservoirs is scalable to a degree. If any of these alternatives are chosen for inclusion in the eventual action plan, the magnitude of certain alternatives may differ from the projects described in this section. The location of the representative storage projects in Region 2 may also differ from the projects described in this section. In addition, projects have been analyzed independently of each other. Several projects rely on the same source of water, in which case, the yields of these projects combined may be less than simply adding the yields of the individual projects. Consequently, the effects described in this section for each alternative are specific to the assumptions the study team has made in defining representative reservoir projects.

The average annual net hydrologic effects associated with reservoir alternatives cover a wide range of values. Excluding the reservoir alternatives that have been deferred from further evaluation for failing to meet economic screening criteria (see Chapter 6), the average annual net hydrologic effects range from –4,221 ac-ft per year for the Riverview Reservoir alternative in Reach 10 to -171 ac-ft per year under the 10,000 ac-ft lined reservoir alternative at the bottom of Reach 9.

The reservoir analyses presented herein are preliminary and can be refined based on on-site feasibility studies and communication with existing owners and other affected parties. Under the assumptions of the representative reservoir projects described in this section, reductions in shortages to target flows at the critical habitat range from

Table 8.B.37
Alternatives Yield and Cost by Reach
Category 1 - Reservoirs

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr) Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach (w/diversion loss)	Net Hydrologic Effects at Top of Downstream Reach (w/o diversion loss)	Net Hydrologic Effects at Habitat (w/diversion loss)	Net Hydrologic Effects at Habitat (w/o diversion loss)	Reduction to Target Flow Shortages at Habitat (w/diversion loss)	Reduction to Target Flow Shortages at Habitat (w/o diversion loss)	Capitalized Costs Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per ac-ft of Average Reduction in Target Flow Shortage At Habitat (w/diversion loss)	Cost per ac-ft of Average Reduction in Target Flow Shortage At Habitat (w/o diversion loss)
REGION 1											
Reach 2											
Seminoe Reservoir Enlargement	(1,932)	(1,938)	(1,938)	(1,776)	370	968	3,314	$46.7	$46.7	$48,240	$14,090
Reach 3											
Deer Creek Reservoir											
10,000 ac ft	(656)	(667)	(667)	(899)	86	405	1,406	$10 - $15	$10 - $15	$10,860	$8,850
30,000 ac ft	(1,095)	(1,118)	(1,118)	104	218	695	2,395	$40 - $50	$40 - $50	$64,750	$18,790
Reach 4											
Guernsey Reservoir Reactivate Storage Lost to Sedimentation								> $40	Cost at Site - $8,000 / ac ft		
Reach 5											
Horse Creek Reregulating Reservoir											
Storage During Shortage Months	(394)	(357)	(357)	351	939	1,112	1,699	$17.5	$17.5	$15,740	$10,300
Storage During All Months	(324)	(323)	(321)	2,298	4,446	1,997	3,814	$17.5	$17.5	$8,760	$4,590
REGION 2											
Above Reach 11											
Grey Mountain Reservoir								$245	$15,300 / ac ft		
Reach 8 Reservoirs											
10,000 ac ft in middle of reach	(351)	(720)	2,978	(1,030)	6,011	2,769	9,632	$9.2	$15.5	$3,320	$1,610
10,000 ac ft lead at middle of reach	(166)	(320)	3,280	(646)	6,183	2,903	9,732	$12.3	$18.6	$4,240	$1,910
50,000 ac ft in middle of reach	(2,290)	(4,360)	6,788	(6,288)	5,839	7,851	19,627	$44.6	$50.9	$5,680	$2,590
Reach 9 Reservoirs											
10,000 ac ft in middle of reach	(557)	(1,320)	684	(1,194)	4,063	4,600	9,700	$9.2	$13.0	$2,000	$1,140
10,000 ac ft lead at middle of reach	(171)	(843)	1,106	(725)	4,312	4,768	9,804	$12.3	$16.1	$2,580	$1,640
50,000 ac ft in middle of reach	(2,315)	(5,971)	605	(6,872)	9,477	12,994	28,413	$44.6	$48.3	$3,430	$1,700
10,000 ac ft at bottom of reach	(557)	(557)	(557)	(1,174)	3,531	5,189	9,743	$9.2	$9.2	$1,770	$940
10,000 ac ft lead at bottom of reach	(171)	(171)	(171)	(721)	3,796	5,337	9,854	$12.3	$12.3	$2,300	$1,250
50,000 ac ft at bottom of reach	(2,352)	(2,352)	(2,352)	(6,800)	8,523	15,323	29,714	$44.6	$44.6	$2,910	$1,500
Julesburg Reservoir											
5,300 ac ft Enlargement	(516)	(608)	(356)	(521)	1,176	1,956	3,557	$12.8	$12.8	$6,540	$3,600
21,900 ac ft Enlargement	(3,140)	(3,478)	(2,608)	(2,968)	2,924	6,872	12,545	$24.1	$24.1	$3,510	$1,920
REGION 3											
Reach 10											
Riverview Reservoir	(4,221)	(4,661)	(2,516)	(6,490)	(302)	5,800	11,821	$34.1	$34.1	$5,880	$2,880
Sutherland Reservoir											
18,000 ac ft Enlargement								$115			
78,750 ac ft Enlargement								$166			
above Reach 14											
Lake McConaughy Remove Storage Restrictions								$130 - $170			
Reach 16											
Jeffrey Canyon Reservoir	(1,675)	(3215) **	(1792) **	(3,146)	(1,997)	4,994	6,112	$13.9	$13.9	$2,780	$2,270
Reach 17											
20,000 ac ft Plum Creek Reservoir	(1,326)	(1,328)	(1,328)	(3,593)	(2,824)	24,837	25,571	$44.1	$44.1	$1,780	$1,720
4,800 ac ft J 2 Re Regulating Reservoir	(429)	(431)	(431)	(845)	(695)	5,156	5,306	$9.0	$9.0	$1,750	$1,700

* Present value of sum of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate

** Net Hydrologic Effects at top of Reach 18

2,769 ac-ft per year under the 10,000 ac-ft ft reservoir alternative at the bottom of Reach 9 to 24,837 ac-ft per year under the 30,000 ac-ft Plum Creek Reservoir alternative, with downstream diversion losses. Without diversion losses downstream, reductions to target flow shortages range from 5,306 ac-ft per year for the J-2 Re-Regulating Reservoir to 25,571 ac-ft for the 30,000 ac-ft Plum Creek Reservoir alternative.

6. Cost Summary

Table 8.B.37 also summarizes the costs associated with the reservoir alternatives. Based on the analysis described in this section, the following shortlisted alternatives are deferred because total project costs or unit costs exceed the economic screening criteria:

- Seminoe Reservoir Enlargement
- Deer Creek Reservoir
- Guernsey Reservoir: Reactivate Storage Lost to Sedimentation
- Horse Creek Re-Regulating Reservoir
- Grey Mountain Reservoir
- Sutherland Reservoir Enlargement

From the reservoir alternatives that have not been deferred based on economic criteria, the J-2 Re-Regulating Reservoir would have the lowest capitalized cost of the reservoir alternatives evaluated at about $9.0 million. The average cost per ac-ft of reductions to target flow shortages ranges from $940 to $2,880 without diversion losses and $1,750 to $2,910 with diversion losses.

7. Associated Issues

Each of the remaining reservoir alternatives were evaluated according to the associated issues evaluation criteria previously reviewed by the Water Management Committee. The five categories of associated issues are physical, legal/institutional, social, economic and environmental. Each of these five characteristics is examined for each of the alternatives in this category below. Tabular scoring according to each criteria are presented in Table 8.B.38 for the With Diversions scenario and Table 8.B.39 for the No Diversions scenario.

Constructing New Storage Facilities on the South Platte River

Physical

The reservoir alternatives presented in this study represent a wide range of storage projects on the South Platte. Each of the alternatives is scalable. There are limitations on the amount of flow available for diversion, canal capacities, and available storage sites. The magnitude and geographic location of alternatives may differ from the representative projects described in this section. The reductions to target flow shortages for this alternative are sustainable over time. The life span of reservoir projects would be expected to last beyond 10 to 13 years. Design and construction of these reservoirs is technically implementable under the assumption that new off-channel sites exist between Kersey and Julesburg (Reaches 8 and 9). Protecting Program water developed from reservoir alternatives to the critical habitat increases estimated yields. Protecting water from diversions in Colorado, however, is currently not possible due to the inability to bypass existing sand dam diversion structures. Significant cost would be incurred if these structures were to be modified and/or replaced to allow additional water to be protected downstream. The time to yield realization is dependent on the length of time required for on-site feasibility studies, approval of the necessary storage rights, and reservoir construction. The time to yield realization would be on the order of 3 to 6 years. Releases from reservoir alternatives are easily quantified. Observation wells would need to be installed and hydrogeologic investigations conducted to measure seepage water returning to the river. The estimated yield may be reduced if storage water is required to compensate owners for the use of existing canals.

Third-party hydrologic impacts are relatively neutral if Program water is not protected. The protection of Program water from downstream diversions would not allow existing users the use of previously bypassed water. In both scenarios, there may be impacts on downstream hydropower diversions.

Table 8.B.38

Scoring Table - With Diversions in Wyoming, Colorado and Nebraska

Category 1 - Reservoirs

	Region 1 Reaches					Region 2 Reaches												Region 3 Reaches					
Physical	2	3a	3b	4	5	11	8a	8b	8c	9a	9b	9c	9d	9e	9f	9g	9h	10a	10b	10c	16	17a	17b
Net Reduction in Shortage to Target Flows										2	2		3	3	3						2	5	3
Sustainability										5	5		5	5	5						5	5	5
Scalability										5	5		5	5	5						2	5	2
Technically Implementable										4	4		4	4	4						4	4	4
Time to Yield Realization										3	3		3	3	3						3	3	3
Ability to Monitor and Measure										4	4		4	4	4						4	4	4
Third Party Hydrologic Impacts										4	4		4	4	4						4	2	2
Subtotal										27	27		28	28	30						24	28	23
Subtotal Average										4	4		4	4	4						3	4	3
Legal/Institutional																							
Ease of Permitting										3	3		3	3	3						3	3	3
Consistent with Interstate Compacts, Federal Laws & Decrees										5	5		5	5	5						5	5	5
Consistent with State Laws										3	3		3	3	3						3	3	3
Potential for Institutional Consensus										3	3		3	3	3						3	3	3
Can be Mitigated										3	3		3	3	3						3	3	3
Administrative Ease										4	4		4	4	4						4	4	4
Consistent with Existing Contract, Facility & Land Ownership										3	3		3	3	3						3	2	2
Subtotal										24	24		24	24	24						24	23	23
Subtotal Average										3	3		3	3	3						3	3	3
Social																							
Effects on Customs and Culture										3	3		3	3	3						3	3	3
Equity of Impacts										3	3		3	3	3						3	3	3
Impacts on Community Organizations and Support Structures										3	3		3	3	3						3	3	3
Effects on Community Sustainability										3	3		3	3	3						3	3	3
Public Acceptability										3	3		3	3	3						3	2	2
Subtotal										15	15		15	15	15						15	14	14
Subtotal Average										3	3		3	3	3						3	3	3
Economic																							
Initial Implementation and Capital Cost						0				5	4		5	4	1				0	0	4	1	5
Average Annual Total Cost per ac-ft Reduction	0	0	0	0	0		0	0	0	3	1	0	3	2	1	0	0	0			1	3	3
Direct Economic Impacts										4	4		4	4	4						1	1	1
Secondary Economic Impacts										3	3		3	3	3						3	3	3
Fiscal Impacts										3	3		3	3	3						2	2	2
Effects on Economic Development Potential										2	2		2	2	2						2	2	2
Subtotal										20	17		20	18	14						11	12	16
Subtotal Average										3	3		3	3	2						2	2	3
Environmental																							
Impacts to Wetlands										2	2		2	2	2						2	2	2
Impacts to Habitat										4	4		4	4	4						4	2	2
Impacts to Water Quality										3	3		3	3	3						3	3	3
Impacts to Prime and Unique Farmlands										5	5		5	5	5						5	5	5
Visual Impacts										3	3		3	3	3						3	3	3
Impacts to Amenities										4	4		4	4	4						4	4	4
Subtotal										21	21		21	21	21						21	19	19
Subtotal Average										4	4		4	4	4						4	3	3
Overall Total (Sum of Averages)										17	17		17	17	16						15	15	15

Legend
2 - Seminoe Reservoir Enlargement
3a - 10,000 ac-ft Deer Creek Reservoir
3b - 30,000 ac-ft Deer Creek Reservoir
4 - Guernsey Reservoir: Reactivate Storage Lost to Sedimentation
5 - Horse Creek Re-Regulating Reservoir
11 - Grey Mountain Reservoir
8a - 10,000 ac-ft Reservoir in middle of reach
8b - 10,000 ac-ft Lined Reservoir in middle of reach
8c - 50,000 ac-ft Reservoir in middle of reach
9a - 10,000 ac-ft Reservoir in middle of reach
9b - 10,000 ac-ft Lined Reservoir in middle of reach
9c - 50,000 ac-ft Reservoir in middle of reach
9d - 10,000 ac-ft Reservoir at bottom of reach
9e - 10,000 ac-ft Lined Reservoir at bottom of reach
9f - 50,000 ac-ft Reservoir at bottom of reach
9g - Julesburg Reservoir Enlargement 5,300 ac-ft
9h - Julesburg Reservoir Enlargement 21,900 ac-ft
10a - Riverview Reservoir
10b - Sutherland Reservoir Enlargement 18,000 ac-ft
10c - Sutherland Reservoir Enlargement 78,750 ac-ft
16 - Jeffrey Canyon Reservoir
17a - 30,000 ac-ft Plum Creek Reservoir
17b - J-2 Re-Regulating Reservoir

Table 8.B.39
Scoring Table - No Diversions in Any State
Category 1 - Reservoirs

	Region 1 Reaches					Region 2 Reaches												Region 3 Reaches					
Physical	2	3a	3b	4	5	11	8a	8b	8c	9a	9b	9c	9d	9e	9f	9g	9h	10a	10b	10c	16	17a	17b
Net Reduction in Shortage to Target Flows							4	4		4	4	5	4	4	5		5	5			3	5	3
Sustainability							5	5		5	5	5	3	5	5		5	5			5	5	5
Scalability							5	5		5	5	5	5	5	5		3	5			2	5	2
Technically Implementable							4	4		4	4	4	4	4	4		4	4			4	4	4
Time to Yield Realization							3	3		3	3	3	5	3	3		3	3			3	3	3
Ability to Monitor and Measure							4	4		4	4	4	4	4	4		4	4			4	4	4
Third Party Hydrologic Impacts							3	3		3	3	3	3	3	3		3	3			4	2	2
Subtotal							28	28		28	28	29	28	28	29		27	29			25	28	23
Subtotal Average							4	4		4	4	4	4	4	4		4	4			4	4	3
Legal/Institutional																							
Ease of Permitting							2	2		2	2	2	2	2	2		2	2			2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees							5	5		5	5	5	5	5	5		5	5			5	5	5
Consistent with State Laws							3	3		3	3	3	3	3	3		3	3			3	3	3
Potential for Institutional Consensus							3	3		3	3	3	3	3	3		3	3			3	3	3
Can be Mitigated							3	3		3	3	3	3	3	3		3	3			3	3	3
Administrative Ease							4	4		4	4	4	4	4	4		4	4			4	4	4
Consistent with Existing Contract, Facility & Land Ownership							3	3		3	3	3	3	3	3		3	3			3	2	2
Subtotal							23	23		23	23	23	23	23	23		23	23			23	22	22
Subtotal Average							3	3		3	3	3	3	3	3		3	3			3	3	3
Social																							
Effects on Customs and Culture							3	3		3	3	3	3	3	3		3	3			3	3	3
Equity of Impacts							3	3		3	3	3	3	3	3		3	3			3	3	3
Impacts on Community Organizations and Support Structures							3	3		3	3	3	3	3	3		3	3			3	3	3
Effects on Community Sustainability							3	3		3	3	3	3	3	3		3	3			3	3	3
Public Acceptability							3	3		3	3	3	3	3	3		3	3			3	2	2
Subtotal							15	15		15	15	15	15	15	15		15	15			15	14	14
Subtotal Average							3	3		3	3	3	3	3	3		3	3			3	3	3
Economic																							
Initial Implementation and Capital Cost						0	4	4	0	4	4	1	5	4	1		3	3	0	0	4	1	5
Average Annual Total Cost per ac-ft Reduction	0	0	0	0	0		3	3		4	3	3	5	4	4	0	3	1			2	3	3
Direct Economic Impacts							4	4		4	4	4	4	4	4		3	4			1	1	1
Secondary Economic Impacts							3	3		3	3	3	3	3	3		3	3			3	3	3
Fiscal Impacts							3	3		3	3	3	3	3	3		3	3			2	2	2
Effects on Economic Development Potential							2	2		2	2	2	2	2	2		2	2			2	2	2
Subtotal							19	19		20	19	16	22	20	17		17	16			14	12	16
Subtotal Average							3	3		3	3	3	4	3	3		3	3			2	2	3
Environmental																							
Impacts to Wetlands							2	2		2	2	2	2	2	2		2	2			2	2	2
Impacts to Habitat							4	4		4	4	4	4	4	4		4	4			4	2	2
Impacts to Water Quality							3	3		3	3	3	3	3	3		3	3			3	3	3
Impacts to Prime and Unique Farmlands							5	5		5	5	5	5	5	5		5	5			5	5	5
Visual Impacts							3	3		3	3	3	3	3	3		3	3			3	3	3
Impacts to Amenities							4	4		4	4	4	4	4	4		4	4			4	4	4
Subtotal							21	21		21	21	21	21	21	21		21	21			21	19	19
Subtotal Average							4	4		4	4	4	4	4	4		4	4			4	3	3
Overall Total (Sum of Averages)							17	17		17	17	17	18	17	17		17	17			16	15	15

Legend
2 - Seminoe Reservoir Enlargement
3a - 10,000 ac-ft Deer Creek Reservoir
3b - 30,000 ac-ft Deer Creek Reservoir
4 - Guernsey Reservoir: Reactivate Storage Lost to Sedimentation
5 - Horse Creek Re-Regulating Reservoir
11 - Grey Mountain Reservoir
8a - 10,000 ac-ft Reservoir in middle of reach
8b - 10,000 ac-ft Lined Reservoir in middle of reach
8c - 50,000 ac-ft Reservoir in middle of reach
9a - 10,000 ac-ft Reservoir in middle of reach
9b - 10,000 ac-ft Lined Reservoir in middle of reach
9c - 50,000 ac-ft Reservoir in middle of reach
9d - 10,000 ac-ft Reservoir at bottom of reach
9e - 10,000 ac-ft Lined Reservoir at bottom of reach
9f - 50,000 ac-ft Reservoir at bottom of reach
9g - Julesburg Reservoir Enlargement 5,300 ac-ft
9h - Julesburg Reservoir Enlargement 21,900 ac-ft
10a - Riverview Reservoir
10b - Sutherland Reservoir Enlargement 18,000 ac-ft
10c - Sutherland Reservoir Enlargement 78,750 ac-ft
16 - Jeffrey Canyon Reservoir
17a - 30,000 ac-ft Plum Creek Reservoir
17b - J-2 Re-Regulating Reservoir

Legal and Institutional

These projects are consistent with interstate compacts, federal laws, and decrees and are easy to administer and enforce. However, the primary legal/institutional obstacle with reservoir projects on the Lower South Platte River is associated with the inability to export water out of state under existing Colorado state water law. As such, reservoir projects are currently not consistent with state laws without and associated in-state beneficial use. An in-state beneficial use must be decreed or approved by the legislature for water to be used for the critical habitat. This issue has been addressed with the proposed Tamarack Plan by decreeing in-state wildlife enhancement benefits associated with the recharge sites. The in-state benefit associated with these projects is the wildlife and environment enhancement associated with recharge ponds. Because new reservoir projects must have a decreed in-state beneficial use, permitting could be a more difficult and lengthy process, however the process itself should be fairly routine as demonstrated by existing reservoir projects in Colorado. Permitting could be more difficult if Program water is protected from downstream users. Institutional consensus may be difficult to attain as certain groups will oppose the development of surface water storage projects in the basin. Consensus with existing owners will be less difficult to attain if compensation is provided for the use of canals to divert storage water. These projects are consistent with existing contracts, however, land may need to be purchased for reservoir sites.

Social

The social effects of these alternatives are likely to be minimal. There are potentially some minor positive and negative effects. There will be no impact on customs and culture, community organizations and support structures or community sustainability. These projects would have relatively equitable impacts and would not adversely impact any one group. Any adverse effects on cultural resources could most likely be mitigated. Public acceptability associated with these projects is in part related to the increase in flat water recreation opportunities.

Economic

Most of the costs of these alternatives are capital costs up front. However, reservoir projects that are associated with a ditch company may require a delivery fee for water diverted to storage sites. The potential direct economic impact associated with these alternatives is from the generation of tourism associated with new recreation areas. These projects may have some impact on business sales, employment and employee wages and wealth. There could be potential negative secondary economic impacts to downstream hydropower generation for alternatives that divert water from the river that are in excess to target flows but which has historically been diverted for hydropower. As such, there could be additional costs associated with paying power interference charges. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There are no definite positive or negative fiscal impacts. There would be no measurable effect on revenues and expenditures of governmental entities resulting from these types of projects.

Environmental

These alternatives would generally result in mixed environmental impacts. There could be potential negative impacts to wetlands from reservoir impoundment. Potential positive impacts could occur from the creation of additional wildlife habitat. Reservoir projects could also have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of areas inundated would not be significantly impacted. No impact to prime and unique farmlands are envisioned with the reservoir alternatives. The reservoir projects could generate some recreational opportunities associated with camping, fishing, and boating.

Julesburg Reservoir Enlargement

Physical

The 21,900 ac-ft enlargement represents the upper limit of enlargement alternatives analyzed for Julesburg Reservoir. The reductions to target flow shortages for this alternative are sustainable over time. The life span of the reservoir enlargement would be expected to last beyond 10 to 13 years. Design and construction of the enlarged storage space is technically implementable. The time to yield realization is dependent on the length of time required for on-site feasibility studies, approval of the necessary storage rights, and reservoir enlargement. The time to yield realization would be on the order of 3 to 6 years. Releases from the enlarged storage space are easily quantified. Observation wells would need to be installed and hydrogeologic investigations conducted to measure seepage water returning to the river. The estimated yield may be reduced if storage water is required to compensate owners for use of existing canals.

Third-party hydrologic impacts are relatively neutral if Program water is not protected. The protection of Program water from downstream diversions would not allow existing users the use of previously bypassed water. In both scenarios, there may be impacts on downstream hydropower diversions.

Legal and Institutional

This project is consistent with interstate compacts, federal laws, and decrees and is easy to administer and enforce. However, the primary legal/institutional obstacle with reservoir projects on the Lower South Platte River is associated with the inability to export water out of state under existing Colorado state water law. As such, reservoir enlargement projects are currently not consistent with state laws without and associated in-state beneficial use. An in-state beneficial use must be decreed or approved by the legislature for water to be used for the critical habitat. Because this project must have a decreed in-state beneficial use, permitting could be a more difficult and lengthy process, however the process to enlarge a reservoir should be fairly routine. Institutional consensus may be difficult to attain as certain groups will oppose the enlargement of surface water reservoirs in the basin. Consensus with existing owners would be less difficult to attain if compensation is provided for the use of canals to divert storage water. This project may require amendments to existing contracts, however, this could be facilitated through compensation to existing owners.

Social

The social effects of this alternative are likely to be minimal. There are potentially some minor positive and negative effects. There will be no impact on customs and culture, community organizations and support structures or community sustainability. This project would have relatively equitable impacts and not adversely impact any one group. Any adverse effects on cultural resources could most likely be mitigated. Public acceptability associated with this project is in part related to the necessary coordination with existing owners.

Economic

Most of the costs of this alternative are capital costs up front. However, enlargement projects associated with a ditch company may require a delivery fee for water delivered to storage sites. There are no definite positive or negative direct or secondary economic impacts or fiscal impacts associated with this alternative. This project would have minimal impact on business sales, employment and employee wages and wealth. There could be potential negative secondary economic impacts to downstream hydropower generation for alternatives that divert water from the river that are in excess to target flows but which has historically been diverted for hydropower. As such, there could be additional costs associated with paying power interference charges. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There would be no measurable effect on revenues and expenditures of governmental entities resulting from this type of project.

Environmental

This alternative would generally result in neutral environmental impacts. There could be potential negative impacts to wetlands from the reduction of seepage water associated with dam rehabilitation.

Potential positive impacts could occur from the enlargement of existing wildlife habitat. Reservoir enlargement could have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from this project returns to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of the surrounding area would not be significantly impacted by enlarging the reservoir. There would be no impact to prime and unique farmlands. Reservoir enlargement projects could generate some additional recreational opportunities but in general, there are minimal impacts to amenities.

Riverview Reservoir

Physical

The Riverview Reservoir alternative is scalable. The South Platte Divide Project report (USBR, 1982) identified a number of reservoir sites south of the Western Canal with variable storage capacities. The magnitude and geographic location of the alternative may differ from the representative project described in this report. There are limitations on the amount of flow available for diversion, canal capacity, and available storage sites. The reductions to target flow shortages for this alternative are sustainable over time. The life span of this project would be expected to last beyond 10 to 13 years. Design and construction of the reservoir is technically implementable. The time to yield realization is dependent on the length of time required for on-site feasibility studies, approval of the necessary storage rights, and reservoir construction. The time to yield realization would be on the order of 3 to 6 years. The yield from this alternative is easily quantified. The estimated yield may be reduced if storage water is required to compensate Western Irrigation Company for the use of the Western Canal.

Third-party hydrologic impacts are relatively neutral if Program water is not protected. The protection of Program water from downstream diversions would not allow existing users the use of previously bypassed water. In both scenarios, there may be impacts to downstream hydropower diversions.

Legal and Institutional

This project is consistent with interstate compacts, federal laws, and decrees and is easy to administer and enforce. Reservoir projects in Nebraska are consistent with state laws. Institutional consensus may be difficult to attain as certain groups will oppose the development of surface water storage projects in the basin. Consensus with Western Irrigation Company will be less difficult to attain if compensation is provided for the use of Western Canal to divert storage water. This project may require amendments to existing contracts, however, this could be facilitated through compensation to existing owners for use of their facilities.

Social

The social effects of this alternative are likely to be minimal. There are potentially some minor positive and negative effects. There will be no impact on customs and culture, community organizations and support structures or community sustainability. This project would have relatively equitable impacts and does not adversely impact any one group. Some storage sites identified south of the Western Canal would require the relocation of a small number of farmsteads. Any adverse effects on cultural resources could most likely be mitigated. Public acceptability associated with these projects is in part related to the increase in flat water recreation opportunities.

Economic

Most of the costs of the alternative are capital costs up front. However, reservoir projects that are associated with a ditch company may require a delivery fee for water delivered to storage sites. The potential direct economic impact associated with the alternative is from the generation of tourism associated with new recreation areas. The project may have some impact on business sales, employment and employee wages and wealth. There could be potential negative secondary economic impacts to downstream hydropower generation for alternatives that divert water from the river that are in excess to target flows but which has historically been diverted for hydropower. As such, there could be additional costs associated with paying power interference charges. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There are no definite positive or negative fiscal impacts. There would be no measurable effect on revenues and expenditures of governmental entities resulting from this type of project.

Environmental

The alternative would generally result in neutral environmental impacts. There could be potential negative impacts to wetlands from reservoir impoundment. Potential positive impacts could occur from the creation of additional wildlife habitat. Reservoir projects could also have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of areas inundated would not be significantly impacted. No impact to prime and unique farmlands are envisioned with this alternative. The reservoir projects could generate some recreational opportunities associated with camping, fishing, and boating.

30,000 ac-ft Plum Creek Reservoir and 4,800 ac-ft J-2 Re-Regulating Reservoir

Physical

The Plum Creek Reservoir alternative is scalable. The J-2 Re-Regulating Reservoir is scalable to a degree but is confined by the surrounding topography. For this study, the study team carried out a monthly analyses of the shortlisted projects. Yield estimates of a Plum Creek Basin project could be enhanced through a daily analysis that would allow the reservoirs to store water during rainstorm events. Historical Plum Creek flow data was not available for this study. An on-site feasibility study including Plum Creek flows would lead to increased yield estimates and corresponding reductions in diversions to storage.

The reductions to target flow shortages for these alternatives are sustainable over time. The life span of these reservoir projects would be expected to last beyond 10 to 13 years. Design and construction of these reservoirs is technically implementable. The time to yield realization is dependent on the length of time required for on-site feasibility studies, approval of the necessary storage rights, and reservoir construction. The time to yield realization would be on the order of 3 to 6 years. Releases from reservoirs are easily quantified. Potential negative third-party hydrologic impacts exist with high groundwater problems in the vicinity as a result of seepage from the reservoir.

Legal and Institutional

These projects are consistent with interstate compacts, federal laws, and decrees and are easy to administer and enforce. Reservoir projects in Nebraska are consistent with state laws. Permitting could be more difficult if Program water is protected from downstream users. Institutional consensus may be difficult to attain as certain groups will oppose the development of surface water storage projects in the basin. This project may require amendments to existing contracts, however, this could be facilitated through compensation to existing owners.

Social

The social effects of these alternatives are likely to be offsetting. These projects would have relatively equitable impacts, however, there is the potential to adversely impact surrounding landowners if seepage from the reservoir are not adequately controlled. A Plum Creek Basin project would be expected to encounter strong resistance from neighboring property owners. Any adverse effects on cultural resources could most likely be mitigated. There will be no impact on customs and culture, community organizations and support structures or community sustainability. A Plum Creek Basin project would provide water-based recreation opportunities. However, due to the other reservoirs in the region, the net effect on the recreation economy and the increased recreation opportunities would not be significant.

Economic

Most of the costs of these alternatives are capital costs up front. Diverting water that would otherwise be used for hydropower generation represents a major direct economic impact associated with these alternatives. Further investigation may indicate that CNPPID operations could be more efficiently coordinated with Plum Creek Basin reservoir alternatives, which may minimize the economic impacts to CNPPID associated with this alternative. The projects may have some impact on business sales, employment and employee wages and wealth. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development. There are negative fiscal impacts associated with these alternatives. State taxes levied on power generation would be lost if water is diverted from the J-2 forebay to storage.

Environmental

These alternatives could have potential negative impacts to wetlands from reservoir impoundment. Concerns with the habitat of aquatic species in the Plum Creek basin were indicated in previous studies. Potential positive impacts could occur from the creation of additional wildlife habitat. Reservoir projects could also have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of areas inundated would not be significantly impacted. There would be no impact to prime and unique farmlands. The reservoir projects could generate some recreational opportunities but in general, there are minimal impacts to amenities.

Jeffrey Canyon Reservoir

Physical

Jeffrey Canyon Reservoir is scalable to a degree but is confined by the surrounding topography. For this study, the study team carried out a monthly analyses of the shortlisted projects. Yield estimates of a Jeffrey Reservoir project could be enhanced through a daily analysis that would allow the reservoir to store water during rainstorm events. The reductions to target flow shortages for this alternative are sustainable over time. The life span of reservoir projects would be expected to last beyond 10 to 13 years. Design and construction of the reservoir is technically implementable. The time to yield realization is dependent on the length of time required for on-site feasibility studies, approval of the necessary storage rights, and reservoir construction. The time to yield realization would be on the order of 3 to 6 years. Releases from Jeffrey Canyon Reservoir are easily quantified. Potential negative third-party hydrologic impacts exist with high groundwater problems in the vicinity as a result of seepage from the reservoir.

Legal and Institutional

The Jeffrey Reservoir project is consistent with interstate compacts, federal laws, and decrees and is easy to administer and enforce. Reservoir projects in Nebraska are consistent with state laws. Permitting could be more difficult if Program water is protected from downstream users. Institutional consensus may be difficult to attain as certain groups will oppose the development of surface water storage projects in the basin. This project may require amendments to existing contracts, however, this could be facilitated through compensation to existing owners.

Social

The social effects of this alternative are likely to be offsetting. This project would have relatively equitable impacts. Any adverse effects on cultural resources could most likely be mitigated. There will be no impact on customs and culture, community organizations and support structures or community sustainability. A Jeffrey Reservoir project would not be expected to encounter strong resistance from neighboring property owners. A Jeffrey Reservoir project would provide water-based recreation opportunities. However, due to the other reservoirs in the region, the net effect on the recreation economy and the increased recreation opportunities would not be significant.

Economic

Most of the costs of this alternative are capital costs up front. Diverting water that would otherwise be used for hydropower generation represents a major direct economic impact associated with this alternative. The economic impact to CNPPID could be reduced by releases of water from Jeffrey Canyon Reservoir to the Tri-County Supply Canal when CNPPID is not diverting a full canal. This would allow for subsequent hydropower generation at the J-1 and J-2 power plants. The project may have some impact on business sales, employment and employee wages and wealth. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development. There are negative fiscal impacts associated with this alternative. State taxes levied on power generation would be lost when water is diverted from Jeffrey Lake to storage.

Environmental

This alternative could have potential negative impacts to wetlands from reservoir impoundment. Potential positive impacts could occur from the creation of additional wildlife habitat. A Jeffrey Reservoir project could also have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from this project returns to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of areas inundated would not be significantly impacted. There would be no impact to prime and unique farmlands. The Jeffrey Reservoir project could generate some recreational opportunities but in general, there are minimal impacts to amenities.

8.C. Agricultural Water Conservation

Agricultural Water Conservation

1. Introduction

This section examines the yields, costs and associated issues of various agricultural conservation alternatives to reduce shortages to target flows at the critical habitat. A number of agricultural conservation alternatives in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into four categories:

On-farm Changes in Irrigation Practices

On-farm Changes in Irrigation Techniques

Water District Structural Alternatives

Water District Non-Structural Alternatives

A brief description of each of these alternatives and how they might be implemented is provided below, followed by region-specific estimates of yields and cost of each alternative. Finally the evaluation of each alternative in terms of physical, legal or institutional, economic, social, and environmental effects is offered to conclude the agricultural water conservation evaluation.

2. Conceptual Definitions

The following conceptual definitions reference specific alternatives within each sub-category that were previously defined in the Alternatives Definitions Memorandum provided to the Water Management Committee in August 1998.

<u>On-farm Changes in Irrigation Practices</u>. This subcategory of water conservation measures includes alternatives that would reduce water use by fundamentally changing farmers' irrigation patterns to use less water, which may entail the use of less water intensive crops. The following alternatives from the long list developed previously are included in this subcategory:

- Conservation cropping patterns
- Deficit irrigation practices

On-farm Changes in Irrigation Techniques. This sub-category of water conservation measures includes alternatives that incorporate changes in on-farm irrigation equipment, techniques and management practices. Conversion from furrow irrigation to center-pivot irrigation, or installation of low flow nozzles on existing center pivot equipment are examples of this conservation approach. Resulting improvements in irrigation efficiency can reduce watering beyond crop needs and excessive evaporative and soil water losses.

Water District Structural Alternatives. This subcategory of water conservation measures includes structural improvements or changes that would reduce water use by physically improving the efficiency of stream to farm water conveyance systems. This subcategory does not address surface water substitution with groundwater, since that option is addressed in the groundwater discussion (see Section 8.G). Examples include:

- Rehabilitate/improve conveyance channels
- Repair/improve water control structures

Water District Non-Structural Alternatives. This subcategory of water conservation measures includes non-structural modifications that would reduce water use by changing the operations of water district systems. Examples include:

- Conservation pricing
- Demand based scheduling versus schedule based scheduling

In general, the benefits of agricultural water conservation reducing critical habitat shortages will be far easier to accomplish if the conserved waters are tied to reservoir storage. Conserving natural flows for benefits in a downstream state would represent a daunting and multi-faceted challenge. The study team did not examine water rights associated with specific water resources. Consideration of water rights is beyond the scope of this reconnaissance-level study.

3. Operational Definitions

The following operational definitions of each alternative were developed to provide a more specific, representative example of how the alternative might be implemented in the study region.

Conservation Cropping Patterns. For purposes of evaluation, the study team examined the implications of a program to encourage conversion of a portion of commonly irrigated, water intensive crops within each reach to production of less water intensive crops or crop rotations also found in the local area. Based upon local cropping pattern information, the study team evaluated conversion of hay acres to corn production in Region 1 and Region 2, and conversion from continuous corn cropping to an alternating rotation of corn and soybeans in Region 3. Although, other more complex crop switching patterns might be possible in the future, these were considered representative of current potential.

The rotation of crops can clearly be shown to reduce consumptive water use per acre of irrigated farmland; the challenge is to estimate the amount of lands that will be converted for a given financial incentive. Ideally, past crop conversions or past government incentive programs could shed light on the phenomenon.

First, it should be noted that crop conversion has occurred historically more commonly in certain geographic areas as compared with others. If crop conversion in a given area is rare, it might be attributable to any of the key farm production factors beyond a grower's control such as slope, soil type, length of growing season, or water availability. In areas where conversion is more common, the geographic area will exhibit diverse crop types at any given point in time.

Second, the motivation for crop conversion historically appears to be based on a complex decision-making process by individual farmers, reflecting changes in the following:

- Equipment technology
- Seed characteristics
- Fertilizers
- Labor availability
- Shifts in market demand and price
- Product transportation
- Crop choices of nearby farmers

The expected gross financial margin does not by itself explain the incidence of crop conversions.

Third, federal government programs have traditionally offered a host of incentives to farmers, but taken as a whole, these incentives have not clearly pushed farmers toward or away from crop conversion. Prior to 1996, federal farm price supports were important considerations but largely unrelated to crop conversion. The U.S. Government's Freedom to Farm approach since 1996 allows market forces to play a larger role, encouraging individual farmers to make their own choices.

Within the U.S. Department of Agriculture, there are currently a number of focused programs, mostly under the auspices of the Natural Resource Conservation Services (U.S. Department of Agriculture [USDA], 1999). The recently implemented Environmental Quality Incentive Program offers a host of opportunities that depend primarily on technical assistance and cost sharing. Marketing assistance loan rate programs exist for different crops that can be important under certain financial conditions. The Conservation Reserve Program and the Conservation Reserve Enhancement Program relate to cessation of farming on certain highly erodable lands. In sum, these programs are evidence that farmers can be encouraged to change certain practices. However, no government program was found that could reveal the likelihood or incentive for conservation crop switching at this point in time.

For the purpose of this study, a range of incentives should be adopted to reflect the uncertainty, especially recognizing that marginal lands for one crop type will switch more easily than average lands. Clearly, more research or a demonstration project is needed for this alternative.

Deficit Irrigation Practices. The study team defined representative deficit irrigation programs in each region for this evaluation. In Region 1 and Region 2, we assumed that participating farmers would be offered incentive payments to reduce irrigation of hay acres by 25 percent. In Region 3, we evaluated a deficit irrigation program based on reducing irrigation on corn acres to six inches per acre in exchange for incentive payments.

Again, the water savings can be calculated theoretically, but the inducement for farmers to deficit irrigate is highly uncertain. No federal or state programs were found to guide such an incentive estimate. Unlike crop switching, the farmers can continue most of their historical practices. They simply irrigate less at certain times in the growing season and experience lower yields plus incentive payments. Farmers will likely be skeptical and reticent to have unhealthy looking plants (University of Nebraska Extension Service, 1999).

For this study, a range of incentives to more than compensate for the yield loss, less the water cost savings, should be used. This will also reflect lands that do not follow best management practices or yield less per acre-inch of water applied.

Changes in Irrigation Techniques. As documented in the memorandum, *Shortlist of Alternatives*, dated March 8, 1999, many on-farm conservation measures are aimed at improving irrigation efficiency. These measures, which are often of considerable benefit to participating farmers and irrigation districts, generally offer much less benefit from the standpoint of overall annual flows in the Platte River because of their focus on reducing return flows from farms rather than reducing consumptive use. However, in the lower portions of Region 3 (reaches 17, 18 and 19), unlike the rest of the study area, a large proportion of return flows do not return to the river above the critical habitat. These flows either accrete to the groundwater mound in the area, travel into the Republican Basin, or return to the Platte River below the critical habitat area in some cases. This circumstance, along with these reaches proximity to the critical habitat, makes these three reaches the most economically and hydrologically favorable for the implementation of on-farm, efficiency improving irrigation techniques. Consequently, the study team evaluated these practices in this area.

Water District Structural Alternatives. Detailed aspects of the irrigation district structural alternatives are system and site specific. For purposes of this evaluation, the study team assumed that irrigation districts would be offered financial support to make the most cost-effective improvements to reduce leakage, spills and other "losses" from their systems.

Water District Non-structural Alternatives. In this evaluation, conservation pricing is defined as converting from pricing irrigation water service on the basis of the number of acres served to pricing on the basis of the volume of water supplied. The study team has assumed that the revised rate structure would be designed to be "revenue neutral" (producing the same total revenues for the irrigation district) in the average year. Conversion to demand based scheduling is defined as making the necessary modification to irrigation systems and management to deliver water to farmers on farm-specific demand, rather than according to district scheduling.

Clearly, uncertainties are evident about each agricultural water conservation program. Information specific to each opportunity should be gathered, perhaps through a demonstration program.

It should be emphasized that agricultural water conservation is well merited on its own, independent of this program. Local districts and farmers should be encouraged to continue to strengthen their conservation efforts.

4. Alternatives

The following evaluation focuses on the potential yields and costs of the agricultural conservation alternatives. Associated issues with each alternative are summarized at the end of this section.

Region 1

Based on the agricultural database obtained by the study team from Natural Resources Consulting Engineers, Inc. (NRCE) and the EIS team, nearly 600,000 acres of irrigated land are harvested annually in Region 1. Table 8.C.1 provides background for considering conservation cropping and deficit irrigation alternatives by summarizing the major crops grown in Region 1 and their estimated consumptive irrigation requirements.

Conservation Cropping Patterns

As shown in Table 8.C.1, approximately one-half of the harvested, irrigated acres in Region 1 are planted in alfalfa and other hay crops. The consumptive irrigation requirements (CIR) for hay crops in this area are generally more water intensive than either corn or dry beans. In Region 1, the study team has assumed that a conservation cropping program would focus on providing financial incentives for farmers to reduce acreage planted in hay and convert those acres to corn or dry beans.

Yield

Theoretically, there would appear to be a substantial water savings potential from an incentive program encouraging reduction in hay acreage and conversion to other crops. If all current alfalfa and other hay acreage in Region 1 were converted to corn or dry beans, the estimated reduction in CIR on Region 1 farms would be approximately 150,000 ac-ft per year. If only surface water irrigated acreage were considered, the theoretical potential water use reduction from wholesale conversion would be more than 125,000 ac-ft of annual consumptive use.

Table 8.C.1 Region 1 Cropping Patterns and Consumptive Irrigation Requirements

Region 1	Irrigated Acres	Average Annual Consumptive Irrigation Requirement/Acre (inches)
Reaches 1-4, 6		
Alfalfa and Other Hay	198,900	20
Corn	15,300	14
All Other Crops	9,900	Various
Total	224,100	
Reaches 5, 12 and 13		
Corn	175,600	17
Alfalfa and Other Hay	100,500	23
Dry Beans	73,300	14
All Other Crops	12,500	Various
Total	361,900	

Source: Study team analysis of NRCE agricultural database, 1999. Based on data from 1992, 1994 and 1996 agricultural years.

In practice, both the extent of participation and the water yield from an incentive based conservation cropping program in Region 1 are much more uncertain. In the upper portions of Region 1 (Reaches 1-4 and 6), hay crops represent nearly 90 percent of harvested, irrigated acres. This predominance suggests that soil, climate, historical practice, farm equipment and market conditions for most farms in this area favor hay production.

Cropping patterns in the lower portions of Region 1 (Reaches 5, 12 and 13), show more balance between hay crops, corn and dry beans. Individual farm choices regarding crop selection in this area may reflect specific local circumstances (e.g. soil, farm equipment, management demands, traditional practice and available water supply) as well as an effort to diversify crops to reduce risk.

From the standpoint of average revenue and farm income per acre in this area, dry beans appear to provide the best return, while corn and hay are fairly comparable to one another based on the study team's analysis of the NRCE data. The fact that dry beans still represent a small proportion of the acreage in this area, despite potentially more favorable financial returns, indicates that numerous factors are important in crop selection. Clearly, such barriers to crop switching are formidable.

Table 8.C.1 presents consumptive irrigation requirements for crops grown in Region 1 under best management practices and assuming adequate water supplies to provide full irrigation. In fact, however, there is evidence that at least some parts of Region 1 frequently suffer from inadequate supplies to provide full irrigation (Lidstone and Anderson, Inc., 1991). In general, hay crops represent a lower risk to the farmer than corn or dry beans when water supplies are frequently less than desired. This has two important implications from the standpoint of this study. First, conversion of additional acreage from hay to corn or beans may represent too great a risk to farmers with uncertain water supplies. Second, many farmers may already be deficit irrigating their hay crops, therefore, the water savings from converting from hay to corn or beans based on full irrigation requirements may be illusory.

The foregoing considerations suggest that a conservation cropping program is unlikely to be feasible in the upper reaches of Region 1 and is problematic, at best, in the lower reaches of the region. If twenty percent of the acres planted in hay in the lower reaches was: 1) currently receiving a full irrigation supply, and 2) would be willingly converted to other crops in exchange for incentive payments; the on-site water savings would be on the order of 15,000 ac-ft for the region as a whole.

Monthly changes in water use associated with conservation cropping in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.2 depicts the estimated on-site net hydrologic effects of the representative conservation cropping program, by reach and by month. Table 8.C.3, depicts the effects of the representative conservation cropping program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.4 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

As suggested previously, cropping choices in the lower portions of Region 1 appear to be motivated by a host of factors beyond just theoretical financial returns. These factors may include soils, water availability, farm equipment, past practice, local market conditions, access to capital, risk tolerance, etc. The cost of overcoming these barriers to changing cropping practices is very uncertain without field research or a demonstration program. It may be that conservation cropping is best left as an option for individual farmers considering participation in other alternatives, such as temporary water leasing arrangements. In order to preserve this alternative for possible further consideration at a later point, the study team has assumed that participating farmers would be compensated with payments per ac-ft conserved on-site comparable to those estimated for short-term leasing arrangements described in Section 8.F (Incentive Based Reductions in Agricultural Water Use). Further research will be needed to determine the acceptability to farmers of this level of compensation for participation in a conservation cropping program.

Deficit Irrigation Practices

As noted earlier, many farms in Region 1 may already be deficit irrigating on a frequent basis due to shortages in available irrigation

Table 8.C.2
Conservation Cropping
Net Hydrologic Effects on Site - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
8	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
9	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	0	33	83	423	704	583	0	1826
12	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
13	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
17	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
18	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
19	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732

NA: Not Analyzed

Table 8.C.3
Conservation Cropping
Average of Years 1975 - 1994
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	28	-138	-47	-30	-151	-132	-98	0	20	10	25	32	-480
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	-3	-6	-2	-2	-24	-16	-6	1	16	1	3	0	-39
8	-129	-212	-77	-58	-348	-270	-100	13	215	27	43	6	-890
9	-368	-472	-153	-96	-432	-345	-126	17	290	128	176	2	-1377
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	3	3	15	1	2	1	0	12
12	62	-445	-146	-91	-459	-405	-328	-47	84	75	165	153	-1382
13	-385	-131	-81	-406	-348	-285	-55	79	88	186	93	71	-592
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-123	-136	-40	-23	-117	-105	-107	-59	223	368	506	-10	377
17	-328	-349	-102	-59	-299	-270	-312	-231	708	1513	1873	-78	2066
18	-303	-325	-93	-53	-271	-246	-295	-231	891	1934	2369	-58	3318
19	-383	-397	-118	-69	-323	-282	-366	-318	1090	2690	3349	-150	4722

NA: Not Analyzed

Table 8.C.4
Conservation Cropping
Average of Years 1975 - 1994
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	48	-138	-47	-30	-151	-132	-98	1	397	681	1019	278	1830
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	-3	-6	-2	-2	-24	-16	-6	20	403	495	590	23	1471
8	-129	-212	-77	-58	-348	-270	-100	166	3168	3301	4287	150	9879
9	-368	-472	-153	-96	-432	-345	-126	90	2223	2709	3327	10	6368
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	0	22	50	244	260	326	0	904
12	106	-445	-146	-91	-459	-405	-328	-47	892	1893	3266	761	4998
13	8	-192	-66	-41	-203	-174	-142	-27	294	692	1144	264	1557
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-123	-136	-40	-23	-117	-105	-107	-59	382	720	962	-10	1343
17	-328	-349	-102	-59	-299	-270	-312	-231	756	1738	2047	-78	2513
18	-303	-325	-93	-53	-271	-246	-295	-231	920	2068	2473	-58	3586
19	-383	-397	-118	-69	-323	-282	-366	-318	1090	2690	3349	-150	4722

NA: Not Analyzed

supplies. In theory, an incentive-based program could be instigated to encourage further reductions in the water supply to participating farms in the region.

Yield

Studies have shown that in areas with more rainfall, corn can be deficit irrigated at certain times with relatively modest impacts on yield (University of Nebraska, 1999). However, in a semi-arid region that also features substantial hay production, acres planted in hay are probably more likely to participate in a voluntary deficit irrigation program due to perceived lower risk associated with shorting the crop. In general, hay yields decline proportionally with reductions in irrigation supply.

For purposes of evaluation, the study team has assumed that the deficit irrigation program would be designed to reduce water use on hay fields by 25 percent. In theory, if every farm planted in hay in Region 1 currently provided full irrigation to its hay acres and could be induced to participate in such a deficit irrigation program, total reductions in consumptive use on surface water irrigated acreage could be nearly 120,000 ac-ft per year. Perhaps more realistically, the program might hope to gain participation from 20 percent of Region 1 irrigated hay acreage if sufficient reimbursement were offered. Only acreage irrigated with surface water supplies would be included in the program. Under these assumptions, consumptive irrigation water use on Region 1 hayfields could be reduced by a total of about 25,000 ac-ft per year. Estimated reductions in consumptive use by reach would range from more than 5,000 ac-ft to less than 2,000 ac-ft.

Monthly changes in water use associated with deficit irrigation in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.5 depicts the estimated on-site net hydrologic effects of the representative deficit irrigation program, by reach and by month. Table 8.C.6, depicts the effects of the representative deficit irrigation

Table 8.C.5
Deficit Irrigation
Net Hydrologic Effects on Site - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	89	0	0	0	0	0	41	262	521	682	556	294	2445
2	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
3	91	0	0	0	0	0	21	204	466	669	609	292	2351
4	89	0	0	0	0	0	20	152	307	488	445	231	1732
5	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
6	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
7	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
8	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
9	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	0	32	79	380	624	517	0	1632
12	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
13	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
17	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
18	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
19	-562	-562	-562	-562	-563	-563	-537	-502	1776	6139	5221	-322	8403

NA: Not Analyzed

Table 8.C.6
Deficit Irrigation
Average of Years 1975 - 1994
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	14	0	0	0	0	0	3	5	5	1	2	2	31
2	37	0	0	0	0	0	4	10	11	3	6	6	77
3	15	0	0	0	0	0	1	4	4	1	2	2	30
4	15	0	0	0	0	0	1	3	3	1	2	2	26
5	21	-116	-39	-25	-126	-110	-81	2	17	8	21	26	-403
6	66	0	0	0	0	0	14	20	20	5	11	20	156
7	-2	-4	-1	-1	-17	-12	-4	1	12	1	2	0	-27
8	-88	-144	-52	-39	-236	-183	-65	10	146	18	29	5	-600
9	-244	-314	-101	-64	-287	-230	-80	14	193	85	123	4	-900
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	0	1	1	7	0	1	0	11
12	49	-383	-126	-78	-395	-349	-280	-37	74	65	144	129	-1187
13	3	-160	-54	-34	-168	-144	-118	-22	33	37	77	59	-491
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-179	-198	-58	-34	-170	-154	-155	-85	333	540	724	-21	544
17	-462	-490	-143	-84	-421	-380	-438	-322	1017	2118	2607	-130	2872
18	-422	-451	-130	-74	-377	-341	-410	-319	1271	2650	3261	-112	4547
19	-416	-431	-129	-75	-350	-307	-398	-345	1197	2912	3622	-176	5105

NA: Not Analyzed

Table 8.C.7
Deficit Irrigation
Average of Years 1975 - 1994
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	52	0	0	0	0	0	26	154	278	236	295	108	1150
2	139	0	0	0	0	0	37	329	682	620	815	285	2905
3	55	0	0	0	0	0	14	122	257	241	337	113	1138
4	54	0	0	0	0	0	13	92	174	180	256	90	861
5	37	-116	-39	-25	-126	-110	-81	14	345	577	846	227	1549
6	116	0	0	0	0	0	27	241	483	419	549	214	2049
7	-2	-4	-1	-1	-17	-12	-4	17	287	349	423	20	1054
8	-88	-144	-52	-39	-236	-183	-65	132	2150	2332	2897	119	6822
9	-244	-314	-101	-64	-287	-230	-80	75	1478	1842	2201	20	4297
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	0	0	0	0	0	0	22	48	219	231	292	0	812
12	84	-383	-126	-78	-395	-349	-280	-37	790	1639	2796	645	4306
13	6	-160	-54	-34	-168	-144	-118	-22	249	582	950	217	1304
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	-179	-198	-58	-34	-170	-154	-155	-85	569	1028	1385	-21	1929
17	-462	-490	-143	-84	-421	-380	-438	-322	1086	2436	2850	-130	3502
18	-422	-451	-130	-74	-377	-341	-410	-319	1313	2830	3405	-112	4912
19	-416	-431	-129	-75	-350	-307	-398	-345	1197	2912	3622	-176	5105

NA: Not Analyzed

program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.7 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

Deficit irrigation of hay crops in Region 1 would likely reduce hay yields by approximately a corresponding proportion (i.e., a 25 percent deficit in irrigation would reduce yields by 25 percent). Consequently, the study team can roughly estimate the impact of deficit irrigation on farm revenues from Region 1 hay production. In the upper portions of Region 1, deficit irrigating hay production by 25 percent would reduce revenues from hay production by approximately $30 to $40 per acre. In the lower reaches that have higher yields from fully irrigated hay production, foregone revenues could be as much as $60 to $70 per acre. Hay revenues per acre are from the NRCE database and originally from state agricultural statistics.

For purposes of providing a rough estimate of potential costs associated with this alternative, the study team has assumed that farmers would have to be paid an additional incentive of at least 20 percent, but no more than 60 percent of their foregone revenues from deficit irrigation to participate. While farmers might experience some savings in variable costs of production, these savings would likely be minimal in comparison to lost revenues. In estimating costs, we have used the mid-point of this range. While there is little or no precedent for large scale incentive-based deficit irrigation programs, the study team has assumed that the costs of implementing and administering the program might be similar to the land fallowing alternative described in Section 8.F. On this basis, we have assumed annual administrative costs would be about $20 per participating acre.

In total, the representative deficit irrigation program in Region 1 would cost an estimated $4 million per year. Capitalized total costs of the representative deficit irrigation program over a 20-year period (using a six percent discount rate appropriate to governmental entities with access to tax free bond financing) would be approximately $51 million, or about $2,000 per ac-ft of consumptive use saved on-farm.

For the region as a whole, average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be $3,340 if the saved water can be protected from downstream diverters. If the water is not protected, a deficit irrigation program in Region 1 will not serve to reduce shortages to target flows. Because the costs per ac-ft of reduction in shortage at the critical habitat exceed $3,000 in Region 1 this alternative has been deferred from further evaluation.

On-farm Changes in Irrigation Techniques

As discussed in the operational definitions at the outset of this section, the study team focused its analysis of on-farm changes in irrigation techniques on the lower reaches in Region 3 because those reaches offer the most favorable hydrologic conditions for these measures from the standpoint of the goal of reducing shortages to target flows. On the basis of the results of the Region 3 examination, reductions to target flow shortages from on-farm changes in irrigation techniques in Region 1 would far exceed the threshold cost of $3,000 per ac-ft for further analysis. Consequently, on-farm changes in irrigation techniques were not evaluated further in Region 1.

Water District Structural Alternatives

As in other portions of the study area, a substantial amount of water is "lost" each year due to seepage from irrigation conveyance facilities and spills. Based upon the most recent USGS data on water use and conveyance losses (for 1995), the study team estimates that annual conveyance losses in Region 1 are approximately 800,000 ac-ft per year. This data indicates that average conveyance efficiency — the amount of water actually delivered to farms relative to the total amount diverted from the river, is about 66 percent.

From the standpoint of this basin-wide study, however, it is vital to recognize that most of this "lost" water eventually returns to the river or provides return flows relied on by other irrigators. The primary effect of rehabilitating or improving conveyance facilities and water control structures is to change the timing of flows in the river rather than a reduction in consumptive use.

Yield

A number of previous studies commissioned by the Wyoming Water Development Commission have examined specific opportunities for rehabilitation and improvement of water district facilities. These studies include potential improvements to the LaPrele Irrigation District system, Wheatland Irrigation District canals, and Goshen Irrigation District facilities, among others. Separately, the Casper-Alcova Irrigation District (CAID) has been working with the City of Casper during the past decade to make improvements to their system. This has resulted in a water service agreement among the United States, CAID, and the city providing a supply of up to 7,000 ac-ft annually to the city from the Kendrick Project water supply.

Potential water savings and costs of irrigation system rehabilitation and improvements depend on site specific factors. However, for purposes of this evaluation, the study team has developed some approximate "rules of thumb" from the above reports. Canal lining, automating turnouts, new siphons, improved flow measurement and other techniques appear to typically increase the conveyance efficiency of Region 1 water districts by about five percent, on average.

Most of the water saved through such measures would ultimately have returned to the system. While this proportion varies greatly by site-specific circumstances, the study team has used the common assumption that 85 percent of system losses would eventually return to the river (Missouri Basin States Association, 1982a; CNPPID, et al., 1999).

Overall, the study team estimates that a comprehensive program focused on the most cost effective improvements to irrigation district facilities and improved water control structures throughout all irrigation systems in the region could reduce Region 1 diversions by at about 120,000 ac-ft per year. Non-productive consumptive use could be reduced by an estimated 18,000 ac-ft per year. However, it must be emphasized that these estimates are subject to considerable uncertainty, which can only be reduced by detailed study on a system by system basis.

Monthly changes in water use associated with irrigation system rehabilitation and improvements in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this alternative and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.8 depicts the estimated on-site net hydrologic effects of water district structural conservation alternatives, by reach and by month. Table 8.C.9, depicts the effects of the structural alternatives in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.10 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

The costs of measures to improve or rehabilitate water district facilities are as site specific as the potential water benefits. Other regions might have much higher or lower costs based upon physical systems that exist in those areas. However, based upon the Region 1 studies cited previously, the study team estimates that the average cost of such measures (in 1999 dollars) would be approximately $1,000 per ac-ft of reduced seepage or spillage. Adding engineering costs and transaction costs to transfer the salvaged water savings, average cost per ac-ft of reduced diversions would be approximately $1,200. This cost estimate translates into an average cost per ac-ft of reduced on-site consumptive use of about $8,000. Because the costs per ac-ft of reduction in shortage at the critical habitat exceed $3,000 in Region 1 this alternative has been deferred from further evaluation.

Water District Non-Structural Alternatives

The study team also evaluated two non-structural irrigation district measures including conservation pricing and changing from schedule based to demand based irrigation delivery timing.

Yield

The potential water savings from adoption of conservation pricing depends on both the extent to which demand for irrigation water responds to price signals (known as price elasticity) and the extent to which districts could be encouraged to adopt conservation rates.

Table 8.C.8
Water District Structural Measures
Net Hydrologic Effects on Site - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	100	0	0	0	0	0	46	293	583	764	622	329	2737
2	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
3	27	0	0	0	0	0	6	62	141	202	184	88	710
4	27	0	0	0	0	0	6	47	94	149	135	70	528
5	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
6	86	0	0	0	0	0	19	181	393	518	457	244	1898
7	-12	-15	-15	-15	-15	-15	14	64	270	465	386	71	1183
8	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
9	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
10	-13	-11	-9	-8	-7	-6	1	5	102	235	148	-130	307
11	0	0	0	0	0	0	38	95	444	725	601	0	1904
12	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
13	67	-17	-18	-18	-17	-17	-8	29	159	417	458	188	1224
14	-6	-4	-3	-2	-2	-2	3	8	61	141	122	4	320
15	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
16	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
17	-223	-222	-222	-222	-222	-222	-182	-129	830	2826	2236	-51	4196
18	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
19	-61	-61	-61	-61	-61	-61	-58	-53	272	892	761	-28	1420

NA: Not Analyzed

Table 8.C.9
Water District Structural Measures
Average of Years 1975 - 1994
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	16	0	0	0	0	0	3	5	5	1	2	2	35
2	31	0	0	0	0	0	3	8	9	2	5	5	63
3	4	0	0	0	0	0	0	1	1	0	1	1	9
4	4	0	0	0	0	0	0	1	1	0	1	1	8
5	14	-4	-1	-1	-5	-4	-1	2	4	1	4	5	13
6	29	0	0	0	0	0	6	9	9	2	5	9	70
7	0	0	0	0	-2	-1	1	2	6	0	1	0	6
8	-23	-40	-14	-11	-65	-50	-4	17	83	10	16	6	-77
9	-56	-74	-24	-15	-67	-54	3	23	97	40	61	19	-46
10	-5	-4	-1	-1	-3	-2	0	1	12	8	9	-20	-6
11	0	0	0	0	0	0	2	2	8	0	1	0	12
12	101	-27	-9	-5	-28	-25	-10	15	38	25	56	62	193
13	25	-7	-3	-2	-8	-7	-3	4	13	10	21	20	64
14	-2	-2	0	0	-1	-1	1	1	7	5	7	1	16
15	-3	-3	-1	-1	-3	-2	-1	1	12	8	13	1	22
16	-3	-4	-1	-1	-3	-3	-1	2	35	50	71	3	147
17	-142	-150	-44	-26	-129	-117	-127	-83	493	981	1186	-21	1823
18	-83	-89	-26	-15	-74	-67	-78	-57	357	762	888	-13	1505
19	-45	-47	-14	-8	-38	-33	-43	-36	183	457	546	-15	907

NA: Not Analyzed

Table 8.C.10
Water District Structural Measures
Average of Years 1975 - 1994
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	58	0	0	0	0	0	29	173	312	264	328	121	1285
2	114	0	0	0	0	0	30	270	560	512	674	234	2395
3	17	0	0	0	0	0	4	37	78	73	104	34	346
4	16	0	0	0	0	0	4	28	53	55	78	27	262
5	24	-4	-1	-1	-5	-4	-1	22	71	100	154	46	400
6	52	0	0	0	0	0	12	108	216	188	257	96	929
7	0	0	0	0	-2	-1	9	39	156	172	220	28	619
8	-23	-40	-14	-11	-65	-50	-4	218	1229	1289	1598	155	4281
9	-56	-74	-24	-15	-67	-54	9	126	746	907	1088	93	2679
10	-5	-4	-1	-1	-3	-2	0	3	63	91	88	-20	209
11	0	0	0	0	0	0	26	58	256	268	336	0	944
12	172	-27	-9	-5	-28	-25	-10	81	407	669	1074	309	2609
13	41	-7	-3	-2	-8	-7	-3	19	96	160	271	75	633
14	-2	-2	0	0	-1	-1	2	5	38	55	73	2	169
15	-3	-3	-1	-1	-3	-2	-1	2	51	80	110	3	234
16	-3	-4	-1	-1	-3	-3	-1	2	60	99	137	5	289
17	-142	-150	-44	-26	-129	-117	-127	-83	527	1124	1296	-21	2109
18	-83	-89	-26	-15	-74	-67	-78	-57	368	812	926	-13	1605
19	-45	-47	-14	-8	-38	-33	-43	-36	183	457	546	-15	907

NA: Not Analyzed

Certain previous studies have shown that irrigation water demand is generally "inelastic", which implies that the percentage reduction in water use would likely be less than the percentage increase in water cost to farmers (Michelsen and Young, 1998). Farmers' inclinations and incentives to irrigate their crops less are addressed under deficit irrigation. In theory, the water price for marginal use could be raised to achieve that same effect. This would require pricing for certain blocks of water at certain times, for which measurement systems are currently unavailable. This feature would suggest that water savings from conservation pricing might be modest unless the new rate structure results in substantial increases in the price of water to farmers. Farming will stop if water price renders it uneconomic.

Water use reduction through conservation pricing faces a host of considerable barriers to adoption. While conservation rates are increasingly common among municipal utilities, such rate structures are very rare among irrigation districts. By definition, conservation pricing implies that district revenue will vary depending on the amount of water delivered to farmers. Unlike most municipal systems, the bulk of irrigation district costs are often fixed rather than varying with the amount of water delivered. Further, irrigation districts face uncertainty both in terms of the amount of water farmers will need in a given year and in the amount of supply that will be available to the district for delivery to the farmers. Therefore, irrigation districts usually avoid revenue methods that depend on price per unit of water delivered. They need more certainty.

A recent study funded by the USGS and Washington State found that irrigation districts were most likely to adopt conservation pricing when farmers already face high costs for their water supplies, are growing high value crops and have warmer and longer growing seasons (Michelsen and Young, 1998). These conditions are more typical in areas like California than in the Platte River study area.

On the basis of the aforementioned issues, the study team has concluded that voluntary conservation pricing of irrigation water supplies is unlikely to lead to meaningful water savings in the study area, or at least is too speculative to proceed based on current information.

For different reasons, the study team also believes that conversion from schedule based to demand based irrigation delivery is impractical for most districts in the study area and unlikely to reduce water use. Current irrigation scheduling practices reflect both the management and the physical capabilities of irrigation systems in the Platte River study area. Certainly, scheduling and delivering water on demand would pose extraordinary new management requirements for irrigation companies. Converting to demand-based irrigation may be physically impossible for many systems. Demand based scheduling might well create excessive peak delivery requirements for conveyance facilities, which were designed for relatively steady water deliveries throughout the irrigation season (Central Nebraska Water Conservation Task Force, 1999). Even if demand based irrigation were physically possible, it is not clear that this form of scheduling actually reduces consumptive use (Northern Colorado Water Conservancy District [NCWCD], 1999a). This program is too speculative to proceed with, based on current information. Therefore, the study team recommends deferring this measure from further evaluation at this time.

Region 2

Almost 700,000 acres of irrigated land are harvested annually in Region 2. Table 8.C.11 summarizes the major crops grown in Region 2 and their estimated consumptive irrigation requirements.

Table 8.C.11 Region 2 Cropping Patterns and Consumptive Irrigation Requirements

Region 2	Irrigated Acres	Average Annual Consumptive Irrigation Requirement/Acre (inches)
Reaches 7-9, 11		
Corn	345,600	15
Alfalfa and Other Hay	202,600	23
Dry Beans	63,400	13
All Other Crops	80,600	Various
Total	692,200	

Source: Study team analysis of NRCE agricultural database, 1999. Based on data from 1992, 1994 and 1996 agricultural years.

Conservation Cropping Patterns

As shown in Table 8.C.11, corn is the most widely grown crop in Region 2, though alfalfa and other hay crops account for more than 25 percent of irrigated acreage in the region. The CIR for hay indicates that hay crops are much more water-intensive than either corn or dry beans. In Region 2, the study team has assumed that a conservation cropping program would focus on providing financial incentives for farmers to reduce acreage planted in hay and convert those acres to corn production.

Yield

Theoretically, there would appear to be potential for considerable water savings from an incentive program encouraging reduction in hay acreage and conversion to corn. If all current alfalfa and other hay acreage in Region 2 were converted to corn, the estimated reduction in CIR on Region 2 farms would be approximately 130,000 ac-ft per year. If only surface water irrigated acreage were considered, the theoretical potential water use reduction from wholesale conversion would still be more than 80,000 ac-ft of annual consumptive use.

The reasons for the cropping decisions made by individual farmers in Region 2 are complex. The study team's analysis of NRCE data suggests that the gross revenues per acre planted in corn and alfalfa in Region 2 are reasonably comparable, although alfalfa may have a somewhat lower cost of production. Farm specific factors may be a more important influence on the cropping choices of individual farmers than average gross margins. These factors may include soils, management requirements, past practice, risk tolerance, existing farm equipment, and others.

As in Region 1, part of the reason for growing hay may also be the tolerance of the crop in the face of uncertain water supplies. Shortage of water to meet the full consumptive irrigation requirements of crops is common, and holders of more variable junior water rights may regard alfalfa production as a "shock absorber" to deal with the possibility of lower than ideal water supplies (CWRRI, 1996; NCWCD, 1999b).

Given these barriers to crop conversion, it is difficult to predict the potential response to an incentive program focused on changes in cropping patterns. For purposes of evaluation, the study team has assumed that such a program might be able to elicit participation from 20 percent of irrigated hay acreage in Region 2. After restricting the program to acreage irrigated with surface water supplies, this prospective penetration rate means that the conservation cropping program might reduce consumptive use in the region by about 23,000 ac-ft per year.

Monthly changes in water use associated with conservation cropping in Region 2 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.2 depicts the estimated on-site net hydrologic effects of the representative conservation cropping program, by reach and by month. Table 8.C.3 depicts the effects of the representative conservation cropping program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.4 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

As noted earlier, the study team believes that the barriers to converting acreage from hay to corn production in Region 2 are not simply a matter of a difference in average financial returns between the two crops. Given the host of factors that influence cropping decisions, estimates of the cost of a conservation cropping program for Region 2 are quite uncertain without field research or a demonstration program that was beyond the scope of this evaluation. It may be that conservation cropping is best left as an option for individual farmers considering participation in other alternatives, such as temporary water leasing arrangements. In order to preserve this alternative for possible further consideration at a later point, the study team has assumed that participating farmers would be compensated with payments per ac-ft conserved on-site comparable to those estimated for short-term leasing arrangements described in Section 8.F. Further research will be needed to determine the acceptability to farmers of this level of compensation for participation in a conservation cropping program.

Deficit Irrigation Practices

As in Region 1, deficit irrigation already occurs to some extent in Region 2 due to shortages in available water supplies (CWRRI, 1996). Given the risks associated with deficit irrigation of corn in an area with as little precipitation as Region 2 experiences, the study team has assumed that only acres planted in hay might be convinced to participate in such a program.

Yield

The study team has assumed that a representative deficit irrigation program in Region 2 would seek 25 percent reductions in water use from hay farmers irrigating with surface water supplies. If all such acres in Region 2 typically receive a full irrigation supply and are willing to participate in this type of voluntary deficit irrigation program, the theoretical on-site reduction in consumptive use from this alternative would be approximately 80,000 ac-ft per year.

A more realistic expectation is that as much as 20 percent of eligible acres might be enrolled in the program if sufficient financial incentive were provided. This level of participation would result in estimated reductions in on-farm consumptive use of approximately 16,000 ac-ft per year in Region 2.

Monthly changes in water use associated with deficit irrigation in Region 2 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.5 depicts the estimated on-site net hydrologic effects of the representative deficit irrigation program, by reach and by month. Table 8.C.6, depicts the effects of the representative deficit irrigation program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.7 provides a similar summary of effects on target flows, without

downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

Based on study team analysis of NRCE data regarding hay production economics in Region 2, the estimated annual impact on farm revenues from the representative deficit irrigation program would be $80 to $100 per participating acre planted in hay. While farmers might experience some savings in variable costs of production, these savings would likely be minimal in comparison to lost revenues.

In estimating potential costs, the study team assumed that farmers would have to be paid an additional incentive premium of 20 to 60 percent over and above their foregone revenues from deficit irrigation to participate. For purposes of estimating costs, we have used the mid-point of this range. While there is little or no precedent for large scale incentive-based deficit irrigation programs, the study team assumed that the costs of implementing and administering the program might be similar to the land fallowing alternative in Category 4. On this basis, we have assumed annual administrative costs would be about $20 per participating acre.

In total, the representative deficit irrigation program in Region 2 would cost an estimated $3.3 million per year excluding additional costs to protect the conserved water from downstream diversions. Capitalized total costs of the representative deficit irrigation program over a 20-year period (using a six percent discount rate appropriate to governmental entities with access to tax free bond financing) would be approximately $41 million, or $3,700 per ac-ft of consumptive use saved on-farm. In Region 2, a number of sand dams would have to be improved or modified if conserved supplies are to be protected from downstream diversions. Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $49 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative were not implemented in every reach.

If sand dams are modified to bypass flows, then more than one alternative could be located above the sand dams without incurring the additional cost of sand dam replacement. The sand dams would only be modified once, therefore, the total cost to replace these dams would be spread among all projects implemented under the Program in Colorado, as opposed to each individual project. Therefore, the cost per acre foot for scenarios without diversion losses could be lower in the Action Plan if more than one alternative is selected in Region 2 that requires sand dam modifications.

Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be $3,750 if the saved water can be protected from downstream diverters. If the water cannot be protected, deficit irrigation in Region 2 cannot provide a substantive contribution toward reducing shortages to target flows at the critical habitat. This alternative has been deferred from further evaluation for most reaches in Region 2 because the costs per ac-ft of reduction in shortage at the critical habitat exceed $3,000.

On-farm Changes in Irrigation Techniques

As discussed in the operational definitions at the outset of this section, the study team focused its analysis of on-farm changes in irrigation techniques on the lower reaches in Region 3 because those reaches offer the most favorable hydrologic conditions for these measures from the standpoint of the goal of reducing shortages to target flows. On the basis of the results of the Region 3 examination, the average annual cost per ac-ft of reductions to target flow shortages from on-farm changes in irrigation techniques in Region 2 would far exceed the threshold cost of $3,000. Consequently, on-farm changes in irrigation techniques were deferred from further evaluation in Region 2.

Water District Structural Alternatives

As in other portions of the study area, a substantial amount of water in Region 2 is "lost" each year due to seepage from irrigation conveyance facilities and spills. Based upon the most recent USGS data on water use and conveyance losses (for 1995), the study team estimates that annual conveyance losses in Region 2 are approximately 600,000 ac-ft per year. Average conveyance efficiency, which is the amount of water actually delivered to farms relative to the total amount diverted from the river, is estimated at about 68 percent.

As noted earlier, most of this "lost" water eventually returns to the river or provides return flows relied on by other irrigators. The primary effect of rehabilitating or improving conveyance facilities and water control structures is to change the timing of flows in the river rather than a reduction in consumptive use.

Yield

Potential water savings and costs of irrigation system rehabilitation and improvements depend on site specific factors. For purposes of this evaluation, the study team has developed some approximate "rules of thumb" from system-specific studies in the Platte River Basin. The most cost effective combination of canal lining, automating turnouts, new siphons, improved flow measurement and other techniques for individual irrigation systems appear to typically increase conveyance efficiency by about five percent.

Most of the water saved through such measures would ultimately have returned to the system. While this proportion varies by location, the study team has used the common assumption that 85 percent of system losses would eventually return to the river (Missouri Basin States Association, 1982a; CNPPID et al., 1999).

Overall, the study team estimates that a comprehensive program focused on the most cost effective improvements to irrigation district facilities and improved water control structures throughout all irrigation systems in the region could reduce Region 2 diversions by more than 100,000 ac-ft per year. Non-productive consumptive use could be reduced by an estimated 16,000 ac-ft per year. Both of these estimates are subject to considerable uncertainty without detailed study on a system by system basis.

Monthly changes in water use associated with irrigation system rehabilitation and improvements in Region 2 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this alternative and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.8 depicts the estimated on-site net hydrologic effects of water district structural conservation alternatives, by reach and by month. Table 8.C.9, depicts the effects of the structural alternatives in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.10 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

The costs of measures to improve or rehabilitate water district facilities are as site specific as the potential water benefits. Costs for Region 2 could be higher or lower than Regions 1 or 3, depending upon physical conditions. Unfortunately, specific Region 2 costs were not identified. Using the mid-point of costs found in Region 1 and Region 3, the study team estimates that the average cost of such measures (in 1999 dollars) would be approximately $750 per ac-ft of reduced seepage or spillage. After adding engineering costs and transaction costs to transfer the salvaged water savings, the average cost per ac-ft of reduced diversions would be approximately $900. This cost estimate translates into an average cost per ac-ft of reduced consumptive use on-site of about $6,000. This alternative has been deferred from further evaluation for all reaches in Region 2 because the costs per ac-ft of reduction in shortage at the critical habitat exceed $3,000.

Water District Non-Structural Alternatives

As discussed in detail earlier for Region 1, the study team believes it is impractical to expect voluntary water savings through conservation pricing or conversion to demand based irrigation scheduling. Both measures face a host of institutional, administrative and physical barriers that make their widespread adoption unlikely. Further, the amount of water that would actually be saved by either measure in the Platte River study area is unlikely to be substantial. This alternative has been deferred from further evaluation for all reaches in Region 2.

Region 3

About 725,000 acres of irrigated land are harvested annually in Region 3. Table 8.C.12 summarizes the major crops grown in Region 3 and their estimated, consumptive irrigation requirements. The study team has depicted the western and eastern portions of Region 3 separately to recognize the greater role of soybeans in irrigated agriculture in the eastern portions of the region.

Table 8.C.12 Region 3 Cropping Patterns and Consumptive Irrigation Requirements

Region 3	Irrigated Acres	Average Annual Consumptive Irrigation Requirement/Acre (inches)
Reaches 10, 14-15 (western portion)		
Corn	85,700	13
Alfalfa and Other Hay	15,100	21
Dry Beans	4,300	12
All Other Crops	3,200	Various
Total	108,300	
Reaches 16-19		
Corn	541,800	13
Soybeans	36,500	9
Alfalfa and Other Hay	29,700	21
All Other Crops	9,700	Various
Total	617,700	

Source: Study team analysis of NRCE agricultural database, 1999. Based on data from 1992, 1994 and 1996 agricultural years.

Conservation Cropping Patterns

As shown in Table 8.C.12, corn is the dominant crop in Region 3. In contrast to the other study regions, hay production accounts for less than ten percent of Region 3 irrigated acreage. Given the modest amount of hay production in the region, a conservation cropping program focused on shifting production from hay to other crops (as described for Region 1 and Region 2) would produce minimal reductions in consumptive use. Instead, the study team has focused this analysis on an alternative crop rotation described by Joel Schneekloth from the University of Nebraska. In Region 3, a deficit irrigation program might include incentive payments to farmers to convert from continuous corn cropping to an alternating corn and soybean rotation.

Yield

Estimated on-farm consumptive use savings from implementing the alternating corn and soybean rotation are three inches per acre per year (University of Nebraska Extension Service, 1999). Since soybeans are not commonly grown in the western portions of Region 3 at present, the study team has focused on potential water savings from implementing the alternating corn and soybean rotation in the eastern portion of the region (Reaches 16 through 19). Of the more than 500,000 acres planted in corn in this area, only 170,000 acres are irrigated with surface water supplies. If all acres currently planted in corn and irrigated with surface supplies were shifted to the alternating water conservation rotation, the annual reduction in on-farm consumptive use would be over 40,000 ac-ft per year.

Changing cropping patterns from a continuous corn rotation to an alternating rotation of corn and soybeans might not be an easy transition. The conservation rotation would require more intensified farm management, a change from historical practice, such as fertilizing, and new equipment in many cases. A complete shift to this revised rotation by surface irrigation corn farmers in Region 3's eastern portion would also more than double total soybean production in the area with uncertain impacts on the price and economic viability of soybeans. However, a shifting to soybeans has been noted in parts of Region 3 in recent years.

Given these issues, the study team has assumed that no more than 30 percent of eligible acres in Region 3 would be enrolled in a voluntary conservation cropping program. With this assumption, the estimated on-farm reduction in consumptive use in Region 3 would be approximately 14,000 ac-ft per year.

Monthly changes in water use associated with conservation cropping in Region 3 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.2 depicts the estimated on-site net hydrologic effects of the representative conservation cropping program, by reach and by month. Table 8.C.3 depicts the effects of the representative conservation cropping program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.4 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

The conservation cropping rotation evaluated by the study team would not be expected to adversely affect farm yields or revenues. Management, operational costs, supplies and equipment costs would likely rise, however. Little basis has been found which might lead to reliable projections of these cost increases, the incentive payments required to induce farmers to change traditional practices, or the administrative cost of such a conservation cropping program.

In order to preserve this alternative for possible further consideration at a later point, the study team has assumed that participating farmers would be compensated with payments per ac-ft conserved on-site comparable to those estimated for short-term leasing arrangements described in Section 8.F. Further research will be needed to determine the acceptability to farmers of this level of compensation for participation in a conservation cropping program. Conservation cropping was deferred from further evaluation in Reaches 14 and 15 because it was estimated that a conservation cropping program would produce less than 500 ac-ft of annual reduction in target flow shortages.

Deficit Irrigation Practices

In Region 3, a deficit irrigation program would logically focus on reducing water use in irrigated corn production. Such a program is more likely to be feasible in the eastern portion of Region 3, which relies more heavily on corn and which receives greater annual precipitation. The study team has assumed that a representative deficit irrigation program would reduce irrigation consumptive use on corn fields in Reaches 16 through 19 by six inches per year. Such a program would likely decrease corn yields by 20 to 25 percent (University of Nebraska Extension Service, 1999).

Yield

The representative deficit irrigation program evaluated by the study team would focus on surface irrigated corn acres. If all eligible acres in the eastern reaches typically received a full irrigation supply and were willing to participate in this type of voluntary deficit irrigation program, the theoretical on-site reduction in consumptive use from this alternative would be approximately 90,000 ac-ft per year.

A more plausible upper bound expectation is that 20 percent of eligible acres might be enrolled in the program if sufficient financial incentive were provided. This level of participation would result in estimated reductions in on-farm consumptive use of over 18,000 ac-ft per year.

Monthly changes in water use associated with deficit irrigation in Region 3 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.5 depicts the estimated on-site net hydrologic effects of the representative deficit irrigation program, by reach and by month. Table 8.C.6, depicts the effects of the representative deficit irrigation program in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.7 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

Based on study team analysis of NRCE data regarding corn production economics in the eastern reaches of Region 3, the estimated annual impact on farm revenues from the representative deficit irrigation program would be $90 to $100 per participating acre planted in corn.

While farmers might experience some savings in variable costs of production, these savings would likely be minimal in comparison to lost revenues.

For purposes of providing a rough estimate of potential costs associated with this alternative, the study team has assumed that farmers would have to be paid an incentive of 20 to 60 percent over and above their foregone revenues from deficit irrigation to participate. For purposes of estimating costs, we have used the mid-point of this potential incentive range. While there is little or no precedent for large scale incentive-based deficit irrigation programs, the study team has assumed that the costs of implementing and administering the program might be similar to the land fallowing alternative described in Section 8.F. On this basis, we have assumed annual administrative costs would be about $20 per participating acre.

In total, the representative deficit irrigation program in Region 3 would cost an estimated $5.0 million per year. Capitalized total costs of the representative deficit irrigation program over a 20-year period (using a six percent discount rate appropriate to governmental entities with access to tax free bond financing) would be approximately $57 million, or over $3,000 per ac-ft of consumptive use saved on-farm.

Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be about $3,700, assuming conserved water is protected from downstream diversion. If the water cannot be protected, deficit irrigation in Region 3 cannot provide a substantive contribution toward reducing shortages to target flows at the critical habitat. This alternative has been deferred from further evaluation for all reaches in Region 3 because the costs per ac-ft of reduction in shortage at the critical habitat exceed $3,000.

On-farm Changes in Irrigation Techniques

Two hydrologic circumstances unique to the lower reaches in Region 3 (reaches 17, 18 and 19) make these reaches the best candidates for reducing shortages to target flows through on-farm alternatives aimed at improving irrigation efficiency. First, these reaches are the closest to the critical habitat, so any additions to Platte flows in these reaches suffer the smallest reductions enroute to the critical habitat. Second, unlike most of the study area, a large portion of the return flows in this area does not return to the Platte system above the critical habitat.

While circumstances vary throughout the study area, in general about 85 percent of return flows throughout the study region are believed to eventually return to the river (Missouri Basin States Association, 1982a; CNPPID, et al., 1999). However, in reaches 17, 18 and 19, a large portion of return flows either return to the Republican River Basin, accrete to the groundwater mound or return to the Platte River below the critical habitat in some cases. While the exact proportion of return flows that do return to the river is not known it was assumed that 50 percent of the returns do not return to the river in reaches 17 through 19. As a consequence, measures that focus on reducing return flows by improving on-farm irrigation efficiency have the potential to offer considerable benefit to the objectives of reducing shortages to target flows.

Yield

Much of the surface water supplied irrigation in reaches 17, 18 and 19 is provided through the system operated by CNPPID. Since the early 1990s, CNPPID has surveyed irrigation practices in its service area and sponsored a substantial program to encourage on-farm changes in irrigation techniques to increase efficiency. To date, CNPPID has assisted in implementing on-farm conservation improvements on more than 19,000 contract acres. On average, on-farm delivery requirements of participating farms have been reduced by an estimated 0.5 ac-ft per acre per year, although the validity of the Irrigation Efficiency Credit System used to estimate savings is still under evaluation. (Central Nebraska Regional Water Conservation Task Force, 1998; CNPPID, 1999f).

A 1993 survey conducted by CNPPID indicates that about 50 percent of the surface supplied irrigated acreage within their district is irrigated with techniques that have substantial potential for increases in efficiency. Such acres may be currently irrigated via open ditches or gated pipe, both without runoff recovery. On the basis of CNPPID's survey results, the study team assumed that up to 50 percent of surface water irrigated acres in reaches 17, 18 and 19 might participate in a program to change irrigation techniques and improve efficiencies if financial compensation for costs was provided.

On this basis, the study team estimated that 25,000 acres in reach 17, 32,000 acres in reach 18 and 27,000 acres in reach 19 might participate in this alternative. Based upon the results of CNPPID's program over the past seven years, this level of participation would reduce on-farm delivery requirements in reach 17 by 12,500 ac-ft per year; in reach 18 by 16,000 ac-ft per year; and in reach 19 by 13,500 ac-ft per year.

Monthly changes in water use associated with a program to change irrigation techniques and improve efficiency in the selected Region 3 reaches were routed downstream using the water budget spreadsheet. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.13 depicts the estimated on-site net hydrologic effects of changes in irrigation techniques, by reach and by month. Table 8.C.14, depicts the effects of changes in irrigation techniques in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.15 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

Improvements in on-farm efficiency through changes in irrigation techniques are not inexpensive. During the past seven years, CNPPID has calculated the average cost of these measures on the more than 19,000 participating acres in its program at $217 per year per ac-ft of reduced on-farm deliveries-- although CNPPID indicates they would expect some farmers to participate even if irrigators paid a share of these costs. (CNPPID, 1999f). Applying the $217 per acre foot unit cost to the larger program described herein and capitalizing the annual costs based on a six percent discount rate and 20-year program horizon implies a capitalized cost of about $31 million in reach 17, about $40 million in reach 18 and about $34 million in reach 19.

These projected costs would result in a capitalized cost of over $3,000 per ac-ft of average annual shortage reduction (ranging from about $3,800 to about $4,400 per ac-ft assuming protection from downstream diverters). Since $3,000 per ac-ft had been previously established by the Water Management Committee as the maximum

Table 8.C.13
Change In Irrigation Techniques (On-farm)
Net Hydrologic Effects on Site - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
18	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
19	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950

NA: Not Analyzed

Table 8.C.14
Change In Irrigation Techniques (On-farm)
Average of Years 1975 - 1994
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	-258	-274	-80	-47	-235	-213	-195	-73	1655	2866	3775	83	7004
18	-287	-307	-88	-51	-256	-232	-249	-152	1901	3508	4581	70	8439
19	-284	-294	-88	-51	-239	-209	-260	-210	1759	3792	4922	-23	8816

NA: Not Analyzed

Table 8.C.15
Change In Irrigation Techniques (On-farm)
Average of Years 1975 - 1994
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
9	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
14	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
15	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
17	-258	-274	-80	-47	-235	-213	-195	-73	1767	3295	4127	85	7900
18	-287	-307	-88	-51	-256	-232	-249	-152	1963	3755	4785	71	8951
19	-284	-294	-88	-51	-239	-209	-260	-210	1759	3792	4922	-23	8816

NA: Not Analyzed

cost per ac-ft of reduction to target flow shortages, this alternative was deferred from further evaluation at this time.

Water District Structural Alternatives

As in other portions of the study area, a substantial amount of water in Region 3 is "lost" each year due to seepage from irrigation conveyance facilities and spills. Based upon the most recent USGS data on water use and conveyance losses (for 1995), the study team estimates that annual conveyance losses in Region 3 are approximately 200,000 ac-ft per year. Average conveyance efficiency — the amount of water actually delivered to farms relative to the total amount diverted from the river, is estimated at about 73 percent.

As noted earlier in the section, most of this "lost" water eventually returns to the river or provides return flows relied on by other irrigators. The primary effect of rehabilitating or improving conveyance facilities and water control structures is to change the timing of flows in the river rather than a reduction in consumptive use.

Yield

Potential water savings and costs of irrigation system rehabilitation and improvements depend on site specific factors. CNPPID has been implementing an aggressive conservation plan since 1994. The 1998 report indicated that approximately 5,400 ac-ft per year had been saved through lateral rehabilitation measures, pipelines and membrane lining. CNPPID's goal is to ultimately reduce losses through canal and delivery system improvements by at least 9,148 ac-ft (Central Nebraska Regional Water Conservation Task Force, 1998).

The Nebraska Public Power District (NPPD) has previously studied possible benefits and costs of lining its large canals. Lining a three mile stretch of the Gothenburg Main Canal might reduce seepage losses by about 8,000 ac-ft per year at. Lining key portions of the Sutherland Supply Canal could reduce annual seepage losses by as much as 15,800 ac-ft per year (Harza, 1993).

In the upper reaches of Region 3, most of the water saved through such measures would ultimately have returned to the system. While this proportion varies by site-specific circumstances, the study team has used the common assumption that 85 percent of system losses in these reaches would eventually return to the river (Missouri Basin States Association, 1982a; CNPPID, et al., 1999). In reaches 17 through 19 a different hydrologic situation exists. Much of the return flow in these reaches does not return to the Platte system above the critical habitat due to accretions to the groundwater mound, movement to the Republican Basin or return to the Platte further downstream. While the exact proportion of return flows from these reaches returning to the Platte above the critical habitat is unknown, the study team has assumed that 50 percent do not return to the river above the habitat.

Additional seepage reduction opportunities beyond these specific examples likely exist in the region. Recognizing the numerous Region 3 canal systems, the study team estimates that canal lining and distribution system improvements might reduce total seepage in Region 3 by about 30,000 ac-ft per year. These measures would result in an estimated reduction of water losses to non-tributary groundwater and non-productive consumptive use of approximately 10,000 ac-ft per year.

Monthly changes in water use associated with irrigation system rehabilitation and improvements in Region 3 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this alternative and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Table 8.C.8 depicts the estimated on-site net hydrologic effects of water district structural conservation alternatives, by reach and by month. Table 8.C.9, depicts the effects of the structural alternatives in reducing shortages to target flows at the critical habitat, assuming no protection from downstream diverters. Table 8.C.10 provides a similar summary of effects on target flows, without downstream diversions. These results are summarized in Table 8.C.16 under the yield summary near the end of this section.

Cost

The costs of measures to improve or rehabilitate water district facilities are as site-specific as the potential water benefits. As of 1998, the average annual cost of CNPPID's program to reduce losses from canals and distribution facilities was about $32 per ac-ft of reduced losses. Capitalizing this cost based on a 20-year period and six percent discount rate implies a capitalized cost per ac-ft of reduced losses of about $375. The cost of the canal lining options examined by NPPD varies from about $200 per ac-ft for lining the three mile stretch of the Gothenburg Main Canal to as much as $640 per ac-ft to line stretches of the Sutherland Supply Canal (Harza, 1993).

Combining these various cost estimates, the study team estimates that the average cost of achieving reduction in seepage and other canal and distribution system losses in Region 3 would be approximately $500 per ac-ft at the site. This implies an average capitalized cost for recovering water lost from the Platte River system to non-productive consumptive use, the groundwater mound, or the Republican Basin of about $1,500 per ac-ft at the site.

Water District Non-Structural Alternatives

As discussed in more detail earlier for Region 1, the study team believes it is too speculative based on current information to expect substantial voluntary water savings through conservation pricing or conversion to demand based irrigation scheduling. In general, both non-structural measures face a host of institutional, administrative and physical barriers that make their widespread adoption unlikely.

CNPPID has adopted an incremental pricing and conservation credit program. CNPPID believes this program has had positive effects in making farmers consider their water use more carefully, but the extent of any water use reduction from this program is unclear at this time. The conservation credit program implemented by CNPPID under the auspices of the Central Nebraska Conservation Task Force represents a first step toward semi-demand based scheduling (CNPPID, 1999c; 1999f).

In essence, irrigators are allowed to earn credits for water they are entitled to take but choose to defer. This program currently shifts irrigation water use to times when farmers are presumably facing a shortage. Although this is a positive program from several standpoints, it is unclear whether farmers are gaining credits for water not needed or whether farmers would give up the deferral feature entirely. The CNPPID version of incremental pricing amounts to a discount in the traditional dollar per acre water charge if the farmer takes less water per acre. The program, geared toward high water use farms, has not shown any quantifiable savings since its initiation in 1995. This alternative has been deferred from further evaluation.

5. Yield Summary

The agricultural conservation alternatives discussed in this section are somewhat scaleable, to varying degrees. In general, deficit irrigation is the most scaleable of these measures throughout the study region.

Based upon the operating definitions and the study team's best estimates of likely participation in the agricultural conservation measures, the total annual on-site reduction in consumptive use from these measures across the study region ranges from about 45,000 ac-ft from irrigation system structural measures and conservation cropping to about 60,000 ac-ft per year from deficit irrigation. However, the principal potential benefit of the structural conservation alternatives may be in changing the timing of much larger flow volumes rather than reducing non-productive consumptive use. Yield for each alternative and each reach is summarized in Table 8.C.16.

Assuming no diversion losses, estimated annual reductions in shortages to target flows at Grand Island from the implementation of each alternative across the entire study area range from about 44,000 ac-ft per year under the deficit irrigation alternative to 22,000 ac-ft per year under the irrigation district structural rehabilitation and improvements alternative. With diversion losses downstream, most of the agricultural conservation measures, in most reaches, would be unable to contribute substantially to the goal of reducing shortages in target flows.

6. Cost Summary

Table 8.C.16 also summarizes the estimated costs associated with the agricultural conservation alternatives. The study team estimates that implementation of deficit irrigation programs throughout the study area as described in this section would cost as much as $150 million as a capitalized, front-end amount. Comprehensive implementation of structural measures to improve irrigation district conveyance and

TABLE 8.C.16

Alternatives Yield and Cost by Reach: Category 2 – Agricultural Conservation Measures

	Yield 20-year Average Annual Values (ac-ft/yr)							Capitalized Costs			
Reach Alternative	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Reach 1											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	2,445	2,418	2,418	134	1,743	31	1,150	$4	$4	$138,760	$3,740
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	2,737	2,706	2,706	150	1,951	35	1,285	$22	$22	$625,600	$17,040
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 2											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	6,211	6,187	6,187	325	4,457	77	2,905	$10	$10	$124,650	$3,300
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	5,106	5,086	5,086	267	3,664	63	2,395	$41	$41	$648,370	$17,060
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 3											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	2,351	2,311	2,311	124	1,720	30	1,138	$4	$4	$133,410	$3,520
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	710	697	697	37	519	9	346	$6	$6	$630,740	$16,410
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 4											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	1,732	1,520	1,727	164	1,290	26	861	$3	$3	$110,870	$3,350
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	528	463	527	50	393	8	262	$4	$4	$528,080	$16,120
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 5											
Conservation Cropping	3,269	2,562	3,256	(890)	2,490	(480)	1,830	$2	$2	NA	$1,180
Deficit Irrigation	2,743	2,148	2,732	(745)	2,094	(403)	1,549	$5	$5	NA	$3,130
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	794	605	703	59	523	13	400	$6	$6	$488,350	$13,870
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 6											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	4,237	4,155	4,155	439	3,126	156	2,049	$9	$9	$60,070	$4,570
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	1,898	1,861	1,861	197	1,400	70	929	$15	$15	$216,880	$16,340
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA

*Capitalized accumulated value of implementation cost, capital costs and operating costs over 20 year period using 6 percent borrowing rate.

**Annual flow changes are reduced diversions net of reduced return flows.

NA: Not Analyzed.

TABLE 8.C.16 (cont.)
Alternatives Yield and Cost by Reach: Category 2 -- Agricultural Conservation Measures

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr)							Capitalized Costs			
	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Reach 7											
Conservation Cropping	1,873	1,102	1,952	(114)	2,108	(39)	1,474	$2	$2	NA	$1,490
Deficit Irrigation	1,337	789	1,393	(80)	1,502	(27)	1,054	$3	$3	NA	$2,920
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	1,183	755	1,038	40	807	6	619	$7	$8	$1,182,820	$12,440
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 8											
Conservation Cropping	14,613	9,770	17,600	(1,712)	14,783	(890)	9,879	$12	$16	NA	$1,580
Deficit Irrigation	9,922	6,636	11,943	(1,150)	10,032	(600)	6,822	$19	$23	NA	$3,370
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	7,831	5,252	8,305	64	6,511	(77)	4,281	$47	$51	NA	$11,910
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 9											
Conservation Cropping	9,515	3,592	10,254	(2,366)	9,196	(1,377)	6,368	$9	$12	NA	$1,860
Deficit Irrigation	6,326	2,399	6,815	(1,556)	6,112	(900)	4,297	$14	$17	NA	$3,950
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	4,930	2,902	5,262	102	4,222	(46)	2,679	$30	$32	NA	$11,980
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 10											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	0	0	0	0	0	0	0	$0	$0	NA	NA
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	307	268	320	5	301	(6)	209	$1	$1	NA	$4,890
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 11											
Conservation Cropping	1,826	1,036	1,824	72	1,358	12	904	$2	$3	$165,000	$2,880
Deficit Irrigation	1,632	927	1,630	65	1,215	11	812	$5	$6	$432,600	$7,080
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	1,904	1,082	1,902	76	1,418	12	944	$11	$12	$952,070	$13,130
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 12											
Conservation Cropping	8,667	4,338	8,724	(2,554)	6,842	(1,582)	4,998	$5	$5	NA	$940
Deficit Irrigation	7,467	3,740	7,509	(2,195)	5,883	(1,187)	4,306	$13	$13	NA	$2,910
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	5,311	3,746	5,289	498	3,928	193	2,609	$42	$42	$220,140	$16,280
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 13											
Conservation Cropping	2,250	1,878	2,200	(1,144)	1,902	(592)	1,557	$1	$1	NA	$810
Deficit Irrigation	1,873	1,565	1,833	(947)	1,581	(491)	1,304	$4	$4	NA	$2,700
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	1,224	1,132	1,209	151	921	64	633	$10	$10	$152,950	$15,460
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA

*Capitalized accumulated value of implementation cost, capital costs and operating costs over 20 year period using 6 percent borrowing rate.

**Annual flow changes are reduced diversions net of reduced return flows.

NA: Not Analyzed

TABLE 8.C.16 (cont.)
Alternatives Yield and Cost by Reach: Category 2 -- Agricultural Conservation Measures

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr) Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach (w/diversion loss)	Net Hydrologic Effects at Top of Downstream Reach (w/o diversion loss)	Net Hydrologic Effects at Habitat (w/diversion loss)	Net Hydrologic Effects at Habitat (w/o diversion loss)	Reduction to Target Flow Shortages at Habitat (w/diversion loss)	Reduction to Target Flow Shortages at Habitat (w/o diversion loss)	Capitalized Costs Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat (w/diversion loss)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat (w/o diversion loss)
Reach 14											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	0	0	0	0	0	0	0	$0	$0	NA	NA
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	320	270	318	44	250	16	169	$1	$1	$66,760	$6,320
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 15											
Conservation Cropping	0	0	0	0	0	0	0	$0	$0	NA	NA
Deficit Irrigation	0	0	0	0	0	0	0	$0	$0	NA	NA
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	444	301	456	63	353	22	234	$1	$1	$67,330	$6,330
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 16											
Conservation Cropping	2,541	1,002	2,543	549	1,881	377	1,343	$1	$1	$3,540	$990
Deficit Irrigation	3,713	1,466	3,721	807	2,758	544	1,929	$7	$7	$12,630	$3,560
On-farm Conservation	0	0	0	0	0	0	0	$0	$0	NA	NA
ID Structural Measures	549	325	541	241	428	147	289	$2	$2	$12,450	$6,330
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 17											
Conservation Cropping	5,116	5,076	5,076	3,376	3,713	2,066	2,513	$3	$3	$1,380	$1,120
Deficit Irrigation	7,197	7,142	7,142	4,475	5,235	2,872	3,502	$14	$14	$5,050	$4,140
On-farm Conservation	16,268	16,176	16,176	11,613	12,719	7,004	7,900	$31	$31	$4,440	$3,940
ID Structural Measures	4,196	4,169	4,169	2,853	3,197	1,823	2,109	$4	$4	$2,300	$1,990
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 18											
Conservation Cropping	7,287	5,552	7,388	5,169	5,490	3,318	3,586	$4	$4	$1,190	$1,100
Deficit Irrigation	10,144	7,730	10,295	7,209	7,658	4,547	4,912	$19	$19	$4,200	$3,890
On-farm Conservation	18,417	14,811	18,417	13,868	14,557	8,439	8,951	$40	$40	$4,720	$4,450
ID Structural Measures	3,130	2,461	3,149	2,303	2,444	1,505	1,605	$3	$3	$2,080	$1,950
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA
Reach 19											
Conservation Cropping	7,732	6,753	6,753	6,753	6,753	4,722	4,722	$4	$4	$870	$870
Deficit Irrigation	9,403	7,431	7,431	7,431	7,431	5,105	5,105	$17	$17	$3,370	$3,320
On-farm Conservation	14,950	13,356	13,356	13,356	13,356	8,836	8,816	$34	$34	$3,810	$3,810
ID Structural Measures	1,420	1,257	1,257	1,257	1,257	907	907	$1	$1	$1,570	$1,570
ID Non-structural Measures	0	0	0	0	0	0	0	$0	$0	NA	NA

*Capitalized accumulated value of implementation cost, capital costs and operating costs over 20 year period using 6 percent borrowing rate.

**Annual flow changes are reduced diversions net of reduced return flows.

NA: Not Analyzed.

delivery systems would cost as much as $250 million across the study area. Based upon the assumption that farmers would participate in a conservation cropping program for the same level of payment as in short-term leasing arrangements discussed in the evaluation of incentive based measures, the total cost of this program in the reaches where it is most likely to be practicable would be about $50 million.

Assuming no diversion losses, the cost per ac-ft of shortage reduction at the critical habitat would average about $3,590 under the deficit irrigation alternative. Average costs of shortage reduction through structural conservation measures would be about $12,000 per ac-ft without diversion losses. However, structural measures in Reaches 18, 18, and 19 produce a total of 4,500 ac-ft of reductions to target flow shortages at $1,500 to $2,000 per ac-ft.

7. Associated Issues

Each of the agricultural conservation alternatives that were not deferred from further evaluation was evaluated according to the associated issues evaluation criteria previously reviewed with the Water Management Committee. The five categories of associated issues are physical, legal/institutional, economic, social and environmental. The remainder of this evaluation section describes the study team's evaluation of the performance of the remaining agricultural conservation alternative in these five areas. Tabular scoring of each alternative according to each criteria are presented in Tables 8.C.17 through 8.G.26. Tables showing tabular scoring with diversions are presented first followed by tables showing tabular scoring without diversions. In all cases, the study team has only evaluated alternatives that have not been deferred from further evaluation. The following discussion initially presents an evaluation of each alternative assuming that conserved water will be protected from downstream diverters. Differences in the evaluation under the alternative scenario of no protection from downstream diversions are discussed at the close of each criteria category.

Conservation Cropping

Tables 8.C.17 and 8.C.22 present the tabular scoring for conservation cropping with and without diversions, respectively.

TABLE 8.C.17
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 2 - Agricultural Conservation
Alternative - Conservation Cropping Patterns

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Physical																			
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2
Sustainability																	3	3	3
Scalability																	1	1	1
Technically Implementable																	2	2	2
Time to Yield Realization																	4	4	4
Ability to Monitor and Measure																	3	3	3
Third Party Hydrologic Impacts																	3	3	3
Subtotal																	17	18	18
Subtotal Average																	2	3	3
Legal/Institutional																			
Ease of Permitting																	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	2	2	2
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	3	3	3
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	23	23	23
Subtotal Average																	3	3	3
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	3	3	3
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	3	3	3
Subtotal																	15	15	15
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction																	4	4	5
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	3	3	3
Effects on Economic Development Potential																	3	3	3
Subtotal																	21	21	22
Subtotal Average																	4	4	4
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	3	3	3
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	18	18	18
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	16	16

TABLE 8.C.18
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 2 - Agricultural Conservation
Alternative - Deficit Irrigation Practices

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Sustainability																			
Scalability																			
Technically Implementab'e																			
Time to Yield Realization																			
Ability to Monitor and Measure																			
Third Party Hydrologic Impacts																			
Subtotal																			
Subtotal Average																			
Legal/Institutional																			
Ease of Permitting																			
Consistent with Interstate Compacts, Federal Laws & Decrees																			
Consistent with State Laws																			
Potential for Institutional Consensus																			
Can be Mitigated																			
Administrative Ease																			
Consistent with Existing Contract, Facility & Land Ownership																			
Subtotal																			
Subtotal Average																			
Social																			
Effects on Customs and Culture																			
Equity of Impacts																			
Impacts on Community Organizations and Support Structures																			
Effects on Community Sustainability																			
Public Acceptability																			
Subtotal																			
Subtotal Average																			
Economic																			
Initial Implementation and Capital Cost																			
Average Annual Total Cost per Acre-Foot Reduction																0	0	0	0
Direct Economic Impacts																			
Secondary Economic Impacts																			
Fiscal Impacts																			
Effects on Economic Development Potential																			
Subtotal																			
Subtotal Average																			
Environmental																			
Impacts to Wetlands																			
Impacts to Habitat																			
Impacts to Water Quality																			
Impacts to Prime and Unique Farmlands																			
Visual Impacts																			
Impacts to Amenities																			
Subtotal																			
Subtotal Average																			
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 8.C.19
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 2 - Agricultural Conservation
Alternative - On-farm Changes in Irrigation Techniques

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Sustainability																			
Scalability																			
Technically Implementable																			
Time to Yield Realization																			
Ability to Monitor and Measure																			
Third Party Hydrologic Impacts																			
Subtotal																			
Subtotal Average																			
Legal/Institutional																			
Ease of Permitting																			
Consistent with Interstate Compacts, Federal Laws & Decrees																			
Consistent with State Laws																			
Potential for Institutional Consensus																			
Can be Mitigated																			
Administrative Ease																			
Consistent with Existing Contract, Facility & Land Ownership																			
Subtotal																			
Subtotal Average																			
Social																			
Effects on Customs and Culture																			
Equity of Impacts																			
Impacts on Community Organizations and Support Structures																			
Effects on Community Sustainability																			
Public Acceptability																			
Subtotal																			
Subtotal Average																			
Economic																			
Initial Implementation and Capital Cost																			
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Economic Impacts																			
Secondary Economic Impacts																			
Fiscal Impacts																			
Effects on Economic Development Potential																			
Subtotal																			
Subtotal Average																			
Environmental																			
Impacts to Wetlands																			
Impacts to Habitat																			
Impacts to Water Quality																			
Impacts to Prime and Unique Farmlands																			
Visual Impacts																			
Impacts to Amenities																			
Subtotal																			
Subtotal Average																			
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 8.C.20
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 2 - Agricultural Conservation
Alternative - Water District Structural Alternatives

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Sustainability																	5	5	5
Scalability																	1	1	1
Technically Implementable																	5	5	5
Time to Yield Realization																	3	3	3
Ability to Monitor and Measure																	3	3	3
Third Party Hydrologic Impacts																	2	2	2
Subtotal																	20	20	20
Subtotal Average																	3	3	3
Legal/Institutional																			
Ease of Permitting																	5	5	5
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	5	5	5
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	5	5	5
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	31	31	31
Subtotal Average																	4	4	4
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	2	2	2
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	2	2	2
Subtotal																	13	13	13
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3
Direct Economic Impacts																	3	3	3
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	3	3	3
Subtotal																	17	17	18
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	2	2	2
Impacts to Habitat																	2	2	2
Impacts to Water Quality																	3	3	3
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	16	16	16
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	16

TABLE 8.C.21
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 2 - Agricultural Conservation
Alternative - Water District Non-Structural Alternatives

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sustainability																			
Scalability																			
Technically Implementable																			
Time to Yield Realization																			
Ability to Monitor and Measure																			
Third Party Hydrologic Impacts																			
Subtotal																			
Subtotal Average																			
Legal/Institutional																			
Ease of Permitting																			
Consistent with Interstate Compacts, Federal Laws & Decrees																			
Consistent with State Laws																			
Potential for Institutional Consensus																			
Can be Mitigated																			
Administrative Ease																			
Consistent with Existing Contract, Facility & Land Ownership																			
Subtotal																			
Subtotal Average																			
Social																			
Effects on Customs and Culture																			
Equity of Impacts																			
Impacts on Community Organizations and Support Structures																			
Effects on Community Sustainability																			
Public Acceptability																			
Subtotal																			
Subtotal Average																			
Economic																			
Initial Implementation and Capital Cost																			
Average Annual Total Cost per Acre-Foot Reduction																			
Direct Economic Impacts																			
Secondary Economic Impacts																			
Fiscal Impacts																			
Effects on Economic Development Potential																			
Subtotal																			
Subtotal Average																			
Environmental																			
Impacts to Wetlands																			
Impacts to Habitat																			
Impacts to Water Quality																			
Impacts to Prime and Unique Farmlands																			
Visual Impacts																			
Impacts to Amenities																			
Subtotal																			
Subtotal Average																			
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 8.C.22
Scoring Table - No Diversions in Any State
Category 2 - Agricultural Conservation
Alternative - Conservation Cropping Patterns

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	1	0	3	1	1	3	3	1	0	0	0	1	2	2	2
Sustainability					3		3	3	3	3	3	3				3	3	3	3
Scalability					1		2	1	1	3	2	1				1	1	1	1
Technically Implementable					2		2	2	2	2	2	2				2	2	2	2
Time to Yield Realization					4		4	4	4	4	4	4				4	4	4	4
Ability to Monitor and Measure					3		3	3	3	3	3	3				3	3	3	3
Third Party Hydrologic Impacts					2		2	2	2	2	2	2				2	2	2	2
Subtotal					16		19	16	16	20	19	16				16	17	17	17
Subtotal Average					2		3	2	2	3	3	2				2	2	2	2
Legal/Institutional																			
Ease of Permitting					2		2	2	2	2	2	2				2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees					5		5	5	5	5	5	5				5	5	5	5
Consistent with State Laws					3		2	2	3	3	3	3				2	2	2	2
Potential for Institutional Consensus					4		4	4	4	4	4	4				4	4	4	4
Can be Mitigated					3		3	3	3	3	3	3				3	3	3	3
Administrative Ease					2		2	2	2	2	2	2				2	2	2	2
Consistent with Existing Contract, Facility & Land Ownership					5		5	5	5	5	5	5				5	5	5	5
Subtotal					24		23	23	24	24	24	24				23	23	23	23
Subtotal Average					3		3	3	3	3	3	3				3	3	3	3
Social																			
Effects on Customs and Culture					3		3	3	3	3	3	3				3	3	3	3
Equity of Impacts					3		3	3	3	3	3	3				3	3	3	3
Impacts on Community Organizations and Support Structures					3		3	3	3	3	3	3				3	3	3	3
Effects on Community Sustainability					3		3	3	3	3	3	3				3	3	3	3
Public Acceptability					3		3	3	3	3	3	3				3	3	3	3
Subtotal					15		15	15	15	15	15	15				15	15	15	15
Subtotal Average					3		3	3	3	3	3	3				3	3	3	3
Economic																			
Initial Implementation and Capital Cost					5		5	5	5	5	5	5				5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction					4		5	5	4	3	3	1				5	4	4	5
Direct Economic Impacts					4		4	4	4	4	4	4				4	4	4	4
Secondary Economic Impacts					3		3	3	3	3	3	3				3	3	3	3
Fiscal Impacts					3		3	3	3	3	3	3				3	3	3	3
Effects on Economic Development Potential					3		3	3	3	3	3	3				3	3	3	3
Subtotal					22		23	23	22	20	21	19				23	22	22	23
Subtotal Average					4		4	4	4	3	4	3				4	4	4	4
Environmental																			
Impacts to Wetlands					3		3	3	3	3	3	3				3	3	3	3
Impacts to Habitat					3		3	3	3	3	3	3				3	3	3	3
Impacts to Water Quality					3		3	3	3	3	3	3				3	3	3	3
Impacts to Prime and Unique Farmlands					3		3	3	3	3	3	3				3	3	3	3
Visual Impacts					3		3	3	3	3	3	3				3	3	3	3
Impacts to Amenities					3		3	3	3	3	3	3				3	3	3	3
Subtotal					18		18	18	18	18	18	18				18	18	18	18
Subtotal Average					3		3	3	3	3	3	3				3	3	3	3
Overall Total (Sum of Averages)	0	0	0	0	15	0	16	15	15	15	16	14	0	0	0	15	15	15	15

TABLE 8.C.23
Scoring Table - No Diversions in Any State
Category 2 - Agricultural Conservation
Alternative - Deficit Irrigation Practices

	Region 1 Reaches									Region 2 Reaches			Region 3 Reaches						
	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Physical																			
Net Reduction in Shortage to Target Flows							2	1	1				0	0	0				
Sustainability							3	3	3										
Scalability							2	1	1										
Technically Implementable							2	2	2										
Time to Yield Realization							5	5	5										
Ability to Monitor and Measure							3	3	3										
Third Party Hydrologic Impacts							2	2	2										
Subtotal							19	17	17										
Subtotal Average							3	2	2										
Legal/Institutional																			
Ease of Permitting							2	2	2										
Consistent with Interstate Compacts, Federal Laws & Decrees							5	5	5										
Consistent with State Laws							2	2	3										
Potential for Institutional Consensus							3	3	3										
Can be Mitigated							3	3	3										
Administrative Ease							3	3	3										
Consistent with Existing Contract, Facility & Land Ownership							5	5	5										
Subtotal							23	23	24										
Subtotal Average							3	3	3										
Social																			
Effects on Customs and Culture							3	3	3										
Equity of Impacts							3	3	3										
Impacts on Community Organizations and Support Structures							3	3	3										
Effects on Community Sustainability							3	3	3										
Public Acceptability							3	3	3										
Subtotal							15	15	15										
Subtotal Average							3	3	3										
Economic																			
Initial Implementation and Capital Cost							5	5	5										
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	1	1	1	0	0	0				0	0	0	0
Direct Economic Impacts							4	4	4										
Secondary Economic Impacts							2	2	2										
Fiscal Impacts							2	2	2										
Effects on Economic Development Potential							3	3	3										
Subtotal							17	17	17										
Subtotal Average							3	3	3										
Environmental																			
Impacts to Wetlands							3	3	3										
Impacts to Habitat							3	3	3										
Impacts to Water Quality							3	3	3										
Impacts to Prime and Unique Farmlands							3	3	3										
Visual Impacts							3	3	3										
Impacts to Amenities							3	3	3										
Subtotal							18	18	18										
Subtotal Average							3	3	3										
Overall Total (Sum of Averages)	0	0	0	0	0	0	15	14	14	0	0	0	0	0	0	0	0	0	0

TABLE 8.C.24
Scoring Table - No Diversions in Any State
Category 2 - Agricultural Conservation
Alternative - On-farm Changes in Irrigation Techniques

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0			
Sustainability																			
Scalability																			
Technically Implementable																			
Time to Yield Realization																			
Ability to Monitor and Measure																			
Third Party Hydrologic Impacts																			
Subtotal																			
Subtotal Average																			
Legal/Institutional																			
Ease of Permitting																			
Consistent with Interstate Compacts, Federal Laws & Decrees																			
Consistent with State Laws																			
Potential for Institutional Consensus																			
Can be Mitigated																			
Administrative Ease																			
Consistent with Existing Contract, Facility & Land Ownership																			
Subtotal																			
Subtotal Average																			
Social																			
Effects on Customs and Culture																			
Equity of Impacts																			
Impacts on Community Organizations and Support Structures																			
Effects on Community Sustainability																			
Public Acceptability																			
Subtotal																			
Subtotal Average																			
Economic																			
Initial Implementation and Capital Cost																			
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Direct Economic Impacts																			
Secondary Economic Impacts																			
Fiscal Impacts																			
Effects on Economic Development Potential																			
Subtotal																			
Subtotal Average																			
Environmental																			
Impacts to Wetlands																			
Impacts to Habitat																			
Impacts to Water Quality																			
Impacts to Prime and Unique Farmlands																			
Visual Impacts																			
Impacts to Amenities																			
Subtotal																			
Subtotal Average																			
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 8.C.25

Scoring Table - No Diversions in Any State

Category 2 - Agricultural Conservation

Alternative - Water District Structural Alternatives

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows			0	0	0								0	0	0	0	1	1	1
Sustainability																	5	5	5
Scalability																	1	1	1
Technically Implementable																	5	5	5
Time to Yield Realization																	3	3	3
Ability to Monitor and Measure																	3	3	3
Third Party Hydrologic Impacts																	2	2	2
Subtotal																	20	20	20
Subtotal Average																	3	3	3
Legal/Institutional																			
Ease of Permitting																	3	3	3
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	3	3	3
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	5	5	5
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	27	27	27
Subtotal Average																	4	4	4
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	2	2	2
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	2	2	2
Subtotal																	13	13	13
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
Direct Economic Impacts																	3	3	3
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	3	3	3
Subtotal																	18	18	18
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	2	2	2
Impacts to Habitat																	2	2	2
Impacts to Water Quality																	3	3	3
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	16	16	16
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	16	16

TABLE 8.C.26
Scoring Table - No Diversions in Any State
Category 2 - Agricultural Conservation
Alternative - Water District Non-Structural Alternatives

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sustainability																			
Scalability																			
Technically Implementable																			
Time to Yield Realization																			
Ability to Monitor and Measure																			
Third Party Hydrologic Impacts																			
Subtotal																			
Subtotal Average																			
Legal/Institutional																			
Ease of Permitting																			
Consistent with Interstate Compacts, Federal Laws & Decrees																			
Consistent with State Laws																			
Potential for Institutional Consensus																			
Can be Mitigated																			
Administrative Ease																			
Consistent with Existing Contract, Facility & Land Ownership																			
Subtotal																			
Subtotal Average																			
Social																			
Effects on Customs and Culture																			
Equity of Impacts																			
Impacts on Community Organizations and Support Structures																			
Effects on Community Sustainability																			
Public Acceptability																			
Subtotal																			
Subtotal Average																			
Economic																			
Initial Implementation and Capital Cost																			
Average Annual Total Cost per Acre-Foot Reduction																			
Direct Economic Impacts																			
Secondary Economic Impacts																			
Fiscal Impacts																			
Effects on Economic Development Potential																			
Subtotal																			
Subtotal Average																			
Environmental																			
Impacts to Wetlands																			
Impacts to Habitat																			
Impacts to Water Quality																			
Impacts to Prime and Unique Farmlands																			
Visual Impacts																			
Impacts to Amenities																			
Subtotal																			
Subtotal Average																			
Overall Total (Sum of Averages)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Physical

In Reaches 1 through 4, 6, 10, 14, and 15 the study team estimates that a conservation cropping program would produce less than the threshold annual reduction in target flow shortages of 500 ac-ft. Consequently, conservation cropping was deferred from further evaluation in those reaches on the basis of net reduction in target flows.

Net reductions in target flows vary for the remaining reaches in Regions 1, 2, and 3, as noted in the scoring table for conservation cropping. Under the without diversions scenario, the other physical subcategories are generally positive. In terms of sustainability, this would be a temporary arrangement, but with the potential to extend the program indefinitely. There is certain scalability to the program, depending upon the level of incentive offered, but expansion of on-site yield beyond 30,000 ac-ft per year in any individual reach is unlikely. The time to realization should not be in excess of four years. There is some uncertainty with the ability to monitor and measure conservation cropping results; an acceptable yield estimation technique will have to be developed. The technical implementability of this program is uncertain given the lack of close precedent. A demonstration project or in depth field research will be needed to document its acceptability to farmers and the water yields it can produce. Moderate third party hydrologic effects may be evident due to changes in return flow volumes and timing. These hydrologic effects could include impacts on irrigated lands served by Lake McConaughy, the EA in Lake McConaughy, minimum operation flows and hydropower production. Negative third party impacts would need to be offset or mitigated.

Under the with diversions scenario, conservation cropping has a diminished net reduction in the shortages, a diminished scalability, but an improvement to third party hydrologic impacts since some of the conserved water will represent a net benefit to downstream diverters.

Legal and Institutional

Under the without diversions scenario, permitting would be required to transfer conserved water downstream. The program is consistent with compacts, federal laws and decrees. The scenario without diversions is inconsistent with state laws, but it may be possible to overcome export statutes in Colorado and Wyoming and water transfer issues in Nebraska. Conservation cropping should be viewed as generally favorable in all three regions, and any impacts are considered to be neutral. There is no existing administrative program to oversee conservation cropping, but existing local irrigation districts and state or local agencies should be able to manage this program once designed. There are no contractual, facility or land ownership issues.

Under the with diversions assumption, permitting and state law issues will be avoided, since a water transfer will not be required. Mitigation will also be easier since third party hydrologic effects will likely be offsetting. Negative effects on adjacent farms will be balanced by positive effects on other downstream diverters.

Social

Generally modest social effects will be evident under the conservation cropping program, assuming no diversions. Effects on customs and culture, community sustainability, and public acceptability are likely to be neutral. Impacts will not be equal, since some areas will choose to participate in conservation cropping while others will not.

Economic

The initial capital cost and average annual cost per ac-ft vary by reach and region. As noted earlier in this section, these costs are difficult to estimate without additional field research or a demonstration project. The study team has assumed that farmers would be willing to accept payments comparable to those estimated for temporary water leases in the evaluation of potential incentive programs.

Direct economic impacts will generally be positive, since the voluntary participants in the conservation cropping program would be paid a premium. Secondary economic effects might be offsetting, since traditional suppliers of agricultural inputs would be negatively affected, while suppliers of other crops might be positively affected. Expenditures of the farmers' premium would represent a positive effect. Fiscal impacts would be largely offsetting. There should be little or no impact on economic development from this program, since all decisions will be temporary and reversible.

No appreciable differences are noted between the with and without diversions scenarios.

Environmental

No substantial environmental impacts are foreseen under the conservation cropping alternative with or without diversions. Changes in crop types may have modest positive or negative impacts on water quality.

Deficit Irrigation Practices

Tables 8.C.18 and 8.C.23 present the tabular scoring for deficit irrigation with and without diversions, respectively.

Physical

Net reductions to target flows under the representative deficit irrigation program described in this section would exceed the 500 ac-ft per year minimum threshold in all reaches except 10, 14 and 15. However, further evaluation of a deficit irrigation program in all reaches except 7, 12, and 13 was precluded because estimated costs per ac-ft of reductions to target flow shortages exceeded the $3,000 threshold. In terms of sustainability, deficit irrigation is a temporary arrangement, but it can be extended indefinitely. In terms of scalability, the study team estimates that potential on-site yields for this program are limited to less than 5,000 ac-ft per year except in reach 12. The technology needed to implement this program must be considered to be in experimental stages, since a comparable incentive program to produce deficit irrigation has not been identified. Given the lack of physical infrastructure requirements this program might be established within two years. Deficit irrigation would be difficult to accurately monitor and measure compliance and quantify water savings. Due to reduced return flows from participating lands, third party hydrologic impacts are possible. These hydrologic effects could include impacts on irrigated lands served by Lake McConaughy, the EA in Lake McConaughy, minimum operation flows and hydropower production. Negative third party impacts would need to be offset or mitigated.

Under the assumption that conserved supplies would not be protected from diversion downstream, a deficit irrigation program would not meet the minimum 500 ac-ft per year shortage reduction threshold in any reach. Consequently, no further analysis of this alternative, under this diversion scenario, was conducted.

Legal and Institutional

As with a conservation cropping program and the other conservation alternatives, a water right transfer would likely be necessary in order to protect flows from downstream diversion. This will raise issues in terms of ease of permitting and consistency with state laws. Deficit irrigation should be consistent with compacts, federal laws and decrees. On a voluntary participant basis, this program will be generally viewed in a favorable light. Deficit irrigation is consistent with existing contracts, facility and land ownership. Mitigation potential exists. The program is likely to be difficult to administer given the challenges of short-term contracts with a large number of participants and difficulty in verifying compliance.

Social

Under the assumption that deficit irrigation would be implemented on a voluntary and limited basis, the social impacts of this alternative are generally modest. Since crops are not likely to change, except in output, a neutral effect can be anticipated on customs and culture, community organizations, support structures, and community sustainability. While impacts will not be equal because some areas will choose to participate while others will not, these impacts will be modest. Public acceptability is unlikely to be a major issue under the type of program described in this section.

Economic

Initial implementation and capital costs of a deficit irrigation program would be low relative to either structural conservation alternatives, or more permanent incentive based conservation measures. Average annual costs per ac-ft of reductions to target flow shortages from a deficit irrigation program are relatively high because deficit irrigating farmers will experience reduced revenues without necessarily being able to substantially reduce input and labor costs. The study team recommends setting aside the deficit irrigation alternative in all reaches except Reaches 7, 12, and13 because the costs per ac-ft of reductions to target flow shortages exceed $3,000. In these three reaches, average annual costs will be over $2,500 per ac-ft. Direct economic impacts will actually be slightly positive, since farmers will receive more than the value of their lost yield in return for their participation. Secondary impacts will be negative, though modest, because diminished yields will not provide the same level of economic stimulus in the community and related industries will incur some negative economic effects. Modest negative fiscal impacts are likely due to lower economic activity in the region. Economic development potential will be largely neutral.

Environmental

The deficit irrigation alternative would pose few issues from an environmental standpoint.

On-farm Changes in Irrigation Techniques

Tables 8.C.19 and 8.C.24 present the tabular scoring for on-farm changes in irrigation techniques with and without diversions, respectively.

Physical

As demonstrated by CNPPID's conservation program, on-farm changes in irrigation techniques can produce substantial reductions in on-farm delivery requirements. However, since most of the reduced water deliveries would otherwise have resulted in return flows, this alternative is only likely to meet the minimum 500 ac-ft per year threshold reduction in target flow shortages in Reaches 17, 18 and 19.

Economic

Study team evaluation of this alternative in Reaches 17, 18 and 19 determined that the average cost per ac-ft of reduced shortage would be between $3,800 and $4,200. This alternative was deferred from further evaluation since the cost per ac-ft of reductions to target flow shortages exceeds $3,000.

Water District Structural Alternatives

Tables 8.C.20 and 8.C.25 present the tabular scoring for water district structural alternatives with and without diversions, respectively.

Physical

The principal physical issues with irrigation district structural conservation measures are that such measures typically result in small reductions in consumptive use, would require extensive engineering evaluations and would likely result in substantial third party hydrologic impacts on farmers and nearby groundwater pumpers that rely on historic return flows from canal seepage. Physical benefits of this alternative to the objective of reducing shortages to target flows are greatest in Reaches 17, 18 and 19 because a large portion of return flows in this area do not return to the Platte River above the critical habitat. Scalability of this alternative is also limited. The study team believes that irrigation district structural conservation measures will not likely meet the 500 ac-ft annual reduction in shortages requirement in reaches 3, 4, 5, 10, 14, 15, and 16. However, any gains from canal lining and other physical measures in the remaining reaches would be sustainable and should be technically implementable. Time to yield realization would be delayed by required engineering studies to focus on the most cost effective improvements.

Under the assumption that water gained from measures in Colorado and Wyoming will not be protected from downstream diverters, the study team recommends deferring this alternative from further evaluation in all reaches except Reaches 17 through 19 for failure to generate at least 500 ac-ft of reductions to target flow shortages per year.

Legal and Institutional

In Wyoming, Colorado, or Nebraska, transferring water saved through structural conservation measures will pose a substantial challenge. There will likely be difficulty in permitting a water right transfer of conserved flows due to export statute issues and lack of a legal vehicle for transfers in Nebraska. Issues with compacts, laws and decrees are unlikely. Likely objections due to the third party hydrologic impacts just described will also complicate the permitting process in many instances. Third party hydrologic impacts could make it fairly difficult to obtain institutional consensus on this alternative. Mitigation with water or monetary compensation is certainly possible. No issues should surface with current contracts, facilities or land ownership, assuming all owners, operators and shareholders of the canal system agree to the canal improvements. Once implemented, however, administration of this alternative would be modest.

Under the scenario in which conserved water is not protected from downstream diversions, no permitting or water right transfer would be required, which would simplify implementation from a legal and institutional standpoint.

Social

Apart from the third party hydrologic impact issue, social impacts from structural conservation measures would be minimal. Physical improvements to canal systems will have generally neutral effects on customs and culture, community organizations, support structures, and community sustainability. Impacts will not be equitable, since third party hydrologic impacts will occur only in areas where these measures are implemented. Public acceptability might be an issue given hydrologic third party effects.

Economic

While irrigation system structural improvements can be cost effective from the standpoint of dollars per ac-ft of seepage or "waste" avoided, they are costly in terms of dollars per ac-ft of consumptive use reduction. On the basis of cost per ac-ft of reductions to target flow shortages at the critical habitat, this alternative fails to meet the $3,000 threshold in Reaches 1, 2, 6, 7, 8, 9, 11, 12, and 13. In the remaining reaches which have not been deferred from further evaluation on the basis of economics or physical criteria (Reaches 17 through 19), other economic impacts from structural improvements would be minimal apart from the hydrologic impact issue.

Direct economic impacts are likely to be a mixture of positive and negative effects, since water deliveries will be more certain to direct canal system participants, but negative if those participants also rely on groundwater seepage for wells. Secondary effects are likely to be negative due to diminished groundwater recharge. Due to reduced water availability and agricultural production fiscal impacts are likely to be negative. Effects on economic development are likely to be modest.

Environmental

Structural measures aimed at reducing losses from irrigation district conveyance facilities might have substantial impacts on local wetlands and habitat. In effect, at least some of the water savings in terms of "non-productive" consumptive use would come at the expense of wetlands and phreatophytes that may provide habitat on-site. Water quality impacts are uncertain and would be site specific. Impacts to prime and unique farmlands and impacts to amenities will be neutral. Visual impacts would likely be modest.

Water District Non-Structural Alternatives

Tables 8.C.21 and 8.C.26 present the tabular scoring for water district non-structural alternatives with and without diversions, respectively.

As discussed earlier, the study team recommends setting aside conservation pricing and demand- based irrigation scheduling due to fatal flaws in the implementability of such programs. We believe that these alternatives are not viable in terms of any yield that might be developed, their potential for institutional consensus, and public acceptability.

8.D. Municipal Water Conservation

Municipal Water Conservation

1. Introduction

This section examines the yields, costs and associated issues of various municipal conservation alternatives which might reduce shortages to target flows at the critical habitat. The municipal conservation alternatives all assume that only reductions in consumptive water use, primarily occurring through outdoor landscaping, can benefit the objectives of the Three States Cooperative Agreement. Municipal water conservation, which reduces indoor water use will reduce water diversions and municipal return flows commensurately, providing no real benefit to the critical habitat. A number of municipal conservation alternatives in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. Following the long list evaluation and the screening of certain municipal conservation alternatives, the remaining alternatives are identified below, as grouped into three categories:

- *Economic incentives to reduce municipal water use*
  - Conservation pricing
  - Financial incentives for municipal conservation
  - Tax incentives or subsidies
  - Universal and city parks metering
- *End-user technology changes*
  - Landscape irrigation improvements
- *Regulatory measures*
  - Outdoor water restrictions
  - Restrictions on specific uses

A brief description of each of these alternatives and how they might be implemented is provided below, followed by region-specific estimates of municipal water use and the yields and cost of each alternative. Finally the evaluation of each alternative in terms of physical, legal or institutional, economic, social, and environmental effects is offered to conclude the municipal water conservation evaluation.

2. Conceptual Definitions

Economic Incentives to Reduce Municipal Water Use. Essentially, this group of alternatives seeks to achieve municipal water conservation by offering municipal water customers or end-users, or the utilities that serve them, an economic benefit to reduce water use or an economic penalty for any excessive water use that might exist. The essential underlying assumption behind all of the alternatives in this category is the traditional economic theory that higher costs can discourage wasteful or non-essential water use. The corollary economic assumption is that if the financial hurdles or costs of implementing conservation are overcome, end-users or utilities will embark upon these conservation efforts. The validity of these assumptions in achieving the program goals is examined below.

End-User Technology Changes. This category assumes that there are opportunities to reduce water use at the point of consumption that will, through equipment or end-user techniques or water-use applications, result in a reduction in consumptive use. This change is referred to as landscape irrigation system improvements, assumed to be either improved landscape irrigation systems or a conversion to urban landscaping options with lower water use per square foot.

Regulatory Measures. Regulatory measures are those actions that can be undertaken by municipalities or urban water providers, which, by virtue of adopting such actions, will reduce municipal consumptive use. This category of municipal conservation assumes general compliance by water users in response to such regulation.

3. Operational Definitions

The operational definitions provided below describe how each of the conservation alternatives might be implemented. The assumption of a reasonable implementation plan is necessary in order to evaluate the yield, cost and associated issues.

Conservation Pricing. Conservation pricing structures for municipal water users assume that a customer's water costs, if increased at higher consumption levels, will result in that same customer's reduction in total water demand. This will occur if the water utility price structure provides an increase for a given quantity of water delivered (per 1000 gallons) as total demand by each customer increases. An increase in a household's water use will result in a higher than proportionate increase in water charges. Conversely, if a household using 50,000 gallons per month cuts its demand by one-half to 25,000 gallons per month, its water bill would drop by more than one-half under a conservation pricing structure, perhaps a 75 percent drop in water costs. Conservation pricing structures can come in the form of increasing block prices, where each increment of increasing water demand has a higher per unit cost, or in the form of seasonal pricing or penalty pricing to discourage high levels of outdoor water use, which commonly occurs during the summer.

For the purposes of this evaluation, it is assumed that each of the municipalities in a particular region change their price structures to an increasing block or a seasonal price structure to achieve outdoor water demand conservation. Water utilities with a flat rate would be assumed to go to an increasing block structure. Water utilities with an increasing block structure would retain that increasing block structure but implement a seasonal pricing approach to further increase summer water prices. Rates for lower volumes of monthly use would be lowered so that conversion to conservation pricing would be revenue-neutral for the utility.

Financial Incentives for Municipal Conservation. This technique entails monetary incentives in the forms of grants, loans or debt financing for use by water utilities in implementing a conservation program within their municipal service areas. For the purpose of this evaluation, it is assumed that municipalities would be offered grants equal to $200 per single-family household equivalent to implement a water conservation program, leakage reduction, water use or landscape audits, or water-use reduction subsidies to customers. The $200 figure, based upon experience elsewhere, should be sufficient to elicit some level of interest from customers to improve landscape irrigation systems.

Tax Incentives or Subsidies. The tax incentives or subsidies alternative step beyond the municipal water utility, offering direct incentives to municipal water users. These tax incentives or subsidies can be lump sum rebates to homeowners or commercial property owners to purchase and install water saving mechanisms or water conserving landscapes that they would otherwise not adopt. Tax reductions can be another version of this alternative, where some percentage of property taxes or mill levies can be rebated to the homeowner or commercial property owner in return for such water saving efforts. For the purpose of this evaluation, a $200 per single-family home equivalent subsidy is assumed.

Universal and City Parks Metering. This alternative simply requires that any municipal or urban area which is unmetered at present install meters for all of its water users. Metering for urban parks is a subset of this metering alternative, and for the purpose of this study, will be assumed to occur along with metering of private water users. For each region, it is assumed that all unmetered urban areas will become metered.

Landscape Irrigation Improvements. This alternative is assumed to consist of increasing landscape irrigation efficiency through the use of such techniques as separate water zones, efficient sprinkler heads, improved application rates, drip or bubbler systems for trees, automatic controls, or proper watering schedules. The installation of new systems of sprinklers on urban landscapes might be another version of this alternative. Finally, a third version could include conversion to lower water-using landscapes such as xeriscapes.

In order to evaluate the yield and cost of this alternative, this study assumes that the upgrading of existing sprinkler systems will be performed, rather than the other two options. New sprinkler systems for tracts previously hand-watered are addressed under the financial incentives alternative above, but would exceed the $200 subsidy identified above. The xeriscaping alternative can also be covered under the financial incentives alternative, but the cost of converting an existing lawn to a low water-using landscape would greatly exceed any financial incentives that could be offered under the Three States Program.

Outdoor Water Restrictions or Restrictions on Specific Uses. This alternative assumes that outdoor watering is confined to a limited time period once every three days. Restrictions on specific uses such as swimming pool filling, lawn irrigation or irrigation overflows onto the street are almost always confined to drought planning and are not appropriate or acceptable to the public as a permanent prohibition.

Therefore, this alternative focuses on watering landscapes once every three days for a limited period.

4. Alternatives

Region 1

Current Municipal Water Use Patterns

Table 8.D.1 indicates the population and Platte River diversions by reach for Region 1. Region 1 includes the Platte River Basin and its tributaries in Wyoming, except that Cheyenne is in Reach 8, Region 2. Also included in Region 1 is the North Platte Basin in Nebraska, upstream from Lewellen. There are six reaches in Region 1, which together included an estimated 130,000 residents and about 41,000 ac-ft (ac-ft) of Platte River diversions for municipal purposes in 1997. Based upon average diversion and treatment loss figures of about 10 percent and a 10 percent municipal system loss factor, municipal demand at the tap in Region 1 is approximately 33,000 ac-ft per year. Municipal water use in Region 1 represents about 1 percent of agricultural water use in the same area.

Given the very small amount of water accounted for by municipalities in Region 1, municipal conservation measures and potential yields will be applied on a region-wide basis since water savings for any single municipality, with the possible exception of Casper, would not yield sufficient water to merit further consideration in the Three States Cooperative Agreement study. The administrative and institutional difficulties in adopting municipal conservation programs among all of the towns in Region 1 of the Platte River Basin will be addressed later in this chapter.

The effects of municipal conservation in the context of this Platte River study differ considerably from the typical conservation plan for a single community. If a community can reduce water demand from any source, this represents a benefit in reduced operating expenses and the opportunity for using saved water for other future customers, thereby avoiding efforts to otherwise increase water supplies. With this motivation, water reductions in either consumptive or non-consumptive uses are normally beneficial to individual water systems.

Table 8.D.1 Estimated Platte River Diversions for Larger Communities Region 1

Reach	Community	Population	Platte River Diversions (ac-ft)
1	Rawlins	8,947	2,200
	Hanna	1,004	700
	Saratoga	1,865	600
2	Sinclair	457	2,200
3	Casper	48,800	13,900
	Mills	1,648	1,000
	Glenrock	2,288	700
	Douglas	5,432	1,700
4	No larger towns	NA	NA
5	Torrington	5,950	1,700
	Guernsey	1,211	700
6	Laramie	26,583	7,000
	Wheatland	3,437	1,800
12	Scottsbluff	14,400	4,400
	Gering	8,000	2,500
13	No larger towns	NA	NA
Estimated Region 1 Totals		**130,022**	**41,100**

Source: Wyoming Water Development Commission, 1998 Water System Survey Report, 1998; the Platte River Basin in Wyoming and Nebraska, (1940-1996), 1998; and BBC interviews with municipal water providers. U.S. Bureau of the Census Web Page, Annual Time Series of Population Estimates 1991 to 1996 and 1990 Census Population for Places, 1997; Purcell Consulting, Changes in Municipal and Industrial Water Use in Portions of the Platte River Basin in Wyoming and Nebraska, 1997.

From the Platte River Basin perspective of this study, conservation of non-consumptive use activities only reduces return flows to the Basin, so no benefit is gained at the critical habitat.

Only that portion of municipal demand that relates to consumptive use is relevant to municipal conservation in the context of this study. Only 5 to 15 percent of indoor municipal water use is typically consumed, based upon interviews and past studies in the Rocky Mountain region. Consequently, there is little or no benefit in conserving indoor water use from a Platte River Basin perspective. Consumptive use is considerably higher for outdoor water use, which takes place primarily in the summer.

Based upon interviews with Wyoming municipalities and experience in other areas, it is estimated that 30 to 50 percent of total municipal and industrial water use occurs outdoors in this region. Of this, roughly 70 to 90 percent is consumptively used. Using the midpoints of these ranges, this study assumes that 40 percent of industrial and municipal (M&I) water use is outdoors and 80 percent of that is consumptively used while 20 percent is return flow to the surface or tributary groundwater aquifers.

In Region 1, a total of 33,000 ac-ft of water is delivered to M&I customers after system and conveyance losses are taken into account. Outdoor water use, at 40 percent of the total, would amount to about 13,000 ac-ft of water use. Using the 80 percent consumptive use factor, municipal water conservation measures would be applied to about 10,000 ac-ft of consumptive use to produce savings relevant to this Platte River Basin study.

Yield

Any yield that might be achieved from municipal conservation must be over and above existing municipal conservation efforts in a given reach or region. In Region 1, the specific municipal conservation programs under consideration in this study have mostly not been undertaken thus far. The one exception is metering, which has been implemented in almost all of the Region 1 communities and, therefore, will not be examined further for this region.

Economic Incentives to Reduce Municipal Water Use. In other areas of the U.S., conservation pricing has resulted in 5 to 20 percent reductions in water use if water charges are doubled for the incremental, outdoor water use. Much of the experience with such measures has been in regions that have experienced considerable shortages, such as northern California and Florida in recent years. Most Region 1 municipal utilities have a unit price structure or fixed rate for each 1,000 gallons delivered to a given customer. Obviously, a doubling of these unit rates or new, increasing block rate structures would be profoundly difficult to achieve for all of the Region 1 communities, as subsequently discussed in this section. The yield of such an endeavor for the entire of Region 1 might be approximately 1,000 ac-ft of consumptive use, in total.

One approach to encourage conservation is to provide financial incentives or subsidies to the municipal utilities themselves. An incentive program aimed at municipal utilities would require providing a sum of money that the utility would then use to accomplish conservation reductions, returning the water to the Platte or not diverting as much. The amount of water that might be made available at a given cost would be based upon each individual utility's anticipated need for additional water supplies and the costs of those water supplies. For example, a municipality would not sell conserved water to the Three States program on a voluntary basis, unless it received more money than the cost of the next available water supply at a minimum and presuming that the same municipal utility believed that it did not need such a water supply.

Most utilities in the Three States region, based upon project team interviews, intend to use any potential conservation savings as a future water supply, since other water supplies are difficult to develop and more expensive than conservation. Therefore, any yield out of this approach is speculative. Water utilities commonly pursue water supplies to meet present and future needs, and neither wish to hold excess supplies nor sell water supplies out of their portfolios. In sum, no yield can be assumed from the financial incentives or subsidies for municipal conservation that would benefit the Three States program.

Financial incentives for municipal conservation require, in essence, a buying-back of water demand from municipal customers and an assignment of this water by individual water utilities to the Three States Cooperative program for return of that water to the river. This type of approach was attempted in Seattle, Washington, where 50 percent of the costs of the water were rebated back to the customer to obtain additional water supplies. In theory, this program could be applied in Region 1, but only by ignoring a host of institutional and legal issues, among them the fact that these water supplies would revert back to the water utilities if the water was not used. One approach used in the Metropolitan Water District of Southern California and the San Diego County Water Authority is to offer rebates for conservation devices such as low-flow toilets or other plumbing retrofits, but that is not applicable in this study since it does not speak directly to outdoor water consumptive use. In sum, there is too little empirical evidence related to the yield or efficacy of this approach to continue it further in this study.

End-User Technology Changes. As a municipal conservation measure, landscape irrigation system improvements are aimed directly at reducing outdoor water use and therefore consumptive use. Automated sprinkler systems in an urban setting can reduce or increase water use, depending on property owner practices. Although no yield can be assumed for the addition of automated sprinkler systems, improvements to existing sprinkler systems have been shown to reduce outdoor water demand by as much as 10 to 30 percent, according to studies in Los Angeles, CA; Salt Lake City, UT; Providence, RI; and Carey, NC. These techniques monitor either rainfall or soil moisture and adjust landscape sprinkler operations accordingly. If 15 percent savings is assumed, approximately 1,500 ac-ft could be conserved in Region 1.

Regulatory Measures. Water utilities could also undertake certain regulatory measures to restrict water use to accomplish municipal water conservation. These could include outdoor water restrictions or restrictions on other specific uses, but to be effective, such restrictions would have to limit not only the number of times of watering per week, but the time of watering. These techniques have been implemented in areas throughout the U.S. in times of drought. South Florida, northern California, upstate New York, and Phoenix as well as Denver have all implemented outdoor watering restrictions of both day and watering period in past years. Water savings appear to range from 10 to 15 percent during such programs. If implemented among all of the cities in Region 1, consumptive use savings might amount to 1,000 to 1,500 ac-ft.

Cost

As regulatory measures, conservation pricing would have considerable program implementation costs for each utility but minimal ongoing expense. It is presumed that $200,000 to $300,000 would be required to restructure the rates of the 12 water utilities and implement the program. Rates presumably would be adjusted to be revenue neutral for each utility, producing no gain for the utility or additional total cost to the customer, on average. Hence, capital costs would be approximately $250 per ac-ft.

Landscape irrigation improvements would cost an estimated $100 per household. This would result in a capital cost of approximately $2000 per ac-ft in Region 1.

The direct costs of outdoor water restrictions are modest, since they can be created by municipal water utilities that deem them necessary. However, the costs of structuring and publicizing such a program would likely be similar to that of conservation pricing or $200 to $300 per ac-ft.

5. Recommendation to Defer Municipal Water Conservation

This section has defined and examined municipal water conservation alternatives potentially relevant to the Platte River Basin study, along with yield and cost estimates for each measure in Region 1, where possible. On the basis of this examination for Region 1 and additional considerations described below regarding Region 2 and Region 3, the study team recommends that municipal water conservation measures as a group be deferred from further evaluation at this time.

There are a host of profound problems with municipal water conservation in the context of the Three States Platte River Basin study:

1. In most circumstances, the potential yield or water savings from municipal conservation of outdoor consumptive use is small. Individually, the water conservation measures examined above are likely to yield a maximum of 10 to 15 percent of consumptive water use. Such savings would not amount to 1,000 ac-ft for any of the municipalities in Region 1. In Region 3, the potential for water

savings is even less, as shown in Table 8.D.2. Conversely, it is almost inconceivable to see all of the municipalities in Region 1 or in Region 3 embark together upon one of the water conservation programs outlined above.

2. Although Region 2 encompasses the large, urbanized area along Colorado's Front Range, water conservation from outdoor consumptive use can result in a contradictory result, a loss to the South Platte Basin instead of a gain. This is because water supplies in the Denver Metropolitan Area and north to Cheyenne include transbasin diversions which, after first use, result in accretions to the South Platte Basin. This is illustrated in Table 8.D.3. It is possible that conserved water would mean reduced transbasin diversions, creating a loss for the South Platte in return flows.

3. The Region 2 area, which includes 80 to 100 municipal water suppliers, presents other complexities with regard to conservation of consumptive use. Unless all of the utilities participate or agree, the conserved municipal water of one utility becomes the new water supply of another. Institutionally, this is extremely difficult to overcome. Region 2 accounts for about 150,000 ac-ft in total municipal water consumptive use, almost all of which is located in Reach 7, which includes the south end of the Denver Metropolitan area north to and including Greeley but excluding Fort Collins, which is in Reach 11. Reach 8 includes Cheyenne and Fort Morgan, whereas Region 9 includes Sterling and Julesburg.

4. Municipalities in the three states generally look to water conservation as a source of future supply. There is increasing awareness that water conservation can result in reduced demand, which is tantamount to a cost-effective, new water supply in many instances. Further, there are limited opportunities to develop alternative new water supplies in the region, which discourages utilities from releasing a potentially available supply.

Table 8.D.2 Estimated Platte River Diversions for Larger Communities in Region 3

Reach	Community	Population	Platte River Diversions (ac-ft)
10	Ogallala	5,072	1,600
12	Scottsbluff	14,400	4,300
	Gering	7,876	2,400
14	No larger towns	NA	NA
15	North Platte	23,396	6,600
16	No larger towns	NA	NA
17	Lexington	10,075	1,800
18	No larger towns	NA	NA
19	Kearney	27,314	6,700
	Grand Island	41,177	15,200
Estimated Region 3 Totals		**129,983**	**38,600**

Note: These communities rely on groundwater wells which have a direct physical relationship to the Platte River.

Source: U.S. Bureau of the Census Web Page, Annual Time Series of Population Estimates 1991 to 1996 and 1990 Census Population for Places, 1997; Estimated Water Use in Nebraska 1990, United States Geological Survey - Nebraska District and Nebraska Natural Resources Commission, 1994.

Table 8.D.3 Estimated Platte River Diversions for Municipal Use Region 2

Reach	Community	Population	Native Platte River Diversions*	Total Water Supply
7	Denver Water	1,000,000	99,000	265,000
	Other Denver Suburbs	898,500	22,500	179,000
	Other	50,000	2,500	6,000
8,9 and 11	All	676,000	25,000	194,000
Estimated Region 2 Totals		**2,624,500**	**149,000**	**644,000**

*Excludes diversions from the Poudre River.

Source: Metropolitan Water Supply Investigation Final Report, Hydrosphere, January 1999.

5. In terms of municipal water supply planning, some forms of conservation are really drought planning alternatives that prudence suggests be retained for that purpose. Outdoor water restrictions or restrictions on a specific use are examples. Municipalities will want to retain such measures to implement quickly and receive immediate savings in times of shortage.

6. Under any circumstance, a municipality is quite unlikely to part with conserved waters without receiving an amount of money commensurate with a replacement of a like amount of water. That like amount of water must be certain and is likely to be quite expensive since it is the marginal supply alternative for a municipality, which has been deferred up to this point. For example, the Denver Water Department indicates that such costs might range from $7,000 to $10,000 per ac-ft.

7. While the municipal utilities are likely to resist conservation for the purpose of the Recovery Program, the constituents and water customers they serve may also resist programs such as conservation pricing in cases where water costs are increased substantially or water restrictions which do not appear necessary due to shortage. In the present environment, it is difficult to conceive of widespread public acceptance for these measures.

Based upon the analysis to date, the study team believes that it is not worthwhile to continue the consideration of municipal water conservation as a viable component of the Platte River Basin study at this time. If other alternatives do not look more promising at a later date, municipal conservation can be analyzed further or become the subject of a demonstration project. Further, this conclusion should not be viewed as questioning the benefits or desirability of municipal conservation itself or the potential to conserve future depletions.

8.E. Reuse

8.E. Reuse

Reuse

1. Introduction

This section examines the yields, costs and associated issues of reuse alternatives to reduce shortages to target flows at the critical habitat. A number of reuse alternatives identified in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into one category:

Relocation of Return Flows

A brief description of the representative projects and how they might be implemented is provided below, followed by estimates of yields and cost for the projects. Finally the evaluation of the projects in terms of physical, legal or institutional, economic, social, and environmental effects is offered to conclude the reuse alternatives evaluation.

2. Conceptual Definition

Relocation of Return Flows. Relocation of return flows refers to rerouting return flows that have historically entered the stream at the lower end of the critical habitat, to a point further upstream in the critical habitat. This alternative is limited to projects of locations close to the critical habitat.

3. Operational Definition

Relocation of Return Flows. Relocation of return flows requires construction of a cutoff and the associated channel works to divert water from one watercourse to another. The Tri-Basin Natural Resources District (NRD) has implemented a small version of this alternative in central Nebraska and is considering a potential expansion.

Return flows that naturally flow east and enter the Platte River in the bottom half of the critical habitat can be diverted north to a tributary that enters the Platte River further upstream in the critical habitat. At some points the land near the Platte is lower than the river. Pumps may be needed in these cases to assure the delivery of diverted water to the critical habitat.

Relocation of return flows in the vicinity of the critical habitat has been exercised twice, during the winter of 1998 and then again in the spring of 1999. Limited data are available related to this alternative. For purposes of evaluation, the study team evaluated the potential yield from this alternative based on conversations with Tri-Basin NRD, CNPPID, FWS, and USGS personnel.

Other opportunities for relocation in the area surrounding the critical habitat exist, including pumping from high groundwater areas and discharging into local canals (see Section 8.G). Tri-Basin is also investigating other relocation of return flow opportunities within their district.

4. Alternatives

Region 3

Lost Creek - North Dry Creek Cutoff

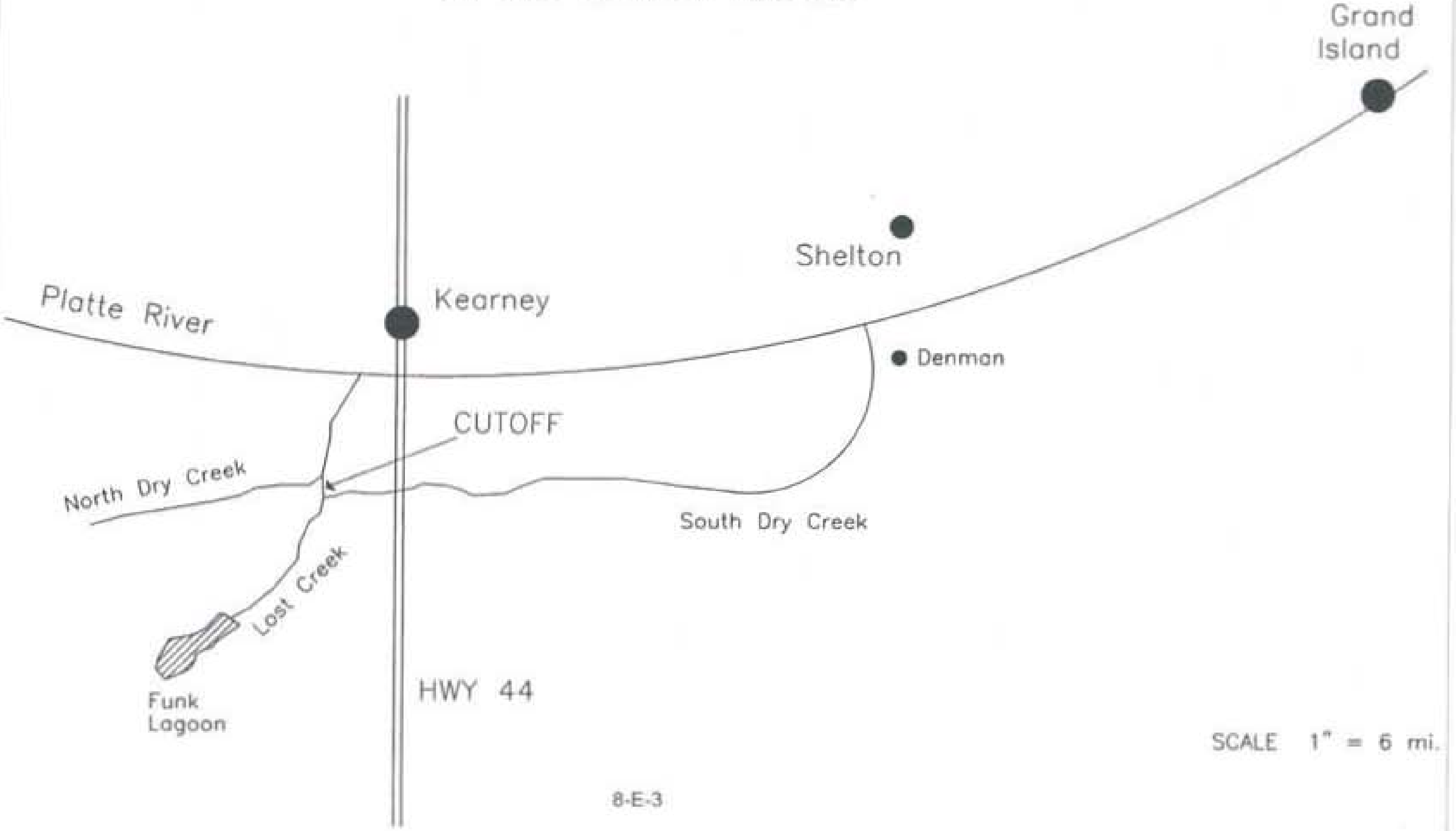
Funk Lagoon is situated in a federal waterfowl production area (WPA) south-southwest of Kearney, Nebraska approximately 10 miles south of the Platte River (see Figure 8.E.1). It is comprised of three different pools with a total design capacity of 1,150 ac-ft. Funk Lagoon is filled via natural runoff, return flows from irrigated land, and contract water from CNPPID. During rain events CNPPID also runs excess water down wasteways that drain into Funk Lagoon.

Water discharged from Funk Lagoon flows down Lost Creek, eventually combining with South Dry Creek before returning to the south channel of the Platte River near Denman, Nebraska in the lower portion of the critical habitat. Lost Creek, in its natural state, is an ephemeral stream that predominantly responds to precipitation events. Return flows from irrigation provide a major component of the baseflow in Lost Creek.

Through an agreement with the North Dry Creek Drainage Board, Tri-Basin NRD installed a 20-cfs cutoff from Lost Creek in May 1998 to

C:_CURRENT_PROJECTS\PRRIP\16930.000\0001\Docs\Proposal-PreviousWork\PlatteRiver\DN-P07-100-08\Platte\Work Products\Task 7\Final Report\Evaluation Memos\8-Reuse.dwg, L

Figure 8.E.1
Relocation of Return Flows
in the critical habitat



divert discharges from Funk Lagoon into North Dry Creek. North Dry Creek enters the Platte River about 1-1/2 miles west of the Kearney Bridge on Highway 44. A water management plan for Funk Lagoon is currently being developed among FWS, Tri-Basin NRD, and CNPPID that will set target elevations for the lagoon's pools throughout the year for the benefit of migratory waterfowl. Opportunities within the FWS's mandate for management of the Funk Lagoon WPA may exist for the lagoon to be drawn down at times of the year when the discharged water will benefit the critical habitat along the Platte River. Lowering lagoon levels in the summer could reduce shortages in the critical habitat and reduce flooding damage to surrounding cropland from high groundwater levels.

The Lost Creek relocation of return flows to North Dry Creek is the only current application of this alternative. Tri-Basin NRD is also looking at a cutoff from Lost Creek, east of Highway 44, into the Ft. Kearny Improvement Project Area (IPA) Canal. For this potential alternative, nearly one mile of additional canal must be built to link Lost Creek to the Ft. Kearny IPA Canal. Based on aerial photos, relocation of return flows from another ditch east of the Fort Kearny IPA Canal also appears to be feasible.

Yield

Diversion of Funk Lagoon discharges to North Dry Creek was carried out for the first time between December 15, 1998 – January 12, 1999. The lagoon was drawn down approximately 1 foot. The volume of water discharged is unknown because aerial photos and area-capacity data for the three pools that make up Funk Lagoon were not available.

A USGS stream gage recorder, installed on North Dry Creek in May 1996, is located two miles southwest of the Kearney Bridge. The volume discharged from Funk Lagoon that reached the USGS recorder is inconclusive because of the backwater effects of icing around the stream gage recorder. The wintertime gage data records could be 2-5 times actual flow rates (USGS, 1999a).

Diversion of Funk Lagoon discharges to North Dry Creek was carried out for a second time between May 21, 1999 – June 1, 1999. The lagoon was drawn down approximately 7 inches. Releases from Funk Lagoon were estimated at 13-14 cfs. An increase of approximately 5 cfs was seen at the North Dry Creek gage (USGS, 1999b). The remaining flow most likely went into bank storage.

The yield of the relocation of return flows is dependent on the management plan developed by the FWS. CNPPID excess flows that fill Funk Lagoon have been approximately 300 ac-ft/yr. The FWS currently has a contract for approximately 700 ac-ft from CNPPID. Return flows from upstream irrigated lands are likely in the range of 1,500 ac-ft – 2,500 ac-ft per year (CNPPID, 1999c). Thus the potential net hydrologic effects at Funk Lagoon for the Lost Creek-North Dry Creek cutoff could be in the range of 2,500 ac-ft – 3,500 ac-ft per year. With Lost Creek a gaining stream, the discharges from Funk Lagoon that are diverted to North Dry Creek would be subject to primarily evaporation losses and possibly diversion losses en route to the Platte River.

The coordination of the timing of discharges from the Funk Lagoon WPA with FWS operations will determine the potential reductions to target flow shortages that could be realized from this alternative. The benefit to the Program objectives from the delivery of water within, not above, the critical habitat has yet to be determined. If protected from downstream diversions the majority of water discharged from Funk Lagoon during shortage months could reach the critical habitat and reduce target flow shortages.

Cost

Costs to date are approximately $300,000. This includes installation of an underdrain at the upstream end of Funk Lagoon, maintenance of 7 miles of creek channel, installation of the cutoff between Lost Creek and North Dry Creek, and concrete and road culverts associated with a 1-3/4 mile connecting ditch. Improving the system to allow available water to be discharged in the spring and summer without affecting downstream agricultural activities would require rebuilding the North Dry Creek outlet and constructing bridge crossings for center pivots. Estimated costs for these improvements are about $30,000.

Assuming the Lost Creek-North Dry Creek cutoff is upgraded the potential cost per ac-ft at the alternative site could be in the range $95 - $130. Table 8.E.1 summarizes the available yield and cost data available for this alternative. The cost per ac-ft of reductions to target

Table 8.E.1 Alternatives Yield and Cost by Reach
Category 3 - Reuse

	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
Reach Alternative	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Region 3											
Reach 19											
Relocation of Return Flows											
Lost Creek-North Dry Creek Cutoff	2,500 - 3,500	N/A	2,500 - 3,500	N/A	2,500 - 3,500	N/A	2,500 - 3,500	N/A	$0.3	N/A	$95 - $130

* Present value of sum of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate.

N/A - not analyzed

flow shortages can be better estimated when more conclusive discharge data becomes available.

5. Associated Issues

The relocation of return flows alternative was evaluated according to the associated issues evaluation criteria previously reviewed by the Water Management Committee. The five categories of associated issues are physical, legal/institutional, social, economic and environmental. Each of these five characteristics are examined for the relocation of return flows alternative below. Tabular scoring according to each criteria are presented in Table 8.E.2 for the No Diversions scenario.

Physical

The relocation of return flows alternative is scalable to a degree. Operation of more than one relocation project, including the routing of pumped water, as discussed in Section 8.G, could increase the potential reductions to target flow shortages at the critical habitat. Relocation of return flow projects are technically implementable and have been instituted in one case in central Nebraska. Adequate grade exists on North Dry Creek as it enters the Platte River; therefore, lift stations are not needed at this location. Monitoring stations may need to be installed to measure diverted water that enters the river. The time to yield realization is on the order of 1 to 2 years. Third-party hydrologic effects anticipated with this alternative include decreasing the waterlogging of lands adjacent to Lost Creek and reducing the available flows further downstream on Lost Creek. The channel at the confluence of Lost Creek and South Dry Creek is not sufficient to handle storm events on top of the baseflow provided by irrigation return flows. Reduction of flow in the channel will help to alleviate this situation.

Any management plan developed between the FWS and other parties would need to be reevaluated annually as needs for the WPA change in wet, dry, and average years. A FWS decision to store or release water in Funk Lagoon in any particular year would be based on hydrologic conditions.

Table 8.E.2
Scoring Table - No Diversions in Any State
Category 3 - Reuse

	Region 3 Reach 19
Physical	
Net Reduction in Shortage to Target Flows	1
Sustainability	2
Scalability	2
Technically Implementable	5
Time to Yield Realization	5
Ability to Monitor and Measure	2
Third Party Hydrologic Impacts	4
Subtotal	21
Subtotal Average	3
Legal/Institutional	
Ease of Permitting	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5
Consistent with State Laws	5
Potential for Institutional Consensus	2
Can be Mitigated	2
Administrative Ease	3
Consistent with Existing Contract, Facility & Land Ownership	3
Subtotal	22
Subtotal Average	3
Social	
Effects on Customs and Culture	3
Equity of Impacts	3
Impacts on Community Organizations and Support Structures	3
Effects on Community Sustainability	3
Public Acceptability	3
Subtotal	15
Subtotal Average	3
Economic	
Initial Implementation and Capital Cost	5
Average Annual Total Cost per Acre-Foot Reduction	5
Direct Economic Impacts	3
Secondary Economic Impacts	3
Fiscal Impacts	3
Effects on Economic Development Potential	3
Subtotal	22
Subtotal Average	4
Environmental	
Impacts to Wetlands	2
Impacts to Habitat	3
Impacts to Water Quality	3
Impacts to Prime and Unique Farmlands	5
Visual Impacts	4
Impacts to Amenities	3
Subtotal	20
Subtotal Average	3
Overall Total (Sum of Averages)	16

Legend:
19 - Lost Creek/North Dry Creek Cutoff

In the short term there is a need to lower lagoon levels to control the cattails that have flourished in Funk Lagoon from frequent inundation. These releases could be timed to benefit the critical habitat. After excess growth is mechanically removed, frequent filling and release of water from Funk Lagoon would run counter to FWS objectives of mimicking the natural cycle of wetlands in the WPA. As water levels recede in the lagoon over the summer, mudflats containing food for shorebirds become exposed. Moist soil vegetation can germinate in the mudflats and grow throughout the season. The FWS would then like to fill the lagoon to provide habitat before the fall migration. The vegetation provides forage for waterfowl during the fall migration.

Legal and Institutional

No surface water permits have been issued on Lost Creek; therefore, no injury is anticipated to water users on Lost Creek from the operation of the Lost Creek-North Dry Creek cutoff. Discharges from Funk Lagoon that are diverted through the cutoff would need to be protected en route to the Platte River and between the point of the new connection with the Platte River and the original point of return. Protection is required to assure that withdrawals do not reduce credit for reductions to target flow shortages or injure water right holders below the original point of return. Cooperative administration of discharges from Funk Lagoon will need to be developed between the FWS, Tri-Basin NRD and CNPPID. Institutional consensus will be difficult to attain if management of Funk Lagoon discharges focus on the critical habitat at the expense of waterfowl within the WPA. Effects from management of Funk Lagoon for the benefit of the critical habitat may produce unfavorable impacts in the WPA. Support from local landowners is necessary in the development of a management plan that would include discharges from Funk Lagoon to benefit the critical habitat.

Economic

Most of the costs of relocating return flows are capital costs up front; amortized total costs are almost completely a function of the capital costs. In addition, there are some annual operations and maintenance costs. Direct economic impacts, secondary economic impacts and fiscal impacts should be minor for this alternative. There are minor negative effects on future economic development on Lost Creek since this water will be unavailable for other uses. There would be no measurable effect on revenues and expenditures of government entities resulting from this type of project.

Social

Relocation of return flows is not anticipated to produce any significant social impacts in the surrounding areas. Public acceptability will depend on how FWS and individual water users in the basin are affected by operation of the relocation of return flows alternative.

Environmental

Through management of Funk Lagoon, relocation of return flows will have a mixed impact on vegetation and wetlands, wildlife, and aquatic resources along the Platte River. Pursuant to the Corps of Engineers permit, operation of the Lost Creek-North Dry Creek cutoff must maintain a minimum stream flow of 5 cfs in Lost Creek before diversions are routed to North Dry Creek. Wet meadows downstream on Lost Creek may be negatively affected by reduced flows. Water quality could be degraded and fish and aquatic habitat negatively impacted during months when flows are reduced on Lost Creek and diverted to North Dry Creek. The 5 cfs baseflow was established to mitigate water quality effects associated with operation of the cutoff.

Discharge of storage water from the lagoon will allow the FWS to mechanically remove vegetative overgrowth from and around the lagoon. Vegetation removal will improve wildlife habitat in the Funk Lagoon WPA. After this time, management of Funk Lagoon counter to FWS objectives would produce negative effects to its purpose as wildlife habitat.

8.F. Incentive Based Reductions in Agricultural Water Use

F. Incentive Based Reductions In Agricultural Water Use

1. Introduction

Incentive based reductions in agricultural water use are measures to reduce consumptive use of water supplied by irrigation or to modify current usage patterns through market-based options. None of the incentive based reductions alternatives identified in the long list of alternatives were previously deferred from further analysis (see Chapter 6). Specific alternatives examined by the study team are listed below.

Agricultural Incentive Based Approaches

- Land purchase and irrigation retirement
- Permanent acquisition of agricultural water rights
- Land fallowing program
- Temporary leasing of agricultural water supplies
- Dry year leasing
- Drought water banking

Although power interference charges were originally included in this category, they bear no relationship to the agricultural incentive programs described herein. Consequently, this alternative has been moved to the systems integration and management category.

2. Conceptual Definitions

The alternatives described in this evaluation category involve the use of economic incentives to encourage changes in water use. In essence, these alternatives seek to either permanently or temporarily decrease water use by participating farmers. Similar approaches have been used in a number of locations throughout the West. Conceptual definitions of each of the alternatives evaluated in this category are provided below.

Land Purchase and Irrigation Retirement. Purchases of farms or farm lands with the intent of retiring irrigation from those lands and vacating the water right appurtenant to the lands or dedicating the water right to instream flow purposes consistent with the objectives of the Cooperative Agreement. Similar effects might be obtained by a program to establish permanent irrigation retirement agreements with farmers without actually purchasing their lands.

Permanent Acquisition of Agricultural Water Rights. Purchase of water rights from existing users with the intent of retiring these rights or transferring use to instream flow purposes.

Land Fallowing Program. An agreement with farmers to not irrigate certain lands in exchange for payment.

Temporary Leasing of Agricultural Water Supplies. Temporary transfers of irrigation water to enhance streamflows. The farmer does not relinquish ownership of water rights.

Dry Year Leasing. Temporary transfers of irrigation water under pre-specified conditions. The farmer does not relinquish ownership of water rights and retains the use of water supplies under all other conditions.

Drought Water Banking. Developing a vehicle to create a spot market for water supplies during times of greatest need for the critical habitat. Ownership of existing water rights is not lost in this process.

The operational definitions provided below describe how the alternatives will be assumed to be implemented within the study region for purposes of evaluation.

3. Operational Definitions

The following discussion presents the operational definition of each of the water conservation alternatives evaluated in this category. The intent of the operational definition is to provide a more specific, representative example of how each technique might be implemented in the study region.

The agricultural incentive based alternatives are generally "scalable." Conceptually, techniques such as purchasing agricultural lands or water rights could be implemented on a limited scale – as one of several components of the plan to reduce shortages to target flows – or on a scale to achieve all of the desired reduction in flow shortages by themselves. For purposes of this alternatives evaluation, the study team has assumed the incentive based alternatives would be implemented on a sufficient scale to achieve a substantial portion of the Cooperative Agreement's targeted reduction in flow shortages.

By assuming large-scale incentive based programs, the study team has taken a conservative approach. This approach is more likely to identify any potential adverse impacts from these alternatives. Since the marginal costs of incentive based agricultural alternatives are likely to rise as participation is sought from a larger share of farmers and farmlands, this approach may also result in higher cost estimates (per ac-ft) than the actual costs and impacts for more limited incentive based programs.

Land Purchase and Irrigation Retirement. For purposes of evaluation (and recognizing that this alternative could be scaled up or down if included in the eventual plan), the study team analyzed the effects of a program to purchase and retire from irrigation 20,000 acres of land in each of the three primary study regions (approximately corresponding to Colorado, Nebraska and Wyoming). Based on average consumptive irrigation requirements throughout the study area of more than one ac-ft per acre, land purchases of this magnitude could, conceptually, reduce the shortage in target flows at the critical habitat area by approximately 60,000 ac-ft per year. Further, the hypothetical purchases were distributed among the stream reaches to assist in modeling the hydrologic effects and in evaluating small area effects under the screening criteria.

Permanent Acquisition of Agricultural Water Rights. For purposes of evaluation (and recognizing that this alternative could be scaled up or down if included in the eventual plan), the study team analyzed the effects of a program to purchase 40,000 ac-ft of agricultural water supplies (diverted volume) in each of the three primary study regions (approximately corresponding to Colorado, Nebraska and Wyoming). This amount would result in approximately 20,000 ac-ft of reduced consumptive irrigation use per state, on average. The prospective water right purchases were distributed among the stream reaches identified for study to assist in modeling the hydrologic effects and in evaluating small area effects under the screening criteria.

Land Fallowing Program. The study team examined the implications of a program to provide payments to farmers in exchange for fallowing a portion of their historically irrigated acreage. To effect study area consumptive use, this fallowed acreage must be over and above historical fallowing practices for purposes of land conservation. For purposes of evaluation (and recognizing that this alternative could be scaled up or down if included in the eventual plan), the study team analyzed the effects of a program to fallow 20,000 acres of agricultural land in each of the three primary study regions (approximately corresponding to Colorado, Nebraska and Wyoming). As under the other incentive based programs, the study team distributed prospective fallowing practices among the respective stream reaches defined for study.

Temporary Leasing of Agricultural Water Supplies. The study team examined the implications of a program to obtain temporary leases of agricultural water supplies. To distinguish such a program from the dry year leasing alternative discussed later, the study team assumed that water supplies will be leased for a three-year period, with sufficient notice for farmers to adjust their land preparation, planting decisions and investments. For purposes of evaluation (and recognizing that this alternative could be scaled up or down if included in the eventual plan), the study team analyzed the effects of a program to lease 40,000 ac-ft of agricultural water supplies in each of the three primary study regions (approximately corresponding to Colorado, Nebraska and Wyoming). Prospective leases were distributed among the stream reaches identified for study to assist in modeling the hydrologic effects and in evaluating smaller area variations in other effects under the screening criteria. The study team assumed that new (or renewed) leases would be entered into prior to the conclusion of each three-year leasing period.

Dry Year Leasing of Agricultural Water Supplies. The study team evaluated the implications of a program designed to lease water supplies from agriculture under specified flow and climate conditions. Unlike the temporary leasing program described above, under dry year leasing there may be insufficient notice for farmers to adjust their land preparation and planting decisions and investments. For purposes of evaluation (and recognizing that this alternative could be scaled up or down if included in the eventual plan), the study team analyzed the effects of a dry year leasing program designed to lease 40,000 ac-ft of agricultural water supplies in each of the three primary study regions (approximately corresponding to Colorado, Nebraska and Wyoming) under designated conditions. The study team distributed the prospective dry year leases among the stream reaches identified for study to assist in modeling the hydrologic effects and in evaluating smaller area variations in other effects under the screening criteria.

Drought Water Banking. The best known example of a drought water bank (California) operated much like the dry year leasing program described previously, except for the participation of multiple "buyers." However, a drought water bank could also be established in order to create a "spot market" for water supplies when needed for streamflow purposes.

Net Hydrologic Effect. The water conservation alternatives in this category represent a change in established irrigation practices. The net hydrologic effect in a given month is the combined effect of reduced diversions and altered return flow patterns. As return flows lag the diversions, the change in return flows results from the change in diversion patterns in previous months. The distance between irrigated lands and the river determines the duration of return flows. Return flow patterns may extend from several months to, in some cases, many years.

The following method and assumptions were used to estimate changes in return flows:

- For each reach, the centroid of irrigated lands was identified and SDF factors selected based on location, mapping, and historical data. Some of these factors exceeded 365 days. A detailed description of the SDF method is provided in Chapter 5 and Appendix B.
- Water available to return (recharge) was set equal to headgate demand less crop consumptive irrigation requirements. Headgate demand was calculated within each reach based on consumptive irrigation requirements for irrigated lands divided by the sum of representative conveyance and on-farm efficiencies. Consumptive irrigation requirements in each reach reflect both local cropping patterns and climatological factors. A twelve-month series of recharge values was developed for both baseline conditions and altered conditions. A "difference" time series was then calculated by subtracting baseline recharge from altered recharge.

- The difference series was input to the model SDF View. The model was allowed to execute for 100 years, which allowed the return difference to closely approach steady state.

Because many of the farmlands that might participate in the incentive based alternatives are located some distance from the river, the net hydrologic effects shown in tables throughout this section are generally larger than the reduction in consumptive use on the participating farms. The difference between these estimates reflects current return flows from participating farms which do not ultimately return to the river.

4. Alternatives

Region 1

For purposes of evaluating incentive based reductions in agricultural water use, the study team focused its analysis on irrigated acres harvested for crop production. While there are other irrigated acres throughout the study region, including both irrigated pasture and irrigated crop acres that were not harvested, irrigated harvested acres represent at least 70 percent of agricultural irrigation. Further, focusing the economic analysis on harvested acres leads to evaluations that are less likely to understate the actual costs and impacts of such programs.

Table 8.F.1, below, summarizes estimated irrigated acres harvested and corresponding crop irrigation water use in Region 1. These estimates were developed by the study team from county-level agricultural information compiled by Natural Resources Consulting Engineers, Inc. (NRCE) in 1998-1999 (NRCE, 1999a). Irrigated acres harvested by reach were based on average cropping patterns in 1992, 1994 and 1996. Consumptive irrigation requirements per acre were calculated by the study team, using the modified SCS Blaney-Criddle technique, based on the three most prominent crops grown in each reach. A detailed description of the SDF method is provided in Chapter 5 and Appendix B.

These requirements reflect crop consumptive use beyond naturally occurring precipitation and reflect climate conditions as well as the crop mix in the reach. On-farm deliveries are double the consumptive irrigation requirements based on the assumption, agreed upon by the Water Management Committee early in the study process, of 50 percent on-farm efficiency throughout the study area. It should be noted that the on-site yield of agriculture related alternatives is primarily effected by the estimated consumptive irrigation requirements. The on-farm deliveries are primarily used to calculate effects on return flows.

Table 8.F.1 Estimated Water Use for Crop Irrigation in Region 1

		Water User Per Acre (in ft.)		Total Annual Water Use	
Reach	Harvested Irrigated Acres	Consumptive Irr. Rqmt.	On-farm Delivery	Consumptive Irr. Rqmt.	On-farm Delivery
1	30,503	1.63	3.26	49,664	99,287
2	68,025	1.85	3.70	125,677	251,353
3	26,653	1.85	3.69	49,209	98,418
4	26,906	1.79	3.58	48,158	96,315
5	54,905	1.52	3.04	83,577	167,155
6	71,996	1.34	2.68	96,323	192,646
12	205,439	1.46	2.92	300,196	600,392
13	101,579	1.47	2.94	149,173	298,346
Region Total/ Averages	586,006	1.61	3.23	901,977	1,803,912

Source: Study team estimates based on NRCE database for 1992, 1994, and 1996; modified Blaney-Criddle estimates of consumptive irrigation requirement.

Both surface water diversions and groundwater are applied to crop irrigation in Region 1. To contribute to the objectives of this program, incentive based programs are assumed to be applicable to reducing irrigation supplies from surface water sources only. While transfers of use of hydrologically connected groundwater could also further program objectives, sufficient data were not readily available across the study area to assess this potential. Table 8.F.2 summarizes the estimated irrigated acres harvested and annual use of surface water supplies by reach.

Table 8.F.2 Estimated Harvested Crop Irrigation by Surface Water Region 1

Reach	Harvested Irrigated Acres	Annual Consumptive Irrigation Requirement	Annual On-farm Delivery
1	30,386	49,473	98,905
2	67,837	125,329	250,657
3	26,392	48,727	97,454
4	21,560	38,589	77,178
5	45,208	68,816	137,634
6	65,781	88,008	176,016
12	178,028	260,142	520,284
13	61,439	90,225	180,451
Region Total	496,630	769,310	1,538,579

Source: Project team estimates based on information summarized in previous exhibit at United States Geological Survey National Water Use Information Program, 1990 and 1995.

Land Purchase and Irrigation Retirement

The study team has assumed for purposes of evaluation that under this alternative an agency would be created to purchase and own 20,000 acres of farmland that would subsequently be retired from irrigation. Based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.2, we have further assumed for this analysis that the following amounts of acreage would be targeted for purchase in each reach, as shown in Table 8.F.3.

Table 8.F.3 Representative Land Purchase and Irrigation Retirement Program in Region 1

Reach	Acres Purchased
Reach 1 (Northgate to Sinclair):	1,200
Reach 2 (Sinclair to Alcova):	2,600
Reach 3 (Alcova to Orin):	1,100
Reach 4 (Orin to Whalen):	900
Reach 5 (Whalen to State line):	1,800
Reach 6 (Lower Laramie River):	2,500
Reach 12 (State line to Bridgeport):	7,400
Reach 13 (Bridgeport to Lewellen):	2,500
Region 1 Total:	20,000

Yield

Based upon the crop mix and consumptive irrigation requirements (CIR) specific to each reach, the representative land purchase program in Region 1 would reduce on-farm consumptive use by 31,000 ac-ft per year. Incorporating the assumption of 50 percent on-farm efficiency agreed upon by the WMC earlier in the study process, on-farm deliveries to participating properties would be reduced by an estimated 62,000 ac-ft per year. . For purposes of this analysis, the study team has assumed that CIR is fully supplied. To the extent that farmlands in certain reaches receive less than a full irrigation supply in the average year, these estimated yields may be overstated and costs per ac-ft, described later, may be understated.

The following are the estimated effects of the representative program on water use by reach, as shown in Table 8.F.4

Table 8.F.4 On-farm Water Use Reductions of Representative Land Purchase and Irrigation Retirement Program in Region 1

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 1 (Northgate to Sinclair):	3,900 ac-ft	1,950 ac-ft
Reach 2 (Sinclair to Alcova):	9,980 ac-ft	4,990 ac-ft
Reach 3 (Alcova to Orin):	4,060 ac-ft	2,030 ac-ft
Reach 4 (Orin to Whalen):	3,220 ac-ft	1,610 ac-ft
Reach 5 (Whalen to State line):	5,480 ac-ft	2,740 ac-ft
Reach 6 (Lower Laramie River	6,960 ac-ft	3,480 ac-ft
Reach 12 (State line to Bridgeport):	21,040 ac-ft	10,520 ac-ft
Reach 13 (Bridgeport to Lewellen):	7,340 ac-ft	3,670 ac-ft
Region 1 Total:	61,980 ac-ft	30,990 ac-ft

Monthly changes in water use associated with this representative program to purchase and retire irrigation on farmland in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.5 summarizes the estimated on-site net hydrologic effects of the representative land purchase program, by reach and by month. Table 8.F.6 summarizes the effects of the representative land purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.7 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

The costs of incentive programs, such as the purchase and dry up of irrigated lands, are inherently uncertain until tested with field research or a demonstration project. The following discussion provides the study team's best estimate of the likely costs of a program to purchase and dry up the specified volumes of irrigated land in Region 1, but the actual costs could vary substantially from the estimated costs.

The estimated cost of a program to purchase and retire irrigation from lands in Region 1 includes three components: the value of irrigated farmland, potential incentives required to induce participation in the program, and administrative and transaction costs.

The study team estimated the value of irrigated lands in each reach within Region 1 based upon two alternative approaches. First, we examined the most recently published information from the United States Department of Agriculture, National Agricultural Statistics Services (NASS) on irrigated land values across the country. While these data are very current, having been published in July 1999, they only provide land value estimates on a statewide basis. To examine potential variations in the value of irrigated lands from reach to reach within Region 1, the study team also calculated an estimated irrigated land value for each reach based on the capitalized value of net income from irrigation in the reach. Our net income estimates were based on average cropping patterns, yields, prices, and costs in the NRCE database for the years 1992, 1994 and 1996.

A proactive program, intended to purchase and retire substantial amounts of irrigated farmland, would likely have to include a premium or incentive to induce participation. Purchases of agricultural land for purposes of water transfers, such as the water ranching experience in Arizona during the late 1980s, often take place at higher prices than

Table 8.F.5
Purchase Land and Irrigation Retirement
Net Hydrologic Effects - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	71	0	0	0	0	0	33	209	415	544	443	235	1950
2	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
3	78	0	0	0	0	0	18	176	403	577	525	252	2030
4	82	0	0	0	0	0	19	142	286	454	413	214	1610
5	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
6	157	0	0	0	0	0	35	332	721	950	838	448	3480
7	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
8	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
9	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
10	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
11	0	0	0	0	0	0	50	124	578	945	783	0	2480
12	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
13	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
14	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
15	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
16	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
17	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
18	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
19	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566

Table 8.F.6
Purchase Land and Irrigation Retirement
Reductions to Target Flow Shortages with Diversions - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	11	0	0	0	0	0	2	4	4	1	2	2	25
2	30	0	0	0	0	0	3	8	9	2	5	4	62
3	13	0	0	0	0	0	1	3	4	1	2	2	26
4	13	0	0	0	0	0	1	3	3	1	2	2	24
5	24	-135	-46	-29	-148	-129	-95	2	21	10	24	31	-471
6	54	0	0	0	0	0	12	16	16	4	9	16	128
7	-4	-7	-2	-2	-30	-20	-7	1	20	1	3	1	-47
8	-165	-272	-98	-74	-446	-345	-121	20	275	34	54	10	-1129
9	-430	-553	-179	-112	-506	-405	-137	27	340	149	200	10	-1595
10	-133	-126	-35	-19	-85	-69	-47	-13	72	52	82	-42	-364
11	0	0	0	0	0	0	2	2	10	1	1	0	16
12	101	-789	-259	-161	-815	-719	-575	-71	155	133	273	266	-2462
13	8	-399	-136	-85	-421	-361	-293	-53	88	99	199	151	-1204
14	-93	-71	-18	-9	-39	-30	-10	4	60	40	56	-39	-148
15	-92	-104	-32	-19	-98	-88	-77	-28	81	68	103	-11	-298
16	-178	-197	-58	-34	-169	-153	-156	-86	331	539	721	-22	539
17	-437	-464	-136	-79	-398	-360	-416	-309	963	2012	2471	-128	2720
18	-386	-413	-119	-68	-345	-312	-376	-295	1165	2457	2987	-108	4187
19	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

Table 8.F.7
Purchase Land and Irrigation Retirement
Reduction to Target Flow Shortages without Diversions - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	41	0	0	0	0	0	21	123	222	188	238	86	920
2	111	0	0	0	0	0	30	264	547	500	659	229	2341
3	47	0	0	0	0	0	12	106	222	208	294	97	986
4	50	0	0	0	0	0	13	86	162	168	238	84	800
5	42	-135	-46	-29	-148	-129	-95	23	408	667	980	265	1802
6	95	0	0	0	0	0	23	198	397	344	455	175	1687
7	-4	-7	-2	-2	-30	-20	-7	33	505	610	723	37	1834
8	-165	-272	-98	-74	-446	-345	-121	268	4056	4093	5426	241	12563
9	-430	-553	-179	-112	-506	-405	-137	148	2606	3084	3849	48	7415
10	-133	-126	-35	-19	-85	-69	-47	-13	367	613	729	-42	1138
11	0	0	0	0	0	0	34	75	334	349	431	0	1224
12	172	-789	-259	-161	-815	-719	-575	-71	1650	3192	5712	1327	8664
13	13	-399	-136	-85	-421	-361	-293	-53	628	1369	2338	543	3143
14	-93	-71	-18	-9	-39	-30	-10	14	328	480	527	-39	1040
15	-92	-104	-32	-19	-98	-88	-77	-28	358	639	830	-11	1276
16	-178	-197	-58	-34	-169	-153	-156	-86	566	1026	1380	-22	1920
17	-437	-464	-136	-79	-398	-360	-416	-309	1028	2315	2701	-128	3318
18	-386	-413	-119	-68	-345	-312	-376	-295	1203	2622	3119	-108	4522
19	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

would be expected based on the pre-existing prices of farmland and the economic value of water in irrigation. Recent purchases of land to acquire water in the Edwards Aquifer region have transacted at prices approaching $2,000 per acre – nearly double the historical going rate for irrigated lands. On the other hand, several factors may tend to reduce the required premium in this instance:

- The amount of farmland to be purchased under the representative program analyzed here is substantial, but still represents a relatively small proportion of total irrigated lands in the region.

- The land values calculated by the study team are average values for the area – but the program should be designed to seek purchase of the least productive lands that are currently irrigated. These lands have lower value and their retirement would have a lower impact on the area's agricultural economy. Variation in gross revenues per acre by crop type within Region 1 suggest marginal lands may be at least 20 percent less valuable than the average.

- Unlike most other areas where water has been purchased and transferred from agriculture to other uses, these water supplies are generally unlikely to be in demand from other purchasers such as municipal buyers.

- Purchase prices could likely be kept relatively close to market rates through a competitive purchasing mechanism. The USDA's Conservation Reserve Program has been able to enroll significant acreage within Colorado and Nebraska (and a smaller amount of Wyoming acreage) in its program to convert cropland for conservation purposes – with incentives typically ranging from zero to 20 percent. However, it should be noted that the vast majority of these acres were previously non-irrigated (1997 Census of Agriculture-State Data, 1999; USDA, 1997). The higher returns and lower risks associated with irrigated farming suggest a considerably larger premium or incentive may be required compared with dryland conservation.

Finally, there will be administrative and one-time transaction costs associated with this type of incentive program. Legal costs will be incurred in transferring title to participating lands. Marketing costs will be incurred to inform and enroll participants. On an ongoing basis, an agency will have to administer the acquired lands. This will be a dynamic program, requiring on-going staff time and other expenditures. While it is possible that existing local, state, or federal agencies, such as the USDA, might be willing to take on this administrative burden, they will incur additional costs for staff and materials which should be included in the estimated program costs.

In consideration of the factors just described and the previous experience with transfers of land for water supply in other areas, the study team estimates the range of potential costs of a program to purchase and retire irrigation from lands in Region 1 would include:

- Current value of irrigated lands: Average value across the Region as a whole estimated at $960 to $1,200 per acre based on the two valuation approaches described earlier. Reach 12, which has the largest number of irrigated acres in Region 1, also has the highest estimated value for irrigated land at $1,600 to $1,700 per acre. Reach specific values were incorporated in the cost estimates. The study team assumed that the program could realize some salvage value from the purchased land by selling or leasing it for dryland cropping or grazing purposes not involving irrigation. One half of the estimated dryland value per acre was assumed to be the salvage value of program lands in each reach.

- An incentive premium of 0 to 30 percent. This range reflects the assumption that marginal lands in Region 1 may be at least 20 percent less valuable than the average described above.

- Administrative and transaction costs of 20 to 30 percent.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, irrigated land values were applied on a reach specific basis. Table 8.F.8 summarizes the estimated costs, by reach, of the representative program to purchase lands and retire irrigation in Region 1. In total, the representative program in Region 1 would cost an estimated $28.5 million. This figure represents an average cost of about $920 per ac-ft of consumptive use saved on-farm. Average cost per ac-ft of reduction in shortage at the critical habitat would be $1,400 if the saved water can be protected from downstream diverters. If the water is not protected, in some reaches this program would produce no reduction in shortages to target flows. In the reaches where this program would reduce shortages, the costs would rise to more than $10,000 per ac-ft of shortage reduction without protection from downstream diverters.

Table 8.F.8 Estimated Cost of Representative Land Purchase and Irrigation Retirement Program in Region 1

		Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
Reach	Estimated Total Cost	CIR	Deliveries	With Diversions*	Without Diversions
1	$1,020,000	$520	$260	$41,100	$1,110
2	$2,500,000	$500	$250	$40,080	$1,070
3	$1,080,000	$530	$265	$41,800	$1,100
4	$1,010,000	$630	$315	$41,170	$1,260
5	$2,900,000	$1,060	$530	N/A	$1,610
6	$2,160,000	$620	$310	$16,890	$1,280
12	$13,460,000	$1,280	$640	N/A	$1,550
13	$4,370,000	$1,190	$595	N/A	$1,390
Region Total/ Average	$28,500,000	$920	$460	N/A	$1,400

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Permanent Acquisition of Agricultural Water Rights

The study team has assumed for purposes of evaluation that under this alternative an agency would be created to purchase and own 40,000 ac-ft of agricultural water rights (on-farm delivered volume) in Region 1. These rights would be either retired or transferred to a point of use near the state line. Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.2, we have further assumed for this analysis that the following amount of water rights would be targeted for purchase in each reach, as shown in Table 8.F.9.

Table 8.F.9 Representative Irrigation Water Right Purchase Program in Region 1

Reach	Ac-ft Purchased (Delivered Volume On-farm)
Reach 1 (Northgate to Sinclair):	2,200
Reach 2 (Sinclair to Alcova):	5,600
Reach 3 (Alcova to Orin):	2,200
Reach 4 (Orin to Whalen):	2,100
Reach 5 (Whalen to State line):	3,700
Reach 6 (Lower Laramie River):	4,300
Reach 12 (State line to Bridgeport):	13,300
Reach 13 (Bridgeport to Lewellen):	6,600
Region 1 Total:	40,000

Yield

As shown in Table 8.F.9, the representative water right purchase program in Region 1 would reduce on-farm deliveries to participating properties by an estimated 40,000 ac-ft per year. Based on an on-farm efficiency of 50 percent, on-farm consumptive use would be reduced by 20,000 ac-ft per year.

Monthly changes in water use associated with this representative water right purchase program in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.10 summarizes the estimated on-site net hydrologic effects of the representative water right purchase program, by reach and by month. Table 8.F.11 summarizes the effects of the representative water right purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.12 provides a similar summary of effects on target streamflows, without downstream diversions.

Table 8.F.10
Permanent Acquisition of Agricultural Water Rights
Net Hydrologic Effects - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	40	0	0	0	0	0	19	118	234	307	250	132	1100
2	105	0	0	0	0	0	26	250	571	801	708	339	2800
3	42	0	0	0	0	0	10	95	218	313	285	136	1100
4	54	0	0	0	0	0	12	92	187	296	269	140	1050
5	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
6	97	0	0	0	0	0	22	205	445	587	518	277	2150
7	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
8	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
9	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
10	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
11	0	0	0	0	0	0	33	83	385	628	521	0	1650
12	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
13	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
14	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1535
15	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
16	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
17	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
18	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
19	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987

Table 8.F.11
Permanent Acquisition of Agricultural Water Rights
Reductions to Target Flow Shortages with Diversions - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	6	0	0	0	0	0	1	2	2	1	1	1	14
2	17	0	0	0	0	0	2	4	5	1	3	3	35
3	7	0	0	0	0	0	1	2	2	1	1	1	14
4	9	0	0	0	0	0	1	2	2	1	1	1	16
5	16	-91	-31	-20	-100	-87	-64	2	14	6	16	21	-318
6	33	0	0	0	0	0	7	10	10	3	6	10	79
7	-3	-5	-2	-2	-21	-14	-5	1	14	1	2	0	-33
8	-114	-187	-68	-51	-307	-238	-83	14	189	24	37	7	-776
9	-293	-377	-122	-77	-345	-276	-93	19	232	101	143	7	-1080
10	-121	-115	-32	-18	-77	-62	-43	-12	66	47	74	-39	-331
11	0	0	0	0	0	0	1	1	7	0	1	0	11
12	64	-499	-164	-102	-515	-455	-363	-45	98	84	180	168	-1548
13	7	-359	-122	-76	-379	-325	-264	-47	76	82	168	132	-1107
14	-88	-67	-17	-8	-37	-29	-9	4	57	38	53	-37	-141
15	-83	-94	-29	-18	-89	-80	-70	-26	74	62	94	-10	-271
16	-162	-179	-53	-31	-154	-139	-142	-79	302	491	659	-20	493
17	-407	-433	-127	-74	-371	-336	-388	-288	898	1880	2306	-119	2542
18	-367	-393	-113	-65	-328	-297	-358	-280	1108	2353	2842	-102	4000
19	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

Table 8.F.12
Permanent Acquisition of Agricultural Water Rights
Reduction to Target Flow Shortages without Diversions - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	23	0	0	0	0	0	12	69	125	106	134	49	519
2	63	0	0	0	0	0	17	148	307	281	379	128	1323
3	26	0	0	0	0	0	6	57	120	113	161	53	536
4	33	0	0	0	0	0	8	56	106	109	155	55	522
5	28	-91	-31	-20	-100	-87	-64	15	276	454	668	179	1228
6	59	0	0	0	0	0	14	122	245	213	289	108	1050
7	-3	-5	-2	-2	-21	-14	-5	23	355	429	515	26	1296
8	-114	-187	-68	-51	-307	-238	-83	184	2791	2919	3740	166	8753
9	-293	-377	-122	-77	-345	-276	-93	101	1777	2192	2631	33	5152
10	-121	-115	-32	-18	-77	-62	-43	-12	333	557	664	-39	1036
11	0	0	0	0	0	0	22	50	222	232	294	0	821
12	109	-499	-164	-102	-515	-455	-363	-45	1043	2112	3619	839	5579
13	12	-359	-122	-76	-379	-325	-264	-47	565	1238	2104	488	2834
14	-88	-67	-17	-8	-37	-29	-9	13	312	455	501	-37	989
15	-83	-94	-29	-18	-89	-80	-70	-26	325	583	756	-10	1164
16	-162	-179	-53	-31	-154	-139	-142	-79	516	940	1260	-20	1757
17	-407	-433	-127	-74	-371	-336	-388	-288	959	2163	2520	-119	3100
18	-367	-393	-113	-65	-328	-297	-358	-280	1144	2510	2967	-102	4318
19	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

Cost

Costs associated with a program to purchase agricultural water rights are subject to similar uncertainties to the representative land purchase program described earlier regarding market response. Once again, the study team's best estimates of costs associated with this program could vary substantially from actual costs if implemented. Field research or a demonstration project would be warranted if this alternative is selected for further consideration in the Action Plan.

To estimate the costs associated with purchasing water rights the study team examined the capitalized present value of irrigation water in crop production throughout Region 1 (based on the differences between net income from irrigated and non-irrigated lands) as well as differences in the market value of irrigated cropland versus non-irrigated cropland according to the 1999 NASS data described earlier in this section. The study team also reviewed previous agricultural water right sales in the Wyoming portion of Region 1.

As with the representative land purchase program described earlier, additional factors beyond the pure economic value of irrigation supplies would influence the cost of a water right purchase program. Dry land farming is inherently different from irrigated farming in terms of risks, access to capital and management approach. Even if payments corresponding to the economic value of irrigation would, theoretically, result in no net financial impact on farmers participating in the program, an additional premium would likely be required to encourage participation. Two water transfers completed in the past ten years in the Casper, Wyoming area involving senior water rights took place at reported prices of $2,000 to $3,000 per ac-ft of consumptive use – including transaction costs. These costs are more than triple the estimated economic value of irrigation water in the area.

Analyses of transaction costs associated with previous water transfers throughout the Western U.S. indicate that these costs vary widely, but may average about 30 percent of the cost of water transfers (MacDonnell, April 1990).

In consideration of the factors just described and the previous experience with sales of water rights from irrigation in the Wyoming portions of Region 1, the study team estimates that the costs of the representative program would include the following components:

- Economic value of irrigation water supplies. For Region 1 as a whole, this value is estimated to be between $325 and $550 per ac-ft of consumptive use based on the two valuation approaches described above.

- An incentive premium of between zero and 100 percent of the economic value. This premium is a larger proportion of the cost than for a land purchase program – reflecting that the water rights market and water rights values are less clearly defined than land markets and values in most of the area. However, the incentive range also recognizes the possibility that water might be drawn from marginal uses with lower value than the average cited above.

- Transaction costs (legal and administrative) of 20 to 30 percent. Water rights purchase transactions may be more complex than the land purchases described previously, although land title does not have to be transferred.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, irrigation economic values were applied on a reach specific basis. Table 8.F.13 summarizes the estimated costs, by reach, of the representative program to purchase agricultural water rights in Region 1. In total, the study team estimates that the representative program in Region 1 would cost approximately $18 million. This figure represents an average cost of about $880 per ac-ft of consumptive use saved on-farm. Average cost per ac-ft of reduction in shortage at the critical habitat would be about $1,310 if the saved water can be protected from downstream diverters. If the water is not protected, in some reaches this program would produce no reduction in shortages to target flows. In the reaches where this program would reduce shortages, the costs would rise to more than $10,000 per ac-ft of shortage reduction without protection from downstream diverters.

Table 8.F.13 Estimated Cost of Representative Water Right Purchase Program in Region 1

Reach	Estimated Total Cost	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions*	Without Diversions
1	$520,000	$470	$235	$37,140	$1,000
2	$1,320,000	$470	$235	$37,710	$1,000
3	$590,000	$540	$270	$42,140	$1,100
4	$680,000	$650	$325	$42,500	$1,300
5	$2,130,000	$1,150	$575	N/A	$1,730
6	$1,310,000	$610	$305	$16,580	$1,250
12	$7,710,000	$1,160	$580	N/A	$1,380
13	$3,500,000	$1,060	$530	N/A	$1,240
Region Total/ Average	$17,760,000	$880	$440	N/A	$1,310

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Land Fallowing

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would administer a voluntary land fallowing program that would provide incentives to farmers in Region 1 to fallow an annual total of 20,000 acres of farmland that would otherwise have been irrigated. To provide maximum flexibility, annual fallowing contracts could be devised and the mix of farms participating in the program allowed to vary from year to year. Individual farm owners could choose to fallow a portion of their acreage, likely subject to a minimum number of participating acres to manage administrative and program management costs.

For purposes of this evaluation, we have further assumed for this analysis that the following amounts of acreage would be fallowed in each reach, as shown in Table 8.F.14, based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.2:

Table 8.F.14 Representative Land Fallowing Program in Region 1

Reach	Acres Fallowed
Reach 1 (Northgate to Sinclair):	1,200
Reach 2 (Sinclair to Alcova):	2,600
Reach 3 (Alcova to Orin):	1,100
Reach 4 (Orin to Whalen):	900
Reach 5 (Whalen to State line):	1,800
Reach 6 (Lower Laramie River):	2,500
Reach 12 (State line to Bridgeport):	7,400
Reach 13 (Bridgeport to Lewellen):	2,500
Region 1 Total:	20,000

Yield

The study team has assumed that acres voluntarily placed into the fallowing program would have otherwise been planted and irrigated in the same manner, on average, as current irrigated crop production in each reach. Under this assumption, the land fallowing program would have the same annual effects on water-use as the representative land purchase program described previously. The following are the estimated effects of the representative program on water use by reach, as shown in Table 8.F.15.

Table 8.F.15 On-farm Water Use Reductions of Representative Land Fallowing Program in Region 1

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 1 (Northgate to Sinclair):	3,900 ac-ft	1,950 ac-ft
Reach 2 (Sinclair to Alcova):	9,980 ac-ft	4,990 ac-ft
Reach 3 (Alcova to Orin):	4,060 ac-ft	2,030 ac-ft
Reach 4 (Orin to Whalen):	3,220 ac-ft	1,610 ac-ft
Reach 5 (Whalen to State line):	5,480 ac-ft	2,740 ac-ft
Reach 6 (Lower Laramie River	6,960 ac-ft	3,480 ac-ft
Reach 12 (State line to Bridgeport):	21,040 ac-ft	10,520 ac-ft
Reach 13 (Bridgeport to Lewellen):	7,340 ac-ft	3,670 ac-ft
Region 1 Total:	61,980 ac-ft	30,990 ac-ft

Monthly changes in water use associated with this representative land fallowing program in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.16 summarizes the estimated on-site net hydrologic effects of the representative land fallowing program, by reach and by month. Table 8.F.17 summarizes the effects of the representative land fallowing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.18 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

A conceptually similar program of voluntary land fallowing to reduce water use was implemented in the Palo Verde Irrigation District (PVID) in California from 1992 through 1994. This example is instructive in terms of the feasibility of such programs and the administrative costs associated with them, although PVID agricultural conditions differ considerably from those in Region 1. In particular, it should be noted that PVID has a year round growing season, extremely productive soils, and receives an average of less than five inches of rainfall per year. As a consequence, annual gross farm revenue per acre in PVID (over $500 per acre) is more than double the typical gross revenues from irrigated crop production in Region 1. Dryland crop production is impossible in PVID, and there were substantial costs associated with maintaining soils on fallowed lands during the program. Further, the Palo Verde Test Program sought (successfully) participation of about 25% of all PVID irrigated acreage in the fallowing program – a much higher proportion than that being considered in the representative fallowing program for Region 1 (Palo Verde Test Program information from reports for MWD, December 1994 and August 1995).

Despite the aforementioned differences, it is useful to note that Metropolitan Water District of Southern California paid about $135 per ac-ft per year (on-farm delivered volume) to enlist participation in the program. Administrative and monitoring costs during the test program were about $720,000 per year, or $35 per acre fallowed.

Table 8.F.16
Land Fallowing Program
Net Hydrologic Effects - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	71	0	0	0	0	0	33	209	415	544	443	235	1950
2	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
3	78	0	0	0	0	0	18	176	403	577	525	252	2030
4	82	0	0	0	0	0	19	142	286	454	413	214	1610
5	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
6	157	0	0	0	0	0	35	332	721	950	838	448	3480
7	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
8	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
9	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
10	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
11	0	0	0	0	0	0	50	124	578	945	783	0	2480
12	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
13	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
14	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
15	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
16	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
17	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
18	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
19	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566

Table 8.F.17

Land Fallowing Program

Reductions to Target Flow Shortages with Diversions - Average of Years 1975 - 1994

(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	11	0	0	0	0	0	2	4	4	1	2	2	25
2	30	0	0	0	0	0	3	8	9	2	5	4	62
3	13	0	0	0	0	0	1	3	4	1	2	2	26
4	13	0	0	0	0	0	1	3	3	1	2	2	24
5	24	-135	-46	-29	-148	-129	-95	2	21	10	24	31	-471
6	54	0	0	0	0	0	12	16	16	4	9	16	128
7	-4	-7	-2	-2	-30	-20	-7	1	20	1	3	1	-47
8	-165	-272	-98	-74	-446	-345	-121	20	275	34	54	10	-1129
9	-430	-553	-179	-112	-506	-405	-137	27	340	149	200	10	-1595
10	-133	-126	-35	-19	-85	-69	-47	-13	72	52	82	-42	-364
11	0	0	0	0	0	0	2	2	10	1	1	0	16
12	101	-789	-259	-161	-815	-719	-575	-71	155	133	273	266	-2462
13	8	-399	-136	-85	-421	-361	-293	-53	88	99	199	151	-1204
14	-93	-71	-18	-9	-39	-30	-10	4	60	40	56	-39	-148
15	-92	-104	-32	-19	-98	-88	-77	-28	81	68	103	-11	-298
16	-178	-197	-58	-34	-169	-153	-156	-86	331	539	721	-22	539
17	-437	-464	-136	-79	-398	-360	-416	-309	963	2012	2471	-128	2720
18	-386	-413	-119	-68	-345	-312	-376	-295	1165	2457	2987	-108	4187
19	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

Table 8.F.18

Land Fallowing Program

Reduction to Target Flow Shortages without Diversions - Average of Years 1975 - 1994

(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	41	0	0	0	0	0	21	123	222	188	238	86	920
2	111	0	0	0	0	0	30	264	547	500	659	229	2341
3	47	0	0	0	0	0	12	106	222	208	294	97	986
4	50	0	0	0	0	0	13	86	162	168	238	84	800
5	42	-135	-46	-29	-148	-129	-95	23	408	667	980	265	1802
6	95	0	0	0	0	0	23	198	397	344	455	175	1687
7	-4	-7	-2	-2	-30	-20	-7	33	505	610	723	37	1834
8	-165	-272	-98	-74	-446	-345	-121	268	4056	4093	5426	241	12563
9	-430	-553	-179	-112	-506	-405	-137	148	2606	3084	3849	48	7415
10	-133	-126	-35	-19	-85	-69	-47	-13	367	613	729	-42	1138
11	0	0	0	0	0	0	34	75	334	349	431	0	1224
12	172	-789	-259	-161	-815	-719	-575	-71	1650	3192	5712	1327	8664
13	13	-399	-136	-85	-421	-361	-293	-53	628	1369	2338	543	3143
14	-93	-71	-18	-9	-39	-30	-10	14	328	480	527	-39	1040
15	-92	-104	-32	-19	-98	-88	-77	-28	358	639	830	-11	1276
16	-178	-197	-58	-34	-169	-153	-156	-86	566	1026	1380	-22	1920
17	-437	-464	-136	-79	-398	-360	-416	-309	1028	2315	2701	-128	3318
18	-386	-413	-119	-68	-345	-312	-376	-295	1203	2622	3119	-108	4522
19	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

The USDA's Conservation Reserve Program (CRP) is also similar in concept to the fallowing program described herein, although it principally targets non-irrigated lands. Approximately 250,000 acres in Wyoming, and more than 1 million acres in Nebraska, have been withdrawn from crop production under the CRP program. The average annual payment for CRP participation, exclusive of administrative costs, is about $30 per acre in Wyoming and over $50 per acre in Nebraska.

The study team has estimated the annual costs of the representative land fallowing program for Region 1 based on the following components:

- Annual value of irrigated lands in Region 1. Based upon two measures – annual net income to farmers and irrigated land rental rates – this value for the region as a whole is between $40 and $50 per acre.
- An incentive premium to induce participation of between zero and 50 percent of the annual economic value would likely be required to induce participation. This range reflects the possibility that marginal lands with lower than average value might comprise the bulk of lands enrolled in the program.
- Administrative costs, in the long run, would average $20 per acre fallowed. This value reflects the assumption that an ongoing program would have lower administrative costs than the Palo Verde test program described earlier.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition economic values were applied on a reach specific basis. On an annual basis, the study team estimates that the representative fallowing program would cost an average of about $80 per ac-ft of consumptive use saved on-farm in Region 1 ($40 per ac-ft of water previously delivered on-farm). Annual costs were converted to capitalized total costs based on a six percent discount rate (appropriate for public entities that can obtain tax-free financing). Table 8.F.19 summarizes the estimated capitalized costs, by reach, of the representative program to fallow irrigated lands in Region 1. The study team estimates that the representative program in Region 1 would have a capitalized total cost of approximately $29 million. This figure represents an average capitalized cost of about $930 per ac-ft of consumptive use saved on-farm. Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be $1,410 if the saved water can be protected from downstream diverters, and more than $10,000 per ac-ft if the water is not protected. In some Region 1 reaches, the representative land fallowing program would offer no reduction in annual shortages to target flows if the water conserved by this program cannot be protected from downstream diverters.

Table 8.F.19 Estimated Capitalized Cost of Representative Land Fallowing Program in Region 1

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings CIR	Deliveries	Cost per Ac-ft of Reduced Shortage at Critical Habitat With Diversions*	Without Diversions
1	$1,130,000	$580	$290	$45,530	$1,230
2	$2,660,000	$530	$265	$42,650	$1,130
3	$1,170,000	$580	$290	$45,290	$1,180
4	$1,040,000	$650	$325	$42,390	$1,300
5	$2,630,000	$960	$480	N/A	$1,460
6	$2,540,000	$730	$365	$19,860	$1,510
12	$13,110,000	$1,250	$625	N/A	$1,510
13	$4,440,000	$1,210	$605	N/A	$1,410
Region Total/ Average	$28,720,000	$930	$465	N/A	$1,410

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Temporary Leasing of Agricultural Water Supplies

The study team has assumed for purposes of evaluation that under this alternative an agency would be created to administer a voluntary leasing program that would provide incentives to farmers in Region 1 to annually lease 40,000 ac-ft of water supplies (delivered on farm) that would otherwise have been used in irrigation. To provide maximum flexibility, short-term, two- to five-year leasing contracts could be devised and the mix of farms participating in the program allowed to vary over time. Individual farm owners could choose to lease a portion of their water supplies, likely subject to a minimum lease volume to manage administrative and program management costs.

Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.2, the study team has further assumed for this analysis that the following amounts of water supplies would be leased in each reach, as shown in Table 8.F.20.

Table 8.F.20 Representative Irrigation Water Leasing Program in Region 1

Reach	Ac-ft Leased (Delivered Volume On-farm)
Reach 1 (Northgate to Sinclair):	2,200
Reach 2 (Sinclair to Alcova):	5,600
Reach 3 (Alcova to Orin):	2,200
Reach 4 (Orin to Whalen):	2,100
Reach 5 (Whalen to State line):	3,700
Reach 6 (Lower Laramie River):	4,300
Reach 12 (State line to Bridgeport):	13,300
Reach 13 (Bridgeport to Lewellen):	6,600
Region 1 Total:	40,000

Yield

As shown in Table 8.F.20, the representative water leasing program in Region 1 would reduce on-farm deliveries to participating properties by an estimated 40,000 ac-ft per year. On-farm consumptive use would be reduced by 20,000 ac-ft per year based on an on-farm efficiency of 50 percent.

Monthly changes in water use associated with this representative water-leasing program in Region 1 were routed downstream using the water budget spreadsheet. The analysis for the water budget spreadsheet also incorporated changes in return flows that would result from this program and reductions in canal and ditch losses and corresponding return flows. This analysis was performed under two scenarios: with and without protection from downstream diverters.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.21 summarizes the estimated on-site net hydrologic effects of the representative water leasing program, by reach and by month. Table 8.F.22 summarizes the effects of the representative water leasing

Table 8.F.21
Temporary Leasing of Agricultural Water Supplies
Net Hydrologic Effects - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	40	0	0	0	0	0	19	118	234	307	250	132	1100
2	105	0	0	0	0	0	26	250	571	801	708	339	2800
3	42	0	0	0	0	0	10	95	218	313	285	136	1100
4	54	0	0	0	0	0	12	92	187	296	269	140	1050
5	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
6	97	0	0	0	0	0	22	205	445	587	518	277	2150
7	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
8	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
9	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
10	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
11	0	0	0	0	0	0	33	83	385	628	521	0	1650
12	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
13	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
14	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1535
15	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
16	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
17	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
18	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
19	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987

Table 8.F.22
Temporary Leasing of Agricultural Water Supplies
Reductions to Target Flow Shortages with Diversions - Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	6	0	0	0	0	0	1	2	2	1	1	1	14
2	17	0	0	0	0	0	2	4	5	1	3	3	35
3	7	0	0	0	0	0	1	2	2	1	1	1	14
4	9	0	0	0	0	0	1	2	2	1	1	1	16
5	16	-91	-31	-20	-100	-87	-64	2	14	6	16	21	-318
6	33	0	0	0	0	0	7	10	10	3	6	10	79
7	-3	-5	-2	-2	-21	-14	-5	1	14	1	2	0	-33
8	-114	-187	-68	-51	-307	-238	-83	14	189	24	37	7	-776
9	-293	-377	-122	-77	-345	-276	-93	19	232	101	143	7	-1080
10	-121	-115	-32	-18	-77	-62	-43	-12	66	47	74	-39	-331
11	0	0	0	0	0	0	1	1	7	0	1	0	11
12	64	-499	-164	-102	-515	-455	-363	-45	98	84	180	168	-1548
13	7	-359	-122	-76	-379	-325	-264	-47	76	82	168	132	-1107
14	-88	-67	-17	-8	-37	-29	-9	4	57	38	53	-37	-141
15	-83	-94	-29	-18	-89	-80	-70	-26	74	62	94	-10	-271
16	-162	-179	-53	-31	-154	-139	-142	-79	302	491	659	-20	493
17	-407	-433	-127	-74	-371	-336	-388	-288	898	1880	2306	-119	2542
18	-367	-393	-113	-65	-328	-297	-358	-280	1108	2353	2842	-102	4000
19	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

Table 8.F.23
Temporary Leasing of Agricultural Water Supplies
Reduction to Target Flow Shortages without Diversions- Average of Years 1975 - 1994
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	23	0	0	0	0	0	12	69	125	106	134	49	519
2	63	0	0	0	0	0	17	148	307	281	379	128	1323
3	26	0	0	0	0	0	6	57	120	113	161	53	536
4	33	0	0	0	0	0	8	56	106	109	155	55	522
5	28	-91	-31	-20	-100	-87	-64	15	276	454	668	179	1228
6	59	0	0	0	0	0	14	122	245	213	289	108	1050
7	-3	-5	-2	-2	-21	-14	-5	23	355	429	515	26	1296
8	-114	-187	-68	-51	-307	-238	-83	184	2791	2919	3740	166	8753
9	-293	-377	-122	-77	-345	-276	-93	101	1777	2192	2631	33	5152
10	-121	-115	-32	-18	-77	-62	-43	-12	333	557	664	-39	1036
11	0	0	0	0	0	0	22	50	222	232	294	0	821
12	109	-499	-164	-102	-515	-455	-363	-45	1043	2112	3619	839	5579
13	12	-359	-122	-76	-379	-325	-264	-47	565	1238	2104	488	2834
14	-88	-67	-17	-8	-37	-29	-9	13	312	455	501	-37	989
15	-83	-94	-29	-18	-89	-80	-70	-26	325	583	756	-10	1164
16	-162	-179	-53	-31	-154	-139	-142	-79	516	940	1260	-20	1757
17	-407	-433	-127	-74	-371	-336	-388	-288	959	2163	2520	-119	3100
18	-367	-393	-113	-65	-328	-297	-358	-280	1144	2510	2967	-102	4318
19	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.23 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Markets for permanent water rights transfers and temporary leases or rentals of water supplies often coexist. Good examples include the Northern Colorado Water Conservancy District in Colorado, the Rio Grande Valley in Texas and, most recently, the Edwards Aquifer Region in Texas. In general, the cost of short-term water transfers through leases or rentals is less than the annualized value of the cost of permanent water transfers. Reasons for this divergence are that farmers do not trade away their rights and their permanent asset value when entering into leases or rental agreements and, because leasing is a more flexible option, leasing programs may work better at attracting water supplies that would have been put to low valued, marginal use.

Based on the preceding considerations, the study team anticipates that the required premium needed to induce farmers to participate in a water leasing program would be less than the premium required for outright purchase of water rights. Legal transaction costs might be lower for a leasing program, but administrative transaction costs might be higher than with permanent water right purchases. The study team has estimated the annual costs of the representative water leasing program for Region 1 based on the following components:

- Annual economic value of irrigation on Region 1 lands. This value was estimated in a similar manner to the annual economic value of irrigated lands for the land fallowing alternative. However, the annual economic value is lower under the leasing alternative than under land fallowing because dry land cropping could offset a portion of the farmers' income loss under the leasing program. Annual value of irrigation supplies for Region 1 as a whole are estimated at between $22 and $38 per ac-ft of consumptive use based on farm net income and land rental differentials between irrigated and non-irrigated lands.

- An incentive premium of between zero and 50 percent to induce participation in the program.
- Transaction and administrative costs representing approximately 30 percent of total program costs.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition economic values were applied on a reach specific basis. On an annual basis, the study team estimates that the representative water leasing program would cost an average of about $50 per ac-ft of consumptive use saved on-farm in Region 1. Converting annual costs over 20 years to capitalized costs based on a six percent discount rate, the study team estimates that the representative leasing program in Region 1 would have a present value capitalized cost of over $12 million, as shown in Table 8.F.24. This figure represents an average capitalized cost of about $610 per ac-ft of consumptive use saved on-farm. Average cost per ac-ft of reduction in shortage at the critical habitat would be $890 if the saved water can be protected from downstream diverters, and more than $10,000 if the water is not protected. In some Region 1 reaches, a water leasing program would have no effect on shortages to target flows without protection from downstream diverters.

Table 8.F.24 Estimated Capitalized Cost of Representative Water Leasing Program in Region 1

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions*	Without Diversions
1	$370,000	$340	$170	$26,430	$710
2	$970,000	$350	$175	$27,710	$730
3	$430,000	$390	$195	$30,710	$800
4	$480,000	$460	$230	$30,000	$920
5	$1,430,000	$770	$385	N/A	$1,160
6	$940,000	$440	$220	$11,900	$900
12	$5,200,000	$780	$390	N/A	$930
13	$2,320,000	$700	$350	N/A	$820
Region Total/ Average	$12,140,000	$610	$305	N/A	$890

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Dry Year Leasing

Dry year leasing is a form of contingent water transfer, in which contracted quantities of water would be transferred from irrigation under contractually specified conditions. Typically such arrangements involve a relatively small annual contractual payment every year plus a larger payment in any year in which the lease is actually exercised (Jay R. Lund, Morris Israel, January/February 1995).

Yield

Unlike the other incentive based alternatives previously described, the yield of a dry year leasing program would be zero in some years and substantial in others, depending on whether or not the leases were activated. The decision rule for determining the conditions under which the leases would be activated is critical in determining the yield from this type of program. Ideally, the dry year leasing program should be activated in years that will have the largest shortages to target flows during the height of the irrigation season between June and September. For such a program to have any chance of being viable and economic, however, farmers must have at least some advance notice of when the leases will be activated.

Because the decision to activate dry year leases must be made in advance, any decision rule will be less than perfect. In some cases, dry year leases will likely be activated in years that do not ultimately turn out to be "dry" and vice-versa.

The study team examined the monthly shortages at Grand Island and determined that whether a year was dry, wet or average from a precipitation standpoint had essentially no relationship to shortages to target flows experienced during the irrigation season. The three years with the largest cumulative shortages to target flows during the historical period of record were 1977, 1978 and 1990 – all classified as average years. The study team did, however, find a correlation between cumulative shortages in the fall and winter and shortages during the subsequent irrigation season. Based upon this analysis, the study team has assumed that participating farmers would be notified that their dry year leases would be activated for the following irrigation season any time the accumulated monthly shortages to target flows at Grand Island during the months of October through February were greater than

150,000 ac-ft. Based on the period of record, this would have resulted in activation of leases in 1975, 1977, 1978, 1979, 1980, 1990 and 1993. Essentially, the program would be activated in about one year in three.

Assuming that the target dry year leasing volume for each reach would be the same as under the representative leasing program described previously, the yield of the dry year lease program would be the same as shown in Table 8.F.20. In years when dry year leases were activated, the total reduction in Region 1 water use would be 40,000 ac-ft delivered on-farm (and 20,000 ac-ft of on-farm consumptive use). Unlike the representative leasing program, however, the yield would only be realized in about one in three years.

Net hydrologic effects of dry year leases were analyzed as if the steady state return flow condition would be realized in the year that the lease operates. The study team acknowledges that, particularly where return flows are delayed for many months, this would not be the case in reality. Actual stream impact during the dry year would be more positive than this analysis shows, because historically diverted water would remain in the stream while last year's return flows would continue to accrue to the stream. Conversely, this approach does not identify a negative effect in the next year, when diversions return to normal but return flows are less than they were historically because the dry year lease was exercised the previous year.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.25 summarizes the estimated on-site net hydrologic effects of the representative dry year leasing program, by reach and by month. Table 8.F.26 summarizes the effects of the representative dry year leasing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.27 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Direct costs of dry year leases typically include both the annual payment for participation in the lease option arrangement and an additional payment in years when the lease is actually exercised. Dry

Table 8.F.25
Dry Year Leasing
Net Hydrologic Effects - Average of Years 1975, 1977-1980, 1990, 1993 When Leases Would Have Been Exercised Only (ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	14	0	0	0	0	0	7	41	82	107	88	46	385
2	37	0	0	0	0	0	9	88	200	280	248	118	980
3	15	0	0	0	0	0	3	33	76	109	100	48	385
4	19	0	0	0	0	0	4	32	65	104	94	49	368
5	16	-74	-76	-77	-78	-77	-65	9	167	428	425	159	757
6	34	0	0	0	0	0	8	72	156	205	181	97	753
7	-58	-62	-63	-64	-64	-64	-36	13	215	407	330	23	577
8	-434	-451	-453	-457	-460	-460	-242	104	1666	3075	2470	148	4505
9	-425	-423	-392	-361	-332	-308	-125	56	1035	2198	1710	29	2663
10	-118	-99	-84	-73	-65	-58	-40	-22	190	504	410	-87	459
11	0	0	0	0	0	0	12	29	135	220	182	0	578
12	62	-400	-399	-399	-400	-401	-355	-141	620	2130	2347	741	3405
13	7	-287	-296	-298	-292	-284	-247	-114	329	1195	1336	426	1475
14	-80	-53	-40	-33	-28	-25	-8	7	178	408	302	-90	538
15	-60	-59	-60	-60	-60	-61	-49	-35	183	518	460	-22	694
16	-93	-93	-93	-93	-93	-93	-77	-59	288	845	769	-27	1178
17	-224	-224	-224	-224	-224	-224	-195	-157	529	1957	1535	-102	2223
18	-195	-195	-195	-195	-195	-195	-176	-149	623	2255	1790	-84	3089
19	-164	-164	-164	-164	-164	-164	-156	-146	518	1788	1519	-95	2445

Table 8.F.26
Dry Year Leasing
Reductions to Target Flow Shortages with Diversions
Average of Years 1975, 1977-1980, 1990, 1993 When Leases Would Have Been Exercised Only
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	4	0	0	0	0	0	1	1	1	0	0	0	8
2	10	0	0	0	0	0	1	2	3	0	1	1	19
3	4	0	0	0	0	0	0	1	1	0	0	0	8
4	5	0	0	0	0	0	0	1	1	0	0	0	9
5	7	-37	-31	-20	-43	-31	-33	1	8	1	7	9	-160
6	15	0	0	0	0	0	4	4	6	1	2	4	37
7	-1	-1	-2	-2	-7	-5	-3	0	11	0	1	0	-9
8	-48	-75	-68	-51	-123	-86	-45	4	128	3	12	3	-345
9	-124	-155	-122	-77	-141	-97	-44	8	136	20	61	3	-532
10	-53	-46	-32	-18	-32	-22	-20	-5	36	10	34	-19	-168
11	0	0	0	0	0	0	1	0	5	0	0	0	7
12	29	-201	-164	-102	-221	-163	-182	-21	55	17	74	76	-803
13	3	-145	-122	-76	-163	-116	-130	-22	41	17	71	61	-581
14	-40	-27	-17	-8	-16	-10	-4	2	31	8	24	-18	-77
15	-38	-39	-29	-18	-39	-29	-32	-12	42	15	41	-4	-143
16	-73	-75	-53	-31	-68	-52	-61	-36	141	184	255	-9	122
17	-179	-182	-127	-74	-165	-125	-158	-127	388	785	859	-56	840
18	-161	-167	-113	-65	-146	-110	-146	-123	479	1027	1071	-49	1498
19	-151	-155	-107	-62	-132	-93	-133	-125	429	1091	1147	-70	1637

Table 8.F.27
Dry Year Leasing
Reductions to Target Flow Shortages without Diversions
Average of Years 1975, 1977-1980, 1990, 1993 When Leases Would Have Been Exercised Only
(ac-ft)

Reach	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1	10	0	0	0	0	0	5	31	54	41	58	23	221
2	28	0	0	0	0	0	7	65	132	110	157	60	558
3	11	0	0	0	0	0	3	25	51	44	69	25	228
4	14	0	0	0	0	0	3	25	45	43	66	26	222
5	13	-37	-31	-20	-43	-31	-33	7	118	179	264	84	471
6	26	0	0	0	0	0	6	54	107	86	123	51	453
7	-1	-1	-2	-2	-7	-5	-3	10	150	168	208	12	527
8	-48	-75	-68	-51	-123	-86	-45	79	1194	1282	1424	78	3562
9	-124	-155	-122	-77	-141	-97	-44	44	768	930	1003	16	2001
10	-53	-46	-32	-18	-32	-22	-20	-5	144	219	262	-19	378
11	0	0	0	0	0	0	9	21	94	91	124	0	340
12	48	-201	-164	-102	-221	-163	-182	-21	450	899	1369	395	2109
13	5	-145	-122	-76	-163	-116	-130	-22	243	515	801	231	1021
14	-40	-27	-17	-8	-16	-10	-4	6	134	179	201	-18	380
15	-38	-39	-29	-18	-39	-29	-32	-12	140	230	296	-4	424
16	-73	-75	-53	-31	-68	-52	-61	-36	222	394	486	-9	643
17	-179	-182	-127	-74	-165	-125	-158	-127	412	963	961	-56	1145
18	-161	-167	-113	-65	-146	-110	-146	-123	493	1130	1132	-49	1676
19	-151	-155	-107	-62	-132	-93	-133	-125	429	1091	1147	-70	1637

year leasing arrangements are currently being explored in the Edwards Aquifer region in Texas, alongside other forms of incentives. The first lesson from this experience is that the annual payment for participation must be substantive to interest farmers in participating in such a program. The second lesson is that the magnitude of the required payment in years when the lease is triggered depends, in part, on how much advance notification is provided to farmers so that they can adjust their planting and investment decisions.

The decision rule assumed by the study team for implementing dry year leases in Region 1, would provide later than optimal notice to farmers and might strand a portion of their investment for the following irrigation season. In addition, arrangements with rental operators might well already be in place. Unfortunately, this late notice is probably unavoidable in order to activate the dry year leases in years when they are most likely to benefit the critical habitat. Because of the uncertainty that dry year leasing arrangements impose on farmers, this mechanism is generally less popular and more costly in the years that the leases are implemented than ongoing, predetermined leases.

Based on the preceding considerations, the study team has estimated the annual costs of the representative dry year leasing program for Region 1 based on the following assumptions:

- Costs of dry year leases in years that the leases are activated would be 50 percent greater than the annual costs of on-going water leases in the same reach.
- Annual contractual payments for participating in the dry year leasing program, in years when the leases are not activated, would be one-half of the annual cost of on-going water leases in the same reach.

Based on the assumption that leases would be activated once every three years, as would have occurred during the period of record under the decision rule used for this evaluation, Table 8.F.28 summarizes the estimated capitalized costs, by reach, of the representative water leasing program in Region 1. Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be $1,530 if the saved water can be protected from downstream diverters. If the water is not protected from downstream diverters, a dry year leasing program in several Region 1 reaches would offer no reduction in target flow shortages. In the other Region 1 reaches the costs would be more than $10,000 per ac-ft without protection from downstream diverters.

Prior studies of dry year leasing, typically focusing on making water available for municipal water supplies under drought conditions, have often found this alternative to be among the most cost effective options. In this instance, however, in which additional flows will be needed in many years and not just under severe drought conditions, it is not surprising that this alternative may be less cost effective than ongoing leasing arrangements or other incentive based measures.

Table 8.F.28 Estimated Capitalized Costs of Representative Dry Year Leasing Program in Region 1

		Cost per Ac-ft of On-farm Water Savings*		Cost per Ac-ft of Reduced Shortage at Critical Habitat*	
Reach	**Estimated Capitalized Cost***	**CIR**	**Deliveries**	**With Diversions****	**Without Diversions**
1	$250,000	$680	$340	$31,250	$1,130
2	$650,000	$700	$350	$34,210	$1,160
3	$290,000	$780	$390	$36,250	$1,270
4	$320,000	$920	$460	$35,560	$1,440
5	$950,000	$1,540	$770	N/A	$2,020
6	$630,000	$880	$440	$17,030	$1,390
12	$3,450,000	$1,560	$780	N/A	$1,640
13	$1,540,000	$1,400	$700	N/A	$1,510
Region Total/ Average	$8,080,000	$1,210	$610	N/A	$1,530

* Calculation reflects estimate that leases will be activated in approximately one in three years.

** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Drought Water Banking

California initiated the most well known water banking activity during the early 1990s; it operated more like the representative leasing program described previously. Other attempts to create flexible water banks have met with mixed success at best. For example, the water bank established by the Texas Water Development Board about five years ago has seen almost no activity. On the other hand, active spot markets for water supplies do exist in a number of places where water supplies are undifferentiated and freely transferable with little or no transaction cost – including the Northern Colorado Water Conservancy

District, California's Central Valley Project and the Rio Grande Valley in Texas. Water banks and spot markets typically exist in areas that share common storage and flexible water allocation rules within a given area. The concept of a drought water bank would be to create an active spot market for short-term water supplies that could be removed from irrigation and left in the river when needed. Under these conditions, water banks may have lower on going administrative and transaction costs than one-on-one leasing arrangements, although start up costs may be greater.

A water bank in the context of the Cooperative Agreement would be unlike others in that water would be purchased from multiple buyers and dedicated for a single purpose, rather than resold to multiple buyers. This type of water bank could only function if current water users were offered compensation for their water to give up rights to its usage temporarily. The amount of compensation would be very similar to that of a dry year leasing program or a temporary leasing program, if the bank were to operate continuously. The yields and impacts of the program would also be similar.

From the perspective of this study, a water bank would only represent a mechanism or administrative structure for implementing any of the incentive programs or even agricultural conservation programs previously addressed. Therefore, it should not be analyzed further in this study as a separate, distinct agricultural incentive program.

Region 2

Except where noted in this section, the study team's approach and assumptions in evaluating incentive based approaches in Region 2 were the same as described previously for Region 1. In the interest of brevity, the following is an abbreviated description of the costs and yields associated with incentive based alternatives in Region 2. This discussion focuses on information specific to Region 2 and the reader is advised to refer back to the Region 1 discussion for additional insight regarding the analytical basis for estimated yields and costs.

Table 8.F.29, below, summarizes estimated irrigated acres harvested and corresponding crop irrigation water use in Region 2.

Table 8.F.29 Estimated Water Use for Crop Irrigation in Region 2

		Water User Per Acre (in ft.)		Total Annual Water Use	
Reach	Harvested Irrigated Acres	Consumptive Irr. Rqmt.	On-farm Delivery	Consumptive Irr. Rqmt.	On-farm Delivery
7	36,985	1.60	3.20	59,155	118,310
8	339,371	1.53	3.06	518,873	1,037,747
9	260,486	1.40	2.81	365,952	731,904
11	55,266	1.24	2.48	68,423	136,846
Region Total/ Averages	692,108	1.44	2.89	1,012,403	2,024,807

Source: Study team estimates based on NRCE database for 1992, 1994, and 1996; modified Blaney-Criddle estimates of consumptive irrigation requirement.

Table 8.F.30 summarizes the estimated irrigated acres harvested and annual use of surface water by reach and by source of water supply.

Table 8.F.30 Estimated Harvested Crop Irrigation by Surface Water in Region 2

Reach	Harvested Irrigated Acres	Annual Consumptive Irrigation Requirement	Annual On-farm Delivery
7	27,028	43,230	86,460
8	211,238	322,967	645,934
9	157,081	220,681	441,362
11	42,995	53,231	106,462
Region Total	438,343	640,109	1,280,218

Source Project team estimates based on information summarized in previous exhibit and United States Geological survey National Water Use Information Program, 1990 and 1995.

Land Purchase and Irrigation Retirement

The study team has assumed for purposes of evaluation that under this alternative an agency would be created to purchase and own 20,000 acres of farmland that would subsequently be retired from irrigation. Based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.30, and the assumption for purposes of evaluation that 20,000 acres would be purchased in Region 2, we have assumed that the following amounts of acreage would be targeted for purchase in each reach, as shown in Table 8.F.31.

Table 8.F.31 Representative Land Purchase and Irrigation Retirement Program in Region 2

Reach	Acres Purchased
Reach 7 (Henderson to Kersey):	1,200
Reach 8 (Kersey to Balzac):	9,600
Reach 9 (Balzac to Julesburg):	7,200
Reach 11 (Poudre River):	2,000
Region 2 Total:	20,000

Yield

Based upon the crop mix and consumptive irrigation requirements (CIR) specific to each reach, the representative land purchase program in Region 2 would reduce on-farm consumptive use by an estimated 29,000 ac-ft per year. Assuming 50 percent on-farm efficiency, on-farm deliveries to participating properties would be reduced by an estimated 58,000 ac-ft per year..

The following are the estimated effects of the representative program on water use by reach, as shown in Table 8.F.32.

Table 8.F.32 On-farm Water Use Reductions of Representative Land Purchase and Irrigation Retirement Program in Region 2

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 7 (Henderson to Kersey):	3,840 ac-ft	1,920 ac-ft
Reach 8 (Kersey to Balzac):	29,360 ac-ft	14,680 ac-ft
Reach 9 (Balzac to Julesburg):	20,240 ac-ft	10,120 ac-ft
Reach 11 (Poudre River):	4,960 ac-ft	2,480 ac-ft
Region 2 Total:	58,400 ac-ft	29,200 ac-ft

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.5 summarizes the estimated on-site net hydrologic effects of the representative land purchase program, by reach and by month. Table 8.F.6 summarizes the effects of the representative land purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.7 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

As in the analysis of this alternative for Region 1, the study team examined the value of irrigated farmland in each reach within Region 2. In the upper reaches of Region 2 (Reaches 7 and 11), along Colorado's Front Range, competition with municipal acquisition of farmland for water supplies and with developers for residential use are additional factors influencing land and water values.

The basic approach was the same as followed in Region 1. The estimated cost of a program to purchase and retire lands from irrigation in Region 2 includes three components: the value of irrigated farmland, potential incentives required to induce participation in the program, and administrative and transaction costs.

The study team estimated the value of irrigated lands in each reach within Region 2 based upon two alternative approaches. First, we examined the most recently published information from the United States Department of Agriculture, National Agricultural Statistics Services (NASS) on irrigated land values across the country (1999a). To examine potential variations in the value of irrigated lands from reach to reach within Region 2, the study team also calculated an estimated irrigated land value for each reach based on the capitalized value of net income from irrigation in the reach. Our net income estimates were based on average cropping patterns, yields, prices, and costs in the NRCE database for the years 1992, 1994 and 1996.

A proactive program, intended to purchase and retire substantial amounts of irrigated farmland, would likely have to include a premium or incentive to induce participation. However, several factors may tend to reduce the required premium in this instance:

- The amount of farmland to be purchased under the representative program analyzed here is substantial, but still represents a relatively small proportion of total irrigated lands in the region.
- The land values calculated by the study team are average values for the area – but the program should be designed to seek purchase of the least productive lands that are currently irrigated. These lands have lower value and their retirement would have a lower impact on the area's agricultural economy.

- Water supplies in the easternmost reaches of Region 2 are generally unlikely to be in demand from other purchasers – such as municipal buyers.
- Purchase prices could likely be kept relatively close to market rates through a competitive purchasing mechanism.

Finally, there will be administrative and one-time transaction costs associated with this type of incentive program. Legal costs will be incurred in transferring title to participating lands and in transferring water use under the with protection scenario. Marketing costs will be incurred to inform and enroll participants. On an ongoing basis, an agency will have to administer the acquired lands.

In consideration of the factors just described and the previous experience with transfers of land for water supply in other areas, the study team estimates the range of potential costs of a program to purchase and retire irrigation from lands in Region 2 would include:

- Current value of irrigated lands: Average value across Region 2 was estimated at $1,600 to $2,000 per acre based on the two valuation approaches described earlier. These values exclude lands in close proximity to the Front Range which have additional value due to development potential. Reach specific values were incorporated in the cost estimates. The study team assumed that the program could realize some salvage value from the purchased land by selling or leasing it for dryland cropping or grazing purposes not involving irrigation. One half of the estimated dryland value per acre was assumed to be the salvage value of program lands in each reach.
- An incentive premium of 0 to 30 percent. This range reflects the assumption that marginal lands in Region 2 may be at least 20 percent less valuable than the average described above.
- Administrative and transaction costs of 20 to 30 percent.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, irrigated land values were applied on a reach specific basis.

Table 8.F.33 summarizes the estimated costs, by reach, of the representative program to purchase lands and retire irrigation in Region 2. In total, the representative program in Region 2 would cost an estimated $43 million. This figure represents an average cost of about $1,470 per ac-ft of consumptive use saved on-farm. The average cost per ac-ft of reduction in shortage at the critical habitat would be $2,210 if the water is protected from downstream diverters. In Region 2, a number of sand dams would have to be improved or modified if conserved supplies are to be protected from downstream diversions.

Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $51 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative is not implemented in every reach.

If sand dams are modified to bypass flows, then more than one alternative could be located above the sand dams without incurring the additional cost of sand dam replacement. The sand dams would only need to be modified once, therefore, the total cost to replace these dams would be spread among all projects implemented under the Program in Colorado, as opposed to each individual project. Therefore, the cost per acre foot for scenarios without diversion losses could be lower if more than one alternative is selected in Region 2 that requires sand dam modifications. This applies to all incentive based programs implemented in Region 2.

If the water is not protected, in some reaches this program would produce no reduction in shortages to target flows. In the reaches where this program would reduce shortages, the costs would rise to more than $10,000 per ac-ft of shortage reduction without the protection from downstream diverters.

Table 8.F.33 Estimated Capitalized Costs of Representative Land Purchase and Irrigation Retirement Program in Region 2

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions**	Without Diversions
7	$2,730,000	$1,420	$710	N/A	$1,780
8	$21,140,000	$1,440	$720	N/A	$2,010
9	$14,880,000	$1,470	$735	N/A	$2,390
11	$4,140,000	$1,670	$835	$250,400	$3,950
Region Total/ Average	$42,890,000	$1,470	$735	N/A	$2,210

* Total cost estimates shown in this table exclude additional costs for sand dam modifications under the scenario in which water is protected from downstream diverters. These costs, estimated at $8.1 million across the region, were prorated to each reach and are reflected in the costs per ac-ft of reduced shortage at the critical habitat without diversions.

** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Permanent Acquisition of Agricultural Water Supplies

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would purchase and own 40,000 ac-ft of agricultural water rights (on-farm delivered volume) in Region 2. Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.30, we have further assumed for this analysis that the following amount of water rights would be targeted for purchase in each reach, as shown in Table 8.F.34.

Table 8.F.34 Representative Irrigation Water Right Purchase Program in Region 2

Reach	Ac-ft Purchased (Delivered Volume On-farm)
Reach 7 (Henderson to Kersey):	2,700
Reach 8 (Kersey to Balzac):	20,200
Reach 9 (Balzac to Julesburg):	13,800
Reach 11 (Poudre River):	3,300
Region 2 Total:	40,000

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table

8.F.10 summarizes the estimated on-site net hydrologic effects of the representative water right purchase program, by reach and by month. Table 8.F.11 summarizes the effects of the representative water right purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.12 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

As in Region 1, the study team's estimates of the costs of a representative program to purchase agricultural water rights began with a multiple of our estimate of the economic value of water in irrigated agriculture, plus estimated transaction costs. To estimate the costs associated with purchasing water rights the study team examined the capitalized present value of irrigation water in crop production throughout Region 2 (based on the differences between net income from irrigated and non-irrigated lands) as well as differences in the market value of irrigated cropland versus non-irrigated cropland according to the 1999 NASS data described earlier in this section.

As with the representative land purchase program described earlier, additional factors beyond the pure economic value of irrigation supplies would influence the cost of a water right purchase program. In the upper portions of Region 2 (especially Reach 7 and Reach 11) native flow water rights that can be used by some municipalities are currently available for $2,500 to $3,000 per ac-ft (values of North Poudre Irrigation Company and Union Reservoir shares per NCWCD communication, 1999a). Other native flow water rights that are not as readily used by municipalities are currently priced at about $1,000 per ac-ft (Lake Loveland and Seven Lakes shares, per conversation with Greeley Water Department, 1999).

Analyses of transaction costs associated with previous water transfers throughout the Western U.S. indicate that these costs vary widely, but may average about 30 percent of the cost of water transfers (MacDonnell, April 1990).

In consideration of the factors just described and the previous experience with sales of water rights from irrigation in Region 2, the study team estimates that the costs of the representative program would include the following components:

- Economic value of irrigation water supplies. For Region 2 as a whole, this value is estimated to be between $750 and $1000 per ac-ft of consumptive use based on the two valuation approaches described above.
- An incentive premium of between zero and 100 percent of the economic value. This premium is a larger proportion of the cost than for a land purchase program – reflecting that the water rights market and water rights values are less clearly defined than land markets and values in most of the area. However, the incentive range also recognizes the possibility that water might be drawn from marginal uses with lower value than the average cited above.
- Transaction costs (legal and administrative) of 20 to 30 percent. Water rights purchase transactions may be more complex than the land purchases described previously although land titles do not have to be transferred.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, the economic value of irrigation supplies were applied on a reach specific basis.

Table 8.F.35 summarizes the estimated costs, by reach, of the representative program to purchase agricultural water rights in Region 2. In total, the study team estimates that the representative program in Region 2 would cost approximately $31 million. This figure represents an average cost of about $1,540 per ac-ft of consumptive use saved on-farm. Average cost per ac-ft of reduction in shortage at the critical habitat would be more than $200,000 per ac-ft in reach 11 if the water is not protected from downstream diverters. In the other reaches, water budget runs indicate there would be no reduction in shortages to target flows if the water is not protected from downstream diverters. If the water is protected from downstream diverters, the estimated costs of this alternative in Region 2 would average $2,420 per ac-ft of reduced shortage.

In order to be able to protect this water from downstream diverters, a number of sand dams would need to be improved or modified in Region 2 reaches. Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $39 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative is not implemented in every reach.

Table 8.F.35 Estimated Costs of Representative Water Right Purchase Program in Region 2

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions**	Without Diversions
7	$2,080,000	$1,540	$770	N/A	$2,030
8	$15,350,000	$1,520	$760	N/A	$2,220
9	$10,560,000	$1,530	$765	N/A	$2,590
11	$2,710,000	$1,640	$820	$246,360	$4,110
Region Total/ Average	$30,700,000	$1,540	$770	N/A	$2,420

* Total cost estimates shown in this table exclude additional costs for sand dam modifications under the scenario in which water is protected from downstream diverters. These costs, estimated at $8.1 million across the region, were prorated to each reach and are reflected in the costs per ac-ft of reduced shortage at the critical habitat without diversions.

** In some reaches, the representative program would produce no reduction in shortages to target flows if there is no protection from downstream diverters. In these reaches, the cost per ac-ft of reduced shortage is shown as not applicable (N/A).

Land Fallowing

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would be created to administer a voluntary land fallowing program that would provide incentives to farmers in Region 2 to fallow an annual total of 20,000 acres of farmland that would otherwise have been irrigated. We have further assumed for this analysis that the following amounts of acreage would be fallowed in each reach, as shown in Table 8.F.36, based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.30

Table 8.F.36 Representative Land Fallowing Program in Region 2

Reach	Acres Fallowed
Reach 7 (Henderson to Kersey):	1,200
Reach 8 (Kersey to Balzac):	9,600
Reach 9 (Balzac to Julesburg):	7,200
Reach 11 (Poudre River):	2,000
Region 2 Total:	20,000

Yield

The study team assumed that acres voluntarily placed into the fallowing program would have otherwise been planted and irrigated in the same manner, on average, as current irrigated crop production in each reach. Under this assumption, the land fallowing program would have the following estimated effects on water use by reach, as shown in Table 8.F.37.

Table 8.F.37 On-farm Water Use Reductions of Representative Land Fallowing Program in Region 2

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 7 (Henderson to Kersey):	3,840 ac-ft	1,920 ac-ft
Reach 8 (Kersey to Balzac):	29,360 ac-ft	14,680 ac-ft
Reach 9 (Balzac to Julesburg):	20,240 ac-ft	10,120 ac-ft
Reach 11 (Poudre River):	4,960 ac-ft	2,480 ac-ft
Region 2 Total:	58,400 ac-ft	29,200 ac-ft

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.16 summarizes the estimated on-site net hydrologic effects of the representative land fallowing program, by reach and by month. Table 8.F.17 summarizes the effects of the representative land fallowing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.18 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Based upon the same approach described for Region 1, the study team estimated the costs of the representative land fallowing program in Region 2. The study team has estimated the annual costs of the representative land fallowing program for Region 2 based on the following components:

- Annual value of irrigated lands in Region 2. Based upon two measures – annual net income to farmers and irrigated land rental rates – this value for the region as a whole is between $60 and $85 per acre.

- An incentive premium to induce participation of between zero and 50 percent of the annual economic value would likely be required to induce participation. This range reflects the possibility that marginal lands with lower than average value might comprise the bulk of lands enrolled in the program.

- Administrative costs, in the long run, would average $20 per acre fallowed. This value reflects the assumption that an ongoing program would have lower administrative costs than the Palo Verde test program described earlier.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, economic values of irrigated lands were applied on a reach specific basis.

The study team estimates that average annual costs of a land fallowing program in Region 2, including incentives and administrative and transaction costs would be approximately $100 per ac-ft of consumptive use saved on-farm. Table 8.F.38 summarizes the estimated capitalized costs, by reach, of the representative program to fallow irrigated lands in Region 2. Annual costs were converted to capitalized present value total costs based on a six percent discount rate and 20-year period. The study team estimates that the representative program in Region 2 would have a capitalized total cost of approximately $36 million. This figure represents an average cost of about $1,230 per ac-ft of consumptive use saved on-farm. Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be more than $100,000 in Reach 11 if the water is not protected from downstream diverters. In some Region 2 reaches, a land fallowing program would have no effect on reducing target flow shortages if the conserved water cannot be protected from downstream diverters. If the water is protected from downstream diverters, the estimated costs of this alternative in Region 2 would average about $1,900 per ac-ft of reduced shortage.

In order to be able to protect this water from downstream diverters, a number of sand dams would need to be improved or modified in Region 2 reaches. Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $44 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative is not implemented in every reach.

Table 8.F.38 Estimated Capitalized Costs of Representative Land Fallowing Program in Region 2

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings		Cost per ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions**	Without Diversions
7	$2,300,000	$1,200	$600	N/A	$1,520
8	$17,670,000	$1,200	$600	N/A	$1,720
9	$12,860,000	$1,250	$625	N/A	$2,100
11	$3,290,000	$1,330	$665	$198,990	$3,350
Region Total/ Average	$35,940,000	$1,230	$615	N/A	$1,910

* Total cost estimates shown in this table exclude additional costs for sand dam modifications under the scenario in which water is protected form downstream diverters. These costs, estimated at $8.1 million across the region, were prorated to each reach and are reflected in the costs per ac-ft of reduced shortage at the critical habitat without diversions.

** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Temporary Leasing of Agricultural Water Supplies

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would administer a voluntary leasing program that would provide incentives to farmers in Region 2 to annually lease 40,000 ac-ft of water supplies (delivered on farm) that would otherwise have been used in irrigation. Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.30, we have further assumed for this analysis that the following water supplies would be leased in each reach, as shown in Table 8.F.39.

Table 8.F.39 Representative Irrigation Water Leasing Program in Region 2

Reach	Ac-ft Leased (Delivered Volume On-farm)
Reach 7 (Henderson to Kersey):	2,700
Reach 8 (Kersey to Balzac):	20,200
Reach 9 (Balzac to Julesburg):	13,800
Reach 11 (Poudre River):	3,300
Region 2 Total:	40,000

Yield

As shown in Table 8.F.39, the representative water leasing program in Region 1 would reduce on-farm deliveries to participating properties by an estimated 40,000 ac-ft per year. On-farm consumptive use would be reduced by 20,000 ac-ft per year based on a farm efficiency of 50 percent.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.21 summarizes the estimated on-site net hydrologic effects of the representative water leasing program, by reach and by month. Table 8.F.22 summarizes the effects of the representative water leasing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.23 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

The study team estimated the costs of the representative leasing program in Region 2 using the approach previously described for Region 1. The study team has estimated the annual costs of the representative water leasing program for Region 2 based on the following components:

- Annual economic value of irrigation on Region 2 lands. This value was estimated in a similar manner to the annual economic value of irrigated lands for the land fallowing alternative. However, the annual economic value is lower under the leasing alternative than under land fallowing because dry land cropping could offset a portion of the farmers' income loss under the leasing program. Annual value of irrigation supplies for Region 1 as a whole are estimated at between $55 and $65 per ac-ft of consumptive use based on farm net income and land rental differentials between irrigated and non-irrigated lands.
- An incentive premium of between zero and 50 percent to induce participation in the program.
- Transaction and administrative costs representing approximately 30 percent of total program costs.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, economic values of irrigation were applied on a reach specific basis.

Table 8.F.40 summarizes the estimated capitalized costs, by reach, of the representative water leasing program in Region 2. The capitalized costs reflect an estimated average annual value for irrigation water across Region 2 of about $30 per ac-ft (on-farm delivered volume). This annual value is approximately consistent with current annual rental prices for water in the region, which generally range from about $20 to $40 per ac-ft (personal communication, NCWCD, 1999).

Converting annual costs to capitalized present value total costs based on a six percent discount rate and 20-year period, the study team estimates that the representative leasing program in Region 2 would have a present value total cost of approximately $21 million. This figure represents an average cost of about $1,030 per ac-ft of consumptive use saved on-farm. Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be more than $100,000 per ac-ft in reach 11 if the saved water is not protected from downstream diverters. In other Region 2 reaches, a water leasing program would have no impact on shortages to target flows if the water cannot be protected from downstream diverters. If the water is protected from downstream diverters, the estimated costs of this alternative in Region 2 would average $1,790 per ac-ft of reduced shortage.

In order to be able to protect this water from downstream diverters, a number of sand dams would need to be improved or modified in Region 2 reaches. Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $29 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative is not implemented in every reach.

Table 8.F.40 Estimated Capitalized Costs of Water Leasing Program in Region 2

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions**	Without Diversions
7	$1,390,000	$1,030	$515	N/A	$1,490
8	$10,320,000	$1,020	$510	N/A	$1,650
9	$7,110,000	$1,030	$515	N/A	$1,920
11	$1,820,000	$1,100	$550	$165,450	$3,030
Region Total/ Average	$20,640,000	$1,030	$515	N/A	$1,790

* Total cost estimates shown in this table exclude additional costs for sand dam modifications under the scenario in which water is protected form downstream diverters. These costs, estimated at $8.1 million across the region, were prorated to each reach and are reflected in the costs per ac-ft of reduced shortage at the critical habitat without diversions.

** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Dry Year Leasing

As in Region 1, the representative dry year leasing program would have the same on-site yield as the leasing alternative in the years when the leases are activated, and no yield in all other years. Under the decision rule described in the Region 1 evaluation, the dry year leasing program would be activated about one in three years.

Yield

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.25 summarizes the estimated on-site net hydrologic effects of the representative dry year leasing program, by reach and by month. Table 8.F.26 summarizes the effects of the representative dry year leasing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.27 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Based on the outline of the representative dry year leasing program and cost considerations described in the Region 1 analysis, the study team has estimated the annual costs of the representative dry year leasing program for Region 2 based on the following assumptions:

- Costs of dry year leases in years that the leases are activated would be 50 percent greater than the annual costs of on-going water leases in the same reach.
- Annual contractual payments for participating in the dry year leasing program, in years when the leases are not activated, would be one-half of the annual cost of on-going water leases in the same reach.

Table 8.F.41 summarizes the estimated capitalized costs, by reach, of the representative water leasing program in Region 2. The study team estimates that the total capitalized cost of a representative leasing program in Region 2 would be approximately $14 million. This figure represents an average cost of about $2,060 per ac-ft of consumptive use saved on-farm. However, these savings will occur in only one in three years. Total capitalized present value cost per ac-ft of reduction in shortage at the critical habitat over the 20 year study period would be more than $100,000 per ac-ft in reach 11 if the conserved water is

not protected from downstream diverters. In other Region 2 reaches, a dry year leasing program would offer no reduction in target flow shortages without protection from downstream diverters. If the water is protected from downstream diverters, the estimated costs of this alternative in Region 2 would average about $3,400 per ac-ft of reduced shortage.

In order to be able to protect this water from downstream diverters, a number of sand dams would need to be improved or modified in Region 2 reaches. Costs for these modifications, estimated at $8.1 million in total, were added to the costs of this alternative under the scenario in which water is protected from downstream diverters. These costs were prorated back to each reach within Region 2 on the basis of the proportion of the total region's on-site yield contributed by that reach. When these costs are included, capitalized costs of this alternative in Region 2 would increase to about $22 million. Because the costs for sand dam modifications were prorated over all reaches in Region 2, the cost per ac-ft of reductions to target flow shortages would increase if this alternative is not implemented in every reach.

Prior studies of dry year leasing, typically focusing on making water available for municipal water supplies under drought conditions, have often found this alternative to be among the most cost effective options. In this instance, however, in which additional flows will be needed in many years and not just under severe drought conditions, it is not surprising that this alternative may be less cost effective than ongoing leasing arrangements or other incentive based measures.

Table 8.F.41 Estimated Costs of Representative Dry Year Leasing Program in Region 2

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings* CIR	Deliveries	Cost per ac-ft of Reduced Shortage at Critical Habitat With Diversions***	Without Diversions
7	$930,000	$2,060	$1,437	N/A	$2,800
8	$6,860,000	$2,040	$1,402	N/A	$3,070
9	$4,730,000	$2,060	$1,359	N/A	$3,760
11	$1,210,000	$2,200	$2,188	$172,860	$5,520
Region Total /Average	$13,730,000	$2,060	$1,030	N/A	$3,400

* Calculation reflects estimate that leases will be activated in approximately one in three years.

** Total cost estimates shown in this table exclude additional costs for sand dam modifications under the scenario in which water is protected from downstream diverters. These costs estimated at $8.1 million across the region, were prorated to each reach and are reflected in the costs per ac-ft of reduced shortage at the critical habitat without diversions.

*** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Drought Water Banking

As noted in the discussion of incentive based alternatives in Region 1, yields and costs associated with drought water banking are completely unpredictable. Consequently, the study team has not analyzed this alternative further.

Region 3

Except where noted in this section, the study team's approach and assumptions in evaluating incentive based approaches in Region 3 were the same as described previously for Region 1. In the interest of brevity, the following is an abbreviated description of the costs and yields associated with incentive based alternatives in Region 3. This discussion focuses on information specific to Region 3 and the reader is advised to refer back to the Region 1 discussion for additional insight regarding the analytical basis for estimated yields and costs.

Table 8.F.42, below, summarizes estimated irrigated acres harvested and corresponding crop irrigation water use in Region 3.

Table 8.F.42 Estimated Water Use for Crop Irrigation in Region 3

		Water User Per Acre (in ft.)		Total Annual Water Use	
Reach	Harvested Irrigated Acres	Consumptive Irr. Rqmt.	On-farm Delivery	Consumptive Irr. Rqmt.	On-farm Delivery
10	44,661	1.10	2.21	49,299	98,599
14	58,043	1.13	2.26	65,636	131,272
15	44,973	1.10	2.19	49,339	98,677
16	74,454	1.07	2.14	79,538	159,076
178	151,748	1.09	2.17	164,795	329,590
18	160,598	1.06	2.12	170,430	340,860
19	230,851	1.05	2.09	241,736	483,472
Region Total/ Averages	765,328	1.09	2.17	820,773	1,641,546

Source: Study team estimates based on NRCE database for 1992, 1994, and 1996; modified Blaney-Criddle estimates of consumptive irrigation requirement.

Table 8.F.43 summarizes the estimated irrigated acres harvested and annual use of surface water supplies by reach.

Table 8.F.43 Estimated Harvested Crop Irrigation by Surface Water in Region 3

Reach	Harvested Irrigated Acres	Annual Consumptive Irrigation Requirement	Annual On-farm Delivery*
10	14,205	15,680	31,360
14	17,428	19,708	39,415
15	19,161	21,022	42,043
16	23,971	25,607	51,215
17	49,861	54,148	108,296
18	63,758	67,661	135,322
19	54,183	56,737	113,475
Region Total	242,566	260,563	521,126

*Includes small amounts of reclaimed water use in some reaches.

Source: Project team estimates based on information summarized in previous exhibit and United States Geological Survey National Water Use Information Program, 1990 and 1995.

Land Purchase and Irrigation Retirement

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would purchase and own 20,000 acres of farmland that would subsequently be retired from irrigation. Based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.43, and the assumption for purposes of evaluation that 20,000 acres would be purchased in Region 3, we have assumed that the following amounts of acreage would be targeted for purchase in each reach, as shown in Table 8.F.44.

Table 8.F.44 Representative Land Purchase and Irrigation Retirement Program in Region 3

Reach	Acres Purchased
Reach 10 (Julesburg to N. Platte):	1,200
Reach 14 (Lewellen to N. Platte):	1,400
Reach 15 (N. Platte to Brady):	1,600
Reach 16 (Brady to Cozad):	2,000
Reach 17 (Cozad to Overton):	4,100
Reach 18 (Overton to Odessa):	5,200
Reach 19 (Odessa to Grand Island):	4,500
Region 3 Total:	20,000

Yield

Based upon the crop mix and consumptive irrigation requirements (CIR) specific to each reach, the representative land purchase program in Region 3 would reduce on-farm consumptive use by an estimated 21,500 ac-ft per year. Assuming 50 percent on-farm efficiency, on-farm deliveries to participating properties would be reduced by an estimated 43,000 ac-ft per year.

The following are the estimated effects of the representative program on water use by reach, as shown in table 8.F.45.

Table 8.F.45 On-farm Water Use Reductions of Representative Land Purchase and Irrigation Retirement Program in Region 3

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 10 (Julesburg to N. Platte):	2,640 ac-ft	1,320 ac-ft
Reach 14 (Lewellen to N. Platte):	3,160 ac-ft	1,580 ac-ft
Reach 15 (N. Platte to Brady):	3,520 ac-ft	1,760 ac-ft
Reach 16 (Brady to Cozad):	4,280 ac-ft	2,140 ac-ft
Reach 17 (Cozad to Overton):	8,900 ac-ft	4,450 ac-ft
Reach 18 (Overton to Odessa):	11,040 ac-ft	5,520 ac-ft
Reach 19 (Odessa to Grand Island):	9,420 ac-ft	4,710 ac-ft
Region 3 Total:	42,960 ac-ft	21,480 ac-ft

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.5 summarizes the estimated on-site net hydrologic effects of the representative land purchase program, by reach and by month. Table

8.F.6 summarizes the effects of the representative land purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.7 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

The basic approach to estimating the costs of this alternative was the same as followed in Region 1. The estimated cost of a program to purchase and retire lands from irrigation in Region 3 includes three components: the value of irrigated farmland, potential incentives required to induce participation in the program, and administrative and transaction costs.

The study team estimated the value of irrigated lands in each reach within Region 3 based upon two alternative approaches. First, we examined the most recently published information from the United States Department of Agriculture, National Agricultural Statistics Services (NASS) on irrigated land values across the country. To examine potential variations in the value of irrigated lands from reach to reach within Region 3, the study team also calculated an estimated irrigated land value for each reach based on the capitalized value of net income from irrigation in the reach. Our net income estimates were based on average cropping patterns, yields, prices, and costs in the NRCE database for the years 1992, 1994 and 1996.

A proactive program, intended to purchase and retire substantial amounts of irrigated farmland would likely have to include a premium or incentive to induce participation. However, several factors may tend to reduce the required premium in this instance:

- The amount of farmland to be purchased under the representative program analyzed here is substantial, but still represents a relatively small proportion of total irrigated lands in the region.
- The land values calculated by the study team are average values for the area – but the program should be designed to seek purchase of the least productive lands that are currently

irrigated. These lands have lower value and their retirement would have a lower impact on the area's agricultural economy.

- Water supplies in Region 3 reaches are generally unlikely to be in demand from other purchasers – such as municipal buyers.
- Purchase prices could likely be kept relatively close to market rates through a competitive purchasing mechanism.

Finally, there will be administrative and one-time transaction costs associated with this type of incentive program. Legal costs will be incurred in transferring title to participating lands and in transferring water use under the with protection scenario. Marketing costs will be incurred to inform and enroll participants. On an ongoing basis, an agency will have to administer the acquired lands.

In consideration of the factors just described and the previous experience with transfers of land for water supply in other areas, the study team estimates the range of potential costs of a program to purchase and retire irrigation from lands in Region 3 would include:

- Current value of irrigated lands: Average value across the region as a whole estimated at $1,600 to $2,000 per acre based on the two valuation approaches described earlier. Reach specific values were incorporated in the cost estimates. The study team assumed that the program could realize some salvage value from the purchased land by selling or leasing it for dryland cropping or grazing purposes not involving irrigation. One half of the estimated dryland value per acre was assumed to be the salvage value of program lands in each reach.
- An incentive premium of 0 to 30 percent. This range reflects the assumption that marginal lands in Region 3 may be at least 20 percent less valuable than the average described above.
- Administrative and transaction costs of 20 to 30 percent.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, irrigated land values were applied on a reach specific basis.

Table 8.F.46 summarizes the estimated costs, by reach, of the representative program to purchase lands and retire irrigation in Region 3. In total, the representative program in Region 3 would cost an estimated $36 million. This figure represents an average cost of about $1,700 per ac-ft of consumptive use saved on-farm. The average cost per ac-ft of reduction in shortage at the critical habitat would be $2,000 if the water is protected from downstream diverters. If the water is not protected, in some reaches this program would produce no reduction in shortages to target flows.

Table 8.F.46 Estimated Costs of Representative Land Purchase and Irrigation Retirement Program in Region 3

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings		Cost per ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions*	Without Diversions
10	$2,010,000	$1,520	$760	N/A	$1,770
14	$2,320,000	$1,470	$735	N/A	$2,230
15	$2,900,000	$1,650	$825	N/A	$2,270
16	$3,510,000	$1,640	$820	$6,510	$1,830
17	$7,030,000	$1,580	$790	$2,580	$2,120
18	$9,330,000	$1,690	$845	$2,230	$2,060
19	$8,530,000	$1,810	$905	$1,850	$1,850
Region Total/ Average	$35,630,000	$1,700	$850	N/A	$2,000

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Permanent Acquisition of Agricultural Water Rights

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would purchase and own 40,000 ac-ft of agricultural water rights (on-farm delivered volume) in Region 3. Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.43, we have further assumed for this analysis that the following amount of water rights would be targeted for purchase in each reach, as shown in Table 8.F.47.

Table 8.F.47 Representative Irrigation Water Right Purchase Program in Region 3

Reach	Ac-ft Purchased (Delivered Volume On-farm)
Reach 10 (Julesburg to N. Platte):	2,400
Reach 14 (Lewellen to N. Platte):	3,000
Reach 15 (N. Platte to Brady):	3,200
Reach 16 (Brady to Cozad):	3,900
Reach 17 (Cozad to Overton):	8,300
Reach 18 (Overton to Odessa):	10,500
Reach 19 (Odessa to Grand Island):	8,700
Region 3 Total:	40,000

Yield

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.10 summarizes the estimated on-site net hydrologic effects of the representative water right purchase program, by reach and by month. Table 8.F.11 summarizes the effects of the representative water right purchase program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.12 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

As in Region 1, the study team's estimates of the costs of a representative program to purchase agricultural water rights were based on the economic value of water in irrigated agriculture, plus incentives to induce participation and estimated transaction and administrative costs. To estimate the costs associated with purchasing water rights the study team examined the capitalized present value of irrigation water in crop production throughout Region 3 (based on the differences between net income from irrigated and non-irrigated lands) as well as differences in the market value of irrigated cropland versus non-irrigated cropland according to the 1999 NASS data described earlier in this section.

As with the representative land purchase program described earlier, additional factors beyond the pure economic value of irrigation supplies would influence the cost of a water right purchase program. Analyses of transaction costs associated with previous water transfers throughout the Western U.S. indicate that these costs vary widely, but may average about 30 percent of the cost of water transfers (MacDonnell, April 1990).

In consideration of the factors just described, the study team estimates that the costs of the representative program would include the following components:

- Economic value of irrigation water supplies. For Region 3 as a whole, this value is estimated to be between $600 and $1000 per ac-ft of consumptive use based on the two valuation approaches described above.
- An incentive premium of between zero and 100 percent of the economic value. This premium is a larger proportion of the cost than for a land purchase program – reflecting that the water rights market and water rights values are less clearly defined than land markets and values in most of the area. However, the incentive range also recognizes the possibility that water might be drawn from marginal uses with lower value than the average cited above.
- Transaction costs (legal and administrative) of 20 to 30 percent. Water rights purchase transactions may be more complex than the land purchases described previously, although land titles do not have to be transferred .

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, economic values of irrigation water supplies were applied on a reach specific basis.

Table 8.F.48 summarizes the estimated costs, by reach, of the representative program to purchase agricultural water rights in Region 3. In total, the study team estimates that the representative program in Region 3 would cost approximately $27 million. This figure represents an average cost of about $1,340 per ac-ft of consumptive use saved on-farm. The average cost per ac-ft of reduction in shortage at the critical habitat would be more than $5,000 per ac-ft in reach 16 and $1,600 to $2,000 per ac-ft in reaches 17 through 19 if the water cannot be

protected from downstream diverters. If the water is protected, the average cost throughout Region 3 per ac-ft of reduced shortage would be estimated at $1,620.

Table 8.F.48 Estimated Costs of Representative Water Right Purchase Program in Region 3

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings		Cost per ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions*	Without Diversions
10	$1,570,000	$1,310	$655	N/A	$1,520
14	$1,910,000	$1,270	$635	N/A	$1,930
15	$2,160,000	$1,350	$675	N/A	$1,860
16	$2,540,000	$1,300	$650	$5,150	$1,450
17	$5,020,000	$1,210	$605	$1,970	$1,620
18	$6,770,000	$1,290	$645	$1,690	$1,570
19	$7,000,000	$1,610	$805	$1,640	$1,640
Region Total /Average	$26,970,000	$1,340	$670	N/A	$1,620

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Land Fallowing

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would administer a voluntary land fallowing program that would provide incentives to farmers in Region 3 to fallow an annual total of 20,000 acres of farmland that would otherwise have been irrigated. We have further assumed for this analysis that the following amounts of acreage would be fallowed in each reach, as shown in Table 8.F.49, based upon the distribution of acres irrigated with surface supplies in the region depicted in Table 8.F.43.

Table 8.F.49 Representative Land Fallowing Program in Region 3

Reach	Acres Fallowed
Reach 10 (Julesburg to N. Platte):	1,200
Reach 14 (Lewellen to N. Platte):	1,400
Reach 15 (N. Platte to Brady):	1,600
Reach 16 (Brady to Cozad):	2,000
Reach 17 (Cozad to Overton):	4,100
Reach 18 (Overton to Odessa):	5,200
Reach 19 (Odessa to Grand Island):	4,500
Region 3 Total:	20,000

Yield

The study team assumed that acres voluntarily placed into the fallowing program would have otherwise been planted and irrigated in the same manner, on average, as current irrigated crop production in each reach. Under this assumption, the land fallowing program in Region 3 would have the following estimated effects on water use by reach, as shown in Table 8.F.50.

Table 8.F.50 On-farm Water Use Reductions of Representative Land Fallowing Program in Region 3

Reach	Annual Reduction in On-farm Delivery	Annual Reduction in CIR
Reach 10 (Julesburg to N. Platte):	2,640 ac-ft	1,320 ac-ft
Reach 14 (Lewellen to N. Platte):	3,160 ac-ft	1,580 ac-ft
Reach 15 (N. Platte to Brady):	3,520 ac-ft	1,760 ac-ft
Reach 16 (Brady to Cozad):	4,280 ac-ft	2,140 ac-ft
Reach 17 (Cozad to Overton):	8,900 ac-ft	4,450 ac-ft
Reach 18 (Overton to Odessa):	11,040 ac-ft	5,520 ac-ft
Reach 19 (Odessa to Grand Island):	9,420 ac-ft	4,710 ac-ft
Region 3 Total:	42,960 ac-ft	21,480 ac-ft

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.16 summarizes the estimated on-site net hydrologic effects of the representative land fallowing program, by reach and by month. Table 8.F.17 summarizes the effects of the representative land fallowing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.18 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Based upon the same approach described for Region 1, the study team estimated the costs of the representative land fallowing program in Region 3. The study team has estimated the annual costs of the representative land fallowing program for Region 3 based on the following components:

- Annual value of irrigated lands in Region 3. Based upon two measures – annual net income to farmers and irrigated land rental rates – this value for the region as a whole is between $100 and $110 per acre.

- An incentive premium to induce participation of between zero and 50 percent of the annual economic value would likely be required to induce participation. This range reflects the possibility that marginal lands with lower than average value might comprise the bulk of lands enrolled in the program.
- Administrative costs, in the long run, would average $20 per acre fallowed. This value reflects the assumption that an ongoing program would have lower administrative costs than the Palo Verde test program described earlier.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, economic values of irrigated lands were applied on a reach specific basis.

Table 8.F.51 summarizes the estimated capitalized costs, by reach, of the representative program to fallow irrigated lands in Region 3. Capitalized costs were based on estimated annual costs of the fallowing program, a six percent discount rate and 20 year study period. The study team estimates that the representative program in Region 3 would have a capitalized total cost of approximately $38 million. This figure represents an average capitalized cost of about $1,750 per ac-ft of consumptive use saved on-farm. Average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be nearly $7,000 per ac-ft in reach 16 if the water cannot be protected from downstream diverters, but less than $3,000 per ac-ft in reaches 17 through 19. A land fallowing program in reach 10, 14 and 15 would offer no reduction to target flow shortages if the water cannot be protected from downstream diverters.

If the water is protected, the average cost per ac-ft of reduced shortage would be about $2,110 across Region 3 as a whole.

Table 8.F.51 Estimated Cost of Representative Land Fallowing Program in Region 3

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings		Cost per ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions*	Without Diversions
10	$2,120,000	$1,610	$805	N/A	$1,860
14	$2,460,000	$1,560	$780	N/A	$2,370
15	$2,980,000	$1,690	$845	N/A	$2,340
16	$3,740,000	$1,750	$875	$6,940	$1,950
17	$7,740,000	$1,740	$870	$2,850	$2,330
18	$9,940,000	$1,800	$900	$2,370	$2,200
19	$8,700,000	$1,850	$925	$1,880	$1,880
Region Total /Average	$37,680,000	$1,750	$875	N/A	$2,110

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Temporary Leasing of Agricultural Water Supplies

The study team has assumed for purposes of evaluation that under this alternative a new or existing agency would administer a voluntary leasing program that would provide incentives to farmers in Region 3 to annually lease 40,000 ac-ft of water supplies (delivered on farm) that would otherwise have been used in irrigation. Based upon the distribution of surface water supplied irrigation in the region depicted in Table 8.F.43, we have further assumed for this analysis that the following amounts of water supplies would be leased in each reach, as shown in Table 8.F.52.

Table 8.F.52 Representative Irrigation Water Leasing Program in Region 3

Reach	Ac-ft Leased (Delivered Volume On-farm)
Reach 10 (Julesburg to N. Platte):	2,400
Reach 14 (Lewellen to N. Platte):	3,000
Reach 15 (N. Platte to Brady):	3,200
Reach 16 (Brady to Cozad):	3,900
Reach 17 (Cozad to Overton):	8,300
Reach 18 (Overton to Odessa):	10,500
Reach 19 (Odessa to Grand Island):	8,700
Region 3 Total:	40,000

Yield

As shown in Table 8.F.52, the representative water leasing program in Region 3 would reduce on-farm deliveries to participating properties by an estimated 40,000 ac-ft per year. On-farm consumptive use would be reduced by 20,000 ac-ft per year.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.21 summarizes the estimated on-site net hydrologic effects of the representative water leasing program, by reach and by month. Table 8.F.22 summarizes the effects of the representative water leasing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.23 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

The study team estimated the costs of the representative leasing program in Region 3 using the approach previously described for Region 1. The study team has estimated the annual costs of the representative water leasing program for Region 3 based on the following components:

- Annual economic value of irrigation on Region 3 lands. This value was estimated in a similar manner to the annual economic value of irrigated lands for the land fallowing alternative. However, the annual economic value is lower under the leasing alternative than under land fallowing because dry land cropping could offset a portion of the farmers' income loss under the leasing program. Annual value of irrigation supplies for Region 3 as a whole are estimated at between $45 and $55 per ac-ft of consumptive use based on farm net income and land rental differentials between irrigated and non-irrigated lands.

- An incentive premium of between zero and 50 percent to induce participation in the program.

- Transaction and administrative costs representing approximately 30 percent of total program costs.

For purposes of simplicity, the study team used the mid-point of the range of values described above in estimating the costs on a reach by reach basis. In addition, economic values or irrigation were applied on a reach specific basis.

Table 8.F.53 summarizes the estimated capitalized costs, by reach, of the representative water leasing program in Region 3.

The study team estimates that the representative leasing program in Region 3 would have a capitalized total cost of approximately $18 million. This figure represents an average capitalized cost of about $900 per ac-ft of consumptive use saved on-farm. The average capitalized cost per ac-ft of reduction in shortage at the critical habitat would be between $1,100 per ac-ft and $3,500 per ac-ft in reaches 16 through 19 if the water cannot be protected from downstream diverters. In other Region 3 reaches, a leasing program would have no impact on shortages to target flows if the water cannot be protected from downstream diverters.

If the water is protected, the average cost per ac-ft of reduced shortage would be about $1,080.

Table 8.F.53 Estimated Capitalized Costs of Representative Water Leasing Program in Region 3

Reach	Estimated Capitalized Cost	Cost per Ac-ft of On-farm Water Savings CIR	Deliveries	Cost per Ac-ft of Reduced Shortage at Critical Habitat With Diversions*	Without Diversions
10	$1,070,000	$890	$445	N/A	$1,030
14	$1,280,000	$850	$425	N/A	$1,290
15	$1,450,000	$910	$455	N/A	$1,250
16	$1,680,000	$860	$430	$3,410	$960
17	$3,360,000	$810	$405	$1,320	$1,080
18	$4,530,000	$860	$430	$1,130	$1,050
19	$4,680,000	$1,080	$540	$1,100	$1,100
Region Total /Average	$18,050,000	$900	$450	N/A	$1,080

* In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Dry Year Leasing

As in Region 1, the representative dry year leasing program would have the same on-site yield as the leasing alternative in the years when the leases are activated, and no yield in all other years. Under the decision rule described in the Region 1 evaluation, the dry year leasing program would be activated about one in three years.

Yield

As shown in Table 8.F.52 the representative dry year leasing program in Region 3 would reduce on-farm deliveries to participating properties by an estimated 40,000 ac-ft per year in years when leases are activated. On-farm consumptive use would be reduced by 20,000 ac-ft per year.

Summary exhibits depicting the results of water budget modeling of each incentive based alternative are presented in Appendix F. Table 8.F.25 summarizes the estimated on-site net hydrologic effects of the representative dry year leasing program, by reach and by month. Table 8.F.26 summarizes the effects of the representative dry year leasing program in reducing shortages to target streamflows at the critical reach, assuming no protection from downstream diverters. Table 8.F.27 provides a similar summary of effects on target streamflows, without downstream diversions.

Cost

Based on the outline of the representative dry year leasing program and cost considerations described in the Region 1 analysis, the study team has estimated the annual costs of the representative dry year leasing program for Region 3 based on the following assumptions:

- Costs of dry year leases in years that the leases are activated would be 50 percent greater than the annual costs of on-going water leases in the same reach.
- Annual contractual payments for participating in the dry year leasing program, in years when the leases are not activated, would be one-half of the annual cost of on-going water leases in the same reach.

Table 8.F.54 summarizes the estimated capitalized costs, by reach, of the representative water leasing program in Region 3. The total capitalized cost of a representative leasing program in Region 3 would be approximately $12 million– recognizing that these savings will occur in only one in three years. This figure represents an average capitalized costs of about $1,800 per ac-ft of consumptive use saved on-farm. Average capitalized total cost per ac-ft of reduction in shortage at the critical habitat would range from $1,900 to more than $9,000 in reaches 16 through 19 if the water cannot be protected from downstream diverters. A dry year leasing program in reaches 10, 14 and 15 would not reduce target flow shortages if the conserved water is not protected from downstream diverters.

If the water is protected, the average cost per ac-ft of reduced shortage would decline to about $1,910.

Prior studies of dry year leasing, typically focusing on making water available for municipal water supplies under drought conditions, have often found this alternative to be among the most cost effective options. In this instance, however, in which additional flows will be needed in many years and not just under severe drought conditions, it is not surprising that this alternative may be less cost effective than ongoing leasing arrangements or other incentive based measures.

Table 8.F.54 Estimated Costs of Representative Dry Year Leasing Program in Region 3

Reach	Estimated Capitalized Cost*	Cost per Ac-ft of On-farm Water Savings		Cost per Ac-ft of Reduced Shortage at Critical Habitat	
		CIR	Deliveries	With Diversions**	Without Diversions
10	$710,000	$1,780	$890	N/A	$1,880
14	$850,000	$1,700	$850	N/A	$2,240
15	$970,000	$1,820	$910	N/A	$2,290
16	$1,120,000	$1,720	$860	$9,180	$1,740
17	$2,240,000	$1,620	$810	$2,670	$1,960
18	$3,010,000	$1,720	$860	$2,010	$1,800
19	$3,130,000	$2,160	$1,080	$1,910	$1,910
Region Total/ Average	$12,030,000	$1,800	$900	N/A	$1,910

* Calculation reflects estimate that leases will be activated in approximately one in three years.

** In some reaches, the representative program would produce no reduction in shortages to target flows if downstream diverters can divert water produced by this program. In these instances, costs per ac-ft are shown as not applicable (N/A).

Drought Water Banking

As noted in the discussion of incentive based alternatives in Region 1, yields and costs associated with drought water banking are completely unpredictable. Consequently, the study team has not analyzed this alternative further.

5. Yield Summary

Each of the alternatives for incentive based reductions in agricultural water use is scalable. If any of these alternatives are chosen for inclusion in the eventual action plan, the magnitude and geographic focus of the alternative may differ from the representative incentive based programs described in this section. Consequently, the total yields described in this section for each alternative are specific to the assumptions the study team has made in defining representative incentive based programs.

Based upon the operating definitions of the incentive based alternatives used in this evaluation, the total annual yield on-site across the study region ranges from over 100,000 ac-ft per year under the land purchase and fallowing alternatives to less than 30,000 ac-ft per year under the dry year leasing alternative (on average, including years when dry year leases are not activated). Three reaches have on-site yields of more than 10,000 ac-ft per year under the land purchase and fallowing alternatives: Reach 8, Reach 9 and Reach 12. Yields for each alternative and each reach are summarized in Table 8.F.55.

Under the assumptions of the representative incentive based programs described in this section, total reductions in shortages to target flows at Grand Island if conserved water is protected from downstream diverters range from 61,500 ac-ft per year under the land purchase and land fallowing alternatives to 18,000 ac-ft per year under the dry year leasing alternative. Average annual dry year leasing yields are reduced because the leases are assumed to be activated only one year in three. With diversion losses downstream, reductions to target flow shortages range would be much less.

Table 8.F.55
Alternatives Yield and Cost by Reach
Category 4 - Incentive Based Reductions in Agricultural Water Use

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Reach 1											
Purchase Lands	1,950	1,929	1,929	106	1,390	25	920	$1.0	$1.0	$41,100	$1,110
Purchase WR	1,100	1,088	1,088	60	784	14	519	$0.5	$0.5	$37,140	$1,000
Fallowing	1,950	1,929	1,929	106	1,390	25	920	$1.1	$1.1	$45,530	$1,230
Lease WR	1,100	1,088	1,088	60	784	14	519	$0.4	$0.4	$26,430	$710
Dry-year Lease	385	381	381	12	270	8	221	$0.3	$0.3	$31,250	$1,130
Water Banking	Uncertain										
Reach 2											
Purchase Lands	4,990	4,970	4,970	262	3,580	62	2,341	$2.5	$2.5	$40,080	$1,070
Purchase WR	2,800	2,789	2,789	147	2,009	35	1,323	$1.3	$1.3	$37,710	$1,000
Fallowing	4,990	4,970	4,970	262	3,580	62	2,341	$2.7	$2.7	$42,650	$1,130
Lease WR	2,800	2,789	2,789	147	2,009	35	1,323	$1.0	$1.0	$27,710	$730
Dry-year Lease	980	976	936	29	691	10	558	$0.7	$0.7	$34,210	$1,160
Water Banking	Uncertain										
Reach 3											
Purchase Lands	2,030	1,995	1,995	107	1,486	26	986	$1.1	$1.1	$41,800	$1,100
Purchase WR	1,100	1,081	1,081	58	805	14	536	$0.6	$0.6	$42,140	$1,100
Fallowing	2,030	1,995	1,995	107	1,486	26	986	$1.2	$1.2	$45,290	$1,180
Lease WR	1,100	1,081	1,081	58	805	14	536	$0.4	$0.4	$30,710	$800
Dry-year Lease	385	379	379	11	236	8	228	$0.3	$0.3	$36,250	$1,270
Water Banking	Uncertain										
Reach 4											
Purchase Lands	1,610	1,412	1,605	153	1,199	25	800	$1.0	$1.0	$41,170	$1,280
Purchase WR	1,050	921	1,047	100	782	16	522	$0.7	$0.7	$42,500	$1,300
Fallowing	1,610	1,412	1,605	153	1,199	25	800	$1.0	$1.0	$42,390	$1,300
Lease WR	1,050	921	1,047	100	782	16	522	$0.5	$0.5	$30,000	$920
Dry-year Lease	368	321	366	23	268	9	222	$0.3	$0.3	$35,560	$1,440
Water Banking	Uncertain										
Reach 5											
Purchase Lands	3,204	2,509	3,190	(869)	2,448	(471)	1,802	$2.9	$2.9	N/A	$1,610
Purchase WR	2,163	1,694	2,154	(587)	1,653	(319)	1,228	$2.1	$2.1	N/A	$1,730
Fallowing	3,204	2,509	3,190	(869)	2,448	(471)	1,802	$2.6	$2.6	N/A	$1,460
Lease WR	2,163	1,694	2,154	(587)	1,653	(319)	1,228	$1.4	$1.4	N/A	$1,160
Dry-year Lease	757	575	753	(228)	575	(160)	471	$1.0	$1.0	N/A	$2,020
Water Banking	Uncertain										
Reach 6											
Purchase Lands	3,480	3,412	3,412	361	2,567	128	1,687	$2.2	$2.2	$16,890	$1,280
Purchase WR	2,150	2,108	2,108	223	1,586	79	1,050	$1.3	$1.3	$16,580	$1,250
Fallowing	3,480	3,412	3,412	361	2,567	128	1,687	$2.5	$2.5	$19,860	$1,510
Lease WR	2,150	2,108	2,108	223	1,586	79	1,050	$0.9	$0.9	$11,900	$900
Dry-year Lease	753	748	748	53	551	37	453	$0.6	$0.6	$17,030	$1,390
Water Banking	Uncertain										

* Capitalized cost is present value of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate.

Table 8.F-55
Alternatives Yield and Cost by Reach
Category 4 - Incentive Based Reductions in Agricultural Water Use

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Reach 7											
Purchase Lands	2,330	1,389	2,446	(139)	2,638	(47)	1,834	$2.7	$3.3	N/A	$1,780
Purchase WR	1,652	976	1,720	(98)	1,855	(33)	1,296	$2.1	$2.6	N/A	$3,030
Fallowing	2,330	1,388	2,446	(139)	2,638	(47)	1,834	$2.3	$2.8	N/A	$1,520
Lease WR	1,652	976	1,720	(98)	1,855	(33)	1,296	$1.4	$1.9	N/A	$1,490
Dry-year Lease	579	312	599	(27)	655	(9)	527	$0.9	$1.5	N/A	$2,800
Water Banking	Uncertain										
Reach 8											
Purchase Lands	18,726	12,527	22,533	(2,158)	18,927	(1,129)	12,567	$21.3	$25.2	N/A	$2,010
Purchase WR	12,884	8,619	15,503	(1,485)	13,022	(776)	8,753	$15.4	$19.4	N/A	$2,220
Fallowing	18,726	12,527	22,533	(2,158)	18,927	(1,129)	12,563	$17.7	$21.6	N/A	$1,720
Lease WR	12,884	8,619	15,503	(1,485)	13,022	(776)	8,753	$10.3	$14.4	N/A	$1,650
Dry-year Lease	4,505	3,059	5,505	(310)	4,605	(345)	3,562	$6.9	$11.0	N/A	$3,030
Water Banking	Uncertain										
Reach 9											
Purchase Lands	11,157	4,242	12,015	(2,728)	10,777	(1,595)	7,415	$14.9	$17.7	N/A	$2,390
Purchase WR	7,607	2,892	8,192	(1,860)	7,348	(1,060)	5,152	$10.6	$13.4	N/A	$2,590
Fallowing	11,157	4,242	12,015	(2,728)	10,777	(1,595)	7,415	$12.9	$15.6	N/A	$2,100
Lease WR	7,607	2,892	8,192	(1,860)	7,348	(1,060)	5,152	$7.1	$9.9	N/A	$1,920
Dry-year Lease	2,663	899	2,863	(654)	2,641	(572)	2,001	$4.7	$7.5	N/A	$3,360
Water Banking	Uncertain										
Reach 10											
Purchase Lands	1,442	1,197	1,564	(387)	1,510	(364)	1,138	$2.0	$2.0	N/A	$1,770
Purchase WR	1,311	1,088	1,422	(354)	1,373	(331)	1,036	$1.6	$1.6	N/A	$1,520
Fallowing	1,442	1,197	1,564	(387)	1,510	(364)	1,138	$2.1	$2.1	N/A	$1,860
Lease WR	1,311	1,088	1,422	(354)	1,373	(331)	1,036	$1.1	$1.1	N/A	$1,030
Dry-year Lease	459	393	510	(193)	495	(168)	378	$0.7	$0.7	N/A	$1,880
Water Banking	Uncertain										
Reach 11											
Purchase Lands	2,480	1,410	2,477	99	1,847	17	1,224	$4.1	$4.9	$250,400	$3,950
Purchase WR	1,650	938	1,648	66	1,229	11	821	$2.7	$3.4	$246,360	$4,110
Fallowing	2,480	1,410	2,477	99	1,847	17	1,224	$3.3	$4.1	$198,990	$3,350
Lease WR	1,650	938	1,648	66	1,229	11	821	$1.8	$2.5	$165,450	$3,030
Dry-year Lease	578	326	577	15	421	7	340	$1.3	$1.9	$172,860	$5,530
Water Banking	Uncertain										
Reach 12											
Purchase Lands	13,392	7,720	15,472	(4,510)	12,113	(2,462)	8,664	$13.5	$17.3	N/A	$1,550
Purchase WR	9,730	4,880	9,780	(2,851)	7,657	(1,548)	5,579	$7.7	$7.7	N/A	$1,380
Fallowing	13,392	7,720	15,472	(4,510)	12,113	(2,462)	8,664	$13.1	$17.1	N/A	$1,510
Lease WR	9,730	4,880	9,780	(2,851)	7,657	(1,548)	5,579	$5.2	$5.2	N/A	$930
Dry-year Lease	3,499	1,594	3,416	(1,115)	2,676	(803)	2,109	$3.5	$3.5	N/A	$1,640
Water Banking	Uncertain										
Reach 13											
Purchase Lands	4,686	3,985	4,584	(2,368)	3,952	(1,294)	3,143	$4.4	$4.4	N/A	$1,390
Purchase WR	4,214	3,520	4,127	(2,129)	3,554	(1,107)	2,854	$3.5	$3.5	N/A	$1,240
Fallowing	4,686	3,985	4,584	(2,368)	3,952	(1,294)	3,143	$4.4	$4.4	N/A	$1,410
Lease WR	4,214	3,520	4,127	(2,129)	3,554	(1,107)	2,854	$2.3	$2.3	N/A	$820
Dry-year Lease	1,475	1,226	1,445	(812)	1,260	(581)	1,021	$1.5	$1.5	N/A	$1,310
Water Banking	Uncertain										

* Capitalized cost is present value of implementation cost, capital costs and operating costs over 30 year period using 6 percent discount rate.

Table 8.F.55
Alternatives Yield and Cost by Reach
Category 4 - Incentive Based Reductions in Agricultural Water Use

Reach Alternative	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach (w/diversion loss)	(w/o diversion loss)	Net Hydrologic Effects at Habitat (w/diversion loss)	(w/o diversion loss)	Reduction to Target Flow Shortages at Habitat (w/diversion loss)	(w/o diversion loss)	Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat (w/diversion loss)	(w/o diversion loss)
Reach 14											
Purchase Lands	1,617	1,268	1,651	(178)	1,484	(149)	1,040	$2.3	$2.3	N/A	$2,230
Purchase WR	1,535	1,204	1,567	(169)	1,409	(141)	989	$1.9	$1.9	N/A	$1,930
Fallowing	1,617	1,268	1,651	(178)	1,484	(149)	1,040	$2.5	$2.5	N/A	$2,370
Lease WR	1,535	1,204	1,567	(169)	1,409	(141)	989	$1.3	$1.3	N/A	$1,290
Dry-year Lease	538	413	553	(71)	495	(77)	380	$0.9	$0.9	N/A	$2,240
Water Banking	Uncertain										
Reach 15											
Purchase Lands	2,182	1,577	2,760	(420)	1,757	(298)	1,276	$2.9	$2.9	N/A	$2,270
Purchase WR	1,984	1,434	2,509	(382)	1,597	(271)	1,164	$2.2	$2.2	N/A	$1,860
Fallowing	2,182	1,577	2,760	(420)	1,757	(298)	1,276	$3.0	$3.0	N/A	$2,340
Lease WR	1,984	1,434	2,509	(382)	1,597	(271)	1,164	$1.5	$1.5	N/A	$1,250
Dry-year Lease	694	496	891	(162)	664	(143)	424	$1.0	$1.0	N/A	$2,290
Water Banking	Uncertain										
Reach 16											
Purchase Lands	3,695	1,457	3,705	801	2,746	539	1,920	$3.5	$3.5	$6,510	$1,830
Purchase WR	3,367	1,328	3,376	730	2,502	493	1,757	$2.5	$2.5	$5,150	$1,450
Fallowing	3,695	1,457	3,705	801	2,746	539	1,920	$3.7	$3.7	$6,940	$1,950
Lease WR	3,367	1,328	3,376	730	2,502	493	1,757	$1.7	$1.7	$3,410	$960
Dry-year Lease	1,178	420	1,169	201	862	122	643	$1.1	$1.1	$9,180	$1,740
Water Banking	Uncertain										
Reach 17											
Purchase Lands	6,810	6,758	6,758	4,232	4,953	2,720	3,318	$7.0	$7.0	$2,580	$2,120
Purchase WR	6,351	6,302	6,302	3,947	4,619	2,542	3,100	$5.0	$5.0	$1,970	$1,620
Fallowing	6,810	6,758	6,759	4,232	4,953	2,720	3,318	$7.7	$7.7	$2,850	$2,330
Lease WR	6,351	6,302	6,302	3,947	4,619	2,542	3,100	$3.4	$3.4	$1,320	$1,080
Dry-year Lease	2,223	2,202	2,022	1,294	1,609	840	1,145	$2.2	$2.2	$2,670	$1,960
Water Banking	Uncertain										
Reach 18											
Purchase Lands	9,281	7,071	9,421	6,596	7,007	4,187	4,522	$9.3	$9.3	$2,230	$2,060
Purchase WR	8,827	6,725	8,960	6,273	6,664	4,000	4,318	$6.8	$6.8	$1,690	$1,570
Fallowing	9,281	7,071	9,421	6,596	7,007	4,187	4,522	$9.9	$9.9	$2,370	$2,200
Lease WR	8,827	6,725	8,960	6,273	6,664	4,000	4,318	$4.5	$4.5	$1,130	$1,050
Dry-year Lease	3,089	2,155	3,145	2,133	2,362	1,498	1,676	$3.0	$3.0	$2,010	$1,800
Water Banking	Uncertain										
Reach 19											
Purchase Lands	7,565	6,609	6,609	6,609	6,609	4,619	4,619	$8.5	$8.5	$1,850	$1,850
Purchase WR	6,987	6,104	6,104	6,104	6,104	4,273	4,273	$7.0	$7.0	$1,640	$1,640
Fallowing	7,565	6,609	6,609	6,609	6,609	4,619	4,619	$8.7	$8.7	$1,880	$1,880
Lease WR	6,987	6,104	6,104	6,104	6,104	4,273	4,273	$4.7	$4.7	$1,100	$1,100
Dry-year Lease	2,445	2,131	2,131	2,131	2,131	1,637	1,637	$3.1	$3.1	$1,910	$1,910
Water Banking	Uncertain										

Table 8.F.55
Alternatives Yield and Cost by Reach
Category 4 - Incentive Based Reductions in Agricultural Water Use

	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
	Net Hydrologic Effects	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction to Target Flow Shortages at Habitat		Cost*	Cost*	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
Reach Alternative	At Site	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	w/ diversion loss ($ Million)	w/out diversion loss ($ Million)	(w/diversion loss)	(w/o diversion loss)

* Capitalized cost is present value of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate.

Table 8.F-55
Alternatives Yield and Cost by Reach
Category 5 - Incentive Based Reductions in Agricultural Water Use

	Yield 20-year Average Annual Values (ac-ft/yr)							Cost Capitalized Costs			
Reach	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach		Net Hydrologic Effects at Habitat		Reduction in Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per acre-foot Reduction in Target Flow Shortage At Habitat	
Alternative		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
Region 1											
Purchase Lands	37,342	27,862	37,157	(6,758)	28,736	(3,872)	20,343	$28.5	$28.5	($7,360)	$1,400
Purchase WR	24,307	18,081	24,169	(4,979)	18,850	(2,815)	15,591	$17.8	$17.8	($6,310)	$1,310
Fallowing	37,342	27,862	37,157	(6,758)	28,736	(3,872)	20,343	$28.7	$28.7	($7,420)	$1,410
Lease WR	24,307	18,081	24,169	(4,979)	18,850	(2,815)	15,591	$12.1	$12.1	($4,310)	$890
Dry-year Lease	8,507	6,200	8,464	(2,015)	6,569	(1,463)	5,283	$8.1	$8.1	($5,520)	$1,530
Water Banking	Uncertain										
Region 2											
Purchase Lands	34,713	19,567	39,471	(4,927)	34,189	(2,753)	23,036	$42.9	$51.0	($15,580)	$2,210
Purchase WR	23,793	13,425	27,063	(3,377)	23,454	(1,878)	16,022	$30.7	$38.8	($16,350)	$2,420
Fallowing	34,713	19,567	39,471	(4,927)	34,189	(2,753)	23,036	$36.2	$44.0	($13,130)	$1,910
Lease WR	23,793	13,425	27,063	(3,377)	23,454	(1,878)	16,022	$20.6	$28.7	($10,990)	$1,790
Dry-year Lease	8,323	4,616	9,542	(1,156)	8,322	(879)	6,430	$13.7	$21.8	($15,620)	$3,400
Water Banking	Uncertain										
Region 3											
Purchase Lands	32,593	25,937	32,467	17,053	26,066	11,254	17,833	$35.6	$35.6	$3,170	$2,000
Purchase WR	30,362	24,135	30,240	15,969	24,268	10,565	16,637	$27.0	$27.0	$2,550	$1,620
Fallowing	32,593	25,937	32,467	17,053	26,066	11,254	17,833	$37.7	$37.7	$3,350	$2,110
Lease WR	30,362	24,135	30,240	15,969	24,268	10,565	16,637	$18.1	$18.1	$1,710	$1,080
Dry-year Lease	10,627	8,210	10,421	5,341	8,618	3,709	6,283	$12.0	$12.0	$3,240	$1,910
Water Banking	Uncertain										
Study Area											
Purchase Lands	104,648	73,366	109,096	5,368	88,991	4,629	61,212	$107.0	$115.1	$23,120	$1,880
Purchase WR	78,462	55,691	81,472	7,613	66,552	5,872	46,250	$75.4	$83.5	$12,850	$1,810
Fallowing	104,648	73,366	109,096	5,368	88,991	4,629	61,212	$102.6	$110.4	$22,150	$1,800
Lease WR	78,462	55,691	81,472	7,613	66,552	5,872	46,250	$50.8	$58.9	$8,660	$1,270
Dry-year Lease	27,458	19,026	28,427	2,170	23,509	1,367	17,996	$33.8	$41.9	$24,750	$2,330
Water Banking	Uncertain										

* Capitalized cost is present value of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate.

6. Cost Summary

Table 8.F.55 also summarizes the costs associated with the incentive based reduction in agricultural water use alternatives. Under the representative incentive based programs evaluated in this section, purchasing or fallowing agricultural lands would have the highest total net present value costs at about $100 million across the three regions. The cost per ac-ft of shortage reduction at the critical habitat would be about $1,800 under the land purchase and fallowing alternatives, without diversion losses. With diversion losses, the cost would rise substantially.

Temporary leases of agricultural water rights would have the lowest total capitalized costs of the incentive based alternatives (except for dry year leasing) – at about $51 million across the three regions (excluding costs for sand dams in Region 2). The cost per ac-ft of shortage reduction at the critical habitat would be about $1,300 under the water right leasing alternative, without diversion losses. With diversion losses, the cost would rise considerably.

7. Associated Issues

Each of the remaining alternative approaches to incentive based programs to reduce agricultural water use were evaluated according to the associated issues evaluation criteria previously reviewed with the WMC. The five categories of associated issues are physical, legal and institutional, economic, social and environmental. Tabular scoring of each alternative according to each of the criteria are presented in Tables 8.F.56 through 8.F.65. In all cases, the study team has evaluated each alternative as previously defined in this section. Where relevant, the associated issues scoring and discussion highlights differences between the scenario in which water is assumed to be protected from downstream diverters and the scenario in which no protection is assumed. The initial discussion in each category focuses on the scenario that assumes protection from downstream diverters.

Table 8.F.56

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 4 - Incentive Based Reductions in Agricultural Water Use: Land Purchase and Irrigation Retirement

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	**1**	**2**	**3**	**4**	**5**	**6**	**12**	**13**	**7**	**8**	**9**	**11**	**10**	**14**	**15**	**16**	**17**	**18**	**19**
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2	2	2
Sustainability																	5	5	5
Scalability																	3	3	3
Technically Implementable																	5	5	5
Time to Yield Realization																	5	5	5
Ability to Monitor and Measure																	4	4	4
Third Party Hydrologic Impacts																	3	3	3
Subtotal																	27	27	27
Subtotal Average																	4	4	4
Legal/Institutional																			
Ease of Permitting																	5	5	5
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	5	5	5
Potential for Institutional Consensus																	2	2	2
Can be Mitigated																	3	3	3
Administrative Ease																	4	4	4
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	29	29	29
Subtotal Average																	4	4	4
Social																			
Effects on Customs and Culture																	2	2	2
Equity of Impacts																	2	2	2
Impacts on Community Organizations and Support Structures																	2	2	2
Effects on Community Sustainability																	2	2	2
Public Acceptability																	2	2	2
Subtotal																	10	10	10
Subtotal Average																	2	2	2
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	2	2	2
Subtotal																	16	17	18
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	4	4	4
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	19	19	19
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)																	16	16	16

Table .57

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 4 - Incentive Based Reductions in Agricultural Water Use: Permanent Acquisition of Agricultural Water Rights

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2
Sustainability																	5	5	5
Scalability																	3	3	3
Technically Implementable																	5	5	5
Time to Yield Realization																	4	4	4
Ability to Monitor and Measure																	4	4	4
Third Party Hydrologic Impacts																	3	3	3
Subtotal																	26	26	26
Subtotal Average																	4	4	4
Legal/Institutional																			
Ease of Permitting																	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	2	2	2
Potential for Institutional Consensus																	2	2	2
Can be Mitigated																	3	3	3
Administrative Ease																	4	4	4
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	23	23	23
Subtotal Average																	3	3	3
Social																			
Effects on Customs and Culture																	2	2	2
Equity of Impacts																	2	2	2
Impacts on Community Organizations and Support Structures																	2	2	2
Effects on Community Sustainability																	2	2	2
Public Acceptability																	2	2	2
Subtotal																	10	10	10
Subtotal Average																	2	2	2
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	3
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	2	2	2
Subtotal																	18	18	18
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	4	4	4
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	19	19	19
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)																	15	15	15

Table 8.F.58

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 4 - Incentive Based Reductions in Agricultural Water Use: Land Fallowing Program

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2	2	2
Sustainability																	3	3	3
Scalability																	3	4	3
Technically Implementable																	5	5	5
Time to Yield Realization																	5	5	5
Ability to Monitor and Measure																	3	3	3
Third Party Hydrologic Impacts																	3	3	3
Subtotal																	24	25	24
Subtotal Average																	3	4	3
Legal/Institutional																			
Ease of Permitting																	5	5	5
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	5	5	5
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	3	3	3
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	29	29	29
Subtotal Average																	4	4	4
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	3	3	3
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	3	3	3
Subtotal																	15	15	15
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	3	3	3
Subtotal																	17	18	19
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	4	4	4
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	19	19	19
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)																	16	17	16

Tabl .59

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 4 - Incentive Based Reductions in Agricultural Water Use: Temporary Leasing of Agricultural Water Supplies

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	**1**	**2**	**3**	**4**	**5**	**6**	**12**	**13**	**7**	**8**	**9**	**11**	**10**	**14**	**15**	**16**	**17**	**18**	**19**
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2
Sustainability																	3	3	3
Scalability																	3	4	3
Technically Implementable																	5	5	5
Time to Yield Realization																	4	4	4
Ability to Monitor and Measure																	4	4	4
Third Party Hydrologic Impacts																	2	2	2
Subtotal																	22	24	23
Subtotal Average																	3	3	3
Legal/Institutional																			
Ease of Permitting																	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	2	2	2
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	3	3	3
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	23	23	23
Subtotal Average																	3	3	3
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	3	3	3
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	3	3	3
Subtotal																	15	15	15
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	4
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	3	3	3
Subtotal																	20	20	20
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	4	4	4
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	19	19	19
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)																	15	15	15

Table 8.F.60

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 4 - Incentive Based Reductions in Agricultural Water Use: Dry Year Leasing

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Sustainability																	3	3	3
Scalability																	2	3	2
Technically Implementable																	5	5	5
Time to Yield Realization																	4	4	4
Ability to Monitor and Measure																	4	4	4
Third Party Hydrologic Impacts																	2	2	2
Subtotal																	21	22	21
Subtotal Average																	3	3	3
Legal/Institutional																			
Ease of Permitting																	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees																	5	5	5
Consistent with State Laws																	2	2	2
Potential for Institutional Consensus																	3	3	3
Can be Mitigated																	3	3	3
Administrative Ease																	3	3	3
Consistent with Existing Contract, Facility & Land Ownership																	5	5	5
Subtotal																	23	23	23
Subtotal Average																	3	3	3
Social																			
Effects on Customs and Culture																	3	3	3
Equity of Impacts																	3	3	3
Impacts on Community Organizations and Support Structures																	3	3	3
Effects on Community Sustainability																	3	3	3
Public Acceptability																	3	3	3
Subtotal																	15	15	15
Subtotal Average																	3	3	3
Economic																			
Initial Implementation and Capital Cost																	5	5	5
Average Annual Total Cost per Acre-Foot Reduction												0					1	2	3
Direct Economic Impacts																	4	4	4
Secondary Economic Impacts																	2	2	2
Fiscal Impacts																	2	2	2
Effects on Economic Development Potential																	3	3	3
Subtotal																	17	18	19
Subtotal Average																	3	3	3
Environmental																			
Impacts to Wetlands																	3	3	3
Impacts to Habitat																	3	3	3
Impacts to Water Quality																	4	4	4
Impacts to Prime and Unique Farmlands																	3	3	3
Visual Impacts																	3	3	3
Impacts to Amenities																	3	3	3
Subtotal																	19	19	19
Subtotal Average																	3	3	3
Overall Total (Sum of Averages)																	15	15	15

Table .61
Scoring Table - No Diversions in Any State
Category 4 - Incentive Based Reductions in Agricultural Water Use: Land Purchase and Irrigation Retirement

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	1	1	1	1	1	1	4	2	1	5	3		1	1	1	1	2	2	2
Sustainability	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Scalability	1	1	1	1	1	1	3	2	1	4	3		1	1	1	2	3	3	3
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	4	4	5	5	5		4	4	4	4	4	4	4
Ability to Monitor and Measure	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Third Party Hydrologic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	23	23	23	23	23	23	27	24	23	30	27		22	22	22	23	25	25	25
Subtotal Average	3	3	3	3	3	3	4	3	3	4	4		3	3	3	3	4	4	4
Legal/Institutional																			
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Consistent with State Laws	3	3	3	3	3	3	2	2	3	3	3		2	2	2	2	2	2	2
Potential for Institutional Consensus	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Administrative Ease	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Subtotal	24	24	24	24	24	24	23	23	24	24	24		23	23	23	23	23	23	23
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Social																			
Effects on Customs and Culture	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Equity of Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Impacts on Community Organizations and Support Structures	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Community Sustainability	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Public Acceptability	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	10	10	10	10	10	10	10	10	10	10	10		10	10	10	10	10	10	10
Subtotal Average	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Economic																			
Initial Implementation and Capital Cost	5	5	5	5	5	5	4	5	5	3	4		5	5	5	5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	4	4	4	4	3	4	3	4	3	2	2	0	3	2	2	3	2	2	3
Direct Economic Impacts	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Fiscal Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Economic Development Potential	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	19	19	19	19	18	19	17	19	18	15	16		18	17	17	18	17	17	18
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Environmental																			
Impacts to Wetlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Habitat	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Water Quality	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Impacts to Prime and Unique Farmlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	19	19	19	19	19	19	19	19	19	19	19		19	19	19	19	19	19	19
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Overall Total (Sum of Averages)	14	14	14	14	14	14	15	14	14	15	15		14	14	14	14	15	15	15

Table 8.F.62
Scoring Table - No Diversions in Any State
Category 4 - Incentive Based Reductions in Agricultural Water Use: Permanent Acquisition of Agricultural Water Rights

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	1	1	1	1	1	1	4	2	1	4	3		1	1	1	1	2	2	2
Sustainability	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Scalability	1	1	1	1	1	1	3	2	1	3	3		1	1	1	2	3	3	3
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	4	4	5	5	5		4	4	4	4	4	4	4
Ability to Monitor and Measure	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Third Party Hydrologic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	23	23	23	23	23	23	27	24	23	28	27		22	22	22	23	25	25	25
Subtotal Average	3	3	3	3	3	3	4	3	3	4	4		3	3	3	3	4	4	4
Legal/Institutional																			
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Consistent with State Laws	3	3	3	3	3	3	2	2	3	3	3		2	2	2	2	2	2	2
Potential for Institutional Consensus	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Administrative Ease	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Subtotal	24	24	24	24	24	24	23	23	24	24	24		23	23	23	23	23	23	23
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Social																			
Effects on Customs and Culture	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Equity of Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Impacts on Community Organizations and Support Structures	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Community Sustainability	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Public Acceptability	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	10	10	10	10	10	10	10	10	10	10	10		10	10	10	10	10	10	10
Subtotal Average	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Economic																			
Initial Implementation and Capital Cost	5	5	5	5	5	5	5	5	5	4	4		5	5	5	5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	4	4	4	4	3	4	4	4	2	2	1	0	3	3	3	4	3	3	3
Direct Economic Impacts	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Fiscal Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Economic Development Potential	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	19	19	19	19	18	19	19	19	17	16	15		18	18	18	19	18	18	18
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Environmental																			
Impacts to Wetlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Habitat	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Water Quality	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Impacts to Prime and Unique Farmlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	19	19	19	19	19	19	19	19	19	19	19		19	19	19	19	19	19	19
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Overall Total (Sum of Averages)	14	14	14	14	14	14	15	14	14	15	15		14	14	14	14	15	15	15

Table .63
Scoring Table - No Diversions in Any State
Category 4 - Incentive Based Reductions in Agricultural Water Use: Land Fallowing Program

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	1	1	1	1	1	1	4	2	1	5	4		1	1	1	1	2	2	2
Sustainability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Scalability	2	3	2	1	2	3	4	3	2	5	4		2	2	2	3	3	4	3
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	4	4	5	5	5		4	4	4	4	4	4	4
Ability to Monitor and Measure	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Third Party Hydrologic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	21	22	21	20	21	22	25	22	21	28	26		20	20	20	21	22	23	22
Subtotal Average	3	3	3	3	3	3	4	3	3	4	4		3	3	3	3	3	3	3
Legal/Institutional																			
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Consistent with State Laws	3	3	3	3	3	3	2	2	3	3	3		2	2	2	2	2	2	2
Potential for Institutional Consensus	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Administrative Ease	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Subtotal	24	24	24	24	24	24	23	23	24	24	24		23	23	23	23	23	23	23
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Social																			
Effects on Customs and Culture	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Equity of Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Effects on Community Sustainability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Public Acceptability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	15	15	15	15	15	15	15	15	15	15	15		15	15	15	15	15	15	15
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Economic																			
Initial Implementation and Capital Cost	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	4	4	4	4	4	4	3	4	3	3	2	0	3	2	2	3	2	2	3
Direct Economic Impacts	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Fiscal Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Economic Development Potential	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	20	20	20	20	20	20	19	20	19	19	18		19	18	18	19	18	18	19
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Environmental																			
Impacts to Wetlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Habitat	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Water Quality	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Impacts to Prime and Unique Farmlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	19	19	19	19	19	19	19	19	19	19	19		19	19	19	19	19	19	19
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Overall Total (Sum of Averages)	15	15	15	15	15	15	16	15	15	16	16		15	15	15	15	15	15	15

Table 8.F.64
Scoring Table - No Diversions in Any State
Category 4 - Incentive Based Reductions in Agricultural Water Use: Temporary Leasing of Agricultural Water Supplies

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	1	1	1	1	1	1	3	2	1	4	3	0	1	1	1	1	2	2	2
Sustainability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Scalability	1	2	1	1	2	2	3	3	2	4	3		1	2	2	3	3	4	3
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	4	4	5	5	5		4	4	4	4	4	4	4
Ability to Monitor and Measure	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Third Party Hydrologic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Subtotal	21	22	21	21	22	22	24	23	22	27	25		20	21	21	22	23	24	23
Subtotal Average	3	3	3	3	3	3	3	3	3	4	4		3	3	3	3	3	3	3
Legal/Institutional																			
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Consistent with State Laws	3	3	3	3	3	3	2	2	3	3	3		2	2	2	2	2	2	2
Potential for Institutional Consensus	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Administrative Ease	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Subtotal	24	24	24	24	24	24	23	23	24	24	24		23	23	23	23	23	23	23
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Social																			
Effects on Customs and Culture	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Equity of Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Effects on Community Sustainability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Public Acceptability	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	15	15	15	15	15	15	15	15	15	15	15		15	15	15	15	15	15	15
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Economic																			
Initial Implementation and Capital Cost	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction	5	5	5	5	4	5	5	5	4	3	3	0	4	4	4	5	4	4	4
Direct Economic Impacts	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Fiscal Impacts	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2
Effects on Economic Development Potential	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	21	21	21	21	20	21	21	21	20	19	19		20	20	20	21	20	20	20
Subtotal Average	4	4	4	4	3	4	4	4	3	3	3		3	3	3	4	3	3	3
Environmental																			
Impacts to Wetlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Habitat	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Water Quality	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4
Impacts to Prime and Unique Farmlands	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Subtotal	19	19	19	19	19	19	19	19	19	19	19		19	19	19	19	19	19	19
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3
Overall Total (Sum of Averages)	16	16	16	16	15	16	16	16	15	16	16		15	15	15	16	15	15	15

Table .65
Scoring Table - No Diversions in Any State
Category 4 - Incentive Based Reductions in Agricultural Water Use: Dry Year Leasing

	Region 1 Reaches								Region 2 Reaches				Region 3 Reaches						
Physical	1	2	3	4	5	6	12	13	7	8	9	11	10	14	15	16	17	18	19
Net Reduction in Shortage to Target Flows	0	1	0	0	0	0	1	1	1			0	0	0	1	1	1	1	1
Sustainability		3					3	3	3						3	3	3	3	3
Scalability		1					3	1	1						1	1	2	3	2
Technically Implementable		5					5	5	5						5	5	5	5	5
Time to Yield Realization		5					4	4	5						4	4	4	4	4
Ability to Monitor and Measure		4					4	4	4						4	4	4	4	4
Third Party Hydrologic Impacts		2					2	2	2						2	2	2	2	2
Subtotal		21					22	20	21						20	20	21	22	21
Subtotal Average		3					3	3	3						3	3	3	3	3
Legal/Institutional																			
Ease of Permitting		2					2	2	2						2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees		5					5	5	5						5	5	5	5	5
Consistent with State Laws		3					2	2	3						2	2	2	2	2
Potential for Institutional Consensus		3					3	3	3						3	3	3	3	3
Can be Mitigated		3					3	3	3						3	3	3	3	3
Administrative Ease		3					3	3	3						3	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership		5					5	5	5						5	5	5	5	5
Subtotal		24					23	23	24						23	23	23	23	23
Subtotal Average		3					3	3	3						3	3	3	3	3
Social																			
Effects on Customs and Culture		3					3	3	3						3	3	3	3	3
Equity of Impacts		3					3	3	3						3	3	3	3	3
Impacts on Community Organizations and Support Structures		3					3	3	3						3	3	3	3	3
Effects on Community Sustainability		3					3	3	3						3	3	3	3	3
Public Acceptability		3					3	3	3						3	3	3	3	3
Subtotal		15					15	15	15						15	15	15	15	15
Subtotal Average		3					3	3	3						3	3	3	3	3
Economic																			
Initial Implementation and Capital Cost		5					5	5	5						5	5	5	5	5
Average Annual Total Cost per Acre-Foot Reduction		4					3	3	1	0	0	0			2	3	3	3	3
Direct Economic Impacts		4					4	4	4						4	4	4	4	4
Secondary Economic Impacts		2					2	2	2						2	2	2	2	2
Fiscal Impacts		2					2	2	2						2	2	2	2	2
Effects on Economic Development Potential		3					3	3	3						3	3	3	3	3
Subtotal		20					19	19	17						18	19	19	19	19
Subtotal Average		3					3	3	3						3	3	3	3	3
Environmental																			
Impacts to Wetlands		3					3	3	3						3	3	3	3	3
Impacts to Habitat		3					3	3	3						3	3	3	3	3
Impacts to Water Quality		4					4	4	4						4	4	4	4	4
Impacts to Prime and Unique Farmlands		3					3	3	3						3	3	3	3	3
Visual Impacts		3					3	3	3						3	3	3	3	3
Impacts to Amenities		3					3	3	3						3	3	3	3	3
Subtotal		19					19	19	19						19	19	19	19	19
Subtotal Average		3					3	3	3						3	3	3	3	3
Overall Total (Sum of Averages)		15					15	15	15						15	15	15	15	15

Land Purchase and Irrigation Retirement (refer to Tables 8.F.56 and 8.F.61)

Physical

As described in this section, the representative program to purchase lands and retire irrigation would result in relatively small reductions in target flow shortages (less than 5,000 ac-ft per year) in all reaches except reaches 8, 9 and 12. Once implemented this alternative would be readily sustainable. This alternative is scalable and a larger program could be implemented in any given reach than that assumed under the representative program evaluated in this section. The study team has evaluated scalability based on the assumption that the upper limit for the program would be to retire five percent of all irrigated lands (including both surface and groundwater supplied lands) in any given reach. If implemented, yield may be realized immediately in Colorado and Wyoming and the alternative yield should be relatively easy to estimate in any of the three states, though it cannot be directly monitored and measured. This type of program is assumed to take longer to implement in Nebraska if conserved water is to be protected from downstream diverters, since a change in state law may be required to allow a water right transfer.

Third party hydrologic effects of incentive based programs implemented above Lake McConaughy may include potential impacts on irrigated lands served by Lake McConaughy, the Environmental Account in Lake McConaughy, minimum operation flows, and hydropower production. These impacts may be minimal or significant depending on how projects are implemented. Negative third party effects would need to be offset or mitigated. Third party hydrologic effects might be partly mitigated by transferring only consumptive use, although changes in return flows would still impact other users. If conserved water cannot be protected from downstream diverters, this alternative would produce less than 500 ac-ft of reduction in shortages to target flows in every reach except reaches 16 through 19. This alternative could be implemented more swiftly in Nebraska without protection from downstream diverters, since irrigation would simply be retired on purchased lands without a water rights transfer.

Legal and Institutional

The purchase of irrigated agricultural lands presents a mixed picture from the legal/institutional perspective. Other than in Nebraska, state laws do not expressly prohibit this alternative, but a water right transfer and/or change of use would be required if conserved water is to be protected downstream. Convincing a water court of beneficial use may be an issue. Objections to water court proceedings are likely. There might well be public opposition, but it is uncertain how severe this will be from state to state. This alternative would be easier to administer than some other incentive based approaches, although management of purchased land is an issue. The alternative is consistent with existing land ownership, Federal laws and interstate compacts and decrees.

Under the scenario in which the conserved water is assumed to not be protected downstream, this alternative would require only irrigation retirement from purchased lands without a water right transfer. As such, both ease of permitting and consistency with state laws are improved.

Social

At the scale of the representative program outlined in this section, social impacts would be generally negative but relatively modest. Less than four percent of irrigated lands in any reach would be purchased and retired from irrigation. With a reduction in irrigated agriculture, there will be apprehensions about loss of traditional customs and culture, the impacts on community organizations and support structures, and community sustainability. All of this will create issues related to public acceptability. In terms of equity of impacts, the program can be structured to be equitable from a geographic standpoint although concentration within certain reaches might be advantageous from the standpoint of ease of implementation and effectiveness at the critical habitat. The focus of this program on retiring irrigation from agricultural lands might be perceived as placing an inequitable burden on the agricultural sector.

Economic

Essentially all of the costs of this alternative are capital costs up front; amortized total costs are almost completely a function of the capital costs. Nonetheless, these costs are less than $10 million in all reaches except reaches 8, 9 and 12. Costs per ac-ft of reduction in shortages at the critical habitat under this alternative are generally between $1,000 and $2,000 per ac-ft of reduction in target flow shortages in most reaches. In reach 11, the cost per ac-ft of reduced shortage exceeds the $3,000 threshold for further analysis. Direct economic impacts on farmers opting to participate in the program are positive, since this is a voluntary measure and must at least compensate the farmer for any financial impact. However, secondary economic impacts (including third party impacts) on agricultural workers and support industries would be negative, though under the representative program described in this section, these losses would be widely distributed and unlikely to be overwhelming in any one area. There could also be negative fiscal impacts stemming from this alternative as formerly irrigated lands would be either removed from the tax role or reclassified as lower value non-irrigated lands. There are also potentially negative effects on economic development, since this water will be unavailable for other possible uses in the future.

Due to the reduced yields, the costs per ac-ft of reduced shortage would be substantially greater in the absence of protection from downstream diverters. Only reaches 17 through 19 would meet the $3,000 per ac-ft maximum threshold under the scenario in which conserved water is not protected downstream.

Environmental

Under the relatively diffused program described in this section, this alternative would be unlikely to result in substantial environmental impacts. Impacts to wetlands and other habitat are likely to be negligible, while a modest improvement in water quality might result due to reduced loading of nutrients, sediments and chemicals. Prime and unique farmlands could be excluded from participation to avoid potential impacts in this area.

Permanent Acquisition of Agricultural Water Rights (refer to Tables 8.F.57 and 8.F.62)

Physical

The water rights purchase alternative is generally comparable from a physical standpoint to the land purchase alternative.

Under the scenario in which conserved water is not protected from downstream diverters, all reaches except reaches 17 through 19 would fail to meet the minimum requirement of producing at least a 500 ac-ft reduction in target flow shortages on an average annual basis.

Legal and Institutional

From a legal and institutional standpoint, purchasing water rights is comparable to a land purchase program under the assumption that the water right would have to be transferred downstream under either alternative. (If the land purchase program were to simply retire agricultural use on the purchased property without transferring the water right, land purchases would be simpler from a legal perspective). The water right purchase alternative would be somewhat easier than land purchases from an ongoing administrative perspective because it would not require management or disposition of purchased properties.

Social

All of the social sub-criteria will be negatively affected, but to a somewhat lesser extent than under the purchase of irrigated agricultural lands alternative. Although the social effects are likely to be similar, the perception will not be as sweeping, since the landowner may stay on the land and dry land farm and the land will not shift into public ownership.

Economic

Almost all of the costs of a water right purchase program would be up-front, capital and implementation costs. In most reaches, however, these costs would be less than $10 million. In most reaches, the cost per ac-ft would be between $1,000 and $2,000 per ac-ft of reduced shortage. Costs in reaches 7, 8 and 9 are greater than $2,000 per ac-ft and in reach 11 costs exceed the $3,000 per ac-ft threshold for further analysis. As under the land purchase program, direct economic impacts on water right holders choosing to sell to the program would have to be positive by definition. Negative economic effects are likely from a third party, secondary and fiscal standpoint. Reductions in economic development potential are also likely, although the representative program for water right purchases analyzed in this section would minimize these effects by diffusing impacts across the study area.

If water is not protected from downstream diverters, costs would exceed the $3,000 per ac-ft threshold in all reaches except 17 through 19.

Environmental

Environmental impacts would be similar to the land purchase alternative.

Land Fallowing (refer to Tables 8.F.58 and 8.F.63)

Physical

In terms of potential reductions in target flow shortages, a land fallowing program would be similar to the land purchase alternative. Given its temporary nature, it is likely that a fallowing program could economically enroll a larger percentage of farmlands than a permanent purchase program. The study team has assumed that up to 10 percent of all irrigated lands might be enrolled in the fallowing alternative as an upper limit on its scalability. Unlike the permanent, one-time transfers under either land or water rights purchase alternatives, on-going sustainability of a temporary fallowing program could be a concern. The ability to monitor and measure water savings from land fallowing agreements is also a concern. Verifying baseline fallowing practices and increased fallowing practices due to the program on individual participating farms would be a challenge. Third-party hydrologic impacts may occur, but could be lessened by both a geographically diffused program and the opportunity for changing which farms participate from one contract period to the next

If conserved water is not protected from downstream diverters, this alternative would only meet the minimum standard of reducing shortages to target flows by 500 ac-ft per year in Reaches 16, 17, 18 and 19. However, the program could be implemented more quickly in those reaches without downstream protection, since a mechanism for water right transfer and potential change in Nebraska State law would not be involved. In this area, third party hydrologic impacts might be offsetting, since accretions to the mound and localized high water tables might be reduced.

Legal and Institutional

Temporary transfers of water use through land fallowing or water right leasing could be very burdensome from a legal and institutional perspective if each agreement with each participating farmer has to be approved in water court. However, this burden could be reduced by negotiating fallowing contracts with irrigation districts and giving the districts flexibility in implementing these agreements among their members. Potential for institutional consensus and public support is greater than under the permanent transfer alternatives since the program can have diffused, incremental and temporary effects in any one area. If farmers have the option to enroll only a portion of their lands in this program, it could be seen as an opportunity to diversify their financial options and reduce risk. Mitigation burden should be minimal, and land fallowing is consistent with existing contracts and land ownership. Steps would be needed to insure that farmers' water rights are not jeopardized through temporary suspension of use. On one sub-criteria in this category, administrative ease, land fallowing scores quite low because of the requirement for changes in cropping and planting strategies and difficulty in verification.

If conserved water is not protected from downstream diverters, this alternative should require no permitting or legal review – since a water transfer would not be invoked.

Social

The land fallowing program can be designed to minimize social impacts. If the program is widely diffused geographically and if requirements are made for weed control and erosion control on fallowed land, public acceptability should be relatively high compared with more permanent incentive based measures.

Economic

Up front capital costs for land fallowing are low compared with permanent transfers, although the capitalized present value costs over the 20-year period would be similar to the permanent transfer alternatives. Implementation and administration costs will be relatively high. As with the other incentive based alternatives, direct economic impacts on participating farmers would be positive. Secondary and third party impacts on others in the farm sector would be negative but relatively modest under the representative program described in this section. Fiscal impacts will also be modest under land fallowing but may impact county assessment processes since the distinction between irrigated land and non-irrigated land will be more variable than at present.

Under the scenario in which water is assumed to not be protected from downstream diverters, only reaches 17, 18 and 19 would meet the $3,000 per ac-ft average annual cost threshold.

Environmental

Assuming that the selection of lands for fallowing avoids wetlands, other important habitat, and prime and unique farmlands, increased fallowing should have no substantial environmental impacts. Modest water quality benefits might result from this alternative.

Temporary Leasing of Agricultural Water Supplies (refer to Tables 8.F.59 and 8.F.64)

Physical

Temporary leasing of agricultural water supplies is very comparable from a physical evaluation standpoint to land fallowing, although water savings may be easier to estimate under the water leasing alternative.

If conserved water is not protected from downstream diverters, only reaches 17, 18 and 19 meet the 500 ac-ft per year threshold for reductions in shortages to target streamflows.

Legal and Institutional

The temporary leasing of agricultural water supplies will raise certain legal and institutional concerns, although they may not be insurmountable. The lease must go through water court and demonstrate no injury to return flows or senior water rights downstream. This will be more burdensome if the program is dispersed geographically, although arrangements might be made for aggregate leasing contracts with individual irrigation districts (as discussed under land fallowing). Although there is no obvious violation of interstate compacts, federal laws or decrees, there is no clear provision in state laws for accomplishing this activity. In Wyoming, the State Board of Control could probably accomplish this if there was widespread support for the program and legislative approval would be desirable. In Nebraska, several laws were proposed related to temporary leasing, but this has not been sanctioned as of spring 1999. There is reasonable potential for institutional consensus since this is a willing-farmer driven program and the effects would be dispersed and temporary. Resistance could be mitigable, assuming that money and oversight responsibility is delegated to irrigation districts or other local organizations responsible for irrigation. The administrative burden of this program will be significant at the outset but moderate on an ongoing basis. Leases would likely be re-negotiated every three to five years, and individual farmer problems are likely to arise over time. This leasing activity is consistent with existing contracts and land ownership.

Social

Social impacts are likely to be modest under the temporary leasing program described in this section given its scale, temporary nature and geographic diffusion. Long-term effects on any one area will not occur, serving to mitigate social impacts and longer-term economic sustainability concerns.

Economic

The implementation and annual costs per ac-ft are likely to be relatively low for the temporary leasing program – less than $1,500 per ac-ft of reduced shortage in most reaches. Capital costs will be minimal. Water leasing costs, per ac-ft, may be lower than land fallowing since farmers have greater flexibility to spread their other water supplies or dryland farm the land under the leasing alternative. There will be positive direct economic impacts and negative secondary economic impacts and fiscal impacts. These impacts should be modest if the program is widely dispersed and temporary in nature. Effects on economic development potential should be minimal.

If conserved water is not be protected from downstream diverters, only reaches 17, 18 and 19 would meet the threshold average cost of less than $3,000 per ac-ft of annual average shortage reduction.

Environmental

The program can be designed to avoid environmental impacts. Some modest improvements in water quality in the overall system might result.

Dry Year Leasing (refer to Tables 8.F.60 and 8.F.65)

Physical

From a physical standpoint, the dry year leasing program would be similar to the on-going water leasing alternative, except that reductions in target flow shortages would occur only in the years when leases are activated. Consequently, on an average annual basis this alternative produces relatively small reductions in target flow shortages – though a larger program than that outlined in this section could be devised. As outlined in this section, only reaches 2, 12 and 13 in Region 1; reaches 7 through 9 in Region 2 and Reaches 16 through 19 in Region 3 meet the minimum requirement of producing average annual shortage reductions of at least 500 ac-ft per year.

If conserved water is not protected from downstream diverters, only reaches 17 through 19 meet the minimum threshold in terms of shortage reduction.

Legal and Institutional

The legal and institutional implications are likely to be generally similar to those of temporary leasing. Although there is no obvious violation of interstate compacts, federal laws or decrees, there is no clear provision in state laws for accomplishing this activity. In Wyoming, the State Board of Control could probably accomplish this if there was widespread support for the program and legislative approval would be desirable. In Nebraska, several laws were proposed related to water leasing, including dry year leasing, but this has not been sanctioned as of spring 1999. There is good potential for institutional consensus since this is a willing-farmer driven program and the effects would be dispersed and temporary. A dry year leasing program will likely be somewhat more difficult to administer than an ongoing annual water leasing program.

Social

Social effects are likely to be modest for the dry year leasing alternative, although they could be greater than described herein if the program is not as geographically diffused as the representative program analyzed by the study team. Due to uncertainty about whether or not leases will be activated in any given year, dry year leasing tends to be less popular than ongoing leases with farm owners and renters.

Economic

The implementation costs will be moderate, due primarily to program establishment, but capital costs would be low. Average annual total costs will be lower than for an ongoing leasing program since dry year leases are not activated in every year. Costs per ac-ft of yield, however, would be higher than for an ongoing leasing program. While economic impacts of a dry year leasing program would be generally similar to those of an ongoing leasing program the impacts would not occur in every year but might be more severe in the years when the leases are activated.

Environmental

The program can be designed to avoid environmental impacts. It will be important to have a covenant that noxious weeds and pests will be controlled and that any environmentally sensitive areas are not eligible for the dry year leasing program. Very modest positive impacts on water quality might result from this alternative.

Drought Water Banking

Physical

The unpredictability of drought water banking prohibits estimation of any specific reduction to target flow shortages. Without a demonstration program, this alternative receives a fatal flaw rating of zero in the physical category and has not been evaluated further.

8.G. Ground Water

G. Groundwater

1. Introduction

This section examines the yields, costs and associated issues of various groundwater alternatives to reduce shortages to target flows at the critical habitat. A number of groundwater alternatives in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into four categories:

Groundwater Recharge/Return Flow Projects

Groundwater Transfer of Uses

Additional Surface Water and/or Groundwater Re-regulation Opportunities

Reduction of Natural Groundwater Exports from the Basin

A brief description of each of the projects and how they might be implemented is provided below, followed by estimates of yields and costs for each project. An evaluation of each project in terms of physical, legal or institutional, economic, social, and environmental effects is also provided.

2. Conceptual Definitions

Groundwater Recharge/Return Flow Projects. Groundwater recharge/return flow projects involve diverting surface water supplies for recharge of groundwater aquifers. Where the recharged aquifers are in direct hydrologic connection with the river, the return flows that result from such recharge accrue to the river for some duration after the recharge event. The strategy of such a project is to capture and recharge surface water, and through appropriate design, cause return flows to reach the river at times when there are target flow shortages at the critical habitat. Ideally surface water would be captured during periods when supplies may be considered to be "surplus" to project needs, however, this restriction was not fully applied to the alternatives evaluated. Sites that are in hydrologically connected aquifers rely on subsurface gravity flow for augmentation of Platte River flows. In cases where the aquifer to be recharged is not in direct hydrologic connection with the river, the project will require the means to recover stored water and deliver it to the river directly. These sites afford greater control over the timing of augmentation flows.

Groundwater Transfer of Uses. Transfer of uses in this case refers to incentive based transfers of groundwater uses, which might occur if agricultural uses of groundwater are retired (i.e., fallow irrigated lands) through an incentive based program and consumptive use made available in the critical habitat area. While increased streamflows might be realized through incentive based alternatives targeting hydrologically connected groundwater users, an additional level of hydrologic and administrative variability, uncertainty, and complexity would be introduced through their participation. Therefore, the analysis of programs involving transfers of use has been limited to reductions in surface water use, which is described in 8.F, Incentive Based Reductions in Agricultural Water Use.

Additional Surface Water and/or Groundwater Re-regulation Opportunities. Projects involving additional surface water and/or groundwater re-regulation opportunities include aquifer storage and recovery projects. One application of this alternative is to utilize groundwater aquifers to store water during periods of excess. During periods of shortage the aquifer is pumped to satisfy the water supply needs/requirements of existing water users that presently divert or pump water during such critical time periods. Another application of this type of alternative would be to recover or pump water from existing groundwater mounds, which have been generated due to reservoir, canal, and/or farm seepage losses, directly back to the Platte River. The focus of this type of alternative is to re-regulate/relocate groundwater return flows. An alternative of this nature would serve to both lower high groundwater conditions and reduce shortages at the critical habitat area.

Reduction of Natural Groundwater Exports from the Basin. The reduction of natural groundwater exports from the basin involves the capture of groundwater which originates within the Platte River basin but which is currently discharging from the basin. Only one such instance of this condition in the Platte River study area is known to exist at this time. In the areas served by the Nebraska Public Power District and Central Nebraska Public Power and Irrigation District, the long-term application of surface water for irrigation has recharged the groundwater system and resulted in the buildup of a groundwater mound. Water levels have risen extensively such that groundwater discharging through the subsurface into the Republican River and Little Blue River basins has increased. These additional groundwater losses due to the growth of the groundwater mound could be captured or otherwise reduced by pumping at strategic locations within the area affected by high groundwater levels. Alternatively, reducing the amount of infiltration and seepage losses from canals and reservoirs in the area by lining canals and/or reservoirs could reduce losses. (see Sections 8.B and 8.C)

3. Operational Definitions

For this reconnaissance level study, it is not possible to investigate every potential groundwater project within each region, therefore, the following limitations and basic assumptions were applied to groundwater related alternatives.

Groundwater Recharge/Return Flow Projects. The following simplifying assumptions were used to define and analyze groundwater recharge/return flow projects:

- The selection of recharge sites that are in the alluvial aquifer was based on favorable conditions for recharge where recharge may be by direct infiltration or by recharge through existing and/or future wells.

- The selection of recharge sites that are not hydrologically connected to the river was based on the ability to store and control recharge water over extended periods (up to one year) without significant loss of this water. These sites must also allow for the efficient recovery of stored water.

- Projects were assumed to be situated in "representative" locations within each applicable stream reach. At a minimum, potential recharge/return flow projects were, therefore, evaluated for sites located in the middle of applicable reaches.

- It was assumed that the SDF method developed by the USGS for analyzing the timing of well depletions and recharge accretions to the river provides a reliable solution of river impacts and return flow timing. A detailed description of the SDF method is provided in Chapter 5 and in Appendix B. The prediction of return flows using the SDF approach are subject to a high level of uncertainty. It is assumed that all recharge projects will be measured and monitored to ensure that the proper timing of the anticipated return flows occurs.

- SDF values of 60, 120, 270, and 300 days were consistently used for representative recharge projects. The MBSA SDF maps were used to determine SDF values for specific sites. Recharge sites could be located over a considerable range of SDF values. Ultimately, if a recharge project is chosen for inclusion in the eventual action plan the SDF value will be based on the specific location of that project. The values chosen for representative projects are intended to provide a range of return flow patterns and are consistent with the SDF values evaluated for the Colorado's Tamarack project. Other SDF values could be evaluated under the action plan phase. Sites were analyzed for a range of SDF factors because recharge credits can potentially be further re-regulated through the use of the Environmental Account in Lake McConaughy. Due to the EA in Lake McConaughy, recharge sites do not necessarily have to produce return flow patterns that approximate the timing of target flow shortages within the critical habitat area because recharge credits can potentially be stored and re-regulated. The benefits associated with re-regulated recharge credits through Lake McConaughy were not considered in the yield analyses. The ability to re-regulate alternatives through the Lake McConaughy EA account is described in more detail in the Introduction to Chapter 8.

- Representative groundwater recharge/return flow projects were assumed to involve either diversions through existing canals or groundwater pumping. Recharge projects that incorporate diversions through canals assume that water is diverted and delivered to a recharge pond, and canal losses and seepage from the pond are lagged back to the river. Canal losses are not subtracted if a canal is used to deliver the water because that loss is assumed to return back to the river at the same SDF factor used for the recharge basin. Groundwater pumping projects assume that water is pumped adjacent to the river, creating an immediate impact on the stream just as a surface diversion. Groundwater is pumped to a recharge pond and seepage losses from the pond are lagged back to the river.

- It was assumed that projects that are located along the river or a tributary where SDF factors have not been developed will result in a depletion or accretion in the same month, and at the full amount of pumping or recharge.

- Evaporation was assumed to be one percent (1%) of gross diversions to recharge sites per Tab 3A of the Cooperative Agreement for Platte River Research. This evaporation rate is the same rate used to evaluate the Tamarack Recharge Plan and is consistent with observed rates in the Lower South River Basin where sandy soil conditions result in high infiltration and low evaporation. This assumption has been applied universally throughout regions 1, 2, and 3, however, evaporation rates could vary from this assumption depending on the local soil conditions and infiltration rates. If the evaporation rates are higher than one percent, then the estimated yields of recharge projects could be lower.

- Groundwater Management Plans exist for each of Nebraska's Natural Resources Districts. All of the groundwater projects in Nebraska must comply with the Natural Resources District's Groundwater Management Plans, rules, and regulations. Any limitations these Plans have on groundwater projects will have to be addressed.

Groundwater Transfer of Uses. The analysis of programs involving transfers of use has been limited to reductions in surface water use, which is described in 8.F, Incentive Based Reductions in Agricultural Water Use.

Additional Surface Water and/or Groundwater Re-regulation Opportunities. The following simplifying assumptions were used to define and analyze projects involving additional surface water and/or groundwater re-regulation opportunities.

- The same assumptions as listed for groundwater recharge/return flow projects apply to additional surface water and/or groundwater re-regulation opportunities.

- The sustainable rate at which water can be pumped from existing groundwater mounds has been inferred from available reports, estimated hydrogeologic properties, water levels, and estimated seepage losses from applicable reservoirs, canals, and/or irrigated lands.

Reduction of Natural Groundwater Exports from the Basin. The following simplifying assumptions were used to define and analyze projects involving a reduction of natural groundwater exports from the basin:

- Only one such project has been identified, therefore, a project specific analysis was completed.
- The same assumptions listed for groundwater recharge/return flow projects apply to a project involving the reduction of natural groundwater exports from the Basin.
- The rate of subsurface flow leaving the basin has been inferred from existing reports.

4. Alternatives

Region 1

Groundwater Recharge/Return Flow Projects

The purpose of groundwater recharge/return flow projects is to re-regulate excess flows so that return flows are generated during periods of target flow shortages. The hydrogeology downstream of Whalen Dam adjacent to the North Platte River is such that groundwater in the alluvium is in close hydrologic connection with surface water in the North Platte River. Unconsolidated alluvial materials, called "valley-fill", are present within the valley of the North Platte River below Whalen Dam. The valley-fill consists mainly of permeable sand and gravel, and comprises three terraces and flood plain deposits (Hydroscience Associates, Inc., 1997).

The alluvium is typically highly permeable with hydraulic conductivities ranging from 200 feet/day to 1,200 feet/day (Hydroscience Associates, Inc., 1997). In the reach from Whalen Dam downstream to Lake McConaughy, groundwater is currently pumped to provide primary and supplemental irrigation water. Although recharge projects have not been implemented previously in this area, the opportunity exists due to the topography and high infiltration rates associated with the flood-plain deposits in the area. Since the early 1900's the river has benefited greatly from recharge from surface water projects.

In this region there may be opportunities to implement groundwater recharge projects that incorporate either diversions through existing canals or groundwater pumping. The analysis of recharge projects in Region 1 focuses on opportunities associated with Pratt-Ferris Irrigation District, which is the most downstream Wyoming irrigation district in this reach, as well as potential recharge projects throughout Reaches 5 and 13. A potential canal recharge system may consist of diversions from the North Platte River to the Pratt-Ferris Canal during the non-irrigation season. Recharge ponds could be constructed along the canal that serve as both recharge sites and wildlife habitat. Groundwater recharge pumping projects similar to the Tamarack Recharge Plan could be implemented throughout Reaches 5 and 13.

Maps of SDF factors were reviewed to determine whether effective recharge sites exist in Reaches 5 and 13. Potential sites overlie the alluvial aquifer and are hydraulically connected to the river. In addition, the depth to the water table must be great enough so that the recharge mound build-up will not create water logging at the land surface. Based on the location of the Pratt-Ferris Canal, a recharge project associated with the Pratt-Ferris Irrigation District could be located approximately 30 miles downstream of Whalen Dam at a location with an average SDF factor of 50 days, as shown on the Missouri Basin States Association SDF maps (MBSA, 1982b). It was assumed that all "representative" sites associated with groundwater pumping to recharge are located in the middle of Reaches 5 and 13 at SDF factors of 60, 120, and 270 days. Because of the many canals located in Reach 13 it was assumed that representative sites associated with surface water diversions to recharge are located in the middle of Reach 13 at an SDF factor of 300 days. Each site or SDF factor has been analyzed separately, and the results are not necessarily additive.

Yield

The amount of water available for diversion in Reach 5 is constrained by the 1945 North Platte Decree, as well as by other downstream demands for water. The 1945 Decree apportions natural flows of the mainstem from Whalen Dam downstream to the state line as 75 percent to Nebraska and 25 percent to Wyoming from May 1 through September 30. To simplify this analysis, it was assumed that no water is available to divert or pump from Reach 5 during May 1 through September 30 because the 1945 Decree limits the amount of water available to Wyoming diverters during that period. In addition, diversions to Pratt-Ferris during these months would most likely not be possible because Pratt-Ferris is diverting for irrigation and there would be limited excess canal capacity available for recharge. Furthermore, recharge diversions to canals typically occur in the fall after the irrigation season until freezing conditions occur, and during spring runoff when there are excess river flows. It was therefore assumed that diversions for recharge could occur during October, November, March, and April. Pumping to recharge could occur from October through April because, from an operational perspective, diversions via wells can occur throughout the year. In addition, water is only diverted to recharge in months of target flow excesses at the critical habitat.

The flow available to recharge projects in Reach 13 equals the gaged flow at Lewellen, which is at the downstream end of the reach. Similar to Reach 5, diversions to recharge were limited to the non-irrigation season from October through April. Wells located next to the river can pump throughout the non-irrigation season, however, diversions to canals in Reach 13 occur in the fall after the irrigation season until freezing conditions occur, and during spring runoff.

Diversions to a recharge project in Region 1 are upstream of Lake McConaughy, and therefore, could have a negative impact on inflows into the lake. In particular, diversions to recharge outside of the irrigation season are during the major part of the Lake McConaughy storage season. Storage or re-timing of these flows could reduce the flows that were previously used as a source of supply to Lake McConaughy and the projects it serves. A primary benefit of recharge projects upstream of Lake McConaughy is to retime water that would otherwise be spilled at Lake McConaughy. Because spills generally only occur during wet years it may be simpler to arrange for the retiming of releases from the EA in Lake McConaughy to accomplish the same results. However, that assumes the storage capacity of the EA is adequate. Despite the shortfalls of recharge projects upstream of Lake McConaughy they offer additional storage space for Program water and increase the potential to retime water from periods of excess to periods of shortage.

The Cooperative Agreement requires the impacts on flow characteristics relied on by other Program facilities, such as Lake McConaughy, be avoided or offset, and that any adverse impacts of Program water activities be compensated. As such, any recharge project in Region 1 would be required to mitigate adverse impacts on Lake McConaughy storage operations. Due to the extensive analysis required to quantify impacts on downstream users the potential to impact downstream water rights has been qualified as opposed to quantified.

Pratt-Ferris is decreed for 22.01 cfs, which is also the capacity of the ditch (USBR, 1997). Therefore, monthly diversions were limited to 1,300 ac-ft. Monthly groundwater pumping in Reaches 5 and 13 was limited to 10,000 ac-ft, which assumes 50 wells pumping at an average rate of 1,500 gpm. Monthly groundwater pumping was limited to 10,000 ac-ft due to potential limitations on available recharge sites including land availability and favorable hydrogeologic conditions. Surface diversions to recharge and groundwater pumping to recharge were analyzed separately.

Flows passing the Whalen Dam gage on the North Platte River and the Laramie River gage, a tributary of the North Platte River, were evaluated to determine the amount of water available for recharge at the Pratt-Ferris headgate and for groundwater pumping. The sum of these two gages essentially equals the inflow to Reach 5. If the sum of the flows at these two gages exceeded 1,300 ac-ft, it was assumed that 1,300 ac-ft would be available at the Pratt-Ferris headgate. Likewise, if the sum of the flows at these two gages exceeded 10,000 ac-ft, it was assumed that 10,000 ac-ft would be available for pumping. This is conservative in that there are several small creeks as well as irrigation and canal seepage return flows that come in to Reach 5 above the Pratt-Ferris headgate or pumps located in the middle of the reach.

Recharge to the Platte River is computed as inflows minus evaporation, which is estimated to be one percent (1%) of gross diversions. The average annual net diversion to canals in Reaches 5 and 13 was 1,430 ac-ft and 10,399 ac-ft, respectively. The average annual net groundwater pumping in Reaches 5 and 13 was 17,300 ac-ft and 29,130 ac-ft, respectively.

Return flows were routed back to the river using the SDF model SDF View developed by the Integrated Decision Support Group of CSU

(1999). Monthly additions to flows in the river occur in months when river accretions exceed diversions to recharge. Monthly depletions occur in months when the diversions to recharge exceed the accretion in that month. The average annual net hydrologic effect for surface water diversion recharge projects (SDF of 300 days) in Reaches 5 and 13 are –136 ac-ft and –2,131 ac-ft, respectively. The average annual net hydrologic effects for groundwater pumping recharge projects range from –1,511 ac-ft to –5,841 ac-ft for SDF factors of 60 to 270 days. The net hydrologic effects for surface water diversion projects and groundwater pumping recharge projects in Reach 13 are summarized in Tables 8.G. 1 through 8.G.5. Tables showing monthly net hydrologic effects for groundwater pumping recharge projects in Reach 5 are provided in Appendix F. The average annual net hydrologic effect is negative due to evaporation and because some of the accretions to the river are not included because they would have occurred after 1994, which is the last year modeled.

The water budget spreadsheet was used to route net hydrologic effects generated by the proposed recharge projects downstream to the critical habitat. The additional flows generated by the Pratt-Ferris recharge project return to the North Platte River just above the Wyoming-Nebraska state line at the top of Reach 12. The additional flows generated by pumping recharge projects are assumed to return to the North Platte River in the middle of Reach 5. The additional flows generated by recharge projects in Reach 13 are assumed to return to the North Platte River in the middle of Reach 13. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. Average annual net reductions to target flow shortages for a Pratt-Ferris surface water diversion recharge project are 278 ac-ft without diversions and 109 ac-ft with diversions, as shown in Tables 8.G.6 and 8.G.7. The annual net reductions to target flow shortages for a surface water diversion recharge project in Reach 13 for an SDF factor of 120 days are 8,648 ac-ft without diversions and 4,257 ac-ft with diversions, as shown in Tables 8.G.8 and 8.G.9. Due to the large number of scenarios evaluated, reductions to target flow shortages for recharge projects have only been provided for a SDF factor of 120 days in Reach 13. Tables showing monthly net reductions to target flow shortages for the remaining SDF factors are provided in Appendix F.

Table 8.G.1
Pratt-Ferris Canal: SDF = 50 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-1044	325	137	78	52	38	29	-386
1979	24	19	16	14	12	11	10	9	8	7	6	6	141
1980	6	5	5	4	4	-1040	-697	484	221	135	95	71	-707
1981	57	46	39	33	29	26	23	21	19	17	16	14	338
1982	13	12	12	11	10	10	9	9	8	8	7	7	115
1983	7	6	6	6	6	-1039	-696	485	223	137	97	73	-689
1984	-986	385	177	115	84	-978	-647	526	258	167	123	96	-680
1985	-965	-640	519	271	178	-912	430	224	152	116	95	80	-451
1986	70	62	55	50	46	-1002	-662	516	252	163	122	96	-233
1987	-964	-632	525	276	182	-907	-591	572	297	201	153	124	-766
1988	104	-954	404	211	143	112	92	79	70	63	57	52	433
1989	48	45	42	40	37	35	33	32	30	29	28	27	425
1990	25	25	24	23	22	21	21	20	19	19	18	18	253
1991	17	17	16	16	15	15	15	14	14	14	13	13	178
1992	13	12	12	12	12	-1033	336	148	89	63	48	39	-250
1993	34	29	26	24	22	-1024	343	154	94	68	53	43	-135
1994	-1007	-675	490	247	156	114	89	73	61	53	47	42	-309
Average	-175	-112	118	68	48	-432	-78	175	95	65	51	42	-136

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.2
Middle of Reach 13 : SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-8482	2409	1067	616	417	303	233	188	155	-3094
1976	131	113	-8110	-5713	3630	1805	1125	802	607	482	398	335	-4396
1977	289	253	223	200	180	164	149	137	126	117	109	102	2049
1978	95	90	84	80	75	-8271	2527	1158	695	483	369	294	-2321
1979	245	209	182	162	145	132	120	111	102	95	89	84	1675
1980	79	75	-8138	-5732	-4591	-3951	-3507	5148	2803	1882	1407	1104	-13421
1981	906	763	-7555	-5226	4058	2188	1468	1114	892	744	640	560	551
1982	499	449	-7801	-3730	3416	1842	1236	938	754	632	547	481	-738
1983	432	390	-7852	-5470	-4349	-3727	-3299	5343	2986	2054	1570	1258	-10663
1984	-7290	3446	-6328	-4447	-3594	-3125	-2803	5766	3352	2375	1857	1516	-9275
1985	-7056	-4682	-3672	-3146	-2782	-2533	5868	3555	2557	2009	1668	1421	-6795
1986	1243	1106	-7216	-4894	-3828	-876	-3558	5441	3187	2289	1815	1504	-3788
1987	-7048	-4614	-3617	-3093	2513	-4134	-2998	5786	3455	2513	2010	1675	-7552
1988	1447	-7066	-4608	-3645	-3065	5638	3307	2404	1899	1581	1368	1205	466
1989	1083	985	-7305	-4962	4332	2466	1747	1391	1167	1015	908	822	3648
1990	756	702	655	-7865	2990	1618	1140	917	781	691	628	577	3590
1991	538	505	-5084	-6211	3617	1934	1315	1021	842	724	644	581	426
1992	534	496	-7744	-5361	3968	-6212	3898	2199	1534	1192	988	845	-3664
1993	745	669	-7601	-5239	4073	-6121	3978	2269	1596	1247	1038	890	-2454
1994	-1658	-6891	-4787	-3899	4871	2776	1930	1500	1227	1043	914	813	-2161
Average	-701	-650	-4814	-4334	903	-866	713	2371	1543	1170	958	811	-2896

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.3
Middle of Reach 13 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9520	1935	1165	737	521	389	304	248	206	-4016
1976	175	152	-9245	-7325	3287	2059	1380	1018	787	634	529	449	-6101
1977	390	342	303	273	246	224	205	189	174	161	150	140	2798
1978	132	124	117	111	105	-9350	2080	1286	844	612	479	388	-3073
1979	327	281	246	220	198	180	165	152	141	131	123	116	2281
1980	109	104	-9279	-7349	-6106	-5342	-4788	5062	3328	2362	1815	1448	-18636
1981	1202	1021	-8498	-6668	3868	2580	1849	1446	1179	994	863	759	595
1982	679	614	-8819	-5026	3269	2171	1556	1219	998	846	739	654	-1099
1983	589	535	-8887	-6988	-5773	-5033	-4501	5332	3581	2601	2041	1663	-14840
1984	-8044	3222	-7116	-5712	-4797	-4241	-3840	5899	4075	3038	2432	2015	-13069
1985	-7723	-5933	-4859	-4244	-3796	-3481	6145	4351	3286	2642	2224	1913	-9474
1986	1685	1505	-8021	-6202	-5058	-1688	-4458	5556	3891	2942	2390	2009	-5449
1987	-7704	-5851	-4784	-4168	2270	-4715	-3934	5989	4245	3243	2653	2241	-10515
1988	1954	-7715	-5835	-4805	-4126	5768	4042	3092	2504	2116	1848	1639	483
1989	1480	1352	-8135	-6287	4258	2974	2243	1838	1566	1376	1239	1128	5031
1990	1041	969	906	-8665	2742	1932	1466	1217	1055	942	861	796	5262
1991	745	700	-5691	-7481	3382	2284	1668	1338	1124	979	877	797	723
1992	736	685	-8735	-6835	3758	-6937	3804	2639	1957	1564	1318	1140	-4905
1993	1013	915	-8544	-6671	3899	-6813	3912	2735	2042	1640	1387	1202	-3284
1994	-1699	-7896	-6160	-5183	4866	3334	2457	1964	1633	1403	1239	1109	-2934
Average	-646	-744	-5552	-5426	421	-1147	609	2642	1940	1527	1273	1091	-4011

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.4
Middle of Reach 13 : SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9881	788	921	729	572	455	371	312	265	-5469
1976	229	201	-9686	-8917	1914	1836	1458	1170	954	796	681	589	-8775
1977	518	461	412	374	339	311	285	264	245	227	213	199	3847
1978	187	177	167	158	150	-9731	958	1079	875	703	582	492	-4203
1979	426	373	332	300	272	250	230	214	199	186	175	165	3122
1980	156	148	-9723	-8941	-7964	-7212	-6606	3735	3299	2650	2170	1804	-26483
1981	1539	1334	-8696	-8034	2703	2549	2106	1764	1500	1301	1151	1026	242
1982	928	847	-9088	-6383	2279	2143	1774	1492	1276	1113	991	890	-1739
1983	811	743	-9179	-8437	-7497	-6776	-6198	4119	3660	2992	2494	2112	-21157
1984	-8041	2412	-7479	-7014	-6321	-5780	-5343	4868	4323	3583	3029	2598	-19164
1985	-7595	-7050	-6277	-5705	-5233	-4877	5284	4698	3926	3328	2891	2542	-14068
1986	2274	2057	-7993	-7352	-6502	-3049	-5579	4645	4192	3524	3020	2626	-8136
1987	-7541	-6951	-6167	-5589	1184	-5285	-5080	5158	4643	3920	3372	2941	-15395
1988	2617	-7515	-6901	-6149	-5516	4824	4369	3712	3180	2779	2480	2235	115
1989	2042	1881	-8122	-7447	3296	3143	2696	2347	2075	1866	1706	1572	7055
1990	1463	1370	1288	-8661	1945	2023	1780	1578	1419	1297	1202	1123	7826
1991	1058	1001	-5732	-8426	2324	2289	1947	1679	1474	1320	1205	1109	1248
1992	1034	971	-8949	-8206	2599	-7375	2920	2740	2307	1966	1719	1526	-6748
1993	1379	1262	-8701	-7991	2786	-7211	3065	2869	2423	2069	1813	1611	-4627
1994	-1435	-8307	-7536	-6752	3772	3447	2877	2447	2117	1867	1679	1523	-4302
Average	-398	-729	-5902	-6453	-634	-1678	184	2558	2227	1893	1644	1447	-5841

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.5
Middle of Reach 13 : SDF = 300 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-9885	681	882	729	580	471	388	-6155
1979	327	279	242	213	189	169	152	138	126	115	106	98	2154
1980	91	85	80	75	70	-9818	-9135	1628	1694	1383	1123	921	-11803
1981	775	664	574	507	449	403	363	331	302	278	257	238	5141
1982	222	208	195	184	173	164	155	147	140	133	127	122	1972
1983	117	112	107	103	99	-9789	-9106	1658	1724	1413	1152	950	-11462
1984	-9081	1349	1484	1275	1065	-8977	-8415	2257	2248	1877	1569	1325	-12024
1985	-8739	-8223	2452	2426	2045	-8160	2151	2163	1856	1584	1378	1212	-7855
1986	1083	978	888	817	752	-6376	-8742	1926	2000	1701	1444	1241	-2289
1987	-8794	-8229	2461	2444	2071	-8129	-7691	2890	2808	2380	2027	1746	-14016
1988	1535	-8516	1910	2007	1760	1535	1351	1210	1094	998	921	854	6660
1989	797	748	703	665	630	598	569	543	519	497	477	458	7203
1990	441	425	410	396	383	370	359	348	337	327	318	309	4421
1991	301	292	285	278	271	264	258	252	246	240	235	230	3149
1992	225	220	215	211	207	-9682	879	1077	920	767	655	568	-3737
1993	505	455	414	383	355	-9552	993	1178	1010	848	727	634	-2051
1994	-2332	-9183	1402	1530	1303	1099	937	818	723	648	589	539	-1926
Average	-1126	-1417	691	676	591	-3788	-1712	972	924	788	679	592	-2131

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.6
Pratt-Ferris Canal: SDF = 50 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	298	124	66	16	18	12	534
1979	14	14	14	11	9	10	9	8	5	0	5	3	102
1980	4	4	0	0	0	0	0	0	0	96	69	39	212
1981	41	33	0	0	23	23	20	19	13	9	0	8	188
1982	10	12	0	0	10	9	8	8	7	7	7	5	81
1983	6	5	0	0	0	0	0	0	0	0	0	0	11
1984	0	363	0	0	0	0	0	0	0	0	78	0	441
1985	0	0	0	0	0	0	396	205	137	104	87	0	929
1986	67	53	0	0	0	0	0	0	0	0	0	0	120
1987	0	0	0	0	0	0	0	0	0	0	107	0	107
1988	78	0	0	0	0	103	78	67	59	49	45	40	520
1989	39	43	0	0	34	31	29	26	27	0	21	0	250
1990	23	22	18	0	21	20	19	18	16	9	15	10	192
1991	11	13	0	0	14	14	12	0	0	4	5	6	79
1992	7	11	0	0	11	0	305	110	78	47	28	25	624
1993	27	25	0	0	13	0	319	139	83	0	49	0	656
1994	0	0	0	0	125	110	81	64	53	0	41	28	502
Average	16	30	2	1	13	16	79	39	27	17	29	9	278

Table 8.G.7
Pratt-Ferris Canal: SDF = 50 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	176	14	2	0	0	1	194
1979	8	8	10	8	6	8	5	1	1	0	0	0	55
1980	2	2	0	0	0	0	0	0	0	0	1	6	11
1981	20	20	0	0	19	17	5	1	0	0	0	1	84
1982	6	8	0	0	8	7	3	0	0	0	0	1	33
1983	3	4	0	0	0	0	0	0	0	0	0	0	7
1984	0	259	0	0	0	0	0	0	0	0	5	0	264
1985	0	0	0	0	0	0	202	33	12	1	2	0	250
1986	51	35	0	0	0	0	0	0	0	0	0	0	86
1987	0	0	0	0	0	0	0	0	0	0	7	0	7
1988	54	0	0	0	0	86	44	24	3	1	1	8	221
1989	20	24	0	0	27	25	9	1	1	0	0	0	108
1990	12	14	13	0	15	15	13	5	0	0	0	1	87
1991	7	12	0	0	11	10	3	0	0	0	0	1	44
1992	2	7	0	0	9	0	171	4	5	2	1	1	203
1993	21	18	0	0	11	0	200	11	9	0	3	0	274
1994	0	0	0	0	109	97	42	7	2	0	1	5	262
Average	10	21	1	0	11	13	44	5	2	0	1	1	109

Table 8.G.8
Middle of Reach 13 : SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1720	1096	699	478	360	274	163	171	4960
1976	115	109	0	0	3005	1908	1230	936	569	234	63	184	8353
1977	322	255	226	213	222	218	173	176	159	91	96	120	2271
1978	110	102	93	76	98	0	1958	1186	726	195	227	161	4931
1979	201	211	208	175	148	176	155	141	96	0	90	63	1664
1980	73	84	0	0	0	0	0	0	0	1724	1345	810	4035
1981	875	728	0	0	3140	2335	1688	1350	845	563	0	424	11948
1982	544	594	0	0	3205	1976	1418	1126	909	739	668	455	11633
1983	568	435	0	0	0	0	0	0	0	0	0	0	1002
1984	0	3056	0	0	0	0	0	0	0	0	1568	0	4624
1985	0	0	0	0	0	0	4889	4080	3031	2416	2065	0	16481
1986	1634	1301	0	0	0	0	0	0	0	0	0	0	2935
1987	0	0	0	0	0	0	0	0	0	0	1900	0	1900
1988	1485	0	0	0	0	5382	3520	2647	2170	1722	1501	1281	19709
1989	1204	1318	0	0	3983	2645	2017	1535	1426	0	976	0	15104
1990	971	863	723	0	2624	1880	1376	1149	930	477	723	462	12178
1991	478	549	0	0	3211	2138	1387	0	0	326	362	366	8816
1992	434	630	0	0	3657	0	3542	2046	1765	1198	794	752	14819
1993	832	804	0	0	2429	0	3721	2519	1856	0	427	0	12588
1994	0	0	0	0	3910	1700	2302	1772	1447	0	1120	748	12998
Average	492	552	62	23	1568	1073	1504	1057	814	498	704	300	8648

Table 8.G.9
Middle of Reach 13 : SDF = 120 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1316	859	488	110	99	12	13	61	2958
1976	59	75	0	0	2493	1466	685	241	70	9	3	60	5160
1977	196	157	168	146	154	151	129	60	18	3	7	41	1230
1978	69	63	66	72	90	0	1189	187	36	10	8	24	1813
1979	110	119	152	132	100	135	89	26	32	0	3	11	909
1980	32	44	0	0	0	0	0	0	0	27	84	242	429
1981	473	449	0	0	2516	1728	509	177	39	84	0	91	6067
1982	359	401	0	0	2591	1582	525	119	44	18	23	141	5803
1983	283	304	0	0	0	0	0	0	0	0	0	0	587
1984	0	2181	0	0	0	0	0	0	0	0	162	0	2343
1985	0	0	0	0	0	0	3174	1404	596	157	148	0	5478
1986	1259	853	0	0	0	0	0	0	0	0	0	0	2113
1987	0	0	0	0	0	0	0	0	0	0	243	0	243
1988	1062	0	0	0	0	4480	2189	1317	213	203	135	469	10069
1989	643	745	0	0	3099	2169	715	118	169	0	69	0	7728
1990	498	551	519	0	1912	1358	963	384	58	11	62	70	6386
1991	320	494	0	0	2536	1524	427	0	0	11	14	82	5407
1992	148	396	0	0	2979	0	2159	256	251	146	87	93	6514
1993	681	582	0	0	2048	0	2379	491	372	0	187	0	6740
1994	0	0	0	0	3431	1700	1213	391	128	0	47	260	7171
Average	310	371	45	18	1263	858	842	264	106	35	65	82	4257

Average annual net reductions to target flow shortages for groundwater pumping recharge projects in Reaches 5 and 13 range from 3,617 ac-ft to 9,196 ac-ft without diversions and from 1,577 ac-ft to 4,257 ac-ft with diversions.

Cost

The direct costs related to these groundwater recharge projects are based on the capital costs associated with the construction of diversion and storage facilities necessary for the project, as well as annual operating costs. The direct costs associated with a Pratt-Ferris groundwater recharge project are limited because the diversion facilities/canal are in place, and wells and pumps are not required. The costs for these projects were based on cost data provided by the Northern Colorado Water Conservancy District (NCWCD) for similar recharge projects. The direct costs associated with groundwater recharge projects consist of the following items.

- Subsurface investigations
- Construction of wells
- Pumping and related facilities
- Diversion facilities
- Construction of recharge ponds
- Conveyance structures
- Regulation and measurement
- Engineering costs associated with the design of facilities and analysis of operations
- Compensation provided to the canal company
- Operations and maintenance.

Two groups of alternatives have been evaluated, which include, 1) Diverting water into an existing irrigation canal (Pratt-Ferris) to a recharge site close to the canal, and 2) Pumping groundwater to sites from a well located adjacent to the river.

Recharge Diversions to Canals. Preliminary subsurface investigations typically entail probing the project site to a depth of 50 feet. Three to five holes typically provide a good indication as to the site's recharge potential. A cost of $3,500 has been included for probing sites.

Costs for diversion structures from the existing irrigation canal are typically about $3,000.

Construction costs associated with recharge ponds are based primarily on the size and location of the ponds. Recharge basins are typically located in naturally occurring sandy upland areas with high infiltration rates; therefore, the amount of embankment earthwork required is minimal. A cost of $6,000, has been included for recharge basin construction.

A cost of $4,000 has been included for regulation and measurement, which includes the cost of flumes, stilling wells, and stage recorders.

An engineering design cost of 10 percent of the project construction cost, or approximately $2,000, was included.

The compensation provided to the canal companies that deliver water to recharge basins in the Lower South Platte River region varies. Most canal companies receive a portion of the accretion credits that derive from the recharge project. The recharge credits are shared in lieu of expenses the canal company may incur while delivering the water. Alternatively, some canal companies choose to charge the owner of the recharge basin a delivery fee per ac-ft delivered. The delivery fees for Reaches 5 and 13 were assumed to be $5 per ac-ft and $10 per ac-ft, respectively. For this analysis it was assumed the project will pay a delivery fee of $5 per ac-ft delivered. Based on an annual diversion to recharge of 1,430 ac-ft, the annual delivery charge is $7.150. Based on a 20-year study period and discount rate of 6 percent, the total present value cost associated with delivery charges is approximately $82,000.

The capitalized costs for surface water recharge projects in Reaches 5 and 13 are about $101,000 and $2.1 million, respectively, as shown in Table 8.G.10. The cost per ac-ft of average reductions to target flow shortages at the critical habitat is about $360 in Reach 5 and $740 in Reach 13 without diversion losses. The cost per ac-ft of average reductions to target flow shortages at the critical habitat is about $930 in Reach 5 and $1,850 in Reach 13 with diversion losses.

TABLE 8.G.10

COST SUMMARY

GROUNDWATER RECHARGE/RETURN FLOW PROJECTS IN REGIONS 1 AND 2

	REGION 1			
	Middle of Reach 5 Div Structure	Middle of Reach 13 Div Structure	Middle of Reach 5 Pumping	Middle of Reach 13 Pumping
CONSTRUCTION COSTS PER DIVERSION STRUCTURE OR WELL				
Subsurface Investigations	3,500	3,500	3,500	3,500
Diversion Structures	3,000	3,000		
Recharge Basins	6,000	6,000	6,000	6,000
Measuring Devices	4,000	4,000		
Well Construction & Pumps			30,000	30,000
Conveyance Conduit			7,000	7,000
Power Hook-up			4,000	4,000
4000' 12" dia pipe @ $5/ft			20,000	20,000
Replacement Costs (Well & Pump Hardware)			54,000	54,000
Total Cost per Structure or Well	**16,500**	**16,500**	**124,500**	**124,500**
No. of structures or wells	1	50	50	50
Total Construction Cost	16,500	825,000	6,225,000	6,225,000
Sand Dam Replacement				
Canal Improvements				
Engineering Fees (10%)	2,000	83,000	623,000	623,000
Total Construction Costs + Engineering Fees	**18,500**	**908,000**	**6,848,000**	**6,848,000**
ANNUAL COSTS				
Amt. Diverted	1,430	10,399	17,300	29,130
Delivery Cost	7,150	103,990		
Use of FRICO recharge sites/facilities ($10/ac-ft)				
Pump operation cost ($8/af)			138,400	233,040
Annual Maintenance Costs ($300/well)			15,000	15,000
Total Annual Cost	**7,150**	**103,990**	**153,400**	**248,040**
No. of years	20	20	20	20
Discount Rate	6%	6%	6%	6%
Present Value of Annual Costs	**82,010**	**1,192,757**	**1,759,486**	**2,844,999**
Total Capitalized Cost of Project	**101,000**	**2,110,000**	**8,610,000**	**9,700,000**

Note: It was assumed that wells and pumping hardware would need to be replaced after 15 years. Future costs are based on an rate of 4 percent and a present day cost of $30,000.

TABLE 8.G.10 (cont.)
COST SUMMARY
GROUNDWATER RECHARGE/RETURN FLOW PROJECTS IN REGIONS 1 AND 2

	REGION 2															
	Middle of Reach 7	Middle of Reach 8	Middle of Reach 9	Middle of Reach 7	Middle of Reach 8	Middle of Reach 9	Middle of Reach 7	Middle of Reach 8	Middle of Reach 9	Bottom of Reach 9	Middle of Reach 7	Middle of Reach 8	Middle of Reach 9	Bottom of Reach 9	Beebe Draw (w/ protection)	Beebe Draw (w/o protection)
	Diversion Structures (w/protection)			Diversion Structures (w/o protection)			Pumping (w/protection)				Pumping (w/o protection)					
CONSTRUCTION COSTS PER DIVERSION STRUCTURE OR WELL																
Subsurface Investigations	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Diversion Structures	3,000	3,000	3,000	3,000	3,000	3,000										
Recharge Basins	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000		
Measuring Devices	4,000	4,000	4,000	4,000	4,000	4,000										
Well Construction & Pumps							30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Conveyance Conduit							7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Power Hook-up							4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
4000' 12" dia pipe @ $5/ft							20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Replacement Costs (Well & Pump Hardware)							54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000
Total Cost per Structure or Well	**16,500**	**16,500**	**16,500**	**16,500**	**16,500**	**16,500**	**124,500**	**124,500**	**124,500**	**124,500**	**124,500**	**124,500**	**124,500**	**124,500**	**118,500**	**118,500**
No. of structures or wells	50	50	50	50	50	50	50	50	50	50	50	50	50	50	25	25
Total Construction Cost	825,000	825,000	825,000	825,000	825,000	825,000	6,225,000	6,225,000	6,225,000	6,225,000	6,225,000	6,225,000	6,225,000	6,225,000	2,962,500	2,962,500
Sand Dam Replacement	8,100,000	6,000,000	3,600,000				8,100,000	6,000,000	3,600,000						8,100,000	
Canal Improvements															500,000	500,000
Engineering Fees (10%)	893,000	683,000	443,000	83,000	83,000	83,000	1,433,000	1,223,000	983,000	623,000	623,000	623,000	623,000	623,000	1,106,000	296,000
Total Construction Costs + Engineering Fees	**9,818,000**	**7,508,000**	**4,868,000**	**908,000**	**908,000**	**908,000**	**15,758,000**	**13,448,000**	**10,808,000**	**6,848,000**	**6,848,000**	**6,848,000**	**6,848,000**	**6,848,000**	**12,668,500**	**3,758,500**
ANNUAL COSTS																
Amt. Diverted	20,790	20,790	20,790	20,790	20,790	20,790	79,510	79,510	79,510	79,510	79,510	79,510	79,510	79,510	7,000	7,000
Delivery Cost	103,950	103,950	103,950	103,950	103,950	103,950									35,000	35,000
Use of FRICO recharge sites/facilities ($10/ac-ft)															70,000	70,000
Pump operation cost ($8/af)							316,000	316,000	316,000	316,000	316,000	316,000	316,000	316,000	56,000	56,000
Annual Maintenance Costs ($300/well)							15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	7,500	7,500
Total Annual Cost	**103,950**	**103,950**	**103,950**	**103,950**	**103,950**	**103,950**	**331,000**	**331,000**	**331,000**	**331,000**	**331,000**	**331,000**	**331,000**	**331,000**	**168,500**	**168,500**
No. of years	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
Discount Rate	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Present Value of Annual Costs	**1,192,298**	**1,192,298**	**1,192,298**	**1,192,298**	**1,192,298**	**1,192,298**	**3,797,462**	**3,797,462**	**3,797,462**	**3,797,462**	**3,797,462**	**3,797,462**	**3,797,462**	**3,797,462**	**1,932,682**	**1,932,682**
Total Capitalized Cost of Project	**11,020,000**	**8,710,000**	**6,070,000**	**2,110,000**	**2,110,000**	**2,110,000**	**19,560,000**	**17,250,000**	**14,610,000**	**10,650,000**	**10,650,000**	**10,650,000**	**10,650,000**	**10,650,000**	**14,610,000**	**5,700,000**

Note: It was assumed that wells and pumping hardware would need to be replaced after 15 years. Future costs are based on an rate of 4 percent and a present day cost of $30,000.

Pumping to Recharge. Some of the costs associated with pumping groundwater to recharge sites are similar to the costs for diverted recharge water through existing canals. As described above a cost of $3,500 has been included for subsurface investigations. A cost of $6,000 has been included for recharge basin construction.

Well construction costs are a function primarily of drilling depth and well diameter. Operating costs for pumps and related facilities are a function primarily of the horsepower required at each well site. A total cost of $30,000 per well was included, which includes costs for the well drilling, casing material, pump, pump column and shaft, discharge head assembly, and electric motor. Wells and pumping hardware will most likely need to be replaced in 10 to 20 years, therefore, replacement costs were included. It was assumed that electrical power would not be available at all well sites, therefore, an additional cost of $4,000 was included to provide power to the well.

Operation costs, which consist primarily of electricity costs, are typically about $8 per ac-ft pumped. Annual maintenance costs are minimal and typically less than $300 per well.

Recharge projects involving wells require pipelines to convey water to recharge basins. Costs for conveyance facilities consist primarily of pipeline costs, trenching and installation, miscellaneous fittings, and flow meters. A pipeline size of 12-inch was assumed, which is representative of similar pipeline sizes that have been used for recharge projects in the Lower South Platte River region. A cost of $5/linear foot has been used to determine pipeline costs in accordance with information provided by NCWCD. The distance to each recharge site from the river is dependent of the location of the site. To simplify this analysis a distance from the river of 4,000 ft was used for all recharge sites associated with pumping groundwater wells. This distance would vary with the SDF factor chosen, however, because specific recharge sites have not been located and SDF factors are not consistently the same distance from the river along the length of river, a constant length of 4,000 feet was deemed appropriate for this level of analysis. A total pipeline cost of $20,000 per well has been included for conveyance facilities and $7,000 for the conveyance conduit.

Engineering costs associated with design of facilities and analysis of operations was assumed to be 10 percent of the total construction cost of each project.

The total capitalized cost for projects involving pumping to recharge in Reaches 5 and 13 is $8.6 million and $9.7 million, respectively, as summarized in Table 8.G.10. The cost per ac-ft of reductions to target flow shortages ranges from about $1,050 to $2,380 assuming additional water can be protected from diversions and from about $2,280 to $5,450 assuming additional water cannot be protected from diversions.

Region 2

Groundwater Recharge/Return Flow Projects

The Colorado State Engineers office currently lists about 60 augmentation/recharge projects along the South Platte River in Water Districts 1, 2, and 64. Not all of these are decreed and some are no longer operated (Warner et al., 1994). The hydrogeology in the Lower South Platte River Basin is such that groundwater in the alluvium is in close hydrologic connection with surface water in the South Platte River. The thickness of the alluvium is up to 300 feet near the center of the river in some places and typically has a high permeability. The sand hills found along the edge of the valley are eolean deposits consisting of fine to medium sand (Warner et al., 1994). Due to the topography and high infiltration rates associated with the deposits that overlie the alluvium, there are several good recharge sites in the region.

Representative groundwater recharge/return flow projects have been evaluated for Reaches 7, 8, and 9 in Region 2. Maps of SDF factors, transmissivities, water-table contours and saturated thicknesses of the valley-fill aquifer from the USGS Open File Report, Hydrogeologic Characteristics of the Valley-Fill Aquifer in Reaches of the South Platte River Valley, Colorado (Hurr and Schneider, 1972), were reviewed to determine whether effective recharge sites with SDF factors ranging from 60 days to 270 days exist in each reach. Potential sites that have been evaluated overlie the alluvial aquifer and are hydraulically connected to the river. In addition, the depth to the water table must be great enough so that the recharge mound build up will not create water logging.

For evaluation purposes it was assumed that all representative sites associated with groundwater pumping to recharge are located in the middle of Reaches 7, 8 and 9 and at the bottom of Reach 9 at SDF factors of 60, 120, and 270 days. In addition, it was assumed that representative sites associated with surface water diversions to recharge are located in the middle of Reaches 7, 8 and 9 at an average SDF factor of 300 days. Each site or SDF factor in each reach has been analyzed separately, and the results are not necessarily additive.

Yield

The facilities required for these projects include wells located adjacent to the South Platte River and/or existing canals that divert water from the South Platte River. The amount of water available for diversion in Reaches 7, 8, and 9 was determined based on the following conditions:

1) All existing legal rights and physical demands and GASP augmentation requirements are satisfied above the State Compact requirements. According to the Division 1 Office of the Colorado Department of Water Resources this condition occurs when the flows at the Colorado-Nebraska State line exceed 180 cfs between April 1 and October 15. State Compact requirements are not applied outside of the compact period.

2) The amounts needed under operation of Colorado's proposed Tamarack Recharge Plan are met. State line flows have been adjusted to account for depletions/additions to historic Julesburg gage flows from Colorado's proposed Tamarack Recharge Plan. The Tamarack Recharge Plan is part of Colorado's contribution to the Cooperative Agreement for Platte River Research and other Efforts Relating to Endangered Species Habitats Along the Central Platte River, Nebraska (1997).

3) Water is only available when monthly target flow shortages do not exist at the critical habitat.

The use of South Platte River flows for recharge projects has an impact on Lake McConaughy operations and the lands it serves. The removal or dedication of South Platte flows will cause greater reliance on North Platte River water to meet the needs of NPPD and CNPPID. If the flows return at a time when they are unable to be diverted by the hydropower producers there is lost hydropower production. In addition, if flows return as protected water they are unavailable to irrigators, which could increase the demand for Lake McConaughy storage. Negative impacts or loss of inflows to Lake McConaughy and hydropower diversions at the Korty diversion and CNPPID's diversion must be mitigated. However, due to the absence of a Lake McConaughy operations model quantification of impacts to Lake McConaughy and hydropower diversions were not completed for this reconnaissance level study.

From an operational perspective, diversions via wells can occur throughout the year. Diversions to canal systems, however, typically occur in the fall after the irrigation season until freezing occurs, and during spring runoff when there are excess river flows. Therefore, it was assumed that diversions to canals only occur in October, November, March, and April due to freezing problems. There are diversions to reservoirs during these months; however, these diversions are possible because there is enough hydraulic head in the respective canals to produce flow velocities high enough to prevent freezing. In addition, seepage from irrigation canals can only be claimed as recharge when there are no deliveries being made for irrigation.

Monthly groundwater pumping was limited to 10,000 ac-ft, which assumes 50 high capacity wells pumping at an average rate of 1,500 gpm. Monthly diversions to canals were also limited to 10,000 ac-ft because there is substantial excess canal capacity in the reaches evaluated. The main constraint with respect to the amount diverted to recharge is the acreage of available recharge sites, as opposed to ditch capacity (NCWCD, 1999a). It was assumed that the full amount diverted less evaporation returns to the river as either seepage from canals or seepage from recharge ponds. Monthly pumping and diversion limits take into consideration existing and potential recharge sites. Results from the Tamarack Recharge Plan show percolation rates of about 10 ft/day, which would indicate that a monthly diversion to recharge of 10,000 ac-ft would require roughly 30 to 35 acres of recharge sites. However, information presented in the report "Recharge as Augmentation in the South Platte River Basin, Groundwater Program Technical Report No. 21" (Warner et al., 1994) regarding existing recharge projects suggests that a monthly diversion of 10,000 ac-ft would require roughly 1,000 acres. It has been assumed that 1,000 acres is available for recharge sites in Reaches 7, 8 and 9.

Recharge to the Platte River is computed as inflows minus evaporation, which is estimated to be one percent (1%) of gross diversions or pumping which is consistent with the Tamarack Recharge Plan. The average annual diversion to canals for recharge was 20,790 ac-ft for Reaches 7, 8 and 9. The average annual groundwater pumping to recharge for the 1975-1994 study period was 39,510 ac-ft for Reaches 7, 8 and 9.

Return flows were lagged back to the river using the SDF model SDF View. Return flows associated with pumping groundwater wells were lagged back to the river using SDF factors of 60, 120, and 270 days. An average SDF factor of 300 days was used to lag return flows associated with diversions to canal systems, which consists of seepage from canals and return flows from recharge ponds. Monthly additions to flows in the river occur in months when river accretions exceed diversions to recharge. Monthly depletions occur in months when the diversions to recharge exceed the accretion in that month. Tables 8.G.11 through 8.G.14 show the net hydrologic effects associated with an SDF factor of 120 days. Tables showing monthly net hydrologic effects for the other SDF factors are provided in Appendix F.

The lagged accretions and depletions were routed downstream to the critical habitat to determine potential reductions to target flow shortages. Two scenarios were evaluated for each recharge project in Reaches 7, 8, and 9. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. The average annual net reductions to target flow shortages for each scenario are summarized in Table 8.G.15. Due to the large number of scenarios that were evaluated the monthly additions and depletions are presented in Tables 8.G.16 through 8.G.23 for an SDF factor of 120 days. Results associated with the remaining SDF factors are presented in the Appendix F.

Cost

The direct costs related to groundwater recharge/return flow alternatives are based on the capital costs associated with the construction of diversion and storage facilities necessary for the alternative, as well as the annual operating costs. The costs for these types of projects were based on cost data provided by NCWCD for the Tamarack Recharge Plan. Direct costs estimated for groundwater

Table 8.G.11
Middle of Reach 7 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9520	1935	1165	737	521	389	304	248	206	-4016
1976	175	152	-9245	-7325	3287	2059	1380	1018	787	634	529	449	-6101
1977	390	342	303	273	246	224	205	189	174	161	150	140	2798
1978	132	124	117	111	105	-9350	2080	1286	844	612	479	388	-3073
1979	327	281	246	220	198	180	165	152	141	-9246	2182	1343	-3810
1980	898	661	-8863	-7019	-5839	-5119	-4600	-4225	-3922	5701	3912	2858	-25558
1981	2245	1836	-7841	-6116	4336	2985	2204	1762	1461	1249	1095	971	6186
1982	874	795	-8652	-4793	3400	2299	1679	1337	1110	952	840	750	591
1983	681	623	-8804	-6908	-5696	-4959	-4430	-4050	-3744	-3500	-3304	-3133	-47223
1984	-2991	6582	-4742	-3879	-3341	-3036	-2825	-2674	-2551	6926	5023	-5507	-13015
1985	-4216	-3499	-3072	-2812	-2614	-2470	7024	5131	3984	3274	2801	-6935	-3406
1986	4234	3210	-6807	-5239	-4263	-936	-3872	-3363	-3017	6599	4787	-5675	-14342
1987	-4334	-3561	-3110	-2830	3407	-3778	-3115	-2732	-2490	7052	5185	-5321	-15628
1988	5434	-5296	-4053	-3372	-2937	6791	4938	3892	3225	2773	2453	2198	16048
1989	2002	1840	-7677	-5854	4668	3363	2613	2190	1903	1698	1548	-7953	339
1990	3385	2491	1959	-7846	3408	2501	1964	1664	1460	1315	1208	1120	14629
1991	1050	989	-5353	-7233	3624	2519	1895	1557	-8041	3221	2303	1769	-1700
1992	1474	1283	-8233	-6396	4147	-6585	4126	2936	2234	1824	1563	1373	-256
1993	1234	1126	-8341	-6476	4087	-6632	4087	2904	2206	1799	1541	-8025	-10489
1994	534	-6511	-5236	-4486	5416	3792	2850	2309	1942	1684	1497	1348	5139
Average	676	173	-4870	-4875	879	-749	955	590	-95	1752	1802	-1382	-5144

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.12
Middle of Reach 8 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9520	1935	1165	737	521	389	304	248	206	-4016
1976	175	152	-9245	-7325	3287	2059	1380	1018	787	634	529	449	-6101
1977	390	342	303	273	246	224	205	189	174	161	150	140	2798
1978	132	124	117	111	105	-9350	2080	1286	844	612	479	388	-3073
1979	327	281	246	220	198	180	165	152	141	-9246	2182	1343	-3810
1980	898	661	-8863	-7019	-5839	-5119	-4600	-4225	-3922	5701	3912	2858	-25558
1981	2245	1836	-7841	-6116	4336	2985	2204	1762	1461	1249	1095	971	6186
1982	874	795	-8652	-4793	3400	2299	1679	1337	1110	952	840	750	591
1983	681	623	-8804	-6908	-5696	-4959	-4430	-4050	-3744	-3500	-3304	-3133	-47223
1984	-2991	6582	-4742	-3879	-3341	-3036	-2825	-2674	-2551	6926	5023	-5507	-13015
1985	-4216	-3499	-3072	-2812	-2614	-2470	7024	5131	3984	3274	2801	-6935	-3406
1986	4234	3210	-6807	-5239	-4263	-936	-3872	-3363	-3017	6599	4787	-5675	-14342
1987	-4334	-3561	-3110	-2830	3407	-3778	-3115	-2732	-2490	7052	5185	-5321	-15628
1988	5434	-5296	-4053	-3372	-2937	6791	4938	3892	3225	2773	2453	2198	16048
1989	2002	1840	-7677	-5854	4668	3363	2613	2190	1903	1698	1548	-7953	339
1990	3385	2491	1959	-7846	3408	2501	1964	1664	1460	1315	1208	1120	14629
1991	1050	989	-5353	-7233	3624	2519	1895	1557	-8041	3221	2303	1769	-1700
1992	1474	1283	-8233	-6396	4147	-6585	4126	2936	2234	1824	1563	1373	-256
1993	1234	1126	-8341	-6476	4087	-6632	4087	2904	2206	1799	1541	-8025	-10489
1994	534	-6511	-5236	-4486	5416	3792	2850	2309	1942	1684	1497	1348	5139
Average	676	173	-4870	-4875	879	-749	955	590	-95	1752	1802	-1382	-5144

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.13
Middle of Reach 9 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9520	1935	1165	737	521	389	304	248	206	-4016
1976	175	152	-9245	-7325	3287	2059	1380	1018	787	634	529	449	-6101
1977	390	342	303	273	246	224	205	189	174	161	150	140	2798
1978	132	124	117	111	105	-9350	2080	1286	844	612	479	388	-3073
1979	327	281	246	220	198	180	165	152	141	-9246	2182	1343	-3810
1980	898	661	-8863	-7019	-5839	-5119	-4600	-4225	-3922	5701	3912	2858	-25558
1981	2245	1836	-7841	-6116	4336	2985	2204	1762	1461	1249	1095	971	6186
1982	874	795	-8652	-4793	3400	2299	1679	1337	1110	952	840	750	591
1983	681	623	-8804	-6908	-5696	-4959	-4430	-4050	-3744	-3500	-3304	-3133	-47223
1984	-2991	6582	-4742	-3879	-3341	-3036	-2825	-2674	-2551	6926	5023	-5507	-13015
1985	-4216	-3499	-3072	-2812	-2614	-2470	7024	5131	3984	3274	2801	-6935	-3406
1986	4234	3210	-6807	-5239	-4263	-936	-3872	-3363	-3017	6599	4787	-5675	-14342
1987	-4334	-3561	-3110	-2830	3407	-3778	-3115	-2732	-2490	7052	5185	-5321	-15628
1988	5434	-5296	-4053	-3372	-2937	6791	4938	3892	3225	2773	2453	2198	16048
1989	2002	1840	-7677	-5854	4668	3363	2613	2190	1903	1698	1548	-7953	339
1990	3385	2491	1959	-7846	3408	2501	1964	1664	1460	1315	1208	1120	14629
1991	1050	989	-5353	-7233	3624	2519	1895	1557	-8041	3221	2303	1769	-1700
1992	1474	1283	-8233	-6396	4147	-6585	4126	2936	2234	1824	1563	1373	-256
1993	1234	1126	-8341	-6476	4087	-6632	4087	2904	2206	1799	1541	-8025	-10489
1994	534	-6511	-5236	-4486	5416	3792	2850	2309	1942	1684	1497	1348	5139
Average	676	173	-4870	-4875	879	-749	955	590	-95	1752	1802	-1382	-5144

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.14
Bottom of Reach 9 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9520	1935	1165	737	521	389	304	248	206	-4016
1976	175	152	-9245	-7325	3287	2059	1380	1018	787	634	529	449	-6101
1977	390	342	303	273	246	224	205	189	174	161	150	140	2798
1978	132	124	117	111	105	-9350	2080	1286	844	612	479	388	-3073
1979	327	281	246	220	198	180	165	152	141	-9246	2182	1343	-3810
1980	898	661	-8863	-7019	-5839	-5119	-4600	-4225	-3922	5701	3912	2858	-25558
1981	2245	1836	-7841	-6116	4336	2985	2204	1762	1461	1249	1095	971	6186
1982	874	795	-8652	-4793	3400	2299	1679	1337	1110	952	840	750	591
1983	681	623	-8804	-6908	-5696	-4959	-4430	-4050	-3744	-3500	-3304	-3133	-47223
1984	-2991	6582	-4742	-3879	-3341	-3036	-2825	-2674	-2551	6926	5023	-5507	-13015
1985	-4216	-3499	-3072	-2812	-2614	-2470	7024	5131	3984	3274	2801	-6935	-3406
1986	4234	3210	-6807	-5239	-4263	-936	-3872	-3363	-3017	6599	4787	-5675	-14342
1987	-4334	-3561	-3110	-2830	3407	-3778	-3115	-2732	-2490	7052	5185	-5321	-15628
1988	5434	-5296	-4053	-3372	-2937	6791	4938	3892	3225	2773	2453	2198	16048
1989	2002	1840	-7677	-5854	4668	3363	2613	2190	1903	1698	1548	-7953	339
1990	3385	2491	1959	-7846	3408	2501	1964	1664	1460	1315	1208	1120	14629
1991	1050	989	-5353	-7233	3624	2519	1895	1557	-8041	3221	2303	1769	-1700
1992	1474	1283	-8233	-6396	4147	-6585	4126	2936	2234	1824	1563	1373	-256
1993	1234	1126	-8341	-6476	4087	-6632	4087	2904	2206	1799	1541	-8025	-10489
1994	534	-6511	-5236	-4486	5416	3792	2850	2309	1942	1684	1497	1348	5139
Average	676	173	-4870	-4875	879	-749	955	590	-95	1752	1802	-1382	-5144

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.15
Summary of Groundwater Recharge/Return Flow Projects in Region 2

				With Diversion Losses			Without Diversion Losses		
Location Description	Project Description	SDF Factor (days)	Net Hydrologic Effects at the Site (ac-ft)	Target Flow Reductions with Diversions (ac-ft)	Total Capitalized Cost ($ M)	Cost per Acre-Foot of Reductions ($/ac-ft)	Target Flow Reductions without Diversions (ac-ft)	Total Capitalized Cost ($ M)	Cost per Acre-Foot of Reductions ($/ac-ft)
Middle of Reach 7	Pumping to recharge	60	-3,679	1,032	$10.7	$10,370	9,524	$19.6	$2,060
Middle of Reach 7	Pumping to recharge	120	-5,144	1,108	$10.7	$9,660	11,002	$19.6	$1,780
Middle of Reach 7	Pumping to recharge	270	-7,573	1,021	$10.7	$10,480	11,684	$19.6	$1,680
Middle of Reach 7	Diversion to recharge	300	-3,961	438	$2.1	$4,790	5,520	$11.0	$1,990
Middle of Reach 8	Pumping to recharge	60	-3,679	2,068	$10.7	$5,170	9,573	$17.3	$1,810
Middle of Reach 8	Pumping to recharge	120	-5,144	2,253	$10.7	$4,750	11,062	$17.3	$1,560
Middle of Reach 8	Pumping to recharge	270	-7,573	2,137	$10.7	$5,010	11,751	$17.3	$1,470
Middle of Reach 8	Diversion to recharge	300	-3,961	902	$2.1	$2,330	5,556	$8.7	$1,570
Middle of Reach 9	Pumping to recharge	60	-3,679	3,731	$10.7	$2,870	9,961	$14.6	$1,470
Middle of Reach 9	Pumping to recharge	120	-5,144	4,121	$10.7	$2,600	11,167	$14.6	$1,310
Middle of Reach 9	Pumping to recharge	270	-7,573	4,040	$10.7	$2,650	11,870	$14.6	$1,230
Middle of Reach 9	Diversion to recharge	300	-3,961	1,757	$2.1	$1,200	5,620	$6.1	$1,090
Bottom of Reach 9	Pumping to recharge	60	-3,679	4,410	$10.7	$2,430	9,720	$10.7	$1,100
Bottom of Reach 9	Pumping to recharge	120	-5,144	4,922	$10.7	$2,170	11,238	$10.7	$950
Bottom of Reach 9	Pumping to recharge	270	-7,573	4,917	$10.7	$2,180	11,950	$10.7	$900

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions to the river not being included because they would have occurred after 1994.

Table 8.G.16
Middle of Reach 7 : SDF = 120 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	346	146	98	13	51	0	0	4	658
1976	4	3	0	0	316	483	60	8	1	0	0	1	877
1977	1	2	10	15	6	24	7	3	0	0	0	1	70
1978	2	1	1	3	2	0	58	5	2	0	0	0	74
1979	3	1	4	18	21	4	7	7	28	0	18	18	131
1980	18	39	0	0	0	0	0	0	0	2	2	33	94
1981	5	72	0	0	301	217	94	18	12	1	0	1	723
1982	4	2	0	0	422	26	16	3	3	2	0	8	486
1983	5	18	0	0	0	0	0	0	0	0	0	0	22
1984	0	1623	0	0	0	0	0	0	0	0	75	0	1698
1985	0	0	0	0	0	0	265	1144	311	9	8	0	1737
1986	763	365	0	0	0	0	0	0	0	0	0	0	1128
1987	0	0	0	0	0	0	0	0	0	0	14	0	14
1988	37	0	0	0	0	1911	385	516	55	4	2	22	2933
1989	8	6	0	0	1555	380	32	4	9	0	1	0	1995
1990	21	8	99	0	850	657	513	17	3	0	2	4	2174
1991	6	6	0	0	671	275	24	0	0	0	1	17	1000
1992	8	10	0	0	1508	0	416	7	26	9	15	23	2022
1993	42	31	0	0	945	0	487	25	14	0	4	0	1549
1994	0	0	0	0	1854	795	91	16	3	0	1	5	2764
Average	46	109	6	2	440	246	128	89	26	1	7	7	1108

Table 8.G.17
Middle of Reach 8 : SDF = 120 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	676	521	199	32	79	1	1	9	1518
1976	29	37	0	0	1220	911	173	31	4	0	0	5	2409
1977	39	68	79	72	71	65	41	11	4	0	0	4	454
1978	15	27	28	28	33	0	144	21	8	0	0	1	306
1979	15	26	42	58	42	35	24	14	38	0	28	49	372
1980	65	89	0	0	0	0	0	0	0	8	6	86	253
1981	87	225	0	0	1362	780	222	61	23	5	0	5	2771
1982	57	75	0	0	1459	485	87	15	14	5	1	29	2228
1983	86	153	0	0	0	0	0	0	0	0	0	0	239
1984	0	2838	0	0	0	0	0	0	0	0	113	0	2951
1985	0	0	0	0	0	0	958	1441	500	23	23	0	2946
1986	1547	1080	0	0	0	0	0	0	0	0	0	0	2626
1987	0	0	0	0	0	0	0	0	0	0	40	0	40
1988	665	0	0	0	0	3026	1049	1023	121	14	8	63	5969
1989	117	141	0	0	2081	1071	192	11	30	0	4	0	3648
1990	208	152	265	0	1303	923	763	62	9	0	6	11	3702
1991	86	138	0	0	1144	656	109	0	0	2	2	45	2179
1992	53	80	0	0	2007	0	939	21	87	45	34	61	3326
1993	268	256	0	0	1290	0	951	78	51	0	13	0	2907
1994	0	0	0	0	2377	1445	323	47	13	0	2	14	4221
Average	167	269	21	8	753	496	309	143	49	5	14	19	2253

Table 8.G.18

Middle of Reach 9 : SDF = 120 Days

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1016	899	339	96	115	8	8	39	2520
1976	62	73	0	0	2158	1343	541	174	38	6	2	34	4430
1977	123	138	149	129	136	105	81	37	15	2	4	33	952
1978	40	55	56	58	67	0	741	128	25	6	6	24	1206
1979	54	81	110	108	62	82	57	27	50	0	52	142	824
1980	146	140	0	0	0	0	0	0	0	46	106	340	778
1981	417	476	0	0	2583	1598	459	151	40	63	0	95	5883
1982	214	282	0	0	2553	1258	358	83	36	15	15	109	4923
1983	327	306	0	0	0	0	0	0	0	0	0	0	633
1984	0	3878	0	0	0	0	0	0	0	0	226	0	4105
1985	0	0	0	0	0	0	3037	1876	894	127	143	0	6077
1986	2488	1681	0	0	0	0	0	0	0	0	0	0	4170
1987	0	0	0	0	0	0	0	0	0	0	269	0	269
1988	1846	0	0	0	0	4415	2077	1675	244	155	117	388	10916
1989	428	526	0	0	2845	1944	555	125	151	0	48	0	6623
1990	844	744	669	0	1795	1264	1084	316	66	8	49	56	6894
1991	264	388	0	0	1757	1190	287	0	0	21	21	116	4044
1992	195	368	0	0	2512	0	1688	198	219	151	80	112	5522
1993	552	542	0	0	1746	0	1561	339	239	0	166	0	5143
1994	0	0	0	0	3198	1700	852	337	126	0	41	250	6503
Average	400	484	49	15	1121	790	686	278	113	30	68	87	4121

Table 8.G.19

Bottom of Reach 9 : SDF = 120 Days

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
1975	0	0	0	0	1027	903	387	144	127	15	14	64	2681
1976	71	76	0	0	2192	1351	810	297	69	11	4	60	4941
1977	170	142	149	129	136	106	91	56	23	4	7	58	1072
1978	52	56	59	63	69	0	1264	220	37	11	12	47	1890
1979	83	111	139	120	64	97	73	33	52	0	70	208	1049
1980	182	141	0	0	0	0	0	0	0	79	202	550	1155
1981	668	577	0	0	2745	1854	586	202	50	117	0	183	6983
1982	318	416	0	0	2613	1573	567	139	49	21	29	168	5892
1983	486	325	0	0	0	0	0	0	0	0	0	0	810
1984	0	3962	0	0	0	0	0	0	0	0	311	0	4273
1985	0	0	0	0	0	0	4457	2071	1155	220	252	0	8155
1986	2693	1712	0	0	0	0	0	0	0	0	0	0	4405
1987	0	0	0	0	0	0	0	0	0	0	478	0	478
1988	2404	0	0	0	0	4691	2477	1907	315	288	220	679	12980
1989	631	778	0	0	3082	2132	770	234	253	0	90	0	7970
1990	1296	1192	925	0	1857	1344	1170	532	117	16	89	95	8633
1991	364	507	0	0	1900	1363	388	0	0	40	39	165	4766
1992	292	587	0	0	2519	0	1941	364	295	225	111	134	6469
1993	616	609	0	0	1857	0	1743	556	391	0	310	0	6083
1994	0	0	0	0	3496	1700	1167	602	230	0	79	479	7753
Average	516	560	64	16	1178	856	895	368	158	52	116	144	4922

Table 8.G.20
Middle of Reach 7 : SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1721	1089	691	472	356	265	159	157	4909
1976	111	109	0	0	2988	1901	1205	922	549	221	59	176	8240
1977	316	252	224	213	221	216	169	172	155	86	93	117	2233
1978	108	101	92	77	98	0	1911	1120	691	182	216	153	4750
1979	195	210	208	176	135	175	152	93	68	0	1561	721	3693
1980	587	535	0	0	0	0	0	0	0	4003	2767	1549	9441
1981	1612	1301	0	0	3525	2689	1981	1629	1034	676	0	524	14971
1982	690	724	0	0	3333	2086	1509	1212	995	809	732	509	12599
1983	648	504	0	0	0	0	0	0	0	0	0	0	1152
1984	0	6223	0	0	0	0	0	0	0	0	2543	0	8766
1985	0	0	0	0	0	0	4889	4681	3379	2895	2546	0	18389
1986	4071	2573	0	0	0	0	0	0	0	0	0	0	6644
1987	0	0	0	0	0	0	0	0	0	0	3583	0	3583
1988	4063	0	0	0	0	6307	4285	3288	2741	2190	1939	1681	26494
1989	1616	1787	0	0	4388	2977	2327	1803	1716	0	1191	0	17805
1990	3141	2207	1581	0	3266	2430	1837	1555	1266	645	987	636	19551
1991	672	772	0	0	3432	2343	1564	0	0	1058	926	803	11570
1992	858	1177	0	0	4018	0	3807	2267	2007	1230	928	898	17190
1993	1006	988	0	0	2558	0	3841	2647	1985	0	427	0	13453
1994	0	0	0	0	4366	1700	2643	2057	1676	0	1294	878	14613
Average	985	973	105	23	1702	1196	1641	1196	931	713	1098	440	11002

Table 8.G.21
Middle of Reach 8 : SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1723	1091	695	475	358	267	160	162	4930
1976	111	109	0	0	2993	1906	1214	928	554	223	60	177	8274
1977	317	252	224	213	221	217	170	174	157	87	94	117	2243
1978	108	101	92	77	98	0	1928	1147	702	184	217	154	4809
1979	196	210	208	176	135	175	153	117	83	0	1569	726	3748
1980	590	535	0	0	0	0	0	0	0	4034	2784	1558	9501
1981	1617	1303	0	0	3529	2696	1998	1638	1042	683	0	528	15035
1982	692	767	0	0	3336	2091	1520	1219	1001	815	737	511	12690
1983	650	505	0	0	0	0	0	0	0	0	0	0	1155
1984	0	6232	0	0	0	0	0	0	0	0	2610	0	8842
1985	0	0	0	0	0	0	4889	4701	3396	2915	2560	0	18461
1986	4085	2686	0	0	0	0	0	0	0	0	0	0	6770
1987	0	0	0	0	0	0	0	0	0	0	3605	0	3605
1988	4076	0	0	0	0	6321	4307	3308	2762	2207	1952	1690	26624
1989	1622	1790	0	0	4389	2985	2342	1816	1726	0	1199	0	17868
1990	3154	2211	1581	0	3269	2435	1846	1564	1275	651	994	639	19619
1991	674	774	0	0	3439	2351	1574	0	0	1067	932	807	11618
1992	862	1178	0	0	4027	0	3830	2283	2018	1230	933	903	17263
1993	1009	989	0	0	2560	0	3862	2665	1996	0	427	0	13509
1994	0	0	0	0	4369	1700	2657	2071	1688	0	1305	883	14673
Average	988	982	105	23	1704	1199	1649	1205	938	718	1107	443	11062

Table 8.G.22
Middle of Reach 9 : SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1726	1097	701	480	362	270	161	169	4966
1976	113	109	0	0	3005	1914	1229	938	562	227	60	179	8336
1977	319	253	225	213	222	218	172	176	159	89	95	119	2260
1978	110	102	93	77	98	0	1954	1183	719	187	220	156	4899
1979	198	210	208	176	135	176	155	142	98	0	1585	734	3817
1980	596	536	0	0	0	0	0	0	0	4092	2814	1574	9613
1981	1625	1308	0	0	3537	2709	2025	1654	1057	693	0	534	15141
1982	696	769	0	0	3342	2098	1535	1232	1013	826	745	516	12773
1983	653	506	0	0	0	0	0	0	0	0	0	0	1159
1984	0	6252	0	0	0	0	0	0	0	0	2771	0	9023
1985	0	0	0	0	0	0	4889	4803	3569	2955	2587	0	18803
1986	4110	2736	0	0	0	0	0	0	0	0	0	0	6846
1987	0	0	0	0	0	0	0	0	0	0	3644	0	3644
1988	4100	0	0	0	0	6347	4347	3346	2802	2237	1974	1707	26860
1989	1632	1795	0	0	4390	2999	2370	1837	1745	0	1212	0	17981
1990	3173	2217	1583	0	3275	2445	1863	1578	1293	659	1004	646	19737
1991	678	776	0	0	3451	2365	1589	0	0	1082	942	816	11698
1992	867	1180	0	0	4042	0	3872	2312	2040	1230	942	913	17397
1993	1018	992	0	0	2561	0	3900	2695	2018	0	427	0	13610
1994	0	0	0	0	4373	1700	2684	2095	1712	0	1323	895	14783
Average	994	987	105	23	1708	1204	1664	1224	957	727	1125	448	11167

Table 8.G.23
Bottom of Reach 9 : SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1728	1102	705	483	364	272	163	170	4986
1976	114	109	0	0	3014	1920	1239	945	566	229	61	181	8378
1977	320	254	226	213	223	219	174	178	161	90	95	120	2272
1978	111	102	93	77	98	0	1971	1194	727	189	222	158	4940
1979	199	211	208	176	136	177	156	143	98	0	1595	739	3836
1980	600	537	0	0	0	0	0	0	0	4128	2833	1585	9683
1981	1630	1312	0	0	3542	2718	2043	1664	1066	698	0	537	15211
1982	699	770	0	0	3347	2103	1545	1240	1022	833	750	519	12829
1983	656	507	0	0	0	0	0	0	0	0	0	0	1163
1984	0	6267	0	0	0	0	0	0	0	0	2869	0	9135
1985	0	0	0	0	0	0	4889	4892	3732	2981	2603	0	19096
1986	4128	2786	0	0	0	0	0	0	0	0	0	0	6914
1987	0	0	0	0	0	0	0	0	0	0	3668	0	3668
1988	4118	0	0	0	0	6365	4375	3371	2827	2255	1987	1718	27015
1989	1639	1798	0	0	4391	3010	2390	1850	1758	0	1220	0	18056
1990	3186	2222	1584	0	3279	2452	1875	1587	1304	664	1010	651	19813
1991	681	777	0	0	3458	2374	1599	0	0	1090	949	822	11750
1992	871	1182	0	0	4051	0	3901	2330	2054	1230	949	919	17486
1993	1024	995	0	0	2562	0	3925	2713	2033	0	427	0	13677
1994	0	0	0	0	4376	1700	2703	2110	1727	0	1335	903	14854
Average	999	991	106	23	1710	1207	1674	1235	972	733	1137	451	11238

recharge/return flow projects consider capital costs of the following items.

- Subsurface investigations
- Construction of wells
- Pumps and related facilities
- Diversion facilities
- Construction of recharge ponds
- Regulation and measurement
- Conveyance structures
- Improvements to existing mainstem diversion structures
- Engineering costs associated with the design of facilities and analysis of operations.
- Compensation provided to the canal company
- Operations and maintenance.

Two groups of alternatives have been evaluated, which include, 1) Diverting water into an existing irrigation canal to a recharge site close to the canal, and 2) Pumping water to sites from a groundwater well located adjacent to a river.

Recharge Diversions to Canals. The costs associated with diverting water into existing canals are described in more detail in the cost section for groundwater recharge/return flow projects in Region 1. The primary difference in Region 2 is the amount of water delivered to recharge. Based on an average annual diversion to recharge of approximately 20,790 ac-ft and a delivery fee of $5 per ac-ft delivered, the total delivery cost would be about $104,000. The total capitalized cost of the delivery charges is about $1.2 million based on a study period of 20 years and a discount rate of six percent.

There are several large sand dams located in the Lower South Platte River region that would need to be replaced in order for water generated from groundwater alternatives to be protected to the

Colorado-Nebraska state line. Based on input from the Division 1 Office of the Colorado Department of Water Resources, approximately 50 percent of the sand dam structures in Reaches 7, 8, and 9 would need to be modified to bypass water downstream at an average cost of $300,000 per structure. If additional water is to be protected from diversions to the Colorado-Nebraska state line, an additional cost of $8,100,000, $6,000,000, and $3,600,000 would be incurred by recharge projects in Reaches 7, 8, and 9, respectively. It would be possible to reduce sand dam replacement costs by locating recharge sites further downstream so as to minimize the number of necessary sand dam modifications. These costs are not incurred if additional water is not protected from downstream diversions.

The costs to replace sand dams have been included for all groundwater projects evaluated in Region 2 when considering the cost of protecting water from diversion. However, if sand dams are modified to bypass flows, then more than one alternative could be located above the sand dams without incurring the additional cost of sand dam replacement. The sand dams would only be modified once, therefore, the total cost to replace these dams would be incurred by all recharge projects implemented under the Program, as opposed to each individual project. Therefore, the cost per ac-ft for scenarios without diversion losses could be lower in the Action Plan if more than one alternative is selected in Region 2 that requires sand dam modifications.

It is possible that the modification or replacement of sand dams could provide additional benefits to operators of diversion structures at the cost of the Program. For example, sand dams that have been replaced with a fixed or hybrid fixed diversion structure in Nebraska typically wash out less frequently and are more efficient in terms of maintaining a diversion head. Typically modifications to sand dam structures as described above result in a more efficient diversion point.

The number of recharge sites that would be required is very uncertain due to many variables including the permeability of the soil, land availability, and groundwater levels. It has been assumed that 50 recharge sites would be required in each reach. The construction costs associated with 50 diversion structures and related facilities would be approximately $908,000 for each reach. This cost includes subsurface investigations, diversion facilities, construction of recharge ponds, and regulation and measurement.

Engineering costs associated with design of facilities and analysis of operations was assumed to be 10 percent of the total construction cost of each project (not including delivery charges). The total capitalized cost is about $11.0, $8.7 and $6.1 million, respectively, for potential projects in Reaches 7, 8, and 9 if additional water is protected from diversion losses as summarized in Table 8.G.10. If additional water is not protected from diversions, the total capitalized cost is about $2.1 million for potential projects in each reach, as summarized in Table 8.G.10. The cost per ac-ft of reductions to target flow shortages ranges from about $1,090 to $1,990 assuming additional water can be protected from diversions, and from about $1,200 to $4,790 assuming additional water cannot be protected from diversions.

Pumping to Recharge. The costs associated with pumping groundwater to recharge sites are similar to the costs for diverting recharge water through existing canals. As described above a cost of $3,500 has been included for subsurface investigations. A cost of $6,000 has been included for recharge basin construction.

Well construction costs are a function primarily of drilling depth and well diameter. Operating costs for pumps and related facilities are a function primarily of the horsepower required at each well site. A total cost of $30,000 per well was included, which includes costs for the well drilling, casing material, pump, pump column and shaft, discharge head assembly, and electric motor. Wells and pumping hardware will most likely need to be replaced in 10 to 20 years, therefore, replacement costs were included. It was assumed that electrical power would not be available at all well sites, therefore, an additional cost of $4,000 was included to provide power to the well.

Operation costs, which consist primarily of electricity costs, are typically about $8 per ac-ft pumped. Based on an average annual amount of 39,510 ac-ft pumped to recharge, the total electricity cost would be about $316,000. Annual maintenance costs are minimal and typically less than $300 per well.

Recharge projects involving wells require pipelines to convey water to recharge basins. Costs for conveyance facilities consist primarily of pipeline costs, trenching and installation, miscellaneous fittings, and flow meters. A pipeline size of 12-inch was assumed, which is representative of similar pipeline sizes that have been used for recharge projects in the Lower South Platte River region. A cost of

$5/linear foot has been used to determine pipeline costs in accordance with information provided by NCWCD. The distance to each recharge site is dependent on the location of the site. This distance would vary with the SDF factor chosen, however, because specific recharge sites have not been located and SDF factors are not consistently the same distance from the river along the length of river, a constant length of 4,000 feet was deemed appropriate for this level of analysis. A total pipeline cost of about $20,000 per well and $7,000 for the conveyance conduit has been included for conveyance facilities.

The costs to replace existing sand dams would be the same as for the alternatives involving diversions to recharge. The costs are considerably less if additional water is not protected from downstream diversions and the sand dams do not have to be replaced. Engineering costs associated with design of facilities and analysis of operations was assumed to be 10 percent of the total construction cost of each project.

The total capitalized cost for projects involving pumping to recharge is about $19.6, $17.3, and $14.6 million, respectively, for potential projects in Reaches 7, 8, and 9 assuming additional water can be protected from diversions, as summarized in Table 8.G.10. The total capitalized cost assuming additional water cannot be protected from diversions is about $10.7 million for potential projects in each reach, as summarized in Table 8.G.10. Groundwater pumping to recharge at the bottom of Reach 9 does not require the replacement of any sand dams. For this scenario, the total capitalized cost is about $10.7 million, as summarized in Table 8.G.10. The cost per ac-ft of reductions to target flow shortages ranges from about $900 to $2,060 assuming additional water can be protected from diversions and from about $2,170 to $10,480 assuming additional water cannot be protected from diversions.

Purchasing Accretion Credits (Groundwater Recharge/Return Flow Projects)

Some recharge projects that are operated by individuals or irrigation districts in the Lower South Platte River region sell accretion credits that exceed their augmentation requirements. There are significant costs associated with the necessary distribution systems and holding structures associated with recharge operations. As a result, most current recharge operations are being conducted by irrigation districts in cooperation with water user organizations such as Ground Water

Appropriators of the South Platte (GASP). GASP currently purchases recharge credits in excess of augmentation requirements from irrigation districts and some private individuals. The following ditch companies conduct recharge projects that are utilized by GASP: 1) Bijou Irrigation Company, 2) Fort Morgan Reservoir and Irrigation Company, 3) Pioneer Water and Irrigation Company, 4) Upper Platte and Beaver Ditch Company, 5) Lower Platte and Beaver Ditch Company, and 6) Riverside Irrigation Company (Warner et al., 1994).

Purchasing excess recharge credits from these companies was evaluated, however, this alternative was eliminated from further evaluation at this time because the amount of excess recharge credit available is limited. The majority of the excess recharge credits that are available are currently purchased by GASP. In the future, excess recharge credits beyond those purchased by GASP will most likely be purchased under Colorado's proposed Tamarack Recharge Plan. If these credits were to be used in the Recovery Program to reduce target flow shortages a change of use would be required in water court to define an in-state beneficial use such as wildlife enhancement.

The best opportunity for generating recharge credits associated with canal diversions is to develop a new recharge project as opposed to purchasing excess recharge credits.

Badger-Beaver Recharge Project

In addition to the representative recharge projects that were evaluated in the preceding section, two specific recharge projects in Region 2 have been analyzed, the Badger-Beaver recharge project and the Beebe Draw recharge project. These projects were analyzed because they were identified in previous reports and studies as specific instances of potential recharge sites.

The Badger-Beaver recharge project is a largely nonstructural approach that could be implemented to re-regulate South Platte River flows. The original project, which was investigated by the USGS, proposed to divert water from the South Platte River through the Bijou Canal for delivery to Badger and Beaver Creeks south of Fort Morgan, where it would recharge the alluvial aquifer. The initial intent of the project was to raise groundwater levels in the alluvium adjacent to the streams so that historical pumping rates could be restored and lands could be returned to their previous irrigated conditions. A study conducted by the USGS in 1978-1979 determined that recharge to the two alluvial aquifers would raise water levels sufficiently to create flowing streams in the channels of Beaver and Badger Creeks while allowing an increase in current groundwater pumping (Burns, 1980). Under the proposed project, water would be diverted from the South Platte River into Bijou Canal. Two additional canals would be constructed to deliver water from Bijou Canal to Beaver and Badger Creeks. In addition, several recharge ponds were proposed throughout the recharge-distribution system. In general the areas of dune-sand deposits are good infiltration areas for recharge to the underlying alluvial material (Bjorklund and Brown, 1957).

In March 1978, the U.S. Fish and Wildlife Service funded an 18-month study of the hydrologic aspects of this proposed artificial-recharge project. In May 1979, however, the U.S. Fish and Wildlife Service notified the Badger and Beaver Water Conservancy District that it could not participate in the wildlife-management part of the recharge plan. Preliminary results of the study indicated that the project would significantly deplete flows in the South Platte River due to additional pumping for irrigation that would occur.

If this project is implemented similar to the general recharge/return flows projects described in the previous section, South Platte River flows should not be depleted significantly due to additional pumping for irrigation. Significant depletions to South Platte River flows would be a concern to all downstream users. The objective of this project would be substantially different from the originally intended purpose, which was to raise water levels to create live streams in Beaver and Badger Creeks and allow an increase in current groundwater pumping. This project could be implemented similar to the general groundwater recharge/return flow, which are intended to re-regulate excess flows. As such, significant losses to the South Platte River associated with increased pumping for irrigation should not occur.

Yield

The centroid of a groundwater recharge project in the Badger-Beaver basins would be located at about mile 50 in Reach 8. Recharge water would be diverted into Bijou Canal; however, as opposed to the originally proposed project, no water would be released to the channels of Badger and Beaver Creeks. Only the canals and ponds through the sand hills would be constructed. Water will recharge the underlying aquifer through the canals and ponds.

Diversions would typically occur in the fall after the irrigation season until freezing conditions occur, and during spring runoff when there are excess river flows. It was, therefore, assumed that diversions to canals do not occur from December through February because water diverted during those months typically freezes in the canals. Monthly diversions to canals were also limited to 10,000 ac-ft. This limitation is based on the excess capacity of Bijou Canal and limitations regarding potential recharge sites. This limit would most likely allow the aquifer system to transmit the water and prevent water logging in the recharge areas. The average annual diversion to recharge for the period of record is approximately 20,790 ac-ft.

Based on the location of the Bijou Canal, and the two proposed canals and associated ponds, an average SDF factor of 5000 days was used to lag return flows back to the South Platte River. The SDF factor of 5,000 days was chosen based on a review of the MBSA SDF maps. Return flows were lagged back to the river using the SDF model SDF View. Monthly additions to flows in the river occur in months when river accretions exceed diversions to recharge. Monthly depletions occur in months when the diversions to recharge exceed the accretion in that month. The net hydrologic effect associated with the project is shown in Table 8.G.24.

The lagged depletions and accretions were routed downstream to the critical habitat using the water budget to determine potential reductions to target flow shortages. Two routing scenarios were evaluated for the proposed recharge project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. The average annual net reductions to target flow shortages for each scenario are about 3,427 ac-ft and 655 ac-ft, respectively, as shown in Tables 8.G.25 and 8.G.26.

Cost

The Badger-Beaver Recharge Project was considered as a potential water supply for a Superconducting Super Collider (particle

Table 8.G.24

Badger-Beaver Recharge Project SDF = 5000 Days

Net Hydrologic Effect

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-9900	0	0	0	0	1	3	-9896
1979	6	9	14	19	23	28	32	36	39	-9858	45	47	-9559
1980	49	51	53	56	59	-9836	-9831	-9826	-9821	84	89	96	-38780
1981	104	116	132	149	169	188	208	226	243	258	271	282	2346
1982	292	299	306	310	314	317	319	320	320	320	319	317	3752
1983	316	313	311	309	306	-9597	-9601	-9604	-9607	-9611	-9613	-9614	-65692
1984	-9612	294	305	319	340	-9536	-9508	-9478	-9447	484	514	-9357	-54682
1985	-9329	-9300	631	660	691	-9179	752	783	814	844	872	-9001	-30763
1986	923	945	965	981	997	-6005	-8880	-8870	-8862	1044	1049	-8846	-34557
1987	-8841	-8833	1076	1086	1099	-8787	-8771	-8754	-8736	1183	1200	-8682	-55759
1988	1237	-8644	1277	1297	1319	1340	1361	1381	1400	1417	1432	1444	6261
1989	1454	1460	1464	1466	1465	1462	1457	1450	1442	1432	1421	-8491	7481
1990	1397	1384	1371	1357	1344	1331	1319	1308	1298	1287	1277	1267	15940
1991	1256	1245	1234	1223	1211	1199	1187	1175	-8738	1149	1137	1124	4402
1992	1112	1100	1089	1080	1071	-8836	1057	1050	1042	1035	1029	1022	2850
1993	1017	1013	1008	1004	1000	-8905	990	985	979	973	967	-8939	-7907
1994	-1914	-8947	949	946	943	942	942	943	946	951	956	960	-1384
Average	-1027	-1375	609	613	618	-3689	-1848	-1844	-2334	-350	148	-2818	-13297

Table 8.G.25
Badger-Beaver Recharge Project SDF = 5000 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	1	1	2
1979	3	7	12	15	16	27	30	30	25	0	32	26	223
1980	32	41	0	0	0	0	0	0	0	59	63	52	248
1981	75	83	0	0	137	170	189	211	174	141	0	154	1333
1982	231	289	0	0	308	288	289	292	289	274	280	216	2757
1983	301	254	0	0	0	0	0	0	0	0	0	0	555
1984	0	279	0	0	0	0	0	0	0	0	270	0	548
1985	0	0	0	0	0	0	697	718	695	753	799	0	3662
1986	892	791	0	0	0	0	0	0	0	0	0	0	1683
1987	0	0	0	0	0	0	0	0	0	0	836	0	836
1988	928	0	0	0	0	1248	1189	1175	1201	1131	1142	1112	9127
1989	1179	1421	0	0	1377	1298	1308	1205	1310	0	1103	0	10201
1990	1303	1229	1106	0	1290	1297	1241	1232	1135	638	1052	724	12249
1991	807	974	0	0	1150	1121	987	0	0	382	461	514	6395
1992	650	1010	0	0	1041	0	982	818	943	785	615	674	7518
1993	832	890	0	0	626	0	937	906	887	0	427	0	5506
1994	0	0	0	0	761	915	879	847	824	0	834	631	5692
Average	362	363	56	1	335	318	436	372	374	208	396	205	3427

Table 8.G.26
Badger-Beaver Recharge Project SDF = 5000 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	1	3	6	6	8	6	4	12	0	1	2	49
1980	5	8	0	0	0	0	0	0	0	0	0	4	17
1981	6	18	0	0	71	65	25	10	4	1	0	2	203
1982	27	40	0	0	176	94	22	5	5	2	1	16	388
1983	56	106	0	0	0	0	0	0	0	0	0	0	163
1984	0	145	0	0	0	0	0	0	0	0	13	0	158
1985	0	0	0	0	0	0	133	236	114	7	9	0	499
1986	407	391	0	0	0	0	0	0	0	0	0	0	798
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	213	0	0	0	0	693	364	428	62	9	6	51	1826
1989	119	158	0	0	725	595	143	9	29	0	5	0	1783
1990	119	119	230	0	588	552	581	62	10	0	7	16	2283
1991	143	245	0	0	451	387	89	0	0	1	1	35	1351
1992	54	95	0	0	574	0	296	9	52	34	27	55	1195
1993	299	316	0	0	352	0	275	33	29	0	10	0	1316
1994	0	0	0	0	454	424	137	24	8	0	1	12	1061
Average	72	82	12	0	170	141	104	41	16	3	5	10	655

accelerator). Although this project was not completed in Colorado the State of Colorado's Site Proposal includes an assessment of the costs associated with the Badger-Beaver Project. Capital costs for the diversion and recharge portions of the Project were $10.4 million as of 1987. The cost was updated to a 1998 cost of $14 million using average annual ENR cost indices. If additional water is to be protected from diversions to the Colorado-Nebraska state line, an additional cost of $6,000,000 would be incurred for sand dam improvements or modifications. The resulting cost per ac-ft of reductions to target flow shortages at the critical habitat is approximately $5,840 assuming additional flows can be protected from downstream diversions, and $21,370 assuming additional flows cannot be protected. The cost per ac-ft in either case exceeds the economic screening criteria limit of $3,000 per ac-ft, therefore, this alternative will not be evaluated further at this time.

The cost estimate developed for Super Collider Proposal is based on different operating criteria because the project would have been developed for a different purpose. However, because further refinement would increase costs, and because it is already too expensive for further consideration the cost estimate was deemed sufficient for this level of analysis.

Beebe Draw Recharge Project

A Beebe Draw recharge project would use the Beebe Draw aquifer for regulation of storable flows. A recharge project could be implemented that involves diverting South Platte River storable flows (water available to a junior water right) using excess capacity in the Burlington - O'Brian Canal to the Beebe Draw watershed. Beebe Draw is a shallow alluvial aquifer located between Barr Lake and Milton Reservoir above Reach 7. The total storage capacity of the aquifer is estimated to be between 1 and 2 million ac-ft. The aquifer is relatively permeable with well capacities as high as 2,000 gpm (Hydrosphere Resource Consultants, 1999).

Beebe Draw is separated from adjacent channels by bedrock divides except below Lower Latham Reservoir where the channel merges with that of the South Platte River (Hydro-Triad, Ltd., 1985). Water could be diverted to recharge the aquifer and high capacity wells could be pumped to deliver water back to the South Platte River when target flow shortages exist. This project is similar in concept to existing recharge projects in the Lower South Platte River basin. However, in this case, infrastructure (pipelines, wells, etc.) would be needed to efficiently recover stored water. This site could afford greater control over the timing of delivery of water to the critical habitat.

Farmers Reservoir and Irrigation Company (FRICO) has an existing recharge program that is decreed for the same drainage for use by the existing water users in the Draw. Any recharge project under the Program would need to work in conjunction with FRICO's existing operation because the project would require the same facilities for delivery and most likely the same recharge sites that FRICO currently has designated. A representative (John Akolt) with FRICO indicated that there is potential for additional recharge in Beebe Draw and FRICO would be willing to work with the Program.

Yield

A recharge program could work in conjunction with FRICO's existing facilities as follows. Excess capacity frequently exists throughout the year in the Burlington-O'Brian Canal. The capacity of the Burlington-O'Brian Canal is 750 cfs. Diversion records were obtained for 1975 through 1994 to determine the excess capacity on a monthly basis. Water could be diverted into the Burlington-O'Brian Canal under a junior recharge right when excess capacity exists.

Potential storable flows at the Burlington-O'Brian Canal headgate were obtained from Denver Water's PACSM modeling of its near term future resource strategy. Water would not be diverted to aquifer storage during months of target flow shortages at the critical habitat, therefore, South Platte storable flows average about 26,600 ac-ft per year over the 1975–1994 study period. Potential monthly diversions to recharge were limited to the minimum of storable flows at the Burlington Ditch headgate during months of excess at the critical habitat or excess capacity in the ditch.

The potential area for recharge lies between Barr Lake and Milton Reservoir. Recharge water diverted into the Burlington-O'Brian Canal would be delivered first to Barr Lake. FRICO typically fills Barr Lake and Milton Reservoir by late May or early June, therefore, excess space available for storage of recharge water would be limited. FRICO indicated that they may be willing to release up to 5,000 ac-ft from Barr Lake into Beebe Draw for storage in the alluvium. FRICO would be willing to make similar releases from Milton Reservoir to create capacity to store program water. Although this arrangement would make some storage space available for Program recharge water, it may difficult to administratively difficult to operate. Alternatively, water could be passed directly through Barr Lake and delivered via existing irrigation ditches to injection wells. Excess capacity would need to exist in the irrigation ditches below Barr Lake for water to be delivered to injection wells. There are several canals that take out of Barr Lake that could potentially be used, which include Speer Canal, West Burlington Extension Ditch, Bowles Seep Canal, Beebe Canal, East Burlington Extension Ditch, and Big Neres Canal. The total capacity of these ditches is roughly 400 cfs. These irrigation ditches are typically operated on an on/off rotation, in which case excess capacity exists in these canals for periods throughout the irrigation season. It was assumed that 200 cfs of excess capacity is available for 10 days each month for delivery of water to injection wells. This limits the monthly recharge diversion from the South Platte River to about 4,000 ac-ft. The excess capacity available would vary significantly based on irrigation demands and would need to be negotiated with FRICO.

FRICO currently has 45 sites designated for recharge or injection wells. They also identified the Big Neres East Canal, which is currently abandoned, as a potential site for recharge because the hydrogeologic conditions are well suited for recharge. FRICO could be compensated by the Program to develop these sites for recharge.

Water would be injected into the alluvium for recovery at a later date. A certain percentage of the water that is injected will naturally return to Beebe Draw throughout the year and be available to other users to divert or store in Milton Reservoir or Lower Latham Reservoir. The percentage that would return to Beebe Draw would vary significantly based on the locations of the injection wells, hydrogeologic conditions, and how long after injection that water is recovered. Further investigation and monitoring would be required to determine the percentage that would return to Beebe Draw. For this level of analysis, it was assumed that 30 percent of the water injected would return to Beebe Draw and subject to use by other downstream irrigators under FRICO. Since Beebe Draw does not return to the South Platte River this water would not be available to the Program.

Water would be pumped from the aquifer during months of target flow shortages. Returning water to the South Platte would require improvements to existing irrigation ditches. Water could also potentially be delivered back to the South Platte River through the Gilmore Canal, which diverts north from Milton Reservoir and eventually connects with the old channel of Box Elder Creek. Water is then delivered to the Box Elder Drainage Ditch, which connects with the South Platte River. A group of several farmers own and maintain the Box Elder Drainage Ditch. The owners of the Box Elder Drainage Ditch allow FRICO to divert 15 to 20 cfs of tailwater back to the South Platte River if FRICO is running excess water for operational reasons. If this ditch were to be used by the Program it would need to be enlarged and rehabilitated. However, the Program would still need to coordinate deliveries back to the South Platte River with the owners of the Box Elder Drainage Ditch and FRICO. The excess capacity available would vary significantly depending on the enlarged capacity of the ditch and irrigation demands. In addition, due to the capacity constraints at Milton Reservoir it would be difficult to store program water and make timely releases to Gilmore Canal. Although this method of delivery could potentially be an option for delivery of program water back to the South Platte River it has not been evaluated for this analysis due to the uncertainty associated with numerous constraints.

It would be difficult to deliver water from Milton Reservoir down to Lower Latham Reservoir and then to the South Platte River. Although FRICO indicated they would be willing to store water in Milton Reservoir there is very little excess capacity particularly from February through early June. In addition, Lower Latham Ditch Company, which operates Lower Latham Reservoir, has consistently opposed the use of either their reservoir or ditch system by others. In addition, there are no existing irrigation ditches below Milton Reservoir that deliver water directly to Lower Latham Reservoir. In which case, existing ditches would need to be enlarged and extended to deliver water directly to Lower Latham Reservoir. Similarly, canal improvements would be needed to deliver water from Lower Latham Reservoir to the South Platte River. Even if canal improvements were made, delivery of water from Milton Reservoir to Lower Latham Reservoir would still be limited if existing ditches are being used for irrigation purposes. Due to the constraints associated with delivering water from Milton Reservoir to Lower Latham Reservoir and to then to the South Platte River it is unlikely that this delivery method would be cost effective or efficient.

Water could be delivered to the Speer Canal, which extends from Barr Lake north along the western edge of Beebe Draw and crosses into the South Platte drainage (FRICO, 1999). Just south of Platteville, Speer Canal is less than 5 miles from the South Platte River. A ditch could be constructed from Speer Canal to the South Platte River at this point, which would enable water to be delivered back to the South Platte. The capacity of the Speer Canal is roughly 125 cfs at Barr Lake (FRICO, 1999). This method of delivery could be a problem if Speer Canal is already flowing full for irrigation purposes and the Program wanted to make deliveries of recharge water to the South Platte River. Therefore, it was assumed that 125 cfs of capacity is only available for 10 days each month from March through November. The excess capacity available would vary significantly based on irrigation demands and would need to be negotiated with FRICO. More capacity could be available during the non-irrigation season, however, deliveries during December through February could be difficult due to freezing problems. Diversions during these months would only be possible if there is enough hydraulic head in the canals to produce flow velocities high enough to prevent freezing. It was assumed that deliveries back to the South Platte River can not be made from December through February.

For this analysis it was assumed that water pumped from the Beebe Draw aquifer would be delivered to Speer Canal. Water could be delivered to Speer Canal via existing ditches to the extent possible or via pipeline. There would be canal seepage losses along Speer Canal that would be lagged back to the river at a slower rate. The change in timing of return flows due to canal seepage has not been accounted for in this analysis. Deliveries back to the South Platte River were limited to 2,500 ac-ft per month due to the capacity constraints associated with Speer Canal.

The project would be located above Reach 7. Loss factors were not developed for the South Platte River above Reach 7, therefore, it was assumed that the effects of this project are added to the top of Reach 7. The net hydrologic effect at the top of Reach 7 is –3,949 ac-ft, as shown in Table 8.G.27. The net hydrologic effect is negative because more water is diverted to recharge than is pumped back to the South Platte River due to losses to Beebe Draw. Additional analysis and

Table 8.G.27
Beebe Draw Recharge Project
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	856	856	0	-45	0	856	856	856	856	856	856	856	7655
1976	856	856	-250	-4000	0	856	856	856	856	856	856	856	3450
1977	856	856	0	0	0	856	856	856	856	856	856	856	7700
1978	963	963	0	0	0	-595	963	963	963	963	963	963	7105
1979	963	963	0	0	0	963	963	963	963	-4000	963	963	3700
1980	1540	1540	-4000	-4000	-586	-430	-4000	-4000	-4000	1540	1540	1540	-13315
1981	963	963	0	0	0	963	963	963	963	963	0	963	7700
1982	856	856	0	-535	0	856	856	856	856	856	856	856	7165
1983	2500	2500	-4000	-4000	0	-4000	-4000	-4000	-4000	-4000	-4000	-2674	-29674
1984	-1708	2500	-4000	-4000	-3220	-4000	-4000	-4000	-4000	-4000	2500	-4000	-31928
1985	-4000	-4000	-4000	-4000	-4000	-4000	1540	1540	1540	1540	1540	0	-16300
1986	2500	2500	-4000	-4000	-695	-201	-3832	-957	-4000	-354	0	0	-13038
1987	0	0	-28	-3957	-1962	-3162	-4000	-4000	-4000	-2061	2500	0	-20670
1988	963	0	-4000	-4000	-3330	963	963	963	963	963	963	963	-3630
1989	1100	1100	0	-915	0	1100	1100	1100	1100	-414	1100	0	6372
1990	856	856	0	-4000	0	856	856	856	856	856	856	856	3700
1991	1100	1100	0	-1976	0	1100	1100	0	-4000	1100	1100	1100	1724
1992	963	963	-2094	-2720	0	-1988	963	963	963	963	963	963	899
1993	1283	1283	-2094	-2720	0	-1988	1283	1283	1283	-3994	427	-523	-4474
1994	-835	-1174	-2094	-2720	0	1283	1283	1283	1283	-3994	1283	1283	-3116
Average	629	774	-1528	-2379	-690	-486	-222	-133	-485	-525	806	291	-3949

modeling is required to determine whether losses to Beebe Draw could be reduced and the efficiency of this alternative improved.

The additions and depletions were routed downstream to the critical habitat using the water budget spreadsheet. Two routing scenarios were evaluated for the proposed recharge project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. The average annual net reductions to target flow shortages for each scenario are 5,443 ac-ft and 251 ac-ft, respectively, as shown in Tables 8.G.28 and 8.G.29.

Cost

The direct costs related to a Beebe Draw recharge project are primarily based on the capital costs associated with the construction of the recharge sites/injection wells, improvements to existing ditches and facilities, and compensation to FRICO to coordinate this recharge operation with their facilities and recharge sites. This project is similar to representative groundwater recharge projects in Reach 7, therefore, it was assumed that the costs associated with this project are similar to an extent to the cost of representative recharge projects in Reach 7.

It was assumed that water could be injected at a rate of 1,500 gpm. Based on a well service factor of 20 percent, approximately 25 wells would be required to inject a maximum of 4,000 ac-ft per month. Costs have also been included to use FRICO's existing facilities (irrigation ditches, reservoirs, and recharge sites), and make improvements to the Speer Canal. There is a high level of uncertainty associated with the costs to use FRICO's existing facilities. These costs would need to be negotiated with FRICO. In addition, costs have been included to modify downstream diversion structures on the South Platte in order for water to be protected to the Colorado-Nebraska state line.

The total capital cost associated with the project would be about $14.6 million assuming additional water is protected from diversions, and about $5.7 million assuming additional water is not protected from diversions, as shown in Table 8.G.10. The resulting cost per ac-ft of reductions to target flow shortages at the critical habitat is

Table 8.G.28
Beebe Draw Recharge Project
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	658	639	0	0	0	799	800	774	782	743	547	652	6394
1976	540	612	0	0	0	789	745	773	596	297	95	334	4783
1977	693	629	0	0	0	825	704	779	762	454	527	708	6080
1978	785	784	0	0	0	0	881	837	787	286	433	378	5171
1979	572	717	0	0	0	934	885	587	462	0	687	516	5361
1980	1004	1246	0	0	0	0	0	0	0	1079	1087	833	5249
1981	690	681	0	0	0	866	862	888	680	520	0	518	5705
1982	674	734	0	0	0	775	767	774	766	725	744	579	6539
1983	2376	2023	0	0	0	0	0	0	0	0	0	0	4399
1984	0	2363	0	0	0	0	0	0	0	0	1264	0	3627
1985	0	0	0	0	0	0	1414	1403	1304	1359	1397	0	6877
1986	2400	1917	0	0	0	0	0	0	0	0	0	0	4317
1987	0	0	0	0	0	0	0	0	0	0	1724	0	1724
1988	718	0	0	0	0	893	833	812	816	758	760	735	6325
1989	886	1067	0	0	0	973	977	904	990	0	845	0	6642
1990	793	757	0	0	0	831	799	798	740	419	698	484	6319
1991	703	858	0	0	0	1022	905	0	0	361	441	498	4789
1992	560	882	0	0	0	0	886	742	863	722	570	628	5853
1993	1044	1126	0	0	0	0	1203	1167	1153	0	390	0	6083
1994	0	0	0	0	0	1241	1187	1140	1105	0	1107	834	6614
Average	755	852	0	0	0	497	692	619	590	386	666	385	5443

Table 8.G.29
Beebe Draw Recharge Project
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	27	20	0	0	0	107	103	14	103	1	1	11	387
1976	18	14	0	0	0	199	29	5	0	0	0	2	268
1977	3	5	0	0	0	87	22	6	0	0	0	2	126
1978	10	5	0	0	0	0	21	3	2	0	0	0	42
1979	7	4	0	0	0	20	40	46	185	0	6	9	317
1980	27	90	0	0	0	0	0	0	0	0	0	14	131
1981	2	36	0	0	0	70	33	8	6	0	0	1	156
1982	3	1	0	0	0	9	4	1	2	1	0	7	29
1983	17	65	0	0	0	0	0	0	0	0	0	0	82
1984	0	519	0	0	0	0	0	0	0	0	32	0	551
1985	0	0	0	0	0	0	50	326	98	3	2	0	480
1986	423	173	0	0	0	0	0	0	0	0	0	0	596
1987	0	0	0	0	0	0	0	0	0	0	4	0	4
1988	6	0	0	0	0	271	68	106	12	1	1	7	470
1989	3	3	0	0	0	122	9	1	4	0	0	0	143
1990	5	2	0	0	0	223	217	6	1	0	1	2	457
1991	5	5	0	0	0	112	9	0	0	0	0	7	139
1992	5	6	0	0	0	0	91	1	8	3	7	10	131
1993	37	30	0	0	0	0	141	7	7	0	0	0	224
1994	0	0	0	0	0	253	32	6	1	0	0	3	296
Average	30	49	0	0	0	74	43	27	22	0	3	4	251

approximately $2,690 without diversion losses and $22,800 with diversion losses.

If sand dams are modified to bypass flows, then more than one alternative could be located above the sand dams without incurring the additional cost of sand dam replacement. The sand dams would only be modified once, therefore, the total cost to replace these dams would be incurred by all projects implemented in Colorado under the Program, as opposed to each individual project. Therefore, the cost per ac-ft for scenarios without diversion losses could be lower in the Action Plan if more than one alternative is selected in Region 2 that requires sand dam modifications.

Region 3

Groundwater Recharge/Return Flow Projects

The South Platte River alluvium thickness and permeability downstream of the Colorado-Nebraska state line is similar to sites in the Lower South Platte River region in Colorado. The sandhills found along the edge of the valley are eolean deposits consisting of fine to medium sand (Warner, et al., 1994). Due to the topography and high infiltration rates associated with the deposits that overlie the alluvium, there are several locations for recharge sites in the region.

Representative groundwater recharge/return flow projects have been evaluated for Reaches 10, 16, and 17 in Region 3. Maps of SDF factors and water table contours were reviewed to determine whether effective recharge sites exist in each reach. Potential sites that have been evaluated overlie the alluvial aquifer and are hydraulically connected to the river. In addition, the depth to the water table must be great enough so that the recharge mound build-up will not create water logging at the land surface. There is a significant groundwater mound build-up in the vicinity of Sutherland Reservoir, which is at the downstream end of Reach 10, therefore, potential recharge sites have not been evaluated in that area due to potential water logging problems.

For the purposes of this study representative sites associated with groundwater pumping to recharge were evaluated in the middle of Reach 10 at SDF factors of 60, 120, and 270. In addition to groundwater pumping recharge projects there may be opportunities to divert water into canals, in which case the canal seepage will be lagged back to the river. Water could potentially be diverted into the Gothenburg and Dawson Canals, in Reaches 16, and 17, respectively, and canal losses lagged back to the river. Based on the MBSA maps the Gothenburg and Dawson Canals and associated laterals are generally located at an SDF factor of 3,250 days.

Yield

An analysis of the amount of water available for diversion was completed for Reaches 10, 16, and 17. To simplify the analysis it was assumed that diversions to recharge can only occur outside of the irrigation season. Diversions to the Gothenburg and Dawson Canals should be possible throughout the non-irrigation season because there is enough hydraulic head in the respective canals to produce flow velocities high enough to prevent freezing.

Monthly diversions to the Gothenburg and Dawson Canals are limited based on the amount of water that can seep from the canal without generating a significant amount of tailwater. Information was provided by the Nebraska Public Power District (NPPD) regarding the maximum rates that can be diverted when no one is taking water for irrigation and the spillways back to the river are running at maximum capacity (NPPD, 1999a; 1999b; 1999c). Based on this information, monthly diversions to the Gothenburg and Dawson Canals were limited to 200 cfs and 150 cfs, respectively. The ditch loss is about 20 percent according to information provided by NPPD, therefore, the maximum ditch loss that would be lagged back to the river is 40 cfs and 30 cfs for the Gothenburg and Dawson Canals, respectively. Monthly diversions to recharge could also potentially be limited by climatic cycles. During wet years, it may not be possible to recharge groundwater when groundwater levels are excessively high. The third party impacts on nearby homeowners and landowners may be too severe to recharge water during wet years.

The flow available to a groundwater pumping recharge project in Reach 10 equals the flow at the Julesburg gage less Western Canal and Korty Canal diversions, which are the only diversions in Reach 10 upstream of the confluence of the South Platte River. CNPPID diversions were not included in the calculation of available flows in Reach 10. A significant portion of CNPPID's diversions are satisfied by NPPD returns and North Platte River flows. Flows available to recharge calculated in this manner may result in a minor impact on CNPPID's diversions, which may need to be offset, or compensated. Power interference charges would need to be paid to NPPD and CNPPID if their non-irrigation season diversions are affected. The cost of mitigating impacts on CNPPID and NPPD's diversions could be more than power interference charges depending on the severity of the impacts. These districts have minimum flow requirements that, when coupled with a change in historical flows in the South or North Platte Rivers, could impact drought protection and their ability to provide irrigation water.

The available flow to the Gothenburg Canal during the non-irrigation season was assumed to be the flow at the North Platte River gage at Brady, which is just upstream of the headgate. The available flow to the Dawson Canal during the non-irrigation season was assumed to be the flow at the North Platte River at Cozad, which is just downstream of the headgate. The Gothenburg Canal and Dawson Canal recharge projects rely on the same source of water and could not be fully implemented together as currently evaluated.

Diversions to recharge for all scenarios were limited to months of target flow excesses at the critical habitat. Recharge to the Platte River is computed as inflows minus evaporation, which is estimated to be one percent (1%) of gross diversions or pumping. The average annual groundwater pumping to recharge in the middle of Reach 10 is 34,845 ac-ft and 29,130 ac-ft, respectively. The average annual diversion to the Gothenburg and Dawson Canals is 5,484 ac-ft and 7,475 ac-ft, respectively.

Return flows were routed back to the river using the SDF model SDF View. Return flows associated with pumping groundwater wells were routed back to the river using SDF factors of 60, 120, and 270 days. An average SDF factor of 3250 days was used to route seepage from the Gothenburg and Dawson Canals. An average SDF factor of 300 days was used to route seepage from canal recharge projects in Reach 13. Monthly additions to flows in the river occur in months when river accretions exceed diversions to recharge. Monthly depletions occur in months when the diversions to recharge exceed the accretion in that month. The net hydrologic effects associated with each potential project are shown in Tables 8.G.30 through 8.G.34. The average

Table 8.G.30
Middle of Reach 10 : SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-4300	1221	541	312	211	154	118	95	78	-1569
1976	66	57	-2222	-6690	2479	1161	698	487	363	285	234	196	-2886
1977	168	146	128	115	103	93	85	78	72	66	62	57	1174
1978	54	51	47	45	42	40	38	36	35	33	31	30	482
1979	29	28	27	26	25	24	23	22	21	21	20	19	282
1980	19	18	-338	-8349	-5733	-4637	-3977	-3549	-3225	5232	2966	2011	-19561
1981	1512	1198	-2640	-2168	2399	1438	1044	835	695	597	525	467	5903
1982	421	383	-1563	-1210	1179	706	520	425	364	321	289	264	2098
1983	244	226	-7997	-5601	-4468	-3835	-3398	-3091	-2847	-2653	-2498	-2365	-38283
1984	-2254	6186	-4529	-3114	-2570	-2301	-2125	-2003	-1906	4817	4479	-5073	-10393
1985	-3285	-2618	-2265	-2061	-1911	-1804	6490	4099	3037	2437	2055	-995	3178
1986	2440	1788	-6720	-4487	-3480	2599	-4216	3655	-4551	5059	2834	-5785	-10863
1987	-3809	-2997	-2560	-2298	-624	-2421	-2039	-1865	-1747	6550	4159	-4740	-14390
1988	4992	1505	-1326	-4771	-3281	5684	3455	2593	2104	1790	1575	1408	15728
1989	1280	1175	-7123	-4786	4501	2628	1903	1542	1311	1154	1042	-2244	2383
1990	1892	1269	1029	-7576	3228	1824	1322	1083	933	832	760	703	7297
1991	657	618	-7623	-5241	4086	2247	1552	1216	-7199	3382	1900	1356	-3049
1992	1092	930	-5638	-5635	3983	-6125	4009	2317	1652	1307	1101	954	-55
1993	850	770	-7503	-5145	4163	-6033	4062	2352	1676	1324	1113	-7245	-9615
1994	-1062	-4605	-3919	-3279	5336	3148	2237	1763	1455	1245	1096	978	4393
Average	265	306	-3137	-3826	534	-251	600	610	-380	1696	1192	-996	-3387

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.31
Middle of Reach 10 : SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-4825	981	591	374	264	197	154	126	104	-2036
1976	89	77	-2528	-7756	2103	1296	847	614	469	374	310	262	-3843
1977	226	198	174	157	141	128	117	107	99	91	85	79	1601
1978	74	70	66	62	59	56	53	50	48	46	44	42	670
1979	40	39	37	36	34	33	32	31	30	29	28	27	395
1980	26	25	-381	-9406	-7365	-6169	-5381	-4846	-4431	5271	3539	2531	-26586
1981	1953	1573	-2836	-2667	2456	1762	1347	1102	930	805	712	636	7774
1982	576	525	-1705	-1493	1195	867	676	567	491	437	396	363	2893
1983	336	312	-9086	-7168	-5935	-5181	-4637	-4244	-3927	-3671	-3466	-3287	-49954
1984	-3138	6442	-4875	-4007	-3463	-3154	-2938	-2783	-2656	5040	5317	-5368	-15584
1985	-4157	-3481	-3079	-2833	-2644	-2507	6983	5087	3938	3227	2754	-767	2521
1986	2821	2335	-7377	-5660	-4588	2318	-4835	3609	-5068	5302	3543	-6273	-13872
1987	-4825	-3973	-3464	-3141	-1205	-3074	-2772	-2572	-2424	7068	5173	-4929	-20138
1988	5300	2104	-1262	-5407	-4217	5907	4282	3371	2798	2413	2140	1923	19352
1989	1755	1617	-7880	-6042	4494	3201	2461	2048	1768	1571	1427	-2342	4077
1990	2018	1624	1377	-8287	3059	2209	1715	1444	1264	1138	1045	970	9576
1991	910	858	-8564	-6666	3924	2676	1978	1599	-8026	3219	2290	1748	-4053
1992	1447	1252	-6263	-6876	3843	-6794	3967	2807	2124	1727	1476	1292	0
1993	1159	1056	-8407	-6539	4026	-6691	4031	2849	2153	1748	1491	-8074	-11197
1994	-1886	-5553	-5086	-4400	5468	3824	2866	2317	1942	1679	1489	1336	3997
Average	236	355	-3557	-4646	118	-435	558	671	-414	1883	1496	-986	-4720

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.32
Middle of Reach 10 : SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-5009	399	467	370	290	231	188	158	134	-2772
1976	116	102	-2639	-8406	1039	1095	871	694	562	466	396	341	-5363
1977	299	265	236	214	194	177	162	150	139	129	120	112	2196
1978	106	100	94	89	84	80	76	73	69	66	63	61	960
1979	58	56	54	52	50	48	46	45	43	42	41	39	574
1980	38	37	-391	-9811	-8999	-8054	-7276	-6688	-6203	4056	3555	2859	-36878
1981	2343	1960	-2685	-3067	2085	1921	1629	1401	1218	1076	965	871	9716
1982	794	729	-1628	-1702	1010	960	836	738	659	597	549	507	4050
1983	472	442	-9449	-8683	-7721	-6982	-6388	-5931	-5546	-5226	-4964	-4730	-64707
1984	-4533	5515	-5020	-5019	-4691	-4413	-4183	-4002	-3846	4274	5601	-5108	-25426
1985	-4985	-4575	-4228	-3978	-3769	-3607	6396	5689	4813	4130	3623	-114	-604
1986	3173	2961	-7199	-6646	-5872	1272	-5368	2847	-5349	4760	3996	-6097	-17523
1987	-5750	-5161	-4693	-4355	-2298	-3998	-3836	-3646	-3479	6525	5819	-4473	-29344
1988	5078	2681	-900	-5623	-5158	5228	4808	4163	3630	3221	2910	2650	22688
1989	2442	2267	-7752	-7090	3638	3472	3012	2652	2369	2150	1980	-2005	7135
1990	2042	2000	1831	-8189	2360	2397	2121	1894	1714	1574	1465	1372	12584
1991	1296	1229	-8694	-7955	2845	2739	2334	2021	-8083	2456	2442	2124	-5249
1992	1869	1673	-6239	-7847	2861	-7116	3178	2994	2553	2204	1949	1747	-175
1993	1592	1467	-8503	-7800	2970	-7032	3238	3037	2585	2227	1967	-8104	-12353
1994	-2908	-6460	-6427	-5862	4501	4064	3409	2916	2534	2244	2023	1839	1873
Average	177	364	-3712	-5334	-724	-864	272	567	-469	1858	1733	-799	-6931

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.33
Gothenburg Canal : SDF = 3250 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-1774	0	0	0	1	2	4	6	8	-1753
1976	9	11	-1668	-1757	14	14	15	17	21	25	28	32	-3239
1977	35	37	39	40	41	42	42	42	42	42	41	41	484
1978	40	40	39	38	38	-1807	36	36	35	35	36	37	-1398
1979	38	40	41	42	42	43	43	43	43	42	42	41	499
1980	41	40	-1805	-1805	-1806	-1806	-1806	40	43	49	57	66	-8693
1981	74	82	-1263	-1389	99	103	106	109	112	115	118	121	-1613
1982	122	123	-1711	-1245	123	122	121	122	123	125	127	128	-1720
1983	129	129	-1715	-1715	-1716	-1717	-1718	127	130	134	140	148	-7645
1984	-1689	162	-1677	-1672	-1669	-1665	-1661	187	193	200	208	217	-8865
1985	-1619	-1612	-1606	-1602	-1599	-1595	253	259	266	274	282	289	-8011
1986	296	300	-1541	-1539	-1539	-1540	-1541	303	304	307	311	317	-5560
1987	-1523	-1519	-1516	-1514	-1513	-1512	-1509	339	344	351	358	366	-8849
1988	372	-1466	-1462	-1460	-1459	385	385	387	389	392	395	398	-2745
1989	399	399	-1299	-1449	392	389	385	382	380	378	376	374	1106
1990	372	368	365	-1216	356	351	346	342	338	334	330	327	2612
1991	323	319	-1351	-1487	306	302	298	296	294	294	293	292	178
1992	291	289	-1469	-1545	282	-1565	277	275	275	276	278	280	-2054
1993	282	283	-1405	-1562	282	-1564	279	278	279	280	283	285	-2001
1994	-1285	-1556	-1556	-1556	288	288	290	293	297	302	306	309	-3582
Average	-165	-177	-1128	-1308	-452	-637	-268	194	195	198	201	204	-3143

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

Table 8.G.34
Dawson Canal : SDF = 3250 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-2459	0	0	0	1	3	6	8	11	-2430
1976	13	15	-2442	-2441	19	20	21	24	29	35	40	45	-4623
1977	49	52	55	57	58	59	59	60	59	59	58	58	683
1978	57	56	55	54	53	-2407	51	50	50	50	50	52	-1828
1979	54	56	57	58	59	59	59	59	59	59	58	57	694
1980	56	56	-2404	-2405	-2406	-2407	-2406	55	60	67	77	89	-11568
1981	101	111	-2073	-2242	134	138	143	147	152	158	162	166	-2904
1982	169	170	-2288	-2189	171	170	170	171	173	176	179	181	-2748
1983	183	183	-2276	-2276	-2277	-2279	-2279	181	184	190	198	208	-10060
1984	-2241	226	-2225	-2220	-2215	-2211	-2206	259	267	276	287	298	-11705
1985	-2150	-2141	-2134	-2128	-2124	-2119	345	352	362	372	383	393	-10589
1986	401	407	-2048	-2046	-2046	-2047	-2048	410	412	415	421	428	-7340
1987	-2025	-2019	-2016	-2014	-2012	-2010	-2007	457	464	472	482	492	-11736
1988	501	-1950	-1945	-1943	-1942	518	518	520	523	527	531	534	-3608
1989	536	536	-1925	-1928	527	522	517	513	510	508	506	504	1325
1990	500	496	491	-1973	480	473	467	461	455	451	446	442	3187
1991	437	432	-2032	-2001	415	410	405	402	400	400	399	398	64
1992	397	395	-2067	-2070	385	-2078	378	376	376	377	380	382	-2771
1993	384	386	-2073	-2074	384	-2077	380	380	380	383	386	389	-2773
1994	-2068	-2066	-2066	-2066	393	393	396	401	407	413	418	423	-5022
Average	-232	-230	-1568	-1815	-597	-844	-352	264	266	270	273	277	-4288

Note: The average annual net hydrologic effect is negative due to evaporation and some of the accretions not being included because they would have occurred after 1994.

annual net hydrologic effect associated with these recharge projects range from –3,143 ac-ft to –6,931 ac-ft.

The water budget spreadsheet was used to route lagged accretions and depletions downstream to the critical habitat. Two routing scenarios were evaluated for the proposed recharge project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. Reductions to target flow shortages for recharge projects with a SDF factor of 120 days and the Gothenburg and Dawson recharge projects are summarized in Tables 8.G.35 through 8.G.40. Tables showing monthly net reductions to target flow shortages for the other SDF factors are provided in Appendix F. The average annual reduction to target flow shortages for groundwater pumping recharge projects, and diversions to Gothenburg and Dawson Canals range from 1,097 ac-ft to 9,987 ac-ft without diversions, and from 667 ac-ft to 4,511 ac-ft with diversions.

Cost

The items that influence the direct costs of recharge projects are described in more detail in the cost sections for representative groundwater recharge/return flow projects in Regions 1 and 2. The total capitalized cost for projects involving pumping to recharge in Reach 10 is about $10.2 million, as shown in Table 8.G.41. The total capital costs associated with potential recharge projects in Reaches 16 (Gothenburg Canal) and 17 (Dawson Canal) are about $650,000 and $880,000, respectively, as shown in Table 8.G.41. The resulting cost per ac-ft of reductions to target flow shortages range from $600 to $1,280 without diversions and from $620 to $2,590 with diversions.

Pumping from the Groundwater Mound

A mound of stored groundwater (the "mound") has been created beneath the canals, reservoirs and irrigated lands associated with the Nebraska Public Power District (NPPD) and the Central Nebraska Public Power and Irrigation District (CNPPID). The existence of the mound is confirmed by Nebraska State maps of groundwater level changes.

Table 8.G.35

Middle of Reach 10 : SDF = 120 Days

Reductions to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	877	560	359	247	186	140	84	87	2539
1976	59	56	0	0	1932	1211	766	575	343	139	37	107	5223
1977	187	147	130	122	128	125	100	102	92	52	55	69	1308
1978	63	58	52	43	55	0	51	47	42	14	21	17	464
1979	25	29	31	28	25	33	30	29	21	0	20	15	286
1980	18	21	0	0	0	0	0	0	0	3877	2619	1425	7959
1981	1429	1127	0	0	2010	1609	1257	1046	684	459	0	357	9978
1982	463	510	0	0	1179	795	629	531	457	386	358	253	5562
1983	325	255	0	0	0	0	0	0	0	0	0	0	580
1984	0	6144	0	0	0	0	0	0	0	0	3256	0	9400
1985	0	0	0	0	0	0	4889	4877	3714	2982	2587	0	19048
1986	2761	2029	0	0	0	0	0	0	0	0	0	0	4790
1987	0	0	0	0	0	0	0	0	0	0	3721	0	3721
1988	4053	0	0	0	0	5551	3814	2941	2477	1993	1762	1520	24111
1989	1446	1585	0	0	4232	2871	2273	1749	1651	0	1140	0	16948
1990	1914	1455	1115	0	2947	2171	1645	1386	1145	587	888	573	15825
1991	595	677	0	0	3751	2530	1680	0	0	1109	961	821	12124
1992	863	1157	0	0	3760	0	3773	2258	1966	1230	905	873	16785
1993	967	934	0	0	2526	0	3890	2684	2006	0	427	0	13434
1994	0	0	0	0	4424	1700	2736	2142	1759	0	1353	912	15025
Average	758	809	66	10	1392	958	1395	1031	827	648	1010	351	9256

Table 8.G.36

Middle of Reach 10 : SDF = 120 Days

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	596	449	233	88	75	9	9	40	1497
1976	37	39	0	0	1504	895	524	203	51	7	2	39	3300
1977	111	87	91	79	83	74	63	39	15	2	5	38	688
1978	35	34	35	38	45	0	32	11	3	1	1	5	239
1979	12	16	22	20	14	21	16	7	12	0	1	5	147
1980	7	8	0	0	0	0	0	0	0	83	211	603	911
1981	689	596	0	0	1584	1144	429	165	40	86	0	134	4866
1982	264	311	0	0	936	616	253	72	28	12	16	99	2607
1983	201	171	0	0	0	0	0	0	0	0	0	0	372
1984	0	4135	0	0	0	0	0	0	0	0	412	0	4547
1985	0	0	0	0	0	0	4628	2424	1283	260	289	0	8884
1986	1966	1289	0	0	0	0	0	0	0	0	0	0	3255
1987	0	0	0	0	0	0	0	0	0	0	577	0	577
1988	2643	0	0	0	0	4356	2296	1751	318	315	228	703	12610
1989	669	791	0	0	3132	2195	834	257	283	0	104	0	8265
1990	887	855	726	0	1909	1379	1115	546	124	17	103	108	7768
1991	361	525	0	0	2512	1629	479	0	0	49	51	215	5821
1992	293	651	0	0	2701	0	2102	398	346	254	131	148	7024
1993	710	624	0	0	1981	0	2110	619	468	0	333	0	6846
1994	0	0	0	0	3709	1700	1406	698	261	0	86	514	8374
Average	444	506	44	7	1035	723	826	364	165	55	128	132	4430

Table 8.G.37
Gothenburg Canal : SDF = 3250 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	1	2	4	4	7	17
1976	6	8	0	0	12	13	14	17	15	9	3	13	112
1977	29	28	29	31	37	41	36	41	40	24	27	36	400
1978	35	33	31	27	36	0	35	34	31	11	17	16	306
1979	24	30	35	33	32	42	41	41	30	0	31	23	363
1980	28	33	0	0	0	0	0	0	0	37	43	38	178
1981	55	59	0	0	81	94	100	104	83	67	0	69	713
1982	99	120	0	0	121	112	115	116	116	112	117	91	1118
1983	126	106	0	0	0	0	0	0	0	0	0	0	232
1984	0	155	0	0	0	0	0	0	0	0	137	0	292
1985	0	0	0	0	0	0	245	250	253	258	268	0	1275
1986	291	262	0	0	0	0	0	0	0	0	0	0	552
1987	0	0	0	0	0	0	0	0	0	0	263	0	263
1988	288	0	0	0	0	363	346	341	350	331	332	319	2670
1989	332	393	0	0	370	350	360	331	360	0	306	0	2802
1990	356	332	296	0	344	346	335	331	312	176	286	198	3312
1991	235	253	0	0	293	287	256	0	0	103	126	140	1693
1992	176	268	0	0	277	0	266	226	258	218	173	192	2053
1993	237	251	0	0	177	0	271	265	264	0	272	0	1738
1994	0	0	0	0	233	284	280	275	276	0	284	216	1848
Average	116	116	20	5	101	97	135	119	120	68	135	68	1097

Table 8.G.38
Gothenburg Canal : SDF = 3250 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	1	0	1	1	4
1976	6	8	0	0	12	13	13	6	3	1	0	4	65
1977	27	27	29	31	37	40	35	30	12	2	2	15	288
1978	34	33	31	27	36	0	34	17	3	1	2	2	220
1979	23	29	35	33	32	42	39	16	24	0	2	5	280
1980	28	33	0	0	0	0	0	0	0	2	5	12	80
1981	54	60	0	0	81	94	35	29	5	17	0	40	416
1982	98	120	0	0	121	112	106	40	18	5	6	33	659
1983	125	106	0	0	0	0	0	0	0	0	0	0	231
1984	0	155	0	0	0	0	0	0	0	0	28	0	183
1985	0	0	0	0	0	0	203	154	69	24	25	0	475
1986	267	264	0	0	0	0	0	0	0	0	0	0	532
1987	0	0	0	0	0	0	0	0	0	0	30	0	30
1988	269	0	0	0	0	359	285	285	50	90	24	75	1437
1989	117	387	0	0	370	350	249	33	76	0	36	0	1619
1990	344	332	296	0	344	346	300	201	31	12	40	35	2280
1991	214	252	0	0	293	287	205	0	0	7	7	46	1311
1992	168	268	0	0	277	0	214	54	36	21	44	38	1120
1993	233	251	0	0	177	0	236	122	55	0	39	0	1113
1994	0	0	0	0	233	277	205	106	32	0	27	124	1004
Average	100	116	20	5	101	96	108	55	21	9	16	21	667

Table 8.G.39
Dawson Canal : SDF = 3250 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	1	3	5	6	9	24
1976	9	11	0	0	17	19	20	23	22	14	5	19	158
1977	41	39	41	45	53	58	52	58	57	38	38	52	573
1978	50	47	44	39	51	0	50	49	45	18	25	22	439
1979	34	42	49	47	45	59	58	58	42	0	43	32	509
1980	39	46	0	0	0	0	0	0	0	61	63	52	260
1981	75	81	0	0	111	128	137	142	115	92	0	96	978
1982	139	167	0	0	170	158	164	165	165	160	165	129	1583
1983	180	151	0	0	0	0	0	0	0	0	0	0	331
1984	0	218	0	0	0	0	0	0	0	0	189	0	407
1985	0	0	0	0	0	0	339	345	350	353	367	0	1755
1986	398	356	0	0	0	0	0	0	0	0	0	0	754
1987	0	0	0	0	0	0	0	0	0	0	357	0	357
1988	392	0	0	0	0	491	473	465	478	449	450	435	3633
1989	449	530	0	0	499	473	494	452	489	0	414	0	3802
1990	487	449	400	0	466	470	458	452	426	256	390	272	4526
1991	325	344	0	0	400	393	354	0	0	142	173	193	2324
1992	243	368	0	0	380	0	369	315	356	299	238	265	2832
1993	329	345	0	0	249	0	374	368	366	0	374	0	2405
1994	0	0	0	0	320	391	388	384	382	0	392	302	2559
Average	160	160	27	7	138	132	187	164	165	94	185	94	1510

Table 8.G.40
Dawson Canal : SDF = 3250 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	1	3	4	5	9	22
1976	8	11	0	0	17	18	19	22	20	13	7	19	155
1977	40	39	41	45	53	57	50	56	53	30	36	49	550
1978	49	47	44	39	51	0	49	47	39	15	21	23	423
1979	33	41	49	47	45	59	56	55	41	0	41	33	500
1980	39	46	0	0	0	0	0	0	0	46	53	52	236
1981	75	81	0	0	111	128	131	138	107	90	0	95	954
1982	138	167	0	0	170	158	152	152	156	136	145	126	1499
1983	180	151	0	0	0	0	0	0	0	0	0	0	331
1984	0	217	0	0	0	0	0	0	0	0	176	0	393
1985	0	0	0	0	0	0	326	331	328	312	342	0	1639
1986	393	360	0	0	0	0	0	0	0	0	0	0	752
1987	0	0	0	0	0	0	0	0	0	0	340	0	340
1988	391	0	0	0	0	486	442	463	434	425	431	431	3504
1989	445	530	0	0	499	473	479	428	468	0	392	0	3715
1990	476	449	400	0	466	470	452	442	398	222	348	243	4366
1991	316	344	0	0	400	393	341	0	0	127	156	190	2267
1992	243	368	0	0	380	0	363	298	322	291	225	254	2744
1993	328	345	0	0	249	0	374	361	356	0	366	0	2379
1994	0	0	0	0	320	391	388	382	359	0	337	292	2469
Average	158	160	27	7	138	132	181	159	154	86	171	91	1462

TABLE 8.G.41
COST SUMMARY
GROUNDWATER RECHARGE/RETURN FLOW PROJECTS IN REGION 3

	REGION 3		
	Gothenburg Canal Recharge Project	Dawson Canal Recharge Project	Groundwater Pumping Projects Middle of Reach 10
CONSTRUCTION COSTS PER DIVERSION STRUCTURE OR WELL			
Subsurface Investigations	3,500	3,500	3,500
Diversion Structures	3,000	3,000	
Recharge Basins	6,000	6,000	6,000
Measuring Devices	4,000	4,000	
Well Construction & Pumps			30,000
Conveyance Conduit			7,000
Power Hook-up			4,000
4000' 12" dia pipe @ $5/ft			20,000
Replacement Costs (Well & Pump Hardware)			54,000
Total Cost per Structure or Well	**16,500**	**16,500**	**124,500**
No. of structures or wells	1	1	50
Total Construction Cost	**16,500**	**16,500**	**6,225,000**
Engineering Fees (10%)	2,000	2,000	623,000
Total Construction Costs + Engineering Fees	**18,500**	**18,500**	**6,848,000**
ANNUAL COSTS			
Amt. Diverted	5,484	7,475	34,845
Delivery Cost ($10/af)	54,840	74,750	
Pump operation cost ($8/af)			278,760
Annual Maintenance Costs ($300/well)			15,000
Total Annual Cost	**54,840**	**74,750**	**293,760**
No. of years	20	20	20
Discount Rate	6%	6%	6%
Present Value of Annual Costs	**629,010**	**857,377**	**3,369,404**
Total Capitalized Cost of Project	**650,000**	**880,000**	**10,220,000**

Note: It was assumed that wells and pumping hardware would need to be replaced after 15 years.
Future costs are based on an rate of 4 percent and a present day cost of $30,000.

The study team has relied on the report "The Impact of NPPD and CNPPID on the Platte River: Nebraska's Ground-Water Mound" by Bredehoeft and Hinckley, July 1998, to evaluate projects that involve pumping from the groundwater mound. This report was prepared by the State of Wyoming to support their position in the Nebraska v. Wyoming lawsuit. While the Bredehoeft-Hinckley report suggests that the mound is growing, the "Report on the South-Central Area Ground Water Planning Study" by NNRC, 1990, suggests the possibility that the growth of the mound could stabilize or even reverse direction in the future. The operations of NNPD and CNPPID greatly influence the growth rate of the mound. There is uncertainty regarding the growth rate of the mound and the extent to which water from the mound could be used to supplement streamflows. Further investigation and monitoring would be required prior to implementing projects that involve pumping from the groundwater mound to ensure the sustainability of these projects. Any project designed to take water from the mound will need to be implemented on a demonstration basis or be phased-in so that actual impacts can be monitored and determinations made that the project is consistent with applicable Nebraska laws, regulations, and groundwater management objectives.

The estimated growth rate of the mound is critical in determining the sustainability of these alternatives, therefore, an accurate understanding of the hydrologic characteristics and growth rate of the mound and the potential impacts of these projects is required prior to implementation. Any project that mines the groundwater mound would likely be to the detriment of existing water users and potentially the environment, in which case the project would come under strong opposition.

Groundwater levels in a number of observation wells have risen for the entire period since 1941 (Bredehoeft and Hinckley, 1998). The mound south of the Platte River is located in parts of Lincoln, Gosper, Phelps, and Kearney Counties. High water table conditions also exist in Dawson County. The mound currently contains approximately 14 million ac-ft of groundwater storage (Bredehoeft and Hinckley, 1998). CNPPID applied for permits for 7 million ac-ft and 2.5 million ac-ft of incidental groundwater storage and recovery in 1984 (Application U-2) and 1988 (Application U-12), respectively.

The groundwater build-up is the result of diversions from the Platte River into the area south of the river (Bredehoeft and Hinckley, 1998).

Water recharging the aquifer in that area is a result of seepage from: 1) several reservoirs including, Sutherland Reservoir, Lake Maloney, Jeffrey Reservoir, Johnson Lake and Elwood Reservoir, 2) canals and laterals including the Sutherland and Tri-County Canals, 3) NPPD and CNPPID irrigation systems, and 4) precipitation recharge. Seepage data were obtained from the Bredehoeft-Hinckley report. In that report, seepage data were calculated from a water balance for each of the following three mound segments:

- The Sutherland Canal from the Sutherland Reservoir to the South Platte River return;
- The Tri-County Canal from the Platte River diversion to the Johnson return; and
- The Phelps, E-65, and E-67 irrigation systems supplied by the Tri-County Canal.

The seepage loss to groundwater in these segments was generally calculated as diversions from the river less evaporation from the canals and reservoirs, less changes in reservoir storage, less returns to the South Platte and/or Platte Rivers, less groundwater irrigation consumption. The data required to complete the water balances for each segment were obtained from CNPPID's U-2 and U-12 applications for incidental underground storage and recovery. The net groundwater recharge for the three segments to the mound for the period 1987 though 1996 was calculated to be 397 cfs (Bredehoeft and Hinckley, 1998).

Bredehoeft and Hinckley (1998) used the flow model JDB-2D/3D to investigate the dynamics of the groundwater build-up in the mound. The model results indicate that the system is still not in equilibrium and that there is approximately 75 cfs going into storage. The model predicted that in the year 2018 approximately 50 cfs would still be going into storage. The amount going into storage was defined as that amount of water in excess of that which returns to surface streams or is consumed by evaporation or crop consumption.

The model has also shown that the growth of the mound has altered groundwater divides and groundwater gradients, which has increased the amount of groundwater flowing out of the Platte River basin to the Republican and Little Blue River Basins. The flow of groundwater from the Platte Basin to the Republican and Little Blue River Basins is a result of natural geologic conditions because the Platte basin is higher in elevation and there is no geologic barrier to flow between the basins. The Platte River, therefore, naturally loses water to the Republican and Little Blue River Basins. Since the development of the groundwater mound, however, there is additional transbasin groundwater movement because of increased saturated thickness and the gradient. The model predicts that an additional 20 cfs of groundwater is flowing into the Republican River Basin to the south of the mound area, and into the Little Blue River Basin to the south and east of the mound. This increased transbasin groundwater export, as opposed to the underlying groundwater export that occurs naturally regardless of the existence of the mound, could potentially be targeted to reduce natural groundwater exports from the basin. Reductions in transbasin exports has implications both in terms of quantity and quality in the Republican and Little Blue River watersheds. Water quantity is at issue in litigation between Kansas and Nebraska over the Republican River, therefore, this alternative could have legal obstacles.

Yield

Based on the results of the Bredehoeft and Hinckley report, the mound will still be gaining in storage at a rate of 50 cfs in 2018 and the amount of groundwater being exported to the Republican and Little Blue Rivers will also be increasing. As such, there exists an opportunity to pump from the mound and return water to either the South Platte River or Platte River. Pumping the mound at a rate of 50 cfs would theoretically eliminate the continued growth of the groundwater mound. Pumping the mound at 70 cfs could possibly eliminate the growth of the mound and the export of groundwater to the Republican and Little Blue Rivers. The five scenarios that have been evaluated are as follows:

1. Pump from the mound up to 51,000 ac-ft/yr (equivalent to a constant rate of about 70 cfs) and discharge water to the Platte River during periods of target flow shortages.
2. Pump from the mound up to 36,500 ac-ft/yr (equivalent to a constant rate of about 50 cfs) and discharge water to the Platte River during periods of target flow shortages.

3. Pump from the mound up to 14,500 ac-ft/yr (equivalent to a constant rate of about 20 cfs) and discharge water to the Platte River during periods of target flow shortages.
4. Pump from the mound up to 14,500 ac-ft/yr (equivalent to a constant rate of about 20 cfs) for irrigation of lands previously irrigated by surface water.
5. Pump from the mound up to 51,000 ac-ft/yr (equivalent to a constant rate of about 70 cfs) for irrigation of lands previously irrigated by surface water.

Each scenario is described in more detail below.

It was assumed that projects involving pumping from the mound would be implemented in areas where the water table is near the surface or in areas further from the river. Pumping from areas that are further from the river increases the likelihood that the majority of the water pumped is from the mound growth and transbasin exports rather than Platte River return flows. Any rate of pumping would take some amount of water from the mound, some from transbasin exports, and some return flows to the Platte River. Alternatives were assumed to be located further from the river to increase the likelihood that the majority of the water pumped is from the mound growth and transbasin exports rather than Platte River return flows. These scenarios are not intended to suggest that any one component of flow can be captured, rather they are intended to provide a range of impacts for pumping the mound at various rates.

It was assumed that scenarios 1 through 3 involve pumping to a drain that will deliver water to the river. There are numerous drains throughout the area impacted by the mound that intercept groundwater and return to the river. The intent of these scenarios is to minimize costs and use these drains to return water to the river to the maximum extent possible. There could be opportunities to route groundwater pumped from the mound through wetlands and wet meadows along the Central Platte, however, this has not been considered in this analysis. Scenarios 4 and 5 assumed water is pumped directly to canals and laterals that currently serve the irrigated lands under E-65, E-67, and Phelps County Canals.

These scenarios apply to the downstream end of Reach 10, Reaches 17 and 18, and the upstream end of Reach 19. Scenarios 1 through 5 target returns flows contributing to the growth of the mound. Scenarios 1 and 5 also have the potential to reduce groundwater exports from the basin. Scenarios 1, 2 and 3 are essentially the same in concept and involve pumping from the mound up to 51,000 ac-ft/yr, 36,500 ac-ft/yr, and 14,500 ac-ft/yr, respectively, as shown in Tables 8.G.42 through 8.G.53. For scenarios 4 and 5, it was assumed that 14,500 ac-ft and 51,000 ac-ft, respectively, of the annual irrigation supply for lands irrigated under the E-65, E-67, and Phelps County Canals could be supplied by groundwater as opposed to surface water. The monthly distribution of pumping is based on the average monthly distribution of surface water diversions for the E-65, E-67, and Phelps County Canals. Reducing the supply in the irrigation system by 20 cfs to 70 cfs would not be great enough to change the operations at Lake McConaughy. Demand changes of up to 70 cfs would be small in relation to the total demand for Lake McConaughy storage releases. If surface water is saved in the irrigated area due to conversion to groundwater irrigation, it was assumed that returns to the Platte River through the J-2 return would increase by a similar amount. Therefore, this water would reduce the need for EA releases in the summer and would have minimal impact on Lake McConaughy operations. The net hydrologic effects of scenarios 4 and 5 are shown in Tables 8.G.54 through 8.G.59.

Maps of the build-up in the water table were reviewed to determine whether effective well sites exist in each reach. The most effective sites for these projects are located in Reaches 10, 17, 18, and 19 where the mound build-up is most prominent. Pumping from the mound in Reaches 10, 17, 18, and 19 applies to about 20 miles, 28 miles, 16 miles, and 16 miles of the Platte River, respectively. It was assumed that a high capacity well could be located every quarter mile along the length of the river in the vicinity of the mound. Irrigation wells in Central Platte area south of the Platte River typically average 1,000 gpm. Based on these factors, monthly groundwater pumping in Reaches 10, 17, 18, and 19 was limited to 10,500 ac-ft, 15,000 ac-ft, 8,500 ac-ft, and 8,500 ac-ft, respectively. The monthly limits on groundwater pumping are constrained by the number of wells and the average pumping rate. These limits do not apply to scenarios 4 and 5 because wells can be located throughout the irrigated area under Phelps County, E-65 and E-67 canals. For all scenarios, it was assumed that pumping occurs only during periods of target flow shortages.

Table 8.G.42
Scenario 1 - Groundwater Pumping from the Mound in Reach 10
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4831	4831	2686	0	4831	4831	4831	4831	4831	4831	4831	4831	51000
1976	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1977	4552	4552	925	4552	4552	4552	4552	4552	4552	4552	4552	4552	51000
1978	4879	4879	2214	4879	4879	0	4879	4879	4879	4879	4879	4879	51000
1979	5243	5243	1698	5243	5243	2118	5243	5243	5243	0	5243	5243	51000
1980	10200	10200	0	0	0	0	0	0	0	10200	10200	10200	51000
1981	5667	5667	0	0	5667	5667	5667	5667	5667	5667	0	5667	51000
1982	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1983	10500	10500	0	0	0	0	0	0	0	0	0	0	21000
1984	0	8552	0	0	0	0	0	0	0	0	10500	0	19052
1985	0	0	0	0	0	0	4889	10500	10500	10500	10500	0	46889
1986	8380	10500	0	0	0	0	0	0	0	0	0	0	18880
1987	0	0	0	0	0	0	0	0	0	0	10500	0	10500
1988	6517	0	0	0	0	6517	6517	6517	6517	5380	6517	6517	51000
1989	6375	6375	0	0	6375	6375	6375	6375	6375	0	6375	0	51000
1990	4636	4636	4636	0	4636	4636	4636	4636	4636	4636	4636	4636	51000
1991	6375	6375	0	0	6375	6375	6375	0	0	6375	6375	6375	51000
1992	6418	4842	0	0	6418	0	6418	6418	6418	1230	6418	6418	51000
1993	8429	8429	0	0	8429	0	8429	8429	8429	0	427	0	51000
1994	0	0	0	0	8217	1700	8217	8217	8217	0	8217	8217	51000
Average	5160	5289	608	734	3791	2649	4361	4323	4323	3423	5519	3887	44066

Table 8.G.43
Scenario 1 - Groundwater Pumping from the Mound in Reach 17
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4831	4831	2686	0	4831	4831	4831	4831	4831	4831	4831	4831	51000
1976	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1977	4552	4552	925	4552	4552	4552	4552	4552	4552	4552	4552	4552	51000
1978	4879	4879	2214	4879	4879	0	4879	4879	4879	4879	4879	4879	51000
1979	5243	5243	1698	5243	5243	2118	5243	5243	5243	0	5243	5243	51000
1980	10200	10200	0	0	0	0	0	0	0	10200	10200	10200	51000
1981	5667	5667	0	0	5667	5667	5667	5667	5667	5667	0	5667	51000
1982	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1983	15000	15000	0	0	0	0	0	0	0	0	0	0	30000
1984	0	8552	0	0	0	0	0	0	0	0	15000	0	23552
1985	0	0	0	0	0	0	4889	11528	11528	11528	11528	0	51000
1986	8380	12479	0	0	0	0	0	0	0	0	0	0	20859
1987	0	0	0	0	0	0	0	0	0	0	15000	0	15000
1988	6517	0	0	0	0	6517	6517	6517	6517	5380	6517	6517	51000
1989	6375	6375	0	0	6375	6375	6375	6375	6375	0	6375	0	51000
1990	4636	4636	4636	0	4636	4636	4636	4636	4636	4636	4636	4636	51000
1991	6375	6375	0	0	6375	6375	6375	0	0	6375	6375	6375	51000
1992	6418	4842	0	0	6418	0	6418	6418	6418	1230	6418	6418	51000
1993	8429	8429	0	0	8429	0	8429	8429	8429	0	427	0	51000
1994	0	0	0	0	8217	1700	8217	8217	8217	0	8217	8217	51000
Average	5385	5613	608	734	3791	2649	4361	4375	4375	3474	6020	3887	45271

Table 8.G.44
Scenario 1 - Groundwater Pumping from the Mound in Reach 18
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4831	4831	2686	0	4831	4831	4831	4831	4831	4831	4831	4831	51000
1976	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1977	4552	4552	925	4552	4552	4552	4552	4552	4552	4552	4552	4552	51000
1978	4879	4879	2214	4879	4879	0	4879	4879	4879	4879	4879	4879	51000
1979	5243	5243	1698	5243	5243	2118	5243	5243	5243	0	5243	5243	51000
1980	8500	8500	0	0	0	0	0	0	0	8500	8500	8500	42500
1981	5667	5667	0	0	5667	5667	5667	5667	5667	5667	0	5667	51000
1982	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1983	8500	8500	0	0	0	0	0	0	0	0	0	0	17000
1984	0	8500	0	0	0	0	0	0	0	0	8500	0	17000
1985	0	0	0	0	0	0	4889	8500	8500	8500	8500	0	38889
1986	8380	8500	0	0	0	0	0	0	0	0	0	0	16880
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	6517	0	0	0	0	6517	6517	6517	6517	5380	6517	6517	51000
1989	6375	6375	0	0	6375	6375	6375	6375	6375	0	6375	0	51000
1990	4636	4636	4636	0	4636	4636	4636	4636	4636	4636	4636	4636	51000
1991	6375	6375	0	0	6375	6375	6375	0	0	6375	6375	6375	51000
1992	6418	4842	0	0	6418	0	6418	6418	6418	1230	6418	6418	51000
1993	8429	8429	0	0	8429	0	8429	8429	8429	0	427	0	51000
1994	0	0	0	0	8217	1700	8217	8217	8217	0	8217	8217	51000
Average	4975	5001	608	734	3791	2649	4361	4223	4223	3238	5134	3802	42738

Table 8.G.45
Scenario 1 - Groundwater Pumping from the Mound in Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4831	4831	2686	0	4831	4831	4831	4831	4831	4831	4831	4831	51000
1976	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1977	4552	4552	925	4552	4552	4552	4552	4552	4552	4552	4552	4552	51000
1978	4879	4879	2214	4879	4879	0	4879	4879	4879	4879	4879	4879	51000
1979	5243	5243	1698	5243	5243	2118	5243	5243	5243	0	5243	5243	51000
1980	8500	8500	0	0	0	0	0	0	0	8500	8500	8500	42500
1981	5667	5667	0	0	5667	5667	5667	5667	5667	5667	0	5667	51000
1982	5100	5100	0	0	5100	5100	5100	5100	5100	5100	5100	5100	51000
1983	8500	8500	0	0	0	0	0	0	0	0	0	0	17000
1984	0	8500	0	0	0	0	0	0	0	0	8500	0	17000
1985	0	0	0	0	0	0	4889	8500	8500	8500	8500	0	38889
1986	8380	8500	0	0	0	0	0	0	0	0	0	0	16880
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	6517	0	0	0	0	6517	6517	6517	6517	5380	6517	6517	51000
1989	6375	6375	0	0	6375	6375	6375	6375	6375	0	6375	0	51000
1990	4636	4636	4636	0	4636	4636	4636	4636	4636	4636	4636	4636	51000
1991	6375	6375	0	0	6375	6375	6375	0	0	6375	6375	6375	51000
1992	6418	4842	0	0	6418	0	6418	6418	6418	1230	6418	6418	51000
1993	8429	8429	0	0	8429	0	8429	8429	8429	0	427	0	51000
1994	0	0	0	0	8217	1700	8217	8217	8217	0	8217	8217	51000
Average	4975	5001	608	734	3791	2649	4361	4223	4223	3238	5134	3802	42738

Table 8.G.46
Scenario 2 - Groundwater Pumping from the Mound in Reach 10
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3381	3381	2686	0	3381	3381	3381	3381	3381	3381	3381	3381	36500
1976	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1977	3234	3234	925	3234	3234	3234	3234	3234	3234	3234	3234	3234	36500
1978	3429	3429	2214	3429	3429	0	3429	3429	3429	3429	3429	3429	36500
1979	3632	3632	1698	3632	3632	2118	3632	3632	3632	0	3632	3632	36500
1980	7300	7300	0	0	0	0	0	0	0	7300	7300	7300	36500
1981	4056	4056	0	0	4056	4056	4056	4056	4056	4056	0	4056	36500
1982	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1983	10500	10500	0	0	0	0	0	0	0	0	0	0	21000
1984	0	8552	0	0	0	0	0	0	0	0	10500	0	19052
1985	0	0	0	0	0	0	4889	7903	7903	7903	7903	0	36500
1986	8380	10500	0	0	0	0	0	0	0	0	0	0	18880
1987	0	0	0	0	0	0	0	0	0	0	10500	0	10500
1988	4563	0	0	0	0	4563	4563	4563	4563	4563	4563	4563	36500
1989	4563	4563	0	0	4563	4563	4563	4563	4563	0	4563	0	36500
1990	3318	3318	3318	0	3318	3318	3318	3318	3318	3318	3318	3318	36500
1991	4563	4563	0	0	4563	4563	4563	0	0	4563	4563	4563	36500
1992	4409	4409	0	0	4409	0	4409	4409	4409	1230	4409	4409	36500
1993	6012	6012	0	0	6012	0	6012	6012	6012	0	427	0	36500
1994	0	0	0	0	5800	1700	5800	5800	5800	0	5800	5800	36500
Average	3932	4237	542	515	2685	1940	3157	3080	3080	2514	4241	2749	32672

Table 8.G.47
Scenario 2 - Groundwater Pumping from the Mound in Reach 17
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3381	3381	2686	0	3381	3381	3381	3381	3381	3381	3381	3381	36500
1976	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1977	3234	3234	925	3234	3234	3234	3234	3234	3234	3234	3234	3234	36500
1978	3429	3429	2214	3429	3429	0	3429	3429	3429	3429	3429	3429	36500
1979	3632	3632	1698	3632	3632	2118	3632	3632	3632	0	3632	3632	36500
1980	7300	7300	0	0	0	0	0	0	0	7300	7300	7300	36500
1981	4056	4056	0	0	4056	4056	4056	4056	4056	4056	0	4056	36500
1982	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1983	15000	15000	0	0	0	0	0	0	0	0	0	0	30000
1984	0	8552	0	0	0	0	0	0	0	0	15000	0	23552
1985	0	0	0	0	0	0	4889	7903	7903	7903	7903	0	36500
1986	8380	12479	0	0	0	0	0	0	0	0	0	0	20859
1987	0	0	0	0	0	0	0	0	0	0	15000	0	15000
1988	4563	0	0	0	0	4563	4563	4563	4563	4563	4563	4563	36500
1989	4563	4563	0	0	4563	4563	4563	4563	4563	0	4563	0	36500
1990	3318	3318	3318	0	3318	3318	3318	3318	3318	3318	3318	3318	36500
1991	4563	4563	0	0	4563	4563	4563	0	0	4563	4563	4563	36500
1992	4409	4409	0	0	4409	0	4409	4409	4409	1230	4409	4409	36500
1993	6012	6012	0	0	6012	0	6012	6012	6012	0	427	0	36500
1994	0	0	0	0	5800	1700	5800	5800	5800	0	5800	5800	36500
Average	4157	4561	542	515	2685	1940	3157	3080	3080	2514	4691	2749	33671

Table 8.G.48
Scenario 2 - Groundwater Pumping from the Mound in Reach 18
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3381	3381	2686	0	3381	3381	3381	3381	3381	3381	3381	3381	36500
1976	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1977	3234	3234	925	3234	3234	3234	3234	3234	3234	3234	3234	3234	36500
1978	3429	3429	2214	3429	3429	0	3429	3429	3429	3429	3429	3429	36500
1979	3632	3632	1698	3632	3632	2118	3632	3632	3632	0	3632	3632	36500
1980	7300	7300	0	0	0	0	0	0	0	7300	7300	7300	36500
1981	4056	4056	0	0	4056	4056	4056	4056	4056	4056	0	4056	36500
1982	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1983	8500	8500	0	0	0	0	0	0	0	0	0	0	17000
1984	0	8500	0	0	0	0	0	0	0	0	8500	0	17000
1985	0	0	0	0	0	0	4889	7903	7903	7903	7903	0	36500
1986	8380	8500	0	0	0	0	0	0	0	0	0	0	16880
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	4563	0	0	0	0	4563	4563	4563	4563	4563	4563	4563	36500
1989	4563	4563	0	0	4563	4563	4563	4563	4563	0	4563	0	36500
1990	3318	3318	3318	0	3318	3318	3318	3318	3318	3318	3318	3318	36500
1991	4563	4563	0	0	4563	4563	4563	0	0	4563	4563	4563	36500
1992	4409	4409	0	0	4409	0	4409	4409	4409	1230	4409	4409	36500
1993	6012	6012	0	0	6012	0	6012	6012	6012	0	427	0	36500
1994	0	0	0	0	5800	1700	5800	5800	5800	0	5800	5800	36500
Average	3832	4035	542	515	2685	1940	3157	3080	3080	2514	4041	2749	32169

Table 8.G.49
Scenario 2 - Groundwater Pumping from the Mound in Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3381	3381	2686	0	3381	3381	3381	3381	3381	3381	3381	3381	36500
1976	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1977	3234	3234	925	3234	3234	3234	3234	3234	3234	3234	3234	3234	36500
1978	3429	3429	2214	3429	3429	0	3429	3429	3429	3429	3429	3429	36500
1979	3632	3632	1698	3632	3632	2118	3632	3632	3632	0	3632	3632	36500
1980	7300	7300	0	0	0	0	0	0	0	7300	7300	7300	36500
1981	4056	4056	0	0	4056	4056	4056	4056	4056	4056	0	4056	36500
1982	3650	3650	0	0	3650	3650	3650	3650	3650	3650	3650	3650	36500
1983	8500	8500	0	0	0	0	0	0	0	0	0	0	17000
1984	0	8500	0	0	0	0	0	0	0	0	8500	0	17000
1985	0	0	0	0	0	0	4889	7903	7903	7903	7903	0	36500
1986	8380	8500	0	0	0	0	0	0	0	0	0	0	16880
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	4563	0	0	0	0	4563	4563	4563	4563	4563	4563	4563	36500
1989	4563	4563	0	0	4563	4563	4563	4563	4563	0	4563	0	36500
1990	3318	3318	3318	0	3318	3318	3318	3318	3318	3318	3318	3318	36500
1991	4563	4563	0	0	4563	4563	4563	0	0	4563	4563	4563	36500
1992	4409	4409	0	0	4409	0	4409	4409	4409	1230	4409	4409	36500
1993	6012	6012	0	0	6012	0	6012	6012	6012	0	427	0	36500
1994	0	0	0	0	5800	1700	5800	5800	5800	0	5800	5800	36500
Average	3832	4035	542	515	2685	1940	3157	3080	3080	2514	4041	2749	32169

Table 8.G.50
Scenario 3 - Groundwater Pumping from the Mound in Reach 10
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1976	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1977	1234	1234	925	1234	1234	1234	1234	1234	1234	1234	1234	1234	14500
1978	1318	1318	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	14500
1979	1318	1318	1318	1318	1318	1318	1318	1318	1318	0	1318	1318	14500
1980	2900	2900	0	0	0	0	0	0	0	2900	2900	2900	14500
1981	1611	1611	0	0	1611	1611	1611	1611	1611	1611	0	1611	14500
1982	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1983	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1984	0	7250	0	0	0	0	0	0	0	0	7250	0	14500
1985	0	0	0	0	0	0	2900	2900	2900	2900	2900	0	14500
1986	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1987	0	0	0	0	0	0	0	0	0	0	10500	0	10500
1988	1813	0	0	0	0	1813	1813	1813	1813	1813	1813	1813	14500
1989	1813	1813	0	0	1813	1813	1813	1813	1813	0	1813	0	14500
1990	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1991	1813	1813	0	0	1813	1813	1813	0	0	1813	1813	1813	14500
1992	1659	1659	0	0	1659	0	1659	1659	1659	1230	1659	1659	14500
1993	2346	2346	0	0	2346	0	2346	2346	2346	0	427	0	14500
1994	0	0	0	0	2133	1700	2133	2133	2133	0	2133	2133	14500
Average	1893	2165	310	194	1039	842	1275	1184	1184	1018	2131	1067	14300

Table 8.G.51
Scenario 3 - Groundwater Pumping from the Mound in Reach 17
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1976	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1977	1234	1234	925	1234	1234	1234	1234	1234	1234	1234	1234	1234	14500
1978	1318	1318	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	14500
1979	1318	1318	1318	1318	1318	1318	1318	1318	1318	0	1318	1318	14500
1980	2900	2900	0	0	0	0	0	0	0	2900	2900	2900	14500
1981	1611	1611	0	0	1611	1611	1611	1611	1611	1611	0	1611	14500
1982	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1983	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1984	0	7250	0	0	0	0	0	0	0	0	7250	0	14500
1985	0	0	0	0	0	0	2900	2900	2900	2900	2900	0	14500
1986	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1987	0	0	0	0	0	0	0	0	0	0	14500	0	14500
1988	1813	0	0	0	0	1813	1813	1813	1813	1813	1813	1813	14500
1989	1813	1813	0	0	1813	1813	1813	1813	1813	0	1813	0	14500
1990	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1991	1813	1813	0	0	1813	1813	1813	0	0	1813	1813	1813	14500
1992	1659	1659	0	0	1659	0	1659	1659	1659	1230	1659	1659	14500
1993	2346	2346	0	0	2346	0	2346	2346	2346	0	427	0	14500
1994	0	0	0	0	2133	1700	2133	2133	2133	0	2133	2133	14500
Average	1893	2165	310	194	1039	842	1275	1184	1184	1018	2331	1067	14500

Table 8.G.52
Scenario 3 - Groundwater Pumping from the Mound in Reach 18
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1976	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1977	1234	1234	925	1234	1234	1234	1234	1234	1234	1234	1234	1234	14500
1978	1318	1318	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	14500
1979	1318	1318	1318	1318	1318	1318	1318	1318	1318	0	1318	1318	14500
1980	2900	2900	0	0	0	0	0	0	0	2900	2900	2900	14500
1981	1611	1611	0	0	1611	1611	1611	1611	1611	1611	0	1611	14500
1982	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1983	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1984	0	7250	0	0	0	0	0	0	0	0	7250	0	14500
1985	0	0	0	0	0	0	2900	2900	2900	2900	2900	0	14500
1986	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	1813	0	0	0	0	1813	1813	1813	1813	1813	1813	1813	14500
1989	1813	1813	0	0	1813	1813	1813	1813	1813	0	1813	0	14500
1990	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1991	1813	1813	0	0	1813	1813	1813	0	0	1813	1813	1813	14500
1992	1659	1659	0	0	1659	0	1659	1659	1659	1230	1659	1659	14500
1993	2346	2346	0	0	2346	0	2346	2346	2346	0	427	0	14500
1994	0	0	0	0	2133	1700	2133	2133	2133	0	2133	2133	14500
Average	1893	2165	310	194	1039	842	1275	1184	1184	1018	2031	1067	14200

Table 8.G.53
Scenario 3 - Groundwater Pumping from the Mound in Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1976	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1977	1234	1234	925	1234	1234	1234	1234	1234	1234	1234	1234	1234	14500
1978	1318	1318	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	14500
1979	1318	1318	1318	1318	1318	1318	1318	1318	1318	0	1318	1318	14500
1980	2900	2900	0	0	0	0	0	0	0	2900	2900	2900	14500
1981	1611	1611	0	0	1611	1611	1611	1611	1611	1611	0	1611	14500
1982	1450	1450	0	0	1450	1450	1450	1450	1450	1450	1450	1450	14500
1983	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1984	0	7250	0	0	0	0	0	0	0	0	7250	0	14500
1985	0	0	0	0	0	0	2900	2900	2900	2900	2900	0	14500
1986	7250	7250	0	0	0	0	0	0	0	0	0	0	14500
1987	0	0	0	0	0	0	0	0	0	0	8500	0	8500
1988	1813	0	0	0	0	1813	1813	1813	1813	1813	1813	1813	14500
1989	1813	1813	0	0	1813	1813	1813	1813	1813	0	1813	0	14500
1990	1318	1318	1318	0	1318	1318	1318	1318	1318	1318	1318	1318	14500
1991	1813	1813	0	0	1813	1813	1813	0	0	1813	1813	1813	14500
1992	1659	1659	0	0	1659	0	1659	1659	1659	1230	1659	1659	14500
1993	2346	2346	0	0	2346	0	2346	2346	2346	0	427	0	14500
1994	0	0	0	0	2133	1700	2133	2133	2133	0	2133	2133	14500
Average	1893	2165	310	194	1039	842	1275	1184	1184	1018	2031	1067	14200

Table 8.G.54
Scenario 4 - Groundwater Pumping from the Mound in Reach 17
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1976	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1977	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1978	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1979	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1980	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1981	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1982	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1983	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1984	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1985	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1986	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1987	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1988	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1989	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1990	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1991	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1992	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1993	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1994	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
Average	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500

Table 8.G.55
Scenario 4 - Groundwater Pumping from the Mound in Reach 18
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1976	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1977	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1978	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1979	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1980	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1981	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1982	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1983	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1984	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1985	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1986	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1987	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1988	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1989	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1990	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1991	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1992	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1993	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1994	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
Average	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500

Table 8.G.56
Scenario 4 - Groundwater Pumping from the Mound in Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1976	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1977	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1978	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1979	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1980	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1981	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1982	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1983	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1984	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1985	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1986	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1987	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1988	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1989	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1990	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1991	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1992	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1993	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
1994	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500
Average	0	0	0	145	1450	2755	4930	4495	725	0	0	0	14500

Table 8.G.57
Scenario 5 - Groundwater Pumping from the Mound in Reach 17
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1976	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1977	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1978	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1979	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1980	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1981	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1982	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1983	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1984	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1985	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1986	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1987	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1988	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1989	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1990	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1991	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1992	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1993	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1994	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
Average	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000

Table 8.G.58
Scenario 5 - Groundwater Pumping from the Mound in Reach 18
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1976	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1977	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1978	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1979	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1980	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1981	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1982	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1983	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1984	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1985	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1986	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1987	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1988	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1989	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1990	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1991	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1992	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1993	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1994	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
Average	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000

Table 8.G.59
Scenario 5 - Groundwater Pumping from the Mound in Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1975	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1976	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1977	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1978	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1979	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1980	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1981	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1982	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1983	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1984	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1985	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1986	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1987	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1988	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1989	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1990	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1991	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1992	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1993	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
1994	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000
Average	0	0	0	510	5100	9690	17340	15810	2550	0	0	0	51000

The net effect on the river is assumed to be the amount pumped returned to the river in that month because wells are assumed to be pumping water that would have been contributing to the growth of the mound and/or into the Republican and Little Blue River Basins. The groundwater mound is in connection with the Platte River and contributes directly to providing return flow gains to the central Platte River, therefore, pumping from the mound could reduce flows to the river. Alternatives were assumed to be located further from the river to increase the likelihood that the majority of the water pumped is from the mound growth and transbasin exports rather than Platte River return flows. Based on this assumption the reductions to Platte River flows from pumping the mound were assumed to be negligible. However, site specific studies would be required to estimate the amounts of water pumped from each source under these scenarios and to account for reductions in Platte River return flows. The yields associated with these projects would decrease if a portion of the water being pumped consists of Platte River return flows.

The water budget spreadsheet was used to route additional flows associated with each scenario downstream to the critical habitat to determine potential reductions to target flow shortages. Two routing scenarios were evaluated for the proposed recharge project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. Reductions to target flow shortages without diversion losses are shown in Tables 8.G.60 through 8.G.77. Tables of reductions to target flow shortages for with diversion losses are provided in Appendix F. The average annual reductions to target flow shortages for these scenarios range from 7,620 ac-ft to 37,895 ac- ft assuming additional flows can be protected and from 5,671 ac-ft to 37,754 ac-ft assuming additional flows cannot be protected. These yields are may be overstated based on the assumption that all water pumped would not have returned to the Platte River.

Cost

The items that influence the direct costs of projects that involve pumping from the mound are described in more detail in the cost sections for Regions 1 and 2 groundwater recharge/return flow

Table 8.G.60
Scenario 1 - Groundwater Pumping from the Mound in Reach 10
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3890	3677	1983	0	4324	4589	4662	4543	4586	4429	3247	4072	44001
1976	3386	3698	0	0	4690	4775	4634	4810	3770	1924	611	2114	34412
1977	3797	3404	691	3563	4137	4469	3908	4362	4277	2616	2955	3976	42157
1978	4151	4040	1764	3388	4609	0	4693	4606	4287	1573	2345	2056	37511
1979	3263	3959	1441	4194	3894	2088	5021	4978	3676	0	3889	2925	39328
1980	6909	8320	0	0	0	0	0	0	0	7591	7671	5807	36298
1981	4169	4069	0	0	4642	5186	5321	5400	4195	3272	0	3219	39472
1982	4125	4970	0	0	5035	4691	4781	4814	4776	4546	4662	3583	45984
1983	10213	8586	0	0	0	0	0	0	0	0	0	0	18799
1984	0	8167	0	0	0	0	0	0	0	0	6757	0	14925
1985	0	0	0	0	0	0	4706	10106	9952	9808	9943	0	44515
1986	8221	9136	0	0	0	0	0	0	0	0	0	0	17357
1987	0	0	0	0	0	0	0	0	0	0	7649	0	7649
1988	5019	0	0	0	0	6136	5829	5717	5812	4498	5431	5198	43640
1989	5279	6264	0	0	6009	5729	5929	5491	5998	0	5144	0	45842
1990	4423	4165	3757	0	4472	4563	4464	4471	4242	2427	3984	2778	43746
1991	4189	5039	0	0	6102	6041	5443	0	0	2226	2713	3017	34770
1992	3851	4482	0	0	6289	0	6131	5216	5975	963	3970	4363	41239
1993	7061	7471	0	0	5293	0	8165	7987	7917	0	408	0	44302
1994	0	0	0	0	6655	1675	7878	7667	7540	0	7574	5682	44671
Average	4097	4472	482	557	3308	2497	4078	4008	3850	2294	3948	2440	36031

Table 8.G.61
Scenario 1 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4003	3710	1993	0	4357	4640	4753	4667	4675	4539	3315	4150	44802
1976	3455	3733	0	0	4721	4826	4731	4939	3896	2015	636	2164	35117
1977	3867	3437	695	3579	4170	4516	3979	4463	4387	2956	3009	4076	43135
1978	4263	4076	1774	3499	4650	0	4802	4728	4420	1817	2397	2113	38538
1979	3349	3996	1450	4217	3968	2107	5148	5104	3725	0	3955	2983	40001
1980	7085	8398	0	0	0	0	0	0	0	9282	8340	5950	39055
1981	4244	4111	0	0	4680	5250	5474	5494	4312	3338	0	3295	40199
1982	4206	5037	0	0	5076	4743	4947	4942	4895	4694	4745	3647	46932
1983	14800	12355	0	0	0	0	0	0	0	0	0	0	27155
1984	0	8226	0	0	0	0	0	0	0	0	9953	0	18179
1985	0	0	0	0	0	0	4815	11321	11185	10991	11113	0	49425
1986	8320	10931	0	0	0	0	0	0	0	0	0	0	19252
1987	0	0	0	0	0	0	0	0	0	0	11157	0	11157
1988	5108	0	0	0	0	6187	5960	5846	5999	4598	5550	5314	44562
1989	5348	6319	0	0	6049	5781	6122	5651	6139	0	5239	0	46647
1990	4527	4206	3780	0	4506	4606	4556	4557	4368	2661	4070	2871	44708
1991	4751	5087	0	0	6151	6117	5585	0	0	2283	2784	3112	35870
1992	3938	4521	0	0	6335	0	6279	5408	6110	979	4049	4477	42096
1993	7233	7540	0	0	5480	0	8313	8196	8139	0	416	0	45316
1994	0	0	0	0	6700	1691	8062	7894	7774	0	7748	5887	45756
Average	4425	4784	485	565	3342	2523	4176	4160	4001	2508	4424	2502	37895

Table 8.G.62
Scenario 1 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4021	3928	2029	0	4398	4726	4771	4702	4724	4601	3351	4453	45705
1976	3763	4181	0	0	4904	4953	4892	4974	3959	2048	650	2207	36531
1977	3893	3799	709	3650	4353	4524	4250	4483	4425	3012	3039	4273	44411
1978	4282	4110	1901	3502	4753	0	4820	4760	4509	1850	2426	2155	39067
1979	3617	4250	1462	4221	3974	2110	5172	5139	3849	0	3992	3007	40792
1980	6041	7011	0	0	0	0	0	0	0	7892	7049	5154	33148
1981	4424	4367	0	0	4739	5444	5514	5529	4375	3362	0	3550	41304
1982	4219	5069	0	0	5081	4912	4980	4982	4943	4774	4792	3663	47414
1983	8411	7566	0	0	0	0	0	0	0	0	0	0	15977
1984	0	8324	0	0	0	0	0	0	0	0	5687	0	14012
1985	0	0	0	0	0	0	4833	8388	8301	8183	8263	0	37968
1986	8334	7958	0	0	0	0	0	0	0	0	0	0	16293
1987	0	0	0	0	0	0	0	0	0	0	6372	0	6372
1988	5118	0	0	0	0	6194	5979	5872	6099	4632	5598	5344	44836
1989	5818	6331	0	0	6055	5788	6172	5718	6189	0	5286	0	47358
1990	4551	4410	3784	0	4565	4614	4572	4576	4430	2716	4140	3031	45387
1991	5052	5096	0	0	6253	6228	5618	0	0	2321	2828	3148	36545
1992	4069	4531	0	0	6367	0	6309	5485	6171	985	4087	4532	42537
1993	7468	7961	0	0	5485	0	8340	8256	8207	0	418	0	46135
1994	0	0	0	0	6706	1693	8097	7958	7877	0	7837	5932	46102
Average	4154	4445	494	569	3382	2559	4216	4041	3903	2319	3791	2522	36395

Table 8.G.63
Scenario 1 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4145	4241	2152	0	4494	4811	4790	4737	4773	4662	3578	4758	47141
1976	4213	4694	0	0	5087	5079	5053	5008	4150	2496	1290	2651	39721
1977	4005	4215	752	3839	4536	4531	4522	4502	4461	3256	3267	4474	46358
1978	4375	4246	2054	3699	4857	0	4836	4791	4611	2296	2789	2571	41126
1979	4072	4607	1505	4368	4157	2112	5193	5169	4148	0	4186	3337	42855
1980	6496	7229	0	0	0	0	0	0	0	8044	7297	5787	34854
1981	4751	4769	0	0	4919	5638	5553	5564	4587	3701	0	4062	43544
1982	4351	5077	0	0	5087	5081	5012	5017	4986	4854	4854	3875	48193
1983	8434	8181	0	0	0	0	0	0	0	0	0	0	16615
1984	0	8473	0	0	0	0	0	0	0	0	6108	0	14581
1985	0	0	0	0	0	0	4849	8426	8353	8260	8322	0	38211
1986	8347	8472	0	0	0	0	0	0	0	0	0	0	16819
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	5321	0	0	0	0	6243	6064	5975	6205	4753	5750	5525	45836
1989	6292	6343	0	0	6104	5875	6224	5843	6236	0	5461	0	48378
1990	4575	4613	3907	0	4623	4620	4588	4592	4486	3013	4255	3384	46656
1991	5487	5282	0	0	6355	6340	5741	0	0	2915	3353	3625	39098
1992	4507	4580	0	0	6399	0	6339	5655	6235	1023	4436	4824	43997
1993	7796	8384	0	0	5906	0	8365	8308	8267	0	421	0	47446
1994	0	0	0	0	6924	1695	8131	8025	7971	0	7930	6278	46955
Average	4358	4670	519	595	3472	2601	4263	4081	3973	2464	4000	2758	37754

Table 8.G.64

Scenario 2 - Groundwater Pumping from the Mound in Reach 10
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2722	2573	1983	0	3026	3212	3263	3180	3210	3100	2273	2850	31391
1976	2423	2647	0	0	3357	3418	3316	3442	2698	1377	437	1513	24628
1977	2698	2419	691	2531	2939	3175	2776	3099	3039	1859	2099	2825	30150
1978	2918	2839	1764	2381	3239	0	3298	3237	3013	1105	1648	1445	26887
1979	2260	2742	1441	2905	2697	2088	3478	3448	2546	0	2694	2026	28327
1980	4944	5955	0	0	0	0	0	0	0	5433	5490	4156	25978
1981	2984	2912	0	0	3322	3712	3808	3865	3002	2342	0	2304	28250
1982	2952	3557	0	0	3604	3357	3422	3445	3418	3253	3336	2565	32910
1983	10213	8586	0	0	0	0	0	0	0	0	0	0	18799
1984	0	8167	0	0	0	0	0	0	0	0	6757	0	14925
1985	0	0	0	0	0	0	4706	7606	7491	7382	7484	0	34668
1986	8221	9136	0	0	0	0	0	0	0	0	0	0	17357
1987	0	0	0	0	0	0	0	0	0	0	7649	0	7649
1988	3514	0	0	0	0	4295	4081	4003	4069	3815	3802	3639	31217
1989	3778	4483	0	0	4300	4100	4243	3930	4293	0	3681	0	32809
1990	3166	2981	2689	0	3200	3265	3195	3200	3036	1737	2851	1988	31308
1991	2998	3606	0	0	4367	4323	3895	0	0	1593	1942	2159	24884
1992	2645	4081	0	0	4320	0	4211	3583	4104	963	2727	2997	29631
1993	5037	5329	0	0	3775	0	5824	5697	5647	0	408	0	31717
1994	0	0	0	0	4697	1675	5561	5412	5322	0	5347	4011	32025
Average	3174	3601	428	391	2342	1831	2954	2857	2744	1698	3031	1724	26775

Table 8.G.65

Scenario 2 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2802	2597	1993	0	3049	3247	3326	3266	3272	3177	2320	2905	31954
1976	2473	2672	0	0	3379	3454	3386	3535	2788	1442	455	1549	25133
1977	2747	2441	695	2543	2963	3209	2827	3171	3117	2100	2138	2896	30846
1978	2996	2864	1774	2459	3268	0	3375	3323	3106	1277	1685	1485	27611
1979	2320	2768	1450	2921	2749	2107	3566	3535	2580	0	2740	2066	28801
1980	5070	6010	0	0	0	0	0	0	0	6643	5969	4258	27951
1981	3037	2942	0	0	3350	3757	3918	3932	3086	2389	0	2358	28770
1982	3010	3605	0	0	3633	3394	3541	3537	3503	3360	3396	2610	33588
1983	14800	12355	0	0	0	0	0	0	0	0	0	0	27155
1984	0	8226	0	0	0	0	0	0	0	0	9953	0	18179
1985	0	0	0	0	0	0	4815	7761	7668	7535	7619	0	35397
1986	8320	10931	0	0	0	0	0	0	0	0	0	0	19252
1987	0	0	0	0	0	0	0	0	0	0	11157	0	11157
1988	3576	0	0	0	0	4332	4173	4092	4200	3899	3885	3721	31877
1989	3827	4522	0	0	4329	4137	4381	4044	4393	0	3749	0	33385
1990	3240	3010	2705	0	3225	3297	3261	3261	3126	1905	2913	2054	31997
1991	3400	3641	0	0	4402	4378	3997	0	0	1634	1992	2227	25672
1992	2705	4117	0	0	4352	0	4313	3715	4197	979	2781	3075	30234
1993	5159	5378	0	0	3909	0	5930	5846	5806	0	416	0	32442
1994	0	0	0	0	4730	1691	5691	5572	5488	0	5469	4155	32796
Average	3474	3904	431	396	2367	1850	3025	2930	2816	1817	3432	1768	28210

Table 8.G.66
Scenario 2 - Groundwater Pumping from the Mound in Reach 18 Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2814	2749	2029	0	3078	3307	3339	3291	3306	3220	2345	3116	32597
1976	2693	2992	0	0	3510	3545	3501	3559	2834	1466	465	1580	26144
1977	2766	2699	709	2593	3092	3214	3020	3185	3144	2140	2159	3036	31756
1978	3009	2888	1901	2461	3341	0	3387	3345	3169	1300	1705	1515	28021
1979	2505	2944	1462	2924	2752	2110	3583	3560	2666	0	2765	2083	29354
1980	5188	6022	0	0	0	0	0	0	0	6778	6054	4427	28468
1981	3166	3125	0	0	3392	3896	3946	3957	3131	2406	0	2541	29560
1982	3019	3627	0	0	3637	3516	3564	3566	3538	3416	3430	2621	33934
1983	8411	7566	0	0	0	0	0	0	0	0	0	0	15977
1984	0	8324	0	0	0	0	0	0	0	0	5687	0	14012
1985	0	0	0	0	0	0	4833	7799	7718	7608	7682	0	35639
1986	8334	7958	0	0	0	0	0	0	0	0	0	0	16293
1987	0	0	0	0	0	0	0	0	0	0	6372	0	6372
1988	3583	0	0	0	0	4336	4186	4111	4269	3929	3919	3741	32074
1989	4164	4531	0	0	4334	4143	4417	4092	4429	0	3783	0	33893
1990	3257	3156	2708	0	3267	3302	3272	3275	3170	1944	2963	2169	32483
1991	3616	3647	0	0	4475	4457	4021	0	0	1661	2024	2253	26155
1992	2795	4125	0	0	4374	0	4334	3768	4239	985	2808	3113	30540
1993	5327	5678	0	0	3912	0	5949	5889	5854	0	418	0	33028
1994	0	0	0	0	4734	1693	5716	5618	5560	0	5532	4187	33040
Average	3232	3602	440	399	2395	1876	3053	2951	2851	1843	3006	1819	27467

Table 8.G.67
Scenario 2 - Groundwater Pumping from the Mound in Reach 19 Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2901	2968	2152	0	3145	3367	3352	3315	3340	3263	2504	3330	33639
1976	3015	3360	0	0	3641	3635	3616	3584	2970	1786	923	1897	28428
1977	2845	2994	752	2727	3222	3219	3212	3199	3169	2313	2321	3178	33152
1978	3075	2984	2054	2600	3413	0	3399	3367	3241	1614	1960	1807	29513
1979	2821	3191	1505	3026	2879	2112	3597	3581	2873	0	2899	2312	30797
1980	5579	6209	0	0	0	0	0	0	0	6909	6267	4970	29934
1981	3400	3413	0	0	3520	4035	3974	3982	3283	2649	0	2907	31164
1982	3114	3633	0	0	3640	3636	3587	3591	3568	3474	3474	2773	34491
1983	8434	8181	0	0	0	0	0	0	0	0	0	0	16615
1984	0	8473	0	0	0	0	0	0	0	0	6108	0	14581
1985	0	0	0	0	0	0	4849	7834	7767	7680	7738	0	35867
1986	8347	8472	0	0	0	0	0	0	0	0	0	0	16819
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	3725	0	0	0	0	4371	4245	4183	4344	4031	4025	3868	32792
1989	4503	4539	0	0	4368	4205	4455	4182	4463	0	3908	0	34624
1990	3274	3302	2797	0	3309	3306	3284	3286	3210	2156	3045	2422	33391
1991	3927	3780	0	0	4548	4537	4109	0	0	2086	2400	2594	27982
1992	3096	4170	0	0	4396	0	4354	3884	4283	1023	3047	3314	31566
1993	5561	5980	0	0	4213	0	5966	5926	5897	0	421	0	33963
1994	0	0	0	0	4888	1695	5740	5665	5626	0	5598	4431	33643
Average	3381	3782	463	418	2459	1906	3087	2979	2902	1949	3167	1990	28483

Table 8.G.68
Scenario 3 - Groundwater Pumping from the Mound in Reach 10
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1061	1003	973	0	1180	1252	1272	1240	1251	1208	886	1111	12437
1976	963	1051	0	0	1333	1358	1317	1367	1072	547	174	601	9784
1977	1029	923	691	966	1122	1212	1059	1182	1160	709	801	1078	11932
1978	1122	1092	1050	915	1245	0	1268	1244	1158	425	633	555	10709
1979	820	995	1119	1054	979	1299	1262	1252	924	0	978	736	11419
1980	1964	2366	0	0	0	0	0	0	0	2158	2181	1651	10320
1981	1185	1157	0	0	1320	1475	1513	1535	1193	930	0	915	11222
1982	1173	1413	0	0	1432	1334	1359	1369	1358	1292	1325	1019	13074
1983	7052	5928	0	0	0	0	0	0	0	0	0	0	12980
1984	0	6924	0	0	0	0	0	0	0	0	4666	0	11590
1985	0	0	0	0	0	0	2791	2791	2749	2709	2746	0	13786
1986	7112	6308	0	0	0	0	0	0	0	0	0	0	13420
1987	0	0	0	0	0	0	0	0	0	0	7649	0	7649
1988	1396	0	0	0	0	1706	1621	1590	1616	1515	1510	1446	12401
1989	1501	1781	0	0	1708	1629	1686	1561	1705	0	1462	0	13034
1990	1258	1184	1068	0	1271	1297	1269	1271	1206	690	1133	790	12438
1991	1191	1433	0	0	1735	1718	1547	0	0	633	771	858	9886
1992	995	1535	0	0	1625	0	1585	1348	1544	963	1026	1128	11749
1993	1965	2079	0	0	1473	0	2272	2223	2203	0	408	0	12623
1994	0	0	0	0	1728	1675	2045	1991	1958	0	1967	1475	12838
Average	1589	1859	245	147	908	798	1193	1098	1055	689	1516	668	11765

Table 8.G.69
Scenario 3 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1092	1012	978	0	1189	1266	1297	1273	1276	1238	904	1132	12658
1976	982	1061	0	0	1342	1372	1345	1404	1108	573	181	615	9984
1977	1048	932	695	970	1131	1224	1079	1210	1189	801	816	1105	12200
1978	1152	1101	1056	945	1256	0	1297	1278	1194	491	648	571	10990
1979	842	1005	1125	1060	998	1311	1294	1283	937	0	994	750	11600
1980	2014	2388	0	0	0	0	0	0	0	2639	2371	1692	11104
1981	1207	1169	0	0	1331	1493	1556	1562	1226	949	0	937	11429
1982	1196	1432	0	0	1443	1348	1407	1405	1392	1335	1349	1037	13343
1983	7153	5972	0	0	0	0	0	0	0	0	0	0	13125
1984	0	6973	0	0	0	0	0	0	0	0	4811	0	11784
1985	0	0	0	0	0	0	2856	2848	2814	2765	2796	0	14078
1986	7198	6351	0	0	0	0	0	0	0	0	0	0	13549
1987	0	0	0	0	0	0	0	0	0	0	10785	0	10785
1988	1421	0	0	0	0	1721	1658	1626	1668	1549	1543	1478	12664
1989	1520	1796	0	0	1720	1644	1741	1607	1745	0	1489	0	13262
1990	1287	1196	1075	0	1281	1310	1295	1296	1242	757	1157	816	12711
1991	1351	1446	0	0	1749	1739	1588	0	0	649	792	885	10198
1992	1018	1549	0	0	1637	0	1623	1398	1579	979	1046	1157	11986
1993	2013	2098	0	0	1525	0	2313	2281	2265	0	416	0	12910
1994	0	0	0	0	1740	1691	2093	2050	2018	0	2012	1528	13132
Average	1625	1874	246	149	917	806	1222	1126	1083	736	1705	685	12175

Table 8.G.70
Scenario 3 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1097	1072	996	0	1200	1289	1302	1283	1289	1255	914	1215	12912
1976	1070	1189	0	0	1394	1408	1391	1414	1126	582	185	628	10386
1977	1055	1030	709	990	1180	1226	1152	1215	1200	816	824	1158	12556
1978	1157	1110	1132	946	1284	0	1302	1286	1218	500	656	582	11174
1979	909	1069	1135	1061	999	1313	1300	1292	968	0	1004	756	11806
1980	2061	2392	0	0	0	0	0	0	0	2693	2405	1759	11309
1981	1258	1241	0	0	1347	1548	1568	1572	1244	956	0	1009	11743
1982	1200	1441	0	0	1445	1397	1416	1416	1405	1357	1362	1041	13480
1983	7174	6454	0	0	0	0	0	0	0	0	0	0	13628
1984	0	7100	0	0	0	0	0	0	0	0	4851	0	11951
1985	0	0	0	0	0	0	2867	2862	2832	2792	2819	0	14171
1986	7210	6788	0	0	0	0	0	0	0	0	0	0	13998
1987	0	0	0	0	0	0	0	0	0	0	6372	0	6372
1988	1423	0	0	0	0	1723	1663	1633	1696	1561	1557	1486	12742
1989	1654	1800	0	0	1722	1646	1755	1626	1760	0	1503	0	13465
1990	1294	1254	1076	0	1298	1312	1300	1301	1259	772	1177	862	12904
1991	1436	1449	0	0	1778	1771	1597	0	0	660	804	895	10390
1992	1052	1552	0	0	1646	0	1630	1418	1595	985	1056	1171	12105
1993	2078	2215	0	0	1526	0	2321	2298	2284	0	418	0	13140
1994	0	0	0	0	1741	1693	2102	2066	2045	0	2035	1540	13223
Average	1656	1958	252	150	928	816	1233	1134	1096	746	1497	705	12173

Table 8.G.71
Scenario 3 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1131	1157	1056	0	1226	1313	1307	1292	1302	1272	976	1298	13331
1976	1198	1335	0	0	1446	1444	1437	1424	1180	710	367	754	11293
1977	1086	1143	752	1041	1230	1228	1226	1221	1209	883	886	1213	13115
1978	1182	1147	1223	999	1312	0	1307	1295	1246	621	753	695	11780
1979	1024	1158	1169	1098	1045	1315	1306	1300	1043	0	1052	839	12349
1980	2216	2466	0	0	0	0	0	0	0	2745	2490	1975	11891
1981	1351	1356	0	0	1399	1603	1579	1582	1304	1052	0	1155	12380
1982	1237	1443	0	0	1446	1445	1425	1426	1417	1380	1380	1102	13702
1983	7194	6978	0	0	0	0	0	0	0	0	0	0	14172
1984	0	7227	0	0	0	0	0	0	0	0	5210	0	12437
1985	0	0	0	0	0	0	2876	2875	2850	2818	2839	0	14259
1986	7221	7226	0	0	0	0	0	0	0	0	0	0	14448
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	1480	0	0	0	0	1736	1687	1662	1726	1601	1599	1537	13027
1989	1789	1803	0	0	1735	1670	1770	1661	1773	0	1553	0	13755
1990	1301	1312	1111	0	1314	1314	1304	1306	1275	857	1210	962	13265
1991	1560	1502	0	0	1807	1803	1632	0	0	829	953	1031	11116
1992	1165	1569	0	0	1654	0	1638	1461	1611	1023	1146	1247	12515
1993	2169	2333	0	0	1644	0	2328	2312	2300	0	421	0	13507
1994	0	0	0	0	1798	1695	2111	2084	2070	0	2059	1630	13446
Average	1715	2058	266	157	953	828	1247	1145	1115	789	1580	772	12624

Table 8.G.72
Scenario 4 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	143	1401	2666	4631	3084	623	12548
1976	0	0	0	0	0	0	135	1404	2104	1948	561	308	6459
1977	0	0	0	0	0	0	127	1422	2655	3202	2971	649	11025
1978	0	0	0	0	0	0	143	1405	2496	1836	2209	314	8403
1979	0	0	0	0	0	0	142	1412	1957	0	3391	412	7315
1980	0	0	0	0	0	0	0	0	0	4486	3675	423	8585
1981	0	0	0	0	0	0	140	1406	2096	2904	0	422	6968
1982	0	0	0	0	0	0	141	1405	2644	4538	4182	518	13429
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	2983	0	2983
1985	0	0	0	0	0	0	143	1424	2673	4700	4333	0	13274
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3343	0	3343
1988	0	0	0	0	0	0	133	1301	2536	4213	3828	591	12602
1989	0	0	0	0	0	0	139	1285	2653	0	3694	0	7771
1990	0	0	0	0	0	0	142	1425	2595	2830	3946	449	11388
1991	0	0	0	0	0	0	127	0	0	1766	1963	354	4210
1992	0	0	0	0	0	0	142	1222	2622	1230	2835	506	8557
1993	0	0	0	0	0	0	143	1410	2660	0	427	0	4640
1994	0	0	0	0	0	0	142	1393	2607	0	4238	519	8900
Average	0	0	0	0	0	0	104	966	1745	1914	2587	304	7620

Table 8.G.73
Scenario 4 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	143	1411	2694	4695	3118	668	12729
1976	0	0	0	0	0	0	139	1414	2139	1980	573	314	6559
1977	0	0	0	0	0	0	135	1428	2678	3262	3000	681	11184
1978	0	0	0	0	0	0	143	1415	2546	1869	2236	320	8529
1979	0	0	0	0	0	0	143	1421	2023	0	3423	416	7426
1980	0	0	0	0	0	0	0	0	0	4578	3728	440	8745
1981	0	0	0	0	0	0	141	1415	2127	2925	0	454	7062
1982	0	0	0	0	0	0	142	1416	2670	4615	4224	521	13587
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	3008	0	3008
1985	0	0	0	0	0	0	143	1431	2691	4746	4369	0	13380
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3370	0	3370
1988	0	0	0	0	0	0	133	1306	2578	4245	3861	595	12718
1989	0	0	0	0	0	0	140	1301	2675	0	3727	0	7843
1990	0	0	0	0	0	0	143	1431	2632	2888	4014	474	11582
1991	0	0	0	0	0	0	128	0	0	1795	1994	358	4275
1992	0	0	0	0	0	0	143	1239	2649	1230	2863	512	8635
1993	0	0	0	0	0	0	143	1420	2682	0	427	0	4673
1994	0	0	0	0	0	0	143	1404	2641	0	4288	523	8999
Average	0	0	0	0	0	0	105	973	1771	1941	2611	314	7715

Table 8.G.74
Scenario 4 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	144	1422	2722	4757	3329	714	13087
1976	0	0	0	0	0	0	144	1424	2242	2413	1137	377	7736
1977	0	0	0	0	0	0	144	1434	2700	3526	3226	712	11742
1978	0	0	0	0	0	0	144	1424	2604	2321	2569	382	9444
1979	0	0	0	0	0	0	144	1430	2180	0	3589	461	7803
1980	0	0	0	0	0	0	0	0	0	4666	3859	494	9018
1981	0	0	0	0	0	0	142	1424	2230	3220	0	520	7535
1982	0	0	0	0	0	0	142	1426	2693	4692	4279	551	13783
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	3230	0	3230
1985	0	0	0	0	0	0	144	1437	2708	4791	4401	0	13481
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3541	0	3541
1988	0	0	0	0	0	0	135	1329	2623	4355	3966	615	13023
1989	0	0	0	0	0	0	142	1329	2695	0	3851	0	8016
1990	0	0	0	0	0	0	143	1436	2666	3204	4126	529	12104
1991	0	0	0	0	0	0	131	0	0	2254	2364	412	5161
1992	0	0	0	0	0	0	143	1277	2676	1230	3106	545	8978
1993	0	0	0	0	0	0	144	1429	2702	0	427	0	4702
1994	0	0	0	0	0	0	143	1416	2673	0	4338	554	9124
Average	0	0	0	0	0	0	106	912	1806	2071	2767	343	8076

Table 8.G.75
Scenario 5 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	502	4927	9377	16290	10847	2190	44133
1976	0	0	0	0	0	0	473	4939	7402	6851	1971	1082	22718
1977	0	0	0	0	0	0	446	5000	9336	11261	10450	2283	38779
1978	0	0	0	0	0	0	502	4943	8779	6457	7769	1105	29554
1979	0	0	0	0	0	0	501	4965	6885	0	11927	1451	25729
1980	0	0	0	0	0	0	0	0	0	15780	12927	1488	30195
1981	0	0	0	0	0	0	493	4945	7374	10214	0	1483	24509
1982	0	0	0	0	0	0	495	4942	9300	15961	14710	1823	47231
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	10490	0	10490
1985	0	0	0	0	0	0	502	5008	9402	16533	15242	0	46687
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	11759	0	11759
1988	0	0	0	0	0	0	466	4575	8920	5380	13463	2079	34884
1989	0	0	0	0	0	0	490	4521	9331	0	12992	0	27334
1990	0	0	0	0	0	0	501	5012	9129	9954	13880	1579	40054
1991	0	0	0	0	0	0	447	0	0	6211	6904	1245	14807
1992	0	0	0	0	0	0	499	4297	9224	1230	9973	1779	27001
1993	0	0	0	0	0	0	505	4959	9357	0	427	0	15246
1994	0	0	0	0	0	0	500	4900	9168	0	14907	1827	31303
Average	0	0	0	0	0	0	366	3397	6149	6106	9022	1071	26121

Table 8.G.76
Scenario 5 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	504	4963	9475	16515	10965	2350	44772
1976	0	0	0	0	0	0	489	4974	7523	6963	2016	1104	23068
1977	0	0	0	0	0	0	476	5023	9420	11472	10553	2394	39337
1978	0	0	0	0	0	0	504	4976	8955	6574	7863	1126	29999
1979	0	0	0	0	0	0	503	4999	7115	0	12038	1463	26118
1980	0	0	0	0	0	0	0	0	0	16100	13111	1546	30758
1981	0	0	0	0	0	0	496	4976	7481	10289	0	1598	24840
1982	0	0	0	0	0	0	498	4982	9391	16231	14855	1831	47789
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	10579	0	10579
1985	0	0	0	0	0	0	504	5033	9463	16693	15369	0	47062
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	11852	0	11852
1988	0	0	0	0	0	0	466	4595	9068	5380	13581	2091	35182
1989	0	0	0	0	0	0	494	4575	9407	0	13109	0	27585
1990	0	0	0	0	0	0	505	5033	9258	10159	14117	1667	40737
1991	0	0	0	0	0	0	449	0	0	6314	7015	1259	15036
1992	0	0	0	0	0	0	501	4359	9317	1230	10068	1800	27275
1993	0	0	0	0	0	0	505	4996	9434	0	427	0	15362
1994	0	0	0	0	0	0	503	4940	9289	0	15080	1841	31653
Average	0	0	0	0	0	0	370	3421	6230	6196	9130	1104	26450

Table 8.G.77
Scenario 5 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	506	5000	9572	16732	11708	2511	46029
1976	0	0	0	0	0	0	505	5008	7885	8486	3999	1325	27208
1977	0	0	0	0	0	0	507	5044	9496	12401	11347	2506	41301
1978	0	0	0	0	0	0	506	5069	9158	8162	9037	1344	33216
1979	0	0	0	0	0	0	505	5029	7667	0	12622	1623	27446
1980	0	0	0	0	0	0	0	0	0	16411	13573	1736	31720
1981	0	0	0	0	0	0	500	5008	7843	11325	0	1828	26504
1982	0	0	0	0	0	0	501	5017	9473	16503	15049	1937	48480
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	11361	0	11361
1985	0	0	0	0	0	0	506	5056	9523	16851	15480	0	47415
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	12455	0	12455
1988	0	0	0	0	0	0	475	4675	9226	5380	13949	2162	35867
1989	0	0	0	0	0	0	498	4674	9479	0	13544	0	28195
1990	0	0	0	0	0	0	505	5051	9375	11269	14511	1861	42571
1991	0	0	0	0	0	0	459	0	0	7929	8316	1450	18154
1992	0	0	0	0	0	0	504	4493	9414	1230	10926	1917	28483
1993	0	0	0	0	0	0	506	5027	9504	0	427	0	15464
1994	0	0	0	0	0	0	505	4981	9400	0	15259	1948	32093
Average	0	0	0	0	0	0	374	3454	6351	6634	9673	1207	27699

projects. As previously discussed, it has been assumed that subsurface investigations will be required. These were estimated at $3,500 per probe. The number of wells required was based on the maximum monthly amount pumped and an average pumping rate of 1,000 gpm. Well installation costs were assumed to be $30,000. Wells and pumping hardware will most likely need to be replaced in 10 to 20 years, therefore, replacement costs were included. Depending on the locations of the wells, the distances to existing drains may vary substantially. Piping costs (up to 10,000 feet of 12" diameter line at $5/foot) were estimated to be $50,000 per well for scenarios 1 through 3. Costs were only included for up to 4,000 feet of pipe for scenarios 4 and 5 because water will be used for irrigation purposes. The capitalized cost associated with potential projects in Reaches 10, 17, 18 and 19 range from about $6.4 million to $22.3 million, as summarized in Table 8.G.78. The resulting costs per ac-ft range from $380 to $1,560 assuming additional flows can be protected and from $380 to $2,450 assuming additional flows cannot be protected. Because yields may be overstated based on the assumption that all water pumped would not have returned to the Platte River, costs may be understated.

For scenarios 1 through 5 the number of wells that can be located in a given reach and the monthly amount that can be pumped was maximized. However, there is considerable opportunity to optimize the cost and yield associated with scenarios 1 through 3. An alternative analysis would be to base the number of wells needed on the volume to be pumped in a month and a percentage of run-time. Substantial cost savings can be realized by reducing the number of wells without sacrificing significant reductions to shortages. This is possible because of the variability in the number of months that pumping occurs each year. If there are excesses in several months in a year, several pumps will not need to be operated based on the current analysis. Because of the consistent pumping schedule estimated for Scenarios 4 and 5 the opportunity to reduce the number of pumps is limited.

A limited analysis to optimize yields and costs associated with Scenarios 1 through 3 was completed. In Reach 10, the number of pumps can be reduced such that cost savings of about 25 percent, 40 percent, and 60 percent are realized for Scenarios 1, 2, and 3, respectively, for about 90 percent of the reductions to target flow shortages. In Reach 17, the number of pumps can be reduced such that

TABLE 8.G.78
COST SUMMARY
Re-regulation Opportunities and Reductions in Natural Groundwater Exports From the Basin

	REGION 3										
	Reach 10	Reach 17	Reaches 18 and 19	Reach 10	Reach 17	Reaches 18 and 19	Reach 10	Reach 17	Reaches 18 and 19	Reaches 17, 18 and 19	Reaches 17, 18 and 19
		Scenario 1			Scenario 2			Scenario 3		Scenario 4	Scenario 5
CONSTRUCTION COSTS PER WELL											
Subsurface Investigations	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Well Construction & Pumps	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Conveyance Conduit	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000
Power Hook-up	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
10000' 12" dia pipe @ $5/ft	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	20,000	20,000
Replacement Costs (Well & Pump Hardware)	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000
Total Cost per Well	**138,500**	**138,500**	**138,500**	**138,500**	**138,500**	**138,500**	**138,500**	**138,500**	**138,500**	**118,500**	**118,500**
No. of wells	80	112	64	80	112	64	80	112	64	37	129
Total Construction Cost	**11,080,000**	**15,512,000**	**8,864,000**	**11,080,000**	**15,512,000**	**8,864,000**	**11,080,000**	**15,512,000**	**8,864,000**	**4,384,500**	**15,286,500**
Engineering Fees (10%)	1,108,000	1,551,000	886,000	1,108,000	1,551,000	886,000	1,108,000	1,551,000	886,000	438,000	1,529,000
Construction Costs + Engineering Fees	**12,188,000**	**17,063,000**	**9,750,000**	**12,188,000**	**17,063,000**	**9,750,000**	**12,188,000**	**17,063,000**	**9,750,000**	**4,822,500**	**16,815,500**
ANNUAL COSTS											
Amt. Diverted	44,100	45,300	42,700	32,700	33,700	32,200	14,300	14,500	14,200	14,500	51,000
Pump operation cost ($8/af)	352,320	376,160	337,040	260,800	268,560	253,680	114,160	115,680	111,920	115,280	115,280
Annual Maintenance Costs ($300/well)	24,000	33,600	19,200	24,000	33,600	19,200	24,000	33,600	19,200	11,100	11,100
Total Annual Cost	**420,420**	**455,060**	**398,940**	**317,500**	**335,860**	**305,080**	**152,460**	**163,780**	**145,320**	**140,880**	**177,380**
No. of years	20	20	20	20	20	20	20	20	20	20	20
Rate	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%	6%
Present Value of Annual Costs	**4,822,184**	**5,219,502**	**4,575,810**	**3,641,700**	**3,852,288**	**3,499,244**	**1,748,704**	**1,878,544**	**1,666,809**	**1,615,883**	**2,034,535**
Total Capitalized Cost of Projec	**17,020,000**	**22,290,000**	**14,330,000**	**15,830,000**	**20,920,000**	**13,250,000**	**13,940,000**	**18,950,000**	**11,420,000**	**6,440,000**	**18,860,000**

Note: It was assumed that wells and pumping hardware would need to be replaced after 15 years. Future costs are based on an rate of 4 percent and a present day cost of $30,000.

cost savings of about 40 percent, 55 percent, and 70 percent are realized for Scenarios 1, 2, and 3, respectively, for about 90 percent of the reductions to target flow shortages. In Reaches 18 and 19, the number of pumps can be reduced such that cost savings of about 15 percent, 30 percent, and 55 percent are realized for Scenarios 1, 2, and 3, respectively, for about 90 percent of the reductions to target flow shortages.

5. Yield Summary

All of the alternatives associated with groundwater are scalable to a degree. If any of these alternatives are chosen for inclusion in the eventual action plan, the magnitude and geographic focus of the alternative may differ from the representative projects described in this section. In addition, projects have been analyzed independently of each other. Several projects rely on the same source of water, in which case, the yields of these projects combined may be less than simply adding the yields of the individual projects. Consequently, the total yields described in this memo for each alternative are specific to the assumptions the study team has made in defining representative programs. Table 8.G.79 summarizes the net hydrologic effects at the site, at the top of the downstream reach, and at the habitat for each alternative. Table 8.G.79 also provides a summary of the reductions to target flow shortages at the habitat for each alternative evaluated. Based upon the operational definitions of the groundwater alternatives used in this evaluation, the average annual net hydrologic effects across the study region range from –13,297 ac-ft per year to 51,000 ac-ft per year, as shown in Table 8.G.79.

The average annual net hydrologic effect can be negative due to evaporation and some of the lagged accretions not being included because they would have occurred after 1994. In addition, there may be recharge losses that never get back to the river due to non-beneficial consumptive uses, such as phreatophyte consumptive use. For example, a 1993 Harza study of the NPPD system estimates that 14 percent of recharge losses never get back to the river. It would be expected that the percentage of recharge losses that do not get back to the river are higher in the central Platte region as compared to the lower South Platte River and North Platte River regions as indicated by the existence of the groundwater mound. Recharge losses that do not get back to river have not been included in the analysis of

TABLE 8.G.79
Alternatives Yield and Cost by Reach
Category 5 - Groundwater

	Yield 20-year Average Annual Values (ac-ft/yr)							Capitalized Cost			
	Net Hydrologic Effect At Site	Net Hydrologic Effect at Top of Downstream Reach		Net Hydrologic Effect at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per Acre-Foot of Average Reduction in Target Flow Shortage At Habitat ($/ac-ft)	
Alternative		(w/diversion loss	(w/o diversion loss	(w/diversion loss	(w/o diversion loss	(w/diversion loss	(w/o diversion loss			(w/diversion loss	(w/o diversion loss
REGION 1											
Reach 5											
Pratt Ferris - GW Recharge Project	(136)	(136)	(136)	(358)	(35)	109	278	$0.1	$0.1	$930	$360
Reach 5											
GW Recharge Project (SDF=60 Days)	(1,511)	(1,946)	(1,476)	(3,771)	(344)	1,577	3,617	$8.6	$8.6	$5,450	$2,380
GW Recharge Project (SDF=120 Days)	(2,109)	(2,651)	(2,066)	(4,906)	(735)	1,772	4,307	$8.6	$8.6	$4,850	$2,000
GW Recharge Project (SDF=270 Days)	(3,097)	(3,759)	(3,047)	(6,294)	(1,555)	1,812	4,836	$8.6	$8.6	$4,750	$1,780
Reach 13											
GW Recharge Project (SDF=60 Days)	(2,896)	(2,931)	(3,168)	(3,573)	(510)	3,884	7,467	$9.7	$9.7	$2,500	$1,300
GW Recharge Project (SDF=120 Days)	(4,011)	(4,055)	(4,366)	(7,368)	(1,171)	4,257	8,648	$9.7	$9.7	$2,280	$1,120
GW Recharge Project (SDF=270 Days)	(5,841)	(5,892)	(6,282)	(9,702)	(2,623)	4,115	9,196	$9.7	$9.7	$2,360	$1,030
GW Recharge Project (SDF=300 Days)	(2,131)	(2,134)	(2,277)	(3,975)	(1,184)	1,137	2,829	$2.1	$2.1	$1,850	$740
REGION 2											
Reach 7											
GW Recharge Project (SDF=60 Days)	(3,679)	(4,620)	(2,543)	(3,438)	6,542	1,032	9,524	$10.7	$19.6	$10,370	$2,060
GW Recharge Project (SDF=120 Days)	(5,144)	(6,352)	(3,528)	(4,509)	7,108	1,108	11,002	$10.7	$19.6	$9,660	$1,780
GW Recharge Project (SDF=270 Days)	(7,573)	(9,015)	(6,138)	(5,892)	6,529	1,021	11,684	$10.7	$19.6	$10,480	$1,680
GW Recharge Project (SDF=300 Days)	(3,961)	(4,474)	(2,792)	(2,809)	4,757	438	5,520	$2.1	$11.0	$4,790	$1,990
Beebe Draw (Above Reach 7	(3,949)	(809)	(809)	(8,656)	10,381	251	5,443	$5.7	$14.6	$22,710	$2,690
Reach 8											
GW Recharge Project (SDF=60 Days)	(3,679)	(4,087)	495	(4,521)	4,415	2,068	9,573	$10.7	$17.3	$5,170	$1,810
GW Recharge Project (SDF=120 Days)	(5,144)	(5,529)	(174)	(5,949)	4,532	2,253	11,062	$10.7	$17.3	$4,750	$1,560
GW Recharge Project (SDF=270 Days)	(7,573)	(7,706)	(1,944)	(7,813)	3,524	2,137	11,751	$10.7	$17.3	$5,010	$1,470
GW Recharge Project (SDF=300 Days)	(3,961)	(3,938)	(459)	(3,774)	2,867	902	5,556	$2.1	$8.7	$2,330	$1,570
Badger Beaver Recharge Projec	(13,297)	(11,966)	(10,854)	(7,831)	(4,238)	655	3,427	$14.0	$20.0	$21,370	$5,840
Reach 9 (Sites in the middle of the reach											
GW Recharge Project (SDF=60 Days)	(3,679)	(5,737)	(2,440)	(5,314)	1,868	3,731	9,961	$10.7	$14.6	$2,870	$1,470
GW Recharge Project (SDF=120 Days)	(5,144)	(7,675)	(3,704)	(7,048)	1,461	4,121	11,167	$10.7	$14.6	$2,600	$1,310
GW Recharge Project (SDF=270 Days)	(7,573)	(10,458)	(5,992)	(9,383)	(35)	4,040	11,870	$10.7	$14.6	$2,650	$1,230
GW Recharge Project (SDF=300 Days)	(3,961)	(4,913)	(2,552)	(4,856)	463	1,757	5,620	$2.1	$6.1	$1,200	$1,090
Reach 9 (Sites at the bottom of the reach											
GW Recharge Project (SDF=60 Days)	(3,679)	(3,679)	(3,679)	(5,167)	1,273	4,410	9,720	$10.7	$10.7	$2,430	$1,100
GW Recharge Project (SDF=120 Days)	(5,111)	(5,144)	(5,144)	(6,850)	760	4,922	11,238	$10.7	$10.7	$2,170	$950
GW Recharge Project (SDF=270 Days)	(7,573)	(7,573)	(7,573)	(9,231)	(825)	4,917	11,950	$10.7	$10.7	$2,180	$900

* Present value of sum of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount ra

TABLE 8.G.79 (cont.)
Alternatives Yield and Cost by Reach
Category 5 - Groundwater

Alternative	Yield 20-year Average Annual Values (ac-ft/yr)							Capitalized Cost			
	Net Hydrologic Effect At Site	Net Hydrologic Effect at Top of Downstream Reach		Net Hydrologic Effect at Habitat		Reduction to Target Flow Shortages at Habitat		Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per Acre Foot of Average Reduction in Target Flow Shortage At Habitat ($/ac-ft)	
		(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)	(w/diversion loss)	(w/o diversion loss)			(w/diversion loss)	(w/o diversion loss)
REGION 3											
Reach 10											
GW Recharge Project (SDF=60 Days)	(3,357)	(3,417)	(2,339)	(5,119)	(60)	3,935	7,942	$10.2	$10.2	$2,590	$1,280
GW Recharge Project (SDF=120 Days)	(4,720)	(4,759)	(3,484)	(6,783)	(734)	4,430	9,256	$10.2	$10.2	$2,300	$1,100
GW Recharge Project (SDF=270 Days)	(6,931)	(6,956)	(5,557)	(9,047)	(2,321)	4,511	9,987	$10.2	$10.2	$2,260	$1,020
GW Reregulation Opportunities - Scenario 1	44,066	42,983	43,965	16,907	36,031	16,907	36,031	$17.0	$17.0	$1,010	$470
GW Reregulation Opportunities - Scenario 2	32,672	31,812	32,596	12,656	26,775	12,656	26,775	$15.8	$15.8	$1,250	$590
GW Reregulation Opportunities - Scenario 3	14,300	13,941	14,266	5,671	11,765	5,671	11,765	$13.9	$15.9	$2,450	$1,180
Reach 16											
Gothenburg Canal GW Recharge Project	(3,143)	(3,143)	(3,143)	(3,486)	(2,936)	667	1,097	$0.7	$0.7	$1,050	$640
Reach 17											
Dawson Canal GW Recharge Project	(4,298)	(4,789)	(4,298)	(4,087)	(4,027)	1,462	1,510	$0.9	$0.9	$620	$600
GW Reregulation Opportunities - Scenario 1	45,271	45,136	45,136	36,521	37,895	36,521	37,895	$22.3	$22.3	$610	$590
GW Reregulation Opportunities - Scenario 2	33,671	39,572	33,572	27,216	28,210	27,216	28,210	$20.9	$20.9	$770	$740
GW Reregulation Opportunities - Scenario 3	14,500	14,459	14,459	11,767	12,175	11,767	12,175	$19.0	$19.0	$1,610	$1,560
GW Reregulation Opportunities - Scenario 4	14,500	14,470	14,430	11,143	11,885	6,944	7,620	$6.4	$6.4	$920	$840
GW Reregulation Opportunities - Scenario 5	51,000	50,755	50,755	39,191	41,802	23,958	26,121	$18.9	$18.9	$790	$720
Reach 18											
GW Reregulation Opportunities - Scenario 1	42,738	37,929	42,126	35,752	36,395	35,752	36,395	$14.3	$14.3	$400	$390
GW Reregulation Opportunities - Scenario 2	32,169	28,558	31,766	26,980	27,467	26,980	27,467	$13.3	$13.3	$490	$480
GW Reregulation Opportunities - Scenario 3	14,200	17,653	13,986	11,973	12,173	11,973	12,173	$11.4	$11.4	$950	$940
GW Reregulation Opportunities - Scenario 4	14,500	12,232	14,406	11,640	12,014	7,499	7,715	$6.4	$6.4	$860	$830
GW Reregulation Opportunities - Scenario 5	51,000	42,951	50,668	40,943	42,256	25,362	26,450	$18.9	$18.9	$750	$710
Reach 19											
GW Reregulation Opportunities - Scenario 1	42,738	37,754	37,754	37,754	37,754	37,754	37,754	$14.3	$14.3	$380	$380
GW Reregulation Opportunities - Scenario 2	32,169	29,483	28,483	28,483	28,483	28,483	28,483	$13.3	$13.3	$470	$470
GW Reregulation Opportunities - Scenario 3	14,200	12,624	12,624	12,624	12,624	12,624	12,624	$11.4	$11.4	$900	$900
GW Reregulation Opportunities - Scenario 4	14,500	12,432	12,432	12,432	12,432	8,076	8,076	$6.4	$6.4	$790	$790
GW Reregulation Opportunities - Scenario 5	51,000	43,728	43,729	43,728	43,728	27,698	27,698	$18.9	$18.9	$680	$680

* Present value of sum of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount ra

Legend
Scenario 1 : Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge directly to the Platte Rive
Scenario 2 : Pump from the groundwater mound up to 36,500 ac-ft/yr and discharge directly to the Platte Rive
Scenario 3 : Pump from the groundwater mound up to 14,500 ac-ft/yr and discharge directly to the Platte Rive
Scenario 4 : Pump from the groundwater mound up to 14,500 ac-ft/yr for irrigation of lands previously irrigated by surface wate
Scenario 5 : Pump from the groundwater mound up to 51,000 ac-ft/yr for irrigation of lands previously irrigated by surface wate

representative groundwater recharge projects, which is consistent with the methodology used to evaluate the Tamarack Recharge Plan. However, the yield associated with these representative projects could be less if there are recharge losses to non-beneficial consumptive uses. The average annual net hydrologic effect at the top of the next downstream reach and at the critical habitat are also summarized in Table 8.G.79.

The reductions in shortages to target flows at the critical habitat range from 278 ac-ft per year to 37,895 ac-ft per year, without diversion losses. With diversion losses downstream, reductions range from 109 ac-ft per year to 37,754 ac-ft per year.

6. Cost Summary

Table 8.G.79 summarizes the total capitalized costs and costs per ac-ft of average reductions in target flow shortages associated with all groundwater alternatives evaluated. Under the representative groundwater programs evaluated in this memo, a Badger-Beaver groundwater recharge projects would have the highest total capitalized cost at about $20 million. A potential Pratt-Ferris Irrigation District groundwater recharge project would have the lowest capitalized cost of the groundwater alternatives evaluated at about $100,000. The average cost per ac-ft of reductions to target flow shortages ranges from $340 to $5,840 without diversion losses and $340 to $21,370 with diversion losses.

7. Associated Issues

Each of the groundwater alternatives that has not been deferred was evaluated according to the associated issues evaluation criteria previously reviewed by the Water Management Committee. The five categories of associated issues are physical, legal and institutional, social, economic and environmental. Tabular scoring according to each criterion is presented in Tables 8.G.80 through 8.G.85 for scenarios both with diversion losses and without diversion losses. A description of the numeric score applied to each sub-criteria is provided below. The following discussion initially presents an evaluation of each alternative assuming that water is protected from downstream diversions. Differences in the scoring evaluation under the scenario with diversion losses are discussed at the close of each

TABLE 8.G.80

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 5 - Groundwater

Alternative - Groundwater Recharge/Return Flow Projects

	Region 1 Reaches								Region 2 Reaches																	Region 3 Reaches				
Physical	5a	5b	5c	5d	13a	13b	13c	13d	7a	7b	7c	7d	7e	8a	8b	8c	8d	8e	9a	9b	9c	9d	9e	9f	9g	10a	10b	10c	16	17
Net Reduction in Shortage to Target Flows	0				2	2	2	1									1		2	2	2	1	2	2	2	2	2	2	1	1
Sustainability					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	2	2
Scalability					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	2	2
Technically Implementable					5	5	5	5									5		5	5	5	5	5	5	5	5	5	5	5	5
Time to Yield Realization					5	5	5	5									5		5	5	5	5	5	5	5	5	5	5	5	5
Ability to Monitor and Measure					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Third Party Hydrologic Impacts					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Subtotal					27	27	27	26									26		27	27	27	26	27	27	27	27	27	27	22	22
Subtotal Average					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	3	3
Legal/Institutional																														
Ease of Permitting					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Consistent with Interstate Compacts, Federal Laws & Decrees					5	5	5	5									5		5	5	5	5	5	5	5	5	5	5	5	5
Consistent with State Laws					5	5	5	5									3		3	3	3	3	3	3	3	5	5	5	5	5
Potential for Institutional Consensus					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Can be Mitigated					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Administrative Ease					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Consistent with Existing Contract, Facility & Land Ownership					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal					27	27	27	27									25		25	25	25	25	25	25	25	27	27	27	27	27
Subtotal Average					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Social																														
Effects on Customs and Culture					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Equity of Impacts					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Effects on Community Sustainability					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Public Acceptability					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal					15	15	15	15									15		15	15	15	15	15	15	15	15	15	15	15	15
Subtotal Average					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Economic																														
Initial Implementation and Capital Cost					5	5	5	5									5		4	4	4	5	4	4	4	4	4	4	5	5
Average Annual Total Cost per Acre Foot Delivered		0	0	0	2	2	2	3	0	0	0	0	0	0	0	0	2	0	1	1	1	4	2	2	2	1	2	2	4	5
Direct Economic Impacts					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Secondary Economic Impacts					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Fiscal Impacts					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Effects on Economic Development Potential					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal					19	19	19	20									19		17	17	17	21	18	18	18	17	18	18	21	22
Subtotal Average					3	3	3	3									3		3	3	3	4	3	3	3	3	3	3	4	4
Environmental																														
Impacts to Wetlands					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Impacts to Habitat					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Impacts to Water Quality					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Prime and Unique Farmlands					5	5	5	5									5		5	5	5	5	5	5	5	5	5	5	5	5
Visual Impacts					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Amenities					3	3	3	3									3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal					22	22	22	22									22		22	22	22	22	22	22	22	22	22	22	22	22
Subtotal Average					4	4	4	4									4		4	4	4	4	4	4	4	4	4	4	4	4
Overall Total (Sum of Averages)					18	18	18	18									18		18	17	17	19	17	17	17	17	17	17	17	17

Legend:

5a : Pratt-Ferris Recharge Project: SDF = 50 Days
5b : SDF Factor = 60 Days
5c : SDF Factor = 120 Days
5d : SDF Factor = 270 Days
7a : SDF Factor = 60 Days
7b : SDF Factor = 120 Days
7c : SDF Factor = 270 Days
7d : SDF Factor = 300 Days
7e : Beebe Draw
8a : SDF Factor = 60 Days
8b : SDF Factor = 120 Days
8c : SDF Factor = 270 Days
8d : SDF Factor = 300 Days
8e : Badger Beaver Project
9a : Middle of reach, SDF Factor = 60 Days
9b : Middle of reach, SDF Factor = 120 Days
9c : Middle of reach, SDF Factor = 270 Days
9d : Middle of reach, SDF Factor = 300 Days
9e : Bottom of reach, SDF Factor = 60 Days
9f : Bottom of reach, SDF Factor = 120 Days
9g : Bottom of reach, SDF Factor = 270 Days
10a : SDF Factor = 60 Days
10b : SDF Factor = 120 Days
10c : SDF Factor = 270 Days
13a : SDF Factor = 60 Days
13b : SDF Factor = 120 Days
13c : SDF Factor = 270 Days
13d : SDF Factor = 300 Days
16 : Gothenburg Canal
17 : Dawson Canal

TABLE 8.G.81

Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska

Category 5 - Groundwater

Alternative - Additional Surface Water and/or Groundwater Re-regulation Opportunities

	Region 3 Reaches													
	10a	10b	17a	17b	17c	17d	18a	18b	18c	18d	19a	19b	19c	19d
Physical														
Net Reduction in Shortage to Target Flows	5	3	5	5	3	5	5	5	3	5	5	5	4	5
Sustainability	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Scalability	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ability to Monitor and Measure	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Third Party Hydrologic Impacts	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Subtotal	33	31	33	33	31	33	33	33	31	33	33	33	32	33
Subtotal Average	5	4	5	5	4	5	5	5	4	5	5	5	5	5
Legal/Institutional														
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Consistent with State Laws	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Potential for Institutional Consensus	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Administrative Ease	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Subtotal	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Subtotal Average	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Social														
Effects on Customs and Culture	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Equity of Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Effects on Community Sustainability	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Public Acceptability	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Economic														
Initial Implementation and Capital Cost	4	4	3	4	5	4	4	4	5	4	4	4	5	4
Average Annual Total Cost per Acre-Foot Delivered	4	2	5	3	5	5	5	5	5	5	5	5	5	5
Direct Economic Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Fiscal Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Effects on Economic Development Potential	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	19	17	19	18	21	20	20	20	21	20	20	20	21	20
Subtotal Average	3	3	3	3	4	3	3	3	4	3	3	3	4	3
Environmental														
Impacts to Wetlands	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Impacts to Habitat	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Impacts to Water Quality	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Prime and Unique Farmlands	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall Total (Sum of Averages)	18	17	18	18	19	18	18	18	19	18	18	18	19	18

Legend:

10a : Scenario 2
10b : Scenario 3
17a : Scenario 2
17b : Scenario 3
17c : Scenario 4
17d : Scenario 5
18a : Scenario 2
18b : Scenario 3
18c : Scenario 4
18d : Scenario 5
19a : Scenario 2
19b : Scenario 3
19c : Scenario 4
19d : Scenario 5

Notes:

Scenario 2 – Pump from the mound up to 36,500 ac-ft/yr and discharge water directly to the Platte River.
Scenario 3 – Pump from the mound up to 14,500 ac-ft/yr and discharge water directly to the Platte River.
Scenario 4 – Pump from the mound up to 14,500 ac-ft/yr for irrigation of lands previously irrigated by surface water.
Scenario 5 – Pump from the mound up to 51,000 ac-ft/yr for irrigation of lands previously irrigated by surface water.

TABLE 8.G.82
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 5 - Groundwater
Alternative - Reduction of Natural Groundwater Exports from the Basin

	Region 3 Reaches			
	10	17	18	19
Physical				
Net Reduction in Shortage to Target Flows	5	5	5	5
Sustainability	4	4	4	4
Scalability	3	3	3	3
Technically Implementable	5	5	5	5
Time to Yield Realization	5	5	5	5
Ability to Monitor and Measure	5	5	5	5
Third Party Hydrologic Impacts	4	4	4	4
Subtotal	31	31	31	31
Subtotal Average	4	4	4	4
Legal/Institutional				
Ease of Permitting	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	3	3	3	3
Consistent with State Laws	5	5	5	5
Potential for Institutional Consensus	2	2	2	2
Can be Mitigated	2	2	2	2
Administrative Ease	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5
Subtotal	22	22	22	22
Subtotal Average	3	3	3	3
Social				
Effects on Customs and Culture	3	3	3	3
Equity of Impacts	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3
Effects on Community Sustainability	3	3	3	3
Public Acceptability	3	3	3	3
Subtotal	15	15	15	15
Subtotal Average	3	3	3	3
Economic				
Initial Implementation and Capital Cost	4	3	4	4
Average Annual Total Cost per Acre-Foot of Target Flow Reductions	4	5	5	5
Direct Economic Impacts	3	3	3	3
Secondary Economic Impacts	3	3	3	3
Fiscal Impacts	3	3	3	3
Effects on Economic Development Potential	3	3	3	3
Subtotal	20	20	21	21
Subtotal Average	3	3	4	4
Environmental				
Impacts to Wetlands	2	2	2	2
Impacts to Habitat	2	2	2	2
Impacts to Water Quality	3	3	3	3
Impacts to Prime and Unique Farmlands	5	5	5	5
Visual Impacts	3	3	3	3
Impacts to Amenities	3	3	3	3
Subtotal	18	18	18	18
Subtotal Average	3	3	3	3
Overall Total (Sum of Averages)	17	17	17	17

Legend:

10 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
17 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
18 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
19 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.

TABLE 8.G.83
Scoring Table - No Diversions in Any State
Category 5 - Groundwater
Alternative - Groundwater Recharge/Return Flow Projects

	Region 1 Reaches								Region 2 Reaches																	Region 3 Reaches				
Physical	5a	5b	5c	5d	13a	13b	13c	13d	7a	7b	7c	7d	7e	8a	8b	8c	8d	8e	9a	9b	9c	9d	9e	9f	9g	10a	10b	10c	16	17
Net Reduction in Shortage to Target Flows	0	2	2	2	3	4	4	2	4	5	5	3	5	4	5	5	3		4	5	5	3	4	5	5	4	4	4	1	1
Sustainability		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	2	2
Scalability		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	2	2
Technically Implementable		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
Time to Yield Realization		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
Ability to Monitor and Measure		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Third Party Hydrologic Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal		26	26	26	27	28	28	26	28	29	29	27	29	28	29	29	27		28	29	29	27	28	29	29	28	28	29	21	21
Subtotal Average		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	3	3
Legal/Institutional																														
Ease of Permitting		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
Consistent with State Laws		2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2		2	2	2	2	2	2	2	2	2	2	2	2
Potential for Institutional Consensus		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Can be Mitigated		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Administrative Ease		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4
Consistent with Existing Contract, Facility & Land Ownership		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22		22	22	22	22	22	22	22	22	22	22	22	22
Subtotal Average		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Social																														
Effects on Customs and Culture		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Equity of Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Effects on Community Sustainability		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Public Acceptability		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal		15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15		15	15	15	15	15	15	15	15	15	15	15	15
Subtotal Average		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Economic																														
Initial Implementation and Capital Cost		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		4	4	4	5	4	4	4	4	4	4	5	5
Average Annual Total Cost per Acre-Foot Delivered		3	3	3	4	4	4	5	3	3	3	3	3	3	3	3	3	0	4	4	4	4	4	5	5	4	4	4	5	5
Direct Economic Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Secondary Economic Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Fiscal Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Effects on Economic Development Potential		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal		20	20	20	21	21	21	22	20	20	20	20	20	20	20	20	20		20	20	20	21	20	21	21	20	20	20	22	22
Subtotal Average		3	3	3	4	4	4	4	3	3	3	3	3	3	3	3	3		3	3	3	4	3	4	4	3	3	3	4	4
Environmental																														
Impacts to Wetlands		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4
Impacts to Habitat		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4
Impacts to Water Quality		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Prime and Unique Farmlands		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5		5	5	5	5	5	5	5	5	5	5	5	5
Visual Impacts		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Amenities		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3		3	3	3	3	3	3	3	3	3	3	3	3
Subtotal		22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22		22	22	22	22	22	22	22	22	22	22	22	22
Subtotal Average		4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4		4	4	4	4	4	4	4	4	4	4	4	4
Overall Total (Sum of Averages)		17	17	17	18	18	18	18	17	17	17	17	17	17	17	17	17	17	17	17	17	18	17	18	18	17	17	17	17	17

Legend:

5a : Pratt-Ferris Recharge Project: SDF = 50 Days
5b : SDF Factor = 60 Days
5c : SDF Factor = 120 Days
5d : SDF Factor = 270 Days
7a : SDF Factor = 60 Days
7b : SDF Factor = 120 Days
7c : SDF Factor = 270 Days
7d : SDF Factor = 300 Days
7e : Beebe Draw
8a : SDF Factor = 60 Days
8b : SDF Factor = 120 Days
8c : SDF Factor = 270 Days
8d : SDF Factor = 300 Days
8e : Badger Beaver Project
9a : Middle of reach, SDF Factor = 60 Days
9b : Middle of reach, SDF Factor = 120 Days
9c : Middle of reach, SDF Factor = 270 Days
9d : Middle of reach, SDF Factor = 300 Days
9e : Bottom of reach, SDF Factor = 60 Days
9f : Bottom of reach, SDF Factor = 120 Days
9g : Bottom of reach, SDF Factor = 270 Days
10a : SDF Factor = 60 Days
10b : SDF Factor = 120 Days
10c : SDF Factor = 270 Days
13a : SDF Factor = 60 Days
13b : SDF Factor = 120 Days
13c : SDF Factor = 270 Days
13d : SDF Factor = 300 Days
16 : Gothenburg Canal
17 : Dawson Canal

TABLE 8.G.84

Scoring Table - No Diversions in Any State

Category 5 - Groundwater

Alternative - Additional Surface Water and/or Groundwater Re-regulation Opportunities

	Region 3 Reaches													
Physical	10a	10b	17a	17b	17c	17d	18a	18b	18c	18d	19a	19b	19c	19d
Net Reduction in Shortage to Target Flows	5	5	5	5	4	5	5	5	4	5	5	5	4	5
Sustainability	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Scalability	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Technically Implementable	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Time to Yield Realization	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Ability to Monitor and Measure	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Third Party Hydrologic Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	32	32	32	32	31	32	32	32	31	32	32	32	31	32
Subtotal Average	5	5	5	5	4	5	5	5	4	5	5	5	4	5
Legal/Institutional														
Ease of Permitting	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Consistent with State Laws	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Potential for Institutional Consensus	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Can be Mitigated	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Administrative Ease	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Subtotal	23	23	23	23	23	23	23	23	23	23	23	23	23	23
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Social														
Effects on Customs and Culture	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Equity of Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Effects on Community Sustainability	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Public Acceptability	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	15	15	15	15	15	15	15	15	15	15	15	15	15	15
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Economic														
Initial Implementation and Capital Cost	4	4	3	4	5	4	4	4	5	4	4	4	5	4
Average Annual Total Cost per Acre-Foot Delivered	5	4	5	3	5	5	5	5	5	5	5	5	5	5
Direct Economic Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Secondary Economic Impacts	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Fiscal Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Effects on Economic Development Potential	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	20	19	19	18	21	20	20	20	21	20	20	20	21	20
Subtotal Average	3	3	3	3	4	3	3	3	4	3	3	3	4	3
Environmental														
Impacts to Wetlands	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Impacts to Habitat	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Impacts to Water Quality	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Prime and Unique Farmlands	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Visual Impacts	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Impacts to Amenities	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Subtotal	18	18	18	18	18	18	18	18	18	18	18	18	18	18
Subtotal Average	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Overall Total (Sum of Averages)	17	17	17	17	17	17	17	17	17	17	17	17	17	17

Legend:

10a : Scenario 2
10b : Scenario 3
17a : Scenario 2
17b : Scenario 3
17c : Scenario 4
17d : Scenario 5
18a : Scenario 2
18b : Scenario 3
18c : Scenario 4
18d : Scenario 5
19a : Scenario 2
19b : Scenario 3
19c : Scenario 4
19d : Scenario 5

Notes:

Scenario 2 = Pump from the mound up to 36,500 ac-ft/yr and discharge water directly to the Platte River.
Scenario 3 = Pump from the mound up to 14,500 ac-ft/yr and discharge water directly to the Platte River.
Scenario 4 = Pump from the mound up to 14,500 ac-ft/yr for irrigation of lands previously irrigated by surface water.
Scenario 5 = Pump from the mound up to 51,000 ac-ft/yr for irrigation of lands previously irrigated by surface water.

TABLE 8.G.85

Scoring Table - No Diversions in Any State

Category 5 - Groundwater

Alternative - Reduction of Natural Groundwater Exports from the Basin

	Region 3 Reaches			
	10	17	18	19
Physical				
Net Reduction in Shortage to Target Flows	5	5	5	5
Sustainability	4	4	4	4
Scalability	3	3	3	3
Technically Implementable	5	5	5	5
Time to Yield Realization	5	5	5	5
Ability to Monitor and Measure	5	5	5	5
Third Party Hydrologic Impacts	3	3	3	3
Subtotal	30	30	30	30
Subtotal Average	4	4	4	4
Legal/Institutional				
Ease of Permitting	2	2	2	2
Consistent with Interstate Compacts, Federal Laws & Decrees	3	3	3	3
Consistent with State Laws	5	5	5	5
Potential for Institutional Consensus	2	2	2	2
Can be Mitigated	2	2	2	2
Administrative Ease	3	3	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	5	5	5
Subtotal	22	22	22	22
Subtotal Average	3	3	3	3
Social				
Effects on Customs and Culture	3	3	3	3
Equity of Impacts	3	3	3	3
Impacts on Community Organizations and Support Structures	3	3	3	3
Effects on Community Sustainability	3	3	3	3
Public Acceptability	3	3	3	3
Subtotal	15	15	15	15
Subtotal Average	3	3	3	3
Economic				
Initial Implementation and Capital Cost	4	3	4	4
Average Annual Total Cost per Acre-Foot of Target Flow Reductions	5	5	5	5
Direct Economic Impacts	3	3	3	3
Secondary Economic Impacts	3	3	3	3
Fiscal Impacts	3	3	3	3
Effects on Economic Development Potential	3	3	3	3
Subtotal	21	20	21	21
Subtotal Average	4	3	4	4
Environmental				
Impacts to Wetlands	2	2	2	2
Impacts to Habitat	2	2	2	2
Impacts to Water Quality	3	3	3	3
Impacts to Prime and Unique Farmlands	5	5	5	5
Visual Impacts	3	3	3	3
Impacts to Amenities	3	3	3	3
Subtotal	18	19	18	18
Subtotal Average	3	3	3	3
Overall Total (Sum of Averages)	17	17	17	17

Legend:

10 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
17 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
18 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.
19 : Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River.

criteria category. For more detail on the numeric score applied to each sub-criteria refer to Chapter 6.

Groundwater Recharge/Return Flow Projects

Physical

Each of the alternatives for groundwater recharge/return flow projects is scalable, however, there are limitations on the amount of flow available for diversion, canal capacities, and available recharge sites. This alternative is sustainable over time. Although the life span of recharge projects can easily be extended beyond 10 to 13 years, wells, pumping equipment and associated facilities would need to be replaced on a periodic basis (every 10 to 20 years). Recharge projects are technically implementable at the scale proposed and have been instituted to a large degree in the Lower South Platte River Basin. Protecting water from diversions in Colorado, however, is currently not possible due to the inability to bypass existing sand dam diversion structures. Significant costs would be incurred if these structures were to be modified and/or replaced to allow additional water to be protected downstream. The time to yield realization is dependent on the length of time required for recharged water to return to the river. If implemented at an SDF factor ranging from 60 to 300 days, the time to yield realization would be within one year from the start of the project. The alternative yield is not very easily measured. Calculations of recharge using the SDF method are engineering estimates with some uncertainty depending on site specific conditions. Observation wells would need to be installed and hydrogeologic investigations conducted to measure recharge water returning to the river. Third party hydrologic effects may include potential impacts on irrigated lands served by Lake McConaughy, the EA in Lake McConaughy, minimum operation flows, and hydropower production. These impacts may be minimal or significant depending on how recharge projects are implemented. Negative third party impacts would need to be offset or mitigated. There could also be additional negative third party impacts under Scenarios 1 through 3 to lands adjacent to drains because there will be increased flows in the drains. Additional flows in the drains could cause water logging at the surface adjacent to the drains, which may result in a loss of irrigated lands and agricultural productivity.

Under the scenario with diversion losses, third party hydrologic impacts would generally be more favorable because more water would be available for downstream users to divert during the summer months.

Legal and Institutional

These projects are consistent with Interstate Compacts, Federal Laws, and Decrees. Groundwater recharge projects in Nebraska are consistent with State laws. However, the primary legal/institutional obstacle associated with groundwater recharge projects in Colorado and Wyoming is associated with the inability to export water out of state under existing State water law. As such, groundwater recharge/return flow projects are currently not consistent with State laws. In Colorado an in-state beneficial use must be decreed or approved by the legislature for water to be used for the critical habitat. This issue has been addressed with the Tamarack Recharge Plan by decreeing in-state wildlife enhancement benefits associated with the recharge sites. The in-state benefit associated with these projects is the wildlife and environment enhancement associated with recharge ponds. Because these projects must have a decreed in-state beneficial use permitting could be a more difficult and lengthy process, however the process itself should be fairly routine as demonstrated by existing recharge projects in Colorado. Because these types of projects have been implemented to a large degree in Colorado already and are generally viewed favorably, there is a high potential for institutional consensus and there is no apparent reason why the same would not hold true for Wyoming and Nebraska. These projects would be relatively easy to administer particularly in Colorado where the required regulating entities already exist. Similar entities exist in Wyoming and Nebraska, however, new administration procedures may be required as these types of projects have not yet been implemented in those states. These projects are consistent with existing contracts, however, land may need to be purchased for recharge sites. These projects may have unidentified impacts that could most likely be mitigated if necessary.

Under the scenario with diversion losses, permitting, consistency with state laws, and potential for institutional consensus score higher. These projects would come under less opposition in general if additional water is not protected from diversions.

Social

The social effects of this alternative are likely to be minimal. There are potentially some minor positive and negative effects. There will be no impact on customs and culture, community organizations and support structures or community sustainability. These projects would have relatively equitable impacts and do not adversely impact any one group. Any adverse effects on cultural resources could most likely be mitigated. Existing groundwater recharge projects are publicly accepted in Colorado. Public acceptability associated with these projects is in part due to the wildlife enhancement benefits associated with the recharge sites. There would be opposition in Nebraska if recharge projects are located in areas that currently have problems with high groundwater levels. These areas typically have problems with water logging at the land surface and flooded basements. Although high water tables have been a problem in recent years north of the Platte River in Reaches 16 and 17, the situation is not as persistent as it is south of the river. The area north of the river is climatically drier with sandy soils which reduces groundwater mounding. According to representatives with NPPD, ground water levels in that area are climatically driven and have only been high in recent years. B-1 Reservoir was used as a recharge reservoir up until the last four to five years, therefore, public acceptability should not be an obstacle in Reaches 16 and 17.

The social sub-criteria are scored equally for both the with and without diversion scenarios.

Economic

Most of the costs of these alternatives are capital costs up front. However, diversion recharge projects that are associated with a ditch company may require an annual fee for water delivered to recharge sites. In addition, there are some annual operations and maintenance costs such as power costs, and pumping equipment and associated facilities would need to be replaced on a periodic basis (every 10 to 20 years). The are no definite positive or negative direct economic impacts and fiscal impacts. There could be potential negative secondary economic impacts to downstream hydropower generation for alternatives that divert water from the river that is in excess to target flows but which has historically been diverted for hydropower. As such, there could be additional costs associated with paying power interference charges. These projects will have minimal direct or indirect and induced impacts on business sales, employment and employee wages and wealth. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There would be no measurable effect on revenues and expenditures of governmental entities resulting from these types of projects.

The qualitative sub-criteria are scored equally for both the with and without diversion scenarios.

Environmental

These alternatives would generally result in positive environmental impacts. There would be positive impacts to wetlands and habitat due the creation of additional wetlands and wildlife habitat. Recharge projects could also have negative impacts on water quality and on fish and wildlife habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to recharge. Recharge projects could also have negative impacts on water quality due to the potential to increase water and soil salinization. Groundwater mounds at recharge sites could raise water tables in the surrounding area causing upflux of salts to the overlying soils. In addition, movement of diverted flows into and through the aquifer matrix could contribute to substantial dissolution of salts native to the geologic material in route back to the river. The visual quality of areas inundated would not be significantly impacted. There would be no impacts to prime and unique farmlands. Wildlife habitat areas created by these projects could generate some recreational opportunities but in general, there are minimal impacts to amenities.

The environmental sub-criteria are scored equally for both the with and without diversion scenarios.

Groundwater Transfer of Uses

Alternatives involving groundwater transfer of uses are incentive based reductions in agricultural groundwater use. The associated issues for incentive based programs to reduce agricultural water use are provided in Section 8.F.

Additional Surface Water and/or Groundwater Re-regulation Opportunities

Physical

Alternatives that provide additional surface water and/or groundwater re-regulation opportunities are generally comparable from a physical standpoint to groundwater recharge/return flow projects with some minor differences. It is possible that pumping water from the mound is not possible or not as effective during drought conditions if the groundwater table is lower during those periods. The limitations on scalability for projects that involve pumping from the mound are related to the sustainability of the projects. The projects as presented are very scalable and are dependent on the growth rate of the mound presented earlier. If the growth rate of the mound is less than presented or decreases in the future, the scalability of these projects would decrease. In addition, these projects are easier to monitor and measure than recharge projects that require the use of the SDF method to estimate the timing of return flows to the river. It is not difficult to monitor and measure groundwater pumping.

Under the scenario with diversion losses, third party hydrologic impacts would generally be more favorable because more water would be available for downstream diverters during the summer months.

Legal/Institutional

Groundwater re-regulation projects in Nebraska are consistent with interstate compacts, federal laws and decrees, and State laws. However, there could be legal/institutional obstacles associated with pumping from the groundwater mound. CNPPID has permits for 7 million acre-feet and 2.5 million acre-feet of incidental groundwater storage and recovery (Application U-2 and Application U-12), respectively. These permits are to recharge and remove groundwater, however, these permits have not yet been tested with respect to removing groundwater from the mound. There is some uncertainty as to the legal implications of pumping from the mound particularly if there are negative impacts on CNPPID's permits. There is uncertainty in Nebraska law regarding the question of ownership of water incidentally stored underground. The proposed alternatives could have negative impacts on CNPPID's permits if the mound is shrinking as opposed to growing. Based on information provided by CNPPID, the CNPPID Board would consider financial incentives to relinquish a portion of their rights so that the program could utilize this water source. However, as there is no precedent for removing water from the mound under the U-2 and U-12 permits, the costs of obtaining a portion of CNPPID's rights are currently unknown. This may or may not be necessary depending on whether the mound is currently growing or shrinking. CNPPID doesn't hold rights to all the water stored in the mound, nor do they hold rights to potential future storage in the mound, therefore, if the mound is growing the potential exists to implement alternatives to pump from the mound without impacting CNPPID's permits.

Pumping from the groundwater mound could possibly reduce the export of groundwater to the Republican and Little Blue Rivers. This could have legal implications with respect to current litigation between Nebraska and Kansas regarding the Republican River. Due to questions regarding impacts on CNPPID's permits and litigation between Nebraska and Kansas, these projects could be difficult to permit and the potential for institutional consensus is not assured. Because this type of project has not yet been implemented in any of the three states it could be more difficult to administer because there is no precedent upon which to base administration. These projects are consistent with existing contracts, facilities and land ownership. These projects may have unidentified impacts that could be mitigated if necessary.

Under the with diversions scenario the ability to protect groundwater pumped from the mound would be problematic under current State laws and could come under more opposition.

Social

Alternatives that provide additional surface water and/or groundwater re-regulation opportunities are generally comparable from a social standpoint to groundwater recharge/return flow projects. However, public acceptability has not been tested to a large degree because groundwater re-regulation projects are not as widely implemented in Wyoming and Nebraska. Pumping from the groundwater mound could be viewed both favorably, because it results in lower groundwater levels, and unfavorably, because there is some uncertainty as to the growth of the mound and the rate at which it can be depleted on a sustainable basis.

The social sub-criteria are scored equally for both the with and without diversion scenarios.

Economic

Most of the costs of this alternative are capital costs up front. There are some annual operations and maintenance costs such as power costs, and pumping equipment and associated facilities would need to be replaced on a periodic basis (every 10 to 20 years). There are no definite positive or negative fiscal impacts. Both direct and secondary economic impacts are offsetting. There could be potential negative secondary economic impacts to downstream hydropower generation for alternatives that divert water from the river that is in excess to target flows but which has historically been diverted for hydropower. As such, there could be additional costs associated with paying power interference charges. There could also be increased costs associated with pumping for irrigation or municipal uses if groundwater levels are lowered significantly, and these impacts need to be mitigated. However, lowering groundwater levels could improve the productivity and yield of certain irrigated lands, which would have a positive economic impact. Certain areas that are pursuing de-watering systems could experience economic benefits from alternatives that lower groundwater levels. In addition, the use of groundwater to irrigate lands previously irrigated with surface water could make more efficient use of existing supplies. These projects will have minimal direct or indirect and induced impacts on business sales, employment and employee wages and wealth. In addition, there are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There would be no measurable effect on revenues and expenditures of governmental entities resulting from these types of projects.

The qualitative economic sub-criteria are scored equally for both the with and without diversion scenarios.

Environmental

There may be negative impacts on wetlands and wildlife habitat if groundwater levels are lowered significantly in areas that are water logged at the surface and wetland areas are eliminated. Alternatively, water pumped from the mound could be used to create wetland meadows near the river. In which case there would be positive impacts to wetlands and habitat due to the creation of additional wetlands and wildlife habitat. These projects could also have negative impacts on water quality and on fish and wildlife habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the River. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to recharge. Recharge projects could also have negative impacts on water quality due to the potential to increase water and soil salinization. Scenarios that involve using groundwater pumped from the mound to irrigate lands previously irrigated by surface could contribute significantly to the salinization of irrigated soils. Groundwater salinity is also typically much higher than river water salinity, therefore, pumping groundwater from the mound back to the river could have negative impacts on Platte River water quality. There would be no visual impacts, impacts to prime and unique farmlands or impacts on amenities associated with these projects.

The environmental sub-criteria are scored equally for both the with and without diversion scenarios.

Reduction of Natural Groundwater Exports from the Basin

The reduction of natural groundwater exports from the basin refers to pumping from the groundwater mound to reduce exports to the Republican and Little Blue Rivers. The associated issues for this alternative are summarized under additional surface water and/or groundwater re-regulation opportunities.

There are some minor differences under legal and institutional, and environmental sub-criteria. Projects that specifically target reductions in transbasin exports of groundwater to the Republican and Little Blue Rivers are questionable regarding consistency with interstate compacts. This could have legal implications with respect to current litigation between Nebraska and Kansas regarding the Republican River. In addition, under environmental associated issues water quality could be degraded in the Republican and Little Blue watersheds if flows are reduced due to reductions in transbasin exports from the Platte River to those watersheds.

8.H. Systems Integration and Management

H. Systems Integration and Management

1. Introduction

This sections examines the yields, costs and associated issues of various systems integration and management alternatives to reduce shortages to target flows at the critical habitat. A number of systems integration and management alternatives in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into three categories:

Modifications to Reservoir Operations

Modifications to Existing Water Rights

Transbasin Diversions/Imports

Power Interference Charges

A brief description of each of the projects and how they might be implemented is provided below, followed by estimates of yields and costs for each project. An evaluation of each project in terms of physical, legal or institutional, economic, social, and environmental effects is also provided.

2. Conceptual Definitions

Modifications to Reservoir Operations. Both modified flow release rules and modified reservoir filling sequences have been included in this subcategory. Modifications to either reservoir release rules or filling sequences may result in opportunities to store excess/surplus water and ultimately improve the magnitude and timing of instream flows at the critical habitat area. For example, modifying reservoir rules that prohibit release of flows during months that correspond with target flow shortages at the critical habitat may significantly improve instream flows during critical time periods. Similarly, allowing two (or more) reservoirs to fill in a manner that contradicts strict administration by prior appropriation can increase the combined supply to both reservoirs. In some portions of the Platte River Basin, the water commissioners or those entities responsible for reservoir operation already practice this concept to a considerable extent. The strategy of filling reservoirs in this manner is to store water during periods when supplies are considered to be excess and release water during periods of target flow shortages.

Modifications to Existing Water Rights. This subcategory includes all modifications to existing water rights including changes in points of diversion, transfer of storage decrees, and water rights transfers and/or exchanges. These measures could provide for better utilization of existing water supplies by reallocating excess flows to months when there are target flow shortages. For example, transfer of storage decrees and water rights transfers and/or exchanges could reduce target flow shortages if water is transferred from an existing use such as irrigation or municipal use, to a use such as wildlife enhancement at the critical habitat. Additional flows could be provided to the critical habitat if a diversion point that is currently upstream of the habitat area is moved to a point downstream of the critical reach or water rights are transferred and dedicated to increasing instream flows in the critical habitat.

A change in point of diversion refers to changing the location at which a water right is diverted from the stream. In so doing, ditch conveyance and seepage losses may be reduced by either decreasing the length of the ditch or changing the legal point of diversion from a surface diversion to a well. Practically speaking, the conveyance losses precluded by this measure are not losses to the Platte River unless the ditch crosses into a basin that is not tributary to the Platte River. Consequently, this measure will not likely result in a significant increase in instream flows.

Transfers of storage decrees generally exist to legally institute modified operations or to create new storage with a more favorable appropriation date. With respect to this study, there may be potential to transfer storage decrees that are currently used for irrigation, power, municipal, flood control or recreation uses to benefit the endangered species at the critical habitat. The storage and release patterns could be modified so that water is stored during periods of excess and released during period of target flow shortages.

Water rights transfers or exchanges can refer to a wide array of mechanisms that move water from one sector, use, or owner to another. They may represent a source of supply, such as agricultural water rights, which are transferred to municipal use. With respect to system integration and management, users may convey water rights to a basin management entity in exchange for storage water, which could be released to reduce target flow shortages during critical times.

Transbasin Diversions/Imports. This alternative involves the import of water from adjacent basins. Use of these sources would require facilities for the capture, storage and conveyance of water to the Platte River Basin. With respect to the Platte River Basin, this alternative would provide a new water supply that could increase the flows available at the critical habitat area. Institutional issues involving state water rights and interstate basin compacts must be addressed, however, as well as environmental issues related to associated depletions in the source basin.

Power Interference Charges. This alternative refers to one distinct group of water users within the Platte River Basin, hydroelectric generators. This section defines an arrangement and the circumstances under which hydroelectric generators could contribute to the target flows at the critical habitat.

The power interference charge compensation alternative entails a monetary payment to a hydroelectric generator sufficient to induce that generator to modify the release of water through the hydropower turbines. The modification might include a change in the timing of such generation or perhaps a bypass of the turbines in order to reduce shortages in target flows at the critical reach. Under this alternative, the monetary payment must at least equal the value of the hydropower that is forsaken on behalf of the target flows. The participation of hydropower producers is assumed to be strictly voluntary, and the transaction terms are based upon the willing buyer/willing seller concept under current market conditions.

The power interference charge alternative is distinct from the changes in hydrogeneration within the Platte River Basin that might be attributable to the implementation of one or more other alternatives as part of the Cooperative Agreement Program. As the flows throughout the basin change, positive or negative impacts upon hydrogeneration are likely to occur. The U.S. Bureau of Reclamation, public power districts and other generators throughout the Platte River Basin might well seek payments if reoperation or rescheduling is required. These are considered to be third party impacts and not directly pertinent to this proactive power interference alternative. Mitigation payments might be relevant under these third party impact circumstances.

Since almost no water consumption occurs with hydrogeneration under any circumstance, there can be assumed to be no increase in average annual total flows to the critical habitat. The only benefit in terms of the program goals may be in the modified timing of stream flows on an hourly, daily, monthly or seasonal basis. In essence, this alternative is a potential means of shifting flows from periods of excess to target flows to periods of shortage.

3. Operational Definitions

For this reconnaissance level study, it is not possible to investigate every potential systems integration and management project within each region. Therefore, in completing this reconnaissance level study, some limitations and basic assumptions were applied to the systems integration and management alternatives to adequately evaluate the physical, economic, legal and institutional, social, and environmental aspects of each alternative. The following operational definitions describe the simplifying assumptions that were used to define and analyze these alternatives in the context of this study.

Modified Reservoir Operations. The following simplifying assumptions were used to define and analyze all alternatives related to modified reservoir operations:

- Reaches where opportunities for modifications of existing reservoirs may exist were identified. Existing operational rules and criteria for those reservoirs were obtained through previous studies, interviews and discussions with representatives of the agencies responsible for the operation of the reservoir.

- Historical filling and release patterns were evaluated to determine the potential for developing additional water for the downstream critical habitat area.

- Simplified revised operating procedures developed with input from agencies responsible for operating the reservoir were used to estimate the additional water yield through modifications of reservoir operations. The simplified operational procedures were applied to the existing reservoir operations and changes in the yield with respect to existing reservoir operations were identified.

Modifications to Existing Water Rights. The following simplifying assumptions were used to define and analyze all alternatives related to modifications to existing water rights:

- Locations where modifications to existing water rights (changes in points of diversion, transfer of storage decrees, and water rights transfers/exchanges) have resulted in significant conservation of existing water supplies were reviewed. Based on this information and previous studies, reaches that have similar potential were identified. If the potential for conservation of existing water supplies appeared to be significant, a more detailed analysis of the alternative was conducted.

- A simplified water budget analysis was conducted with and without implementation of the alternative when a more detailed analysis was required to determine the timing and magnitude of water available for delivery to the critical habitat area.

Transbasin Diversions/Imports. The following simplifying assumptions were used to define and analyze all alternatives related to transbasin diversions/imports:

- Previous reports and studies that involve transbasin diversions/imports from adjacent basins into the Platte River Basin were reviewed to identify potential alternatives.

- Specific reaches where implementation of transbasin diversions/imports may be feasible were identified.

- A simplified analysis was conducted to determine the net hydrologic effect (timing and magnitude) associated with implementation of the alternative if a transbasin diversion/import appeared feasible.

- A simplified water budget analysis was conducted if necessary to account for losses associated with conveying the additional water supplies from the adjacent basin to the Platte River Basin.

Power Interference Charges. To analyze this alternative, there are three defining elements that must be established. First, what type of hydrogeneration owner is in a legal position to participate in a power interference compensation program? Second, what type of hydrogeneration facility can feasibly modify releases? Third, what basis for payment is realistic? The following simplifying assumptions were used to define and analyze all alternatives related to power interference charges:

- It is assumed that only hydrogeneration facility owners can participate, but there are several different types of hydrogeneration facility owners. Owners can include public entities such as the U.S. Government, commonly through the USBR or municipalities. Public power entities such as rural electric associations and public power districts also own hydro facilities. Private, investor-owned utilities (IOUs) own hydrogeneration facilities as well.
- Owners of hydrogeneration facilities must be in a clear position to change power production schedules to be eligible to enter into a power interference program. Power generation is often a secondary purpose of USBR impoundment facilities in the Platte River Basin, secondary to water releases for irrigation purposes. USBR facilities also have repayment contracts that are established by federal law and power as well as other resources that are dedicated to specific local resource providers or consumers. Such facilities are not considered eligible under this alternative as defined. Entities are eligible if they can, largely on their own accord, reduce their power generation capacity and output in return for payment. It is recognized that all electricity generators and providers have supply obligations, and customers whose power needs must be satisfied.
- To be eligible, the hydro facility must have upstream storage; power generation should preferably be the primary purpose associated with the water released through the turbines; and the facility must be in a ready position to enter into a power interference charge arrangement. Hydrogeneration can be produced through run-of-river facilities, through power plants that are part of an impoundment structure, and through pumped storage facilities.

Run-of-river facilities with no storage are largely incapable of altering water release patterns and are, therefore, assumed to be ineligible for the power interference charge program. Pumped storage facilities have two impoundment facilities, the forebay and the power generation structure. These facilities require selling power on peak; since they are predicated on scheduling, it is not feasible for these facilities to alter that pattern.

- It is assumed that lost revenues from the sale of this resource must be compensated, at a minimum. Additional cost to replace the lost resource through other electricity generation may also be imposed. The basis for the charge or the compensation must be defined. If a reduction in the flow regimen through hydroturbines occurs, this means that a reduced amount of electricity will be produced, expressed in kilowatt hours (Kwh) or megawatt hours (Mwh). The capacity to produce power instantaneously is also reduced; this capacity loss is expressed in kilowatts (Kw) or megawatts (Mw). Both the loss in capacity to produce and the electric energy generated must be compensated by the power interference compensation program. Capacity accreditations for individual facilities have a value also, and system-wide capacity rating losses must be addressed as well.

- The incentive for power producers to participate, in addition to compensation for lost revenues, is assumed to be the power generation they will receive when the water is released at a different time to meet critical reach needs. This power is presumed to be much less valuable than the forsaken power, since its timing is no longer controlled (or optimized) by the hydroelectric facility owner. Still, off-peak generation should offer some benefit to the power producer. It is possible that this incentive might be insufficient, since the loss of capacity value must also be compensated.

4. Alternatives

Modifications to Reservoir Operations

Region 1

Glendo Reservoir

Glendo Reservoir, which is located near Glendo, Wyoming, is operated in conformity with the North Platte River Decree of 1945. It provides for irrigation, power generation, flood control, fish and wildlife enhancement, recreation, sediment retention, pollution abatement and improvement of the quality of municipal and industrial water supply in the North Platte River Valley between Gray Reef Dam and Glendo Reservoir. The storage capacity of the reservoir is 789,402 ac-ft (USBR, 1975) of which 271,917 ac-ft is allotted for flood control. The alternative considered here is reallocation of Glendo's storage space. Specifically, it has been proposed that storage capacity in the flood pool could be dedicated to a pool for the benefit of instream uses at the critical habitat.

The U.S. Army Corps of Engineers (Corps) conducted a preliminary reevaluation of the flood control space in Glendo Reservoir as part of the Deer Creek Reservoir Final Environmental Impact Statement (FEIS), dated September 1987, to determine if space could be reallocated to different uses. This reevaluation, which was discussed in the FEIS, was based only on a review of hydrologic parameters that might have changed since the project was designed. The Corps concluded that the rainfall magnitude for the design event had increased significantly, however, their latest data indicated that infiltration losses above Glendo had also increased significantly. The net result was an 8,000 ac-ft decrease in the amount of storage required at Glendo Reservoir to contain the Standard Project Flood, which was the basis of the original flood storage design.

USBR subsequently conducted a comprehensive study of structural integrity and related safety issues for its dams on the North Platte River. The Safety of Dams (SOD) Corrective Action Study (CAS) was performed by USBR's Technical Service Center in Denver, Colorado. All potential SOD deficiencies were analyzed and documented in

Modification Decision Analyses (USBR, 1992). Glendo Dam was identified as being unable to pass the theoretical Probable Maximum Flood (PMF). Decision Memorandum No. DEC-GL-3620-1, dated June 30, 1992, concluded that Glendo Reservoir could not pass the theoretical PMF without overtopping the dam. The Corps also references USBR's revised PMF for Glendo Dam and Reservoir and its inability to pass the PMF in their Water Control Manual. USBR is now committed to modifying the structure, although it is unclear whether they will enlarge the reservoir, the spillway capacity, or both.

Since it is clearly recognized that Glendo Reservoir is unable to pass the PMF, the possibility of reducing flood storage appears to be precluded. Accordingly, this alternative has been deferred from further evaluation at this time.

Region 2

Chatfield Reservoir

Chatfield Reservoir is located on the South Platte River about eight miles upstream of Denver. The Corps completed Chatfield Reservoir in 1977 as a flood control facility with recreation as a secondary function. In the early 1980's, the Corps reevaluated the storage capacity for the design flood and found that additional space could be made available for approximately 22,700 ac-ft of water for water supply purposes without requiring additional structural work on the dam (USACOE, 1986). However, major relocation of recreational facilities, placement of additional riprap and installation of monitoring instruments would be necessary.

More recently, Hydrosphere Resource Consultants (Hydrosphere) completed a report, Evaluating South Platte Storage Alternatives (1999) to evaluate South Platte storage alternatives for the ongoing Environmental Impact Statement (EIS). Data from this report was derived from the Metropolitan Denver Water Supply EIS (USACOE, 1986).

Yield

The operational analysis conducted by Hydrosphere (1999) showed that 23,000 ac-ft of additional storage in Chatfield Reservoir could yield an average of 3,300 ac-ft per year at the reservoir if South Platte River storable flows were utilized. The on-site yield was calculated as the average annual amount of water released over the model period. Yields at North Platte, Nebraska, according to the Hydrosphere report, would be 3,200 ac-ft.

Cost

The Metropolitan Denver Water Supply EIS (USACOE, 1986) estimated the costs of alterations to accommodate water supply as $9.1 million in 1983 dollars. This estimate includes major relocation of recreational facilities, installation of additional riprap, and monitoring instrumentation. These costs were adjusted to reflect 1998 dollars based on average annual ENR cost indices and were estimated to be $13.3 million. The resulting cost per ac-ft of yield at the site was $4,030. Because the average annual cost per ac-ft of reduction to target flow shortages exceeds $3,000, this alternative does not warrant further evaluation at this time.

Region 3

B-1 Reservoir

B-1 Reservoir, which is located approximately 15 miles west of Gothenburg, Nebraska, was constructed in the early 1980's for flood control and to induce groundwater recharge in the surrounding area in accord with the Central Platte Natural Resources District's (CPNRD) groundwater management plan (1993). The current capacity of the reservoir is approximately 7,305 ac-ft.

B-1 Reservoir currently has a 4,990 ac-ft flood control pool and a 2,015 ac-ft conservation pool. The reservoir is located on West Buffalo Creek and is filled via an inlet canal from water diverted through the Gothenburg Canal. Historically the conservation pool was filled in both the spring and fall to induce groundwater recharge in the area. It has been used for recharge only sporadically during the 1990's because of increased groundwater levels in the surrounding area.

Operation of the conservation pool could be modified to store water during periods of excess when Gothenburg Canal is not used for irrigation. Releases from the reservoir are currently made through an 8-inch gate at the bottom of the dam. Rehabilitation of the outlet structure to allow larger flows and automation of the gate controls to allow for remote operations would be required for use by the Program.

The study team relied on conversations with CPNRD and Nebraska Public Power District (NPPD) personnel to evaluate conservation storage in B-1 Reservoir to reduce target flow shortages at the critical habitat (CPNRD, 1999; NPPD, 1999c).

Yield

To evaluate the yield of the B-1 Reservoir conservation pool, the study team developed a simplified reservoir operations model. The following operating rules and assumptions were used in the analysis.

- Storable flows were considered to be the amount available above the Gothenburg Canal at Brady, Nebraska during months of excess flows at the critical habitat.
- The conservation pool was assumed to be empty at the beginning of the study period.
- The conservation pool was operated to fill to maximum capacity with available supply through a 25-cfs inlet canal.
- Based on historical operations through the Gothenburg Canal, diversions for storage were enabled in late September through November and late March through June. Diversions for storage in the winter were not allowed because of the possibility of ice jams.
- Monthly evaporation amounts were based on the previous month's capacity and appropriate monthly evaporation rates. A simple area-capacity relationship based on maximum reservoir capacity and an average reservoir depth of 35 feet was used.

- Releases from the reservoir were made during months of target flow shortages at the critical habitat.

- A seepage rate of 8 percent of monthly storage volume was developed in the Riverside Water Study (W.W. Wheeler, 1979) for an off-channel reservoir. Seepage water was returned to the Buffalo Creek in the same month for this on-stream reservoir.

Table 8.H.1 shows the local net hydrologic effects through the 20-year study period. Negative values indicate months when water goes into storage; positive values indicate months when water is released.

Releases from B-1 Reservoir are discharged into Buffalo Creek in Reach 17. The flow additions and reductions from this alternative were assumed to occur 10 miles below the Cozad stream gage. The water budget spreadsheet was used to route the water downstream to the critical habitat. Two routing scenarios were evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

The summary table in Section 5 summarizes the average annual values for net hydrologic effects at the alternative site; at the top of Reach 18, with and without diversions; and at the critical habitat, with and without diversions. Tables 8.H.2 and 8.H.3 show the reductions to target flow shortages at the critical habitat for the B-1 Reservoir alternative. The average annual reductions to target flow shortages with and without downstream diversion losses are 493 ac-ft and 552 ac-ft, respectively.

The Gothenburg Canal can currently spill about 90 cfs. The B-1 Reservoir inlet canal is constrained to about 25 cfs because the canal is siphoned under an intervening creek. The opportunity to upgrade the inlet canal to convey up to 90 cfs from the Gothenburg Canal was investigated. Average annual reductions to target flow shortages with and without downstream diversion losses with a 90-cfs inlet canal are 567 ac-ft and 621 ac-ft, respectively. The increased yield is marginal considering the additional cost that would be incurred to improve the inlet canal, therefore, this particular scenario does not warrant further evaluation at this time.

Table 8.H.1
B-1 Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1537	1056	477	0	0	-769	-483	1234	0	0	0	-744	-765
1976	-531	524	60	55	626	-769	-483	1234	0	0	0	-744	-28
1977	-531	524	743	0	0	-769	-483	1234	0	0	0	-744	-25
1978	-533	524	743	0	0	-769	-483	1235	0	0	0	-744	-26
1979	-532	524	743	0	0	-769	-484	1235	0	0	0	-744	-26
1980	-532	524	60	55	50	-722	-615	152	139	1554	0	-744	-79
1981	-530	524	60	55	626	-769	-485	1237	0	0	0	-744	-25
1982	-531	524	60	55	626	-769	-485	1235	0	0	0	-744	-27
1983	-530	524	60	55	50	-722	-615	152	139	127	115	-639	-1285
1984	72	1686	13	12	11	-759	-1061	155	141	128	1446	-744	1102
1985	-1212	93	148	136	125	-654	2067	0	0	0	0	-744	-39
1986	-531	524	60	55	50	-722	-615	152	138	126	114	-640	-1288
1987	72	-22	149	137	126	-653	167	152	139	126	1410	-744	1059
1988	-531	-642	153	140	129	706	-484	1232	0	0	0	-744	-42
1989	-533	524	60	55	626	-769	-485	1233	0	0	0	-744	-32
1990	-532	524	743	0	0	-769	-484	1236	0	0	0	-744	-25
1991	-533	524	60	55	626	-769	-483	100	91	1018	0	-744	-55
1992	-531	524	60	55	626	-769	-484	1231	0	0	0	-744	-32
1993	-532	524	60	55	626	-769	-482	1236	0	0	0	-744	-26
1994	-1212	92	148	136	1561	-769	-483	1233	0	0	0	-744	-36
Average	-589	480	233	55	324	-676	-372	846	39	154	154	-733	-85

Table 8.H.2
B-1 Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1226	778	350	0	0	-731	-459	1134	0	0	0	-612	-767
1976	-344	375	0	0	580	-722	-431	1144	0	0	0	-316	286
1977	-434	390	558	0	0	-747	-411	1171	0	0	0	-632	-104
1978	-454	437	595	0	0	0	-465	1147	0	0	0	-329	931
1979	-330	390	634	0	0	-764	-458	1148	0	0	0	-436	184
1980	-372	435	0	0	0	0	0	0	0	1072	0	-434	701
1981	-393	383	0	0	517	-709	-445	1162	0	0	0	-428	88
1982	-434	517	0	0	623	-715	-435	1102	0	0	0	-518	141
1983	-523	432	0	0	0	0	0	0	0	0	0	0	-91
1984	0	1620	0	0	0	0	0	0	0	0	891	0	2511
1985	0	0	0	0	0	0	1955	0	0	0	0	0	1955
1986	-520	464	0	0	0	0	0	0	0	0	0	0	-56
1987	0	0	0	0	0	0	0	0	0	0	998	0	998
1988	-415	0	0	0	0	664	-414	1100	0	0	0	-601	333
1989	-443	520	0	0	594	-697	-451	1034	0	0	0	0	557
1990	-507	476	605	0	0	-763	-470	1187	0	0	0	-411	116
1991	-386	417	0	0	604	-737	-408	0	0	326	0	-356	-540
1992	-326	490	0	0	618	0	-466	982	0	0	0	-496	802
1993	-454	469	0	0	407	0	-476	1178	0	0	0	0	1125
1994	0	0	0	0	1273	-764	-474	1178	0	0	0	-516	696
Average	-378	430	137	0	261	-334	-215	733	0	70	94	-304	493

Table 8.H.3
B-1 Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1226	811	354	0	0	-731	-459	1191	0	0	0	-612	-673
1976	-344	384	0	0	580	-722	-431	1194	0	0	0	-316	345
1977	-434	396	558	0	0	-747	-411	1209	0	0	0	-632	-61
1978	-454	438	595	0	0	0	-465	1196	0	0	0	-329	981
1979	-330	400	634	0	0	-764	-458	1201	0	0	0	-436	247
1980	-372	432	0	0	0	0	0	0	0	1410	0	-434	1036
1981	-393	380	0	0	517	-709	-445	1199	0	0	0	-428	122
1982	-434	517	0	0	623	-715	-435	1196	0	0	0	-518	235
1983	-523	432	0	0	0	0	0	0	0	0	0	0	-91
1984	0	1622	0	0	0	0	0	0	0	0	958	0	2580
1985	0	0	0	0	0	0	2035	0	0	0	0	0	2035
1986	-520	459	0	0	0	0	0	0	0	0	0	0	-60
1987	0	0	0	0	0	0	0	0	0	0	1047	0	1047
1988	-415	0	0	0	0	670	-414	1104	0	0	0	-601	344
1989	-443	520	0	0	594	-697	-451	1091	0	0	0	0	615
1990	-507	476	605	0	0	-763	-470	1214	0	0	0	-411	144
1991	-386	418	0	0	604	-737	-408	0	0	364	0	-356	-501
1992	-326	490	0	0	618	0	-466	1035	0	0	0	-496	855
1993	-454	469	0	0	407	0	-476	1200	0	0	0	0	1147
1994	0	0	0	0	1273	-764	-474	1184	0	0	0	-516	703
Average	-378	432	137	0	261	-334	-211	761	0	89	100	-304	552

Cost

The direct costs of this alternative are associated with upgrading the outlet gate, installing an automated control system (e.g. SCADA) to allow for remote operations, and delivery fees through the Gothenburg Canal.

Upgrading the outlet works and installing a SCADA system would cost approximately $600,000, based on similar work done on small reservoir systems. For this analysis it was assumed the project would pay a delivery fee of $10 per ac-ft delivered in accordance with NPPD charges for irrigation water deliveries in the Gothenburg Canal. Delivery fees (~$43,000/yr) were amortized over 20 years at a discount rate of 6 percent.

The initial estimate for this alternative, including engineering and contingency costs, is approximately $1.3 million. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $2,310 assuming releases can be protected from downstream diversions. The cost per ac-ft of target flow reductions at the critical habitat would be approximately $2,590 assuming releases cannot be protected from downstream diversions.

Modifications to Existing Water Rights

Region 1

La Prele Reservoir

La Prele Reservoir, which is located on La Prele Creek in Wyoming, was constructed between 1905 and 1909. The current capacity of the reservoir is approximately 20,000 ac-ft and it is permitted for irrigation, domestic, and industrial uses. From the time construction was completed, the dam leaked considerably, and as a result of progressive deterioration due to freezing and thawing, winter storage has at times been restricted.

In 1974 the Douglas Water Users Association (Association), which was the owner of the La Prele Reservoir at that time, reached an agreement with the Panhandle Eastern Pipeline Company (PEPL) to rehabilitate the reservoir. PEPL was seeking water rights to supply a proposed coal gasification project in the region. The terms of the agreement provided that PEPL purchase 5,000 ac-ft of storage from the Association at a price equivalent to the principal and interest of a loan, which the Association obtained for the purpose of rehabilitating the reservoir and associated transbasin supply ditches. Under the agreement, the Association would deliver its portion of storage water to downstream users that are members of the Association, while PEPL's water would be delivered down La Prele Creek to the North Platte River. The terms of the agreement and further regulations placed on the agreement by the State Board of Control are as follows:

- PEPL can receive up to 2,500 ac-ft during the non-irrigation season from October 1 through April 30.
- During the irrigation season, PEPL can receive up to the difference between actual winter deliveries during the preceding non-irrigation season and 5,000 ac-ft.
- During the irrigation season, the available supply is prorated 75 percent to the Association and 25 percent to PEPL in the event of a shortage.
- Leakage is accounted for as storage and charged and delivered to PEPL as a portion of PEPL's 5,000 ac-ft entitlement.
- No water rights on La Prele Creek shall be injured.
- The reservoir shall be operated under the one-fill criteria with all releases to PEPL deducted from the annual entitlement of water for the La Prele Reservoir.
- Conveyance losses shall be determined by the Superintendent and Hydrographer Commissioner, and allowances for losses shall be made in administering the appropriation.

La Prele Reservoir was originally managed by the Association, however, later in 1978 the La Prele Irrigation District (District) was formed and assumed management of the water and the reservoir. The reservoir rehabilitation project was completed in 1980 and storage restrictions were lifted. By the early 1980's, PEPL had abandoned their coal gasification enterprise and as a result PEPL's storage right for 5,000 ac-ft may be available for lease or sale for use by the Platte

River Recovery Implementation Program (Program). PEPL's 5,000 ac-ft share in La Prele Reservoir is limited only by the yield of its share and the conditions under which it may be put to beneficial use in the context of the Program. PEPL's agreement with the District is in effect for 25 years beginning October 1986, when PEPL projected that they would be ready to take delivery of the water. At PEPL's option, the agreement can be extended for up to 15 years after the first 25 years. Therefore, 12 years remain on PEPL's original agreement, with the option to renew the agreement for another 15 years. Accordingly the agreement is sustainable until the year 2026.

Yield

To evaluate the yield of PEPL's portion of La Prele Reservoir, a simplified operations study was conducted for the study period from 1975 through 1994. The study is based on a similar investigation done by Banner and Associates in 1981. The logic and data sources of the study are described below:

1. Inflow to La Prele Reservoir: The USGS maintained a streamflow gage on La Prele Creek a short distance above the reservoir. USBR estimated reservoir inflow as 105.5 percent of gage flow in their 1969 feasibility report on the La Prele Reservoir. The extra 5.5 percent accounts for inflow between the gage and the dam.

2. Senior Downstream Rights: The reservoir must bypass water to downstream senior, direct-flow diverters that have no storage in La Prele Reservoir. The bypass requirement is based on 1,469 irrigated acres and the statutory diversion allowance of 1 cfs per 70 irrigated acres. In addition, the bypass requirement is reduced by 800 ac-ft distributed uniformly over the irrigation season based on the USBR's estimate of average annual return flows that are used for irrigation.

3. District Demand: The reservoir must bypass to project lands after the senior direct flow users have been satisfied. Project lands consist of 11,454 irrigated acres, of which, 10,305 acres are District lands, and 1,149.5 acres are associated with "carrier rights". The bypass requirement is based on USBR's estimate of annual water requirements and its monthly distribution.

4. Seepage: The current stage-seepage relationship as reported by the Hydrographer-Water Commissioner is that seepage varies linearly with stage, from 0 cfs at the dead pool elevation to 7 cfs at the spillway height. Seepage calculations were simplified to be 3.5 cfs throughout the study period.

5. Evaporation: Evaporation is based on the reservoir surface area and appropriate monthly evaporation rates. Evaporation calculations were simplified using an average surface area of approximately 450 acres throughout the study period, which corresponds with a storage volume of approximately 10,000 ac-ft, or half of the current capacity. Evaporation was prorated 25 percent to PEPL's storage account and 75 percent to the District's storage account, respectively, based on the maximum storage capacities of each account.

PEPL's storage water in La Prele Reservoir is currently being used by the District, therefore, diversions to storage under PEPL's account were not treated as negative flows. Monthly releases from La Prele Reservoir were routed downstream using the water budget spreadsheet. Two routing scenarios were evaluated for the proposed project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions.

Table 8.H.4 summarizes the net hydrologic effects, or reservoir releases from La Prele Reservoir, which is the additional water to be routed downstream to the critical habitat. La Prele Reservoir is located approximately at mile 115 of reach 3. The water budget spreadsheet was first used to determine the additional flows that occur at the top of reach 4. The average annual additional flow at the top of reach 4 is 3,579 ac-ft under both scenarios. Tables 8.H.5 and 8.H.6 summarize the reductions to target flow shortages at the critical habitat with and without diversion losses, respectively. The average annual reductions to target flow shortages without downstream diversion losses and with downstream diversion losses are approximately 2,238 ac-ft and 954 ac-ft, respectively. Information regarding the additional flow at Grand Island is provided in the yield summary section.

Table 8.H.4
PEPL's Storage Account in La Prele Reservoir
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	549	537	513	211	672	0	0	786	0	0	0	0	3268
1976	549	537	211	211	965	0	0	1485	0	0	0	0	3958
1977	549	537	513	475	426	0	0	560	0	0	0	0	3060
1978	549	537	513	475	426	0	0	2500	0	0	0	0	5000
1979	549	537	513	475	426	0	0	143	0	0	0	0	2643
1980	549	537	211	211	211	211	211	211	211	2177	0	0	4740
1981	549	537	211	211	965	0	0	0	0	0	0	0	2473
1982	549	537	211	211	965	0	0	950	0	0	0	0	3423
1983	549	537	211	211	211	211	211	211	211	211	211	211	3195
1984	211	2257	211	211	211	211	211	211	211	211	471	0	4627
1985	211	211	211	211	211	211	1107	0	0	0	0	0	2373
1986	549	537	211	211	211	211	211	211	211	211	211	211	3195
1987	211	211	211	211	211	211	211	211	211	211	577	0	2687
1988	549	211	211	211	211	1045	0	2500	0	0	0	0	4938
1989	549	537	211	211	965	0	0	0	0	0	0	0	2473
1990	549	537	513	211	672	0	0	0	0	0	0	0	2482
1991	549	537	211	211	965	0	0	211	211	1897	0	0	4791
1992	549	537	211	211	965	0	0	0	0	0	0	0	2473
1993	549	537	211	211	965	0	0	2500	0	0	0	0	4973
1994	211	211	211	211	1581	0	0	2500	0	0	0	0	4925
Average	481	558	287	251	622	116	108	760	63	246	73	21	3585

Table 8.H.5
PEPL's Storage Account in La Prele Reservoir
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	113	275	297	0	453	0	0	16	0	0	0	0	1153
1976	40	263	0	0	724	0	0	31	0	0	0	0	1058
1977	75	244	282	252	264	0	0	15	0	0	0	0	1131
1978	260	267	285	308	363	0	0	111	0	0	0	0	1594
1979	85	224	315	284	213	0	0	2	0	0	0	0	1124
1980	29	227	0	0	0	0	0	0	0	2	0	0	258
1981	44	233	0	0	617	0	0	0	0	0	0	0	895
1982	51	346	0	0	754	0	0	7	0	0	0	0	1159
1983	79	303	0	0	0	0	0	0	0	0	0	0	382
1984	0	1513	0	0	0	0	0	0	0	0	8	0	1520
1985	0	0	0	0	0	0	249	0	0	0	0	0	249
1986	71	302	0	0	0	0	0	0	0	0	0	0	373
1987	0	0	0	0	0	0	0	0	0	0	5	0	5
1988	279	0	0	0	0	799	0	244	0	0	0	0	1323
1989	51	291	0	0	695	0	0	0	0	0	0	0	1037
1990	246	300	289	0	462	0	0	0	0	0	0	0	1297
1991	32	373	0	0	713	0	0	0	0	1	0	0	1118
1992	33	307	0	0	755	0	0	0	0	0	0	0	1095
1993	307	337	0	0	501	0	0	29	0	0	0	0	1175
1994	0	0	0	0	1101	0	0	37	0	0	0	0	1138
Average	90	290	73	42	381	40	12	25	0	0	1	0	954

Table 8.H.6
PEPL's Storage Account in La Prele Reservoir
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	426	402	374	0	592	0	0	696	0	0	0	0	2490
1976	353	382	0	0	873	0	0	1317	0	0	0	0	2926
1977	446	395	379	368	380	0	0	500	0	0	0	0	2468
1978	449	435	403	326	396	0	0	2153	0	0	0	0	4162
1979	330	398	430	377	315	0	0	126	0	0	0	0	1977
1980	358	431	0	0	0	0	0	0	0	1526	0	0	2315
1981	391	378	0	0	771	0	0	0	0	0	0	0	1539
1982	431	512	0	0	933	0	0	847	0	0	0	0	2723
1983	520	433	0	0	0	0	0	0	0	0	0	0	953
1984	0	2120	0	0	0	0	0	0	0	0	297	0	2416
1985	0	0	0	0	0	0	1009	0	0	0	0	0	1009
1986	524	460	0	0	0	0	0	0	0	0	0	0	984
1987	0	0	0	0	0	0	0	0	0	0	396	0	396
1988	408	0	0	0	0	960	0	2067	0	0	0	0	3435
1989	437	515	0	0	893	0	0	0	0	0	0	0	1846
1990	498	469	403	0	634	0	0	0	0	0	0	0	2004
1991	343	414	0	0	903	0	0	0	0	601	0	0	2262
1992	316	488	0	0	926	0	0	0	0	0	0	0	1731
1993	441	466	0	0	594	0	0	2222	0	0	0	0	3723
1994	0	0	0	0	1255	0	0	2155	0	0	0	0	3410
Average	334	435	99	54	473	48	50	604	0	106	35	0	2238

Cost

PEPL's position in La Prele Reservoir was obtained, in effect, by PEPL agreeing to indemnify the full repayment of the rehabilitation loan that was made by the State of Wyoming Farm Loan Board to the District. The total loan by the Farm Loan Board to the District was $4,975,000 and bears interest as an annual rate of four percent on the declining balance. The annual debt service payment is a constant amount of about $318,460. The remaining principal payment on the note is approximately $1,156,000. The terms of the agreement between PEPL and the District indicate that PEPL is also responsible for a portion of the annual operation and maintenance costs associated with the reservoir, however, this cost is minimal.

Any transaction involving the sale or lease of PEPL's water right would require the approval of the Board of Directors of the District. An Information Memorandum was prepared by National Water Company that provided information on the cost of 2,500 ac-ft of water and storage rights in La Prele Reservoir. As of October 1994, the cost provided in the Information Memorandum to purchase 2,500 ac-ft of water and storage was $3,000,000, of which $2,261,530 consisted of the remaining principal on the note.

Based on information provided by a representative for PEPL, the remaining principal payment on the note is currently $1,156,000 (National Water Company, 1999). The additional cost in 1994 for 2,500 ac-ft of storage beyond the remaining principal payment on the note was approximately $740,000. Assuming, that additional cost also applies today for 5,000 ac-ft, the total cost to purchase 5,000 ac-ft of storage is estimated to be $1,896,000. Obtaining the approval of the District could further impact the cost of purchasing PEPL's water and storage.

Based on a total cost of $1,896,000 the cost per ac-ft of reductions to target flow shortages at the critical habitat would be approximately $850 assuming additional flows can be protected from downstream diversions and $1,990 assuming additional flows cannot be protected from downstream diversions. Based on the agreement between PEPL and the District, this water is only available for 27 years assuming the agreement is renewed after the next 12 years.

Grayrocks Reservoir

Grayrocks Reservoir is located on the Laramie River approximately 20 river miles upstream of its confluence with the North Platte River. The reservoir was constructed between 1978 and 1980. In November of 1980, Basin Electric Power Cooperative (BEPC) assumed operation of Grayrocks Reservoir and Dam. The maximum storage capacity of the reservoir is 104,110 ac-ft which is allocated as indicated below:

Irrigation	22,500 ac-ft
Fish and Wildlife	15,000 ac-ft
Recreation (Inactive Storage)	2,558 ac-ft
Industrial (also available for fish and wildlife)	64,052 ac-ft
Total	104,110 ac-ft

During construction of the Grayrocks Reservoir and Dam, a dispute arose concerning loan guarantees for the project and the issuance of a dredge and fill permit under Section 404 of the Federal Water Pollution Control Act. To settle the dispute, an Agreement of Settlement and Compromise was entered into on December 4, 1978.

The agreement stipulated that releases must be made from Grayrocks Reservoir to maintain minimum flows, as measured at the first gaging station below the dam, of 40 cfs during April, and 40 cfs or 75% of the natural flow at the same gaging station during the remaining five months of the water year (May through September, inclusive), whichever is greater. In addition, BEPC agreed to operate Grayrocks Reservoir to provide for the delivery of 40 cfs at the mouth of the Laramie River during six months of the year (October through March, inclusive), 50 cfs during April, and 40 cfs or 75% of the natural flow of the Laramie River at its mouth during the remaining five months of the year (May through September, inclusive), whichever is greater; provided that BEPC will not be required to release more than 200 cfs at any one time nor more than 12,000 ac-ft during any month. Whenever total reservoir storage drops below 50,000 ac-ft, the flow levels to be maintained by BEPC are 20 cfs from October through March, and 40 cfs from April through September, as measured at the mouth of the Laramie River.

The State of Wyoming was not a signatory to the agreement and has not presently agreed to administer the Laramie River in accordance with the agreement. Historically, BEPC has released flows from Grayrocks Reservoir to meet its obligations in accordance with the agreement. Recently, the Wyoming State Engineer approved a secondary permit which provides for the protection of the fish and wildlife storage releases from Grayrocks Reservoir to the mouth of the Laramie River. Downstream of the mouth of the Laramie River, the flows released from the reservoir are not protected from diversion. Consequently, the minimum flows at the mouth of the Laramie River are administered as natural inflow to the North Platte River. In accordance with the North Platte Decree, the natural flows entering the North Platte River are split 75% to Nebraska and 25% to Wyoming during the irrigation season. Presently, the natural flows entering the North Platte River from the Laramie River are diverted by water users in both Wyoming and Nebraska in accordance with the North Platte Decree.

This alternative is simply the protection of the minimum flow releases associated with the Agreement of Settlement and Compromise. However, implementation of this alternative assumes that the signatory parties to the North Platte Decree would either agree or approve to the protections of these flows that are presently administered as natural flow in the North Platte River. The comments received from parties signatory to the North Platte Decree during the review of this study report indicated that implementation of this alternative is not consistent with the Decree and cannot be circumvented. Therefore, this alternative was deferred from further consideration at this time based upon failure to pass the Legal/Institutional screening criteria.

Toltec Dam and Reservoir

Toltec Dam and Reservoir is a small reservoir located on the North Laramie River in Albany County, Wyoming. The reservoir was built in the early 1980's to provide storage for irrigation water, develop an improved fishery, and to reduce flood damages (USDA, 1980). The reservoir was included in this category because there may be a potential to reallocate all or a portion of the existing storage rights. The total available capacity of the reservoir is 2,945 ac-ft, of which 2,425 ac-ft is allocated for irrigation, stock and recreation uses. The reservoir has a dead storage pool of 520 ac-ft allocated to recreation and stock usage (Wyoming SEO, 1999a, 1999b, 1999c).

Presently, the reservoir is used for irrigation of approximately 1,745 acres of pasture and hay (USDA, 1980). This equates to an irrigation application of approximately 1.4 feet per acre assuming the entire active storage of 2,425 ac-ft is available for irrigation of the 1,745 acres. The consumptive irrigation requirement of pasture grass and hay for this area is about 1.7 feet per acre (Pochop, et al., 1992). Given the magnitude of irrigated acreage and the consumptive irrigation requirement of pasture grass and hay, the storage available is fully utilized. Consequently, there is limited, if any, available storage for reallocation. This alternative was deferred from further evaluation at this time based upon failure to pass the physical screening criteria.

Dodge Dam and Reservoir

In 1993, the Dodge Dam and Reservoir Level II investigation was completed for the Wyoming Water Development Commission by Western Water Consultants (Western Water Consultants, 1993). The proposed dam site for this alternative is located approximately 40 miles north of the city of Laramie and downstream of Wheatland No. 2 Reservoir. The reservoir would provide storage to replace or supplement water now stored in Wheatland No. 2 and Wheatland No. 3 Reservoirs. Small dam alternatives (less than 70,000 ac-ft) would not encroach upon Wheatland No. 2 Reservoir and would supplement its storage. Large dam alternatives (greater than 70,000 ac-ft up to 170,000 ac-ft) would replace Wheatland No. 2 Reservoir. The surface area of Dodge Reservoir would be smaller in comparison to Wheatland No. 2 Reservoir, which would result in average annual savings of up to 3,382 ac-ft per year in evaporation losses for a maximum reservoir size of 170,000 ac-ft.

The evaluation of alternative configurations of Dodge Dam and Reservoir that would reduce evaporation losses was conducted using the following assumptions and methods:

1. The water identified for reducing the target flow shortages at the critical habitat is derived from savings in evaporation losses resulting from replacing and/or supplementing Wheatland No. 2 and No. 3 Reservoirs with the proposed Dodge Reservoir. The total

estimated average quantity of water resulting from evaporation savings is assumed to be available every year.

2. Dam and reservoir configurations were limited to those presented in the 1993 Western Water Consultants report. These alternatives include reservoir sizes of 40,000, 70,000, 130,000, and 170,000 ac-ft. The 40,000 ac-ft configuration was determined to be the maximum size reservoir that would not encroach upon Wheatland No. 2. The 70,000 ac-ft reservoir represents the approximate, active capacity of Wheatland No. 3. The 170,000 ac-ft reservoir is equivalent to the total active capacities of Wheatland Nos. 2 and 3. The 130,000 ac-ft reservoir represented a reasonable intermediate size.

3. Average annual evaporation savings associated with the four reservoir alternatives were reported to be 2,200 ac-ft (40,000 ac-ft reservoir), 970 ac-ft (70,000 ac-ft reservoir), 2,750 ac-ft (130,000 ac-ft reservoir), and 3,382 ac-ft (170,000 ac-ft reservoir).

4. The Western Water Consultants report estimated the costs of construction (1993 dollars) of the four reservoir alternatives to be $12.8 million (40,000 ac-ft reservoir), $14.1 million (70,000 ac-ft reservoir), $16.2 million (130,000 ac-ft reservoir), and $17.1 million (170,000 ac-ft reservoir). These costs were adjusted to reflect 1998 dollars based on average annual ENR cost indices and were estimated to be $14.5 million (40,000 ac-ft reservoir), $16.0 million (70,000 ac-ft reservoir), $18.4 million (130,000 ac-ft reservoir), and $19.4 million (170,000 ac-ft reservoir).

Based on the total 1998 costs for the various reservoir sizes, the costs per ac-ft as measured at the dam site range from about $5,700 to $16,500. Given these unit costs, which exceed the economic screening criteria, all of the Dodge Reservoir alternatives were deferred from further analysis and consideration at this time.

Transbasin Diversions/Imports

Region 1

Middle Fork Powder River Transbasin Diversion

A dam and reservoir has been proposed approximately 20 miles upstream from the confluence of the Middle Fork and the North Fork of the Powder River for irrigation, recreation, instream flows, and industrial purposes. The Powder River is a tributary of the Missouri River Basin. This project could be modified to generate water for the critical habitat. A modified project would consist of construction of the dam, reallocating the industrial pool to the critical habitat, and construction of a pipeline to the North Platte basin so that a transbasin diversion can be made.

This alternative would include a 59,600 ac-ft capacity reservoir providing a firm yield of 27,000 after satisfaction of existing water rights and instream flow demands (Harza Engineering Company, et al., 1986b). As currently proposed, a total of 15,000 ac-ft is allocated to an industrial pool, 6,500 ac-ft to support a minimum instream flow provision, and the remainder to agriculture. There is potential for reallocation of the 15,000 ac-ft industrial pool to the critical habitat.

A transbasin diversion is required to convey the water allocated to the industrial pool to the North Platte River via Casper Creek. Alignment of the pipeline from the dam to Casper Creek was not determined, however, the Casper Creek drainage represents the shortest possible means of delivering water from the Powder River Basin to the North Platte River Basin.

A preliminary cost estimate associated with a pipeline capable of conveying 20 cfs was developed based on unit costs presented by Natural Resources Consulting Engineers (NRCE) (1999b) for a similar transbasin pipeline that would convey water from the Wind River to the North Platte River basin. Assuming a pipeline length of approximately 65 miles, the construction cost was estimated to be in excess of $55 million. The costs of construction for the proposed dam were $43.5 million in 1986 (Harza Engineering Company, et al., 1986b). Dam construction costs were updated to a 1998 cost of $60 million based on average annual ENR cost indices. Consequently, total project costs of the dam plus the pipeline may exceed $115 million, or approximately $7,670 per ac-ft on site. Finally, assuming evaporative, seepage, and diversion losses, which would be incurred as the water is conveyed to the critical habitat, these unit costs would increase. These costs do not include the potential cost to acquire and transfer the 15,000 ac-ft of storage from industrial to environmental use.

Legal constraints could present hurdles to the implementation of any transbasin diversion from the Powder River Basin. The Middle Fork Powder River and the Powder River are tributary to the Yellowstone River and are governed by the Yellowstone River Compact (State of Wyoming, 1982). In regard to out of basin diversion, the Yellowstone River Compact of 1950 states:

> *"No water shall be diverted from the Yellowstone River Basin without the unanimous consent of all the signatory States."*

Unanimous agreement among the three states regarding a transbasin diversion to the North Platte River may be difficult to achieve.

Based upon the economic screening criteria, and legal and institutional issues associated with this alternative, it does not warrant further evaluation at this time.

Cooper Creek Diversion

The Cooper Creek drainage basin is located within the Medicine Bow Mountains near the town of Arlington, Wyoming. The watershed encompasses approximately 10.6 square miles. All runoff generated within the Cooper Creek watershed collects in Cooper Lake from which there is no outlet. Water from the Cooper Creek basin could theoretically be diverted from the closed basin via the Dutton Canal to the Laramie River and ultimately to the North Platte River.

In recent years, water generated within the Cooper Creek watershed, which was previously collected in Cooper Lake and subsequently lost to evaporation, has been put to use by landowners within the basin (Wyoming SEO, 1999c). Currently, there are 21 adjudicated water rights on Cooper Creek that total 70.57 cfs. According to the Wyoming State Engineer's Office, the stream is presently over-appropriated and no surplus water is available to a new water right. Assuming an appropriation of 1 cfs to 70 acres, the existing water rights provide a source of irrigation water to 4,940 acres.

An analysis of mean annual runoff was conducted based upon stream gaging data measured on Dutton Creek. Dutton Creek is located adjacent to the Cooper Creek watershed and is of comparable size and character. Based upon this analysis, the mean annual runoff in Cooper Creek was estimated to be approximately 800 ac-ft. Given the magnitude of the irrigated acreage and the estimated mean annual runoff in Cooper Creek, the water available to satisfy the irrigation requirements may be fully utilized by the existing land owners. Consequently, there is a limited amount of water available for diversion into the North Platte River Basin.

Based on failure of the physical screening criteria, this alternative does not warrant further evaluation at this time.

Wind River Transbasin Diversion

The Wind River Reservation lies within the Wind River watershed in the vicinity of the towns of Riverton and Lander, Wyoming. The Wind River Tribes (Tribes) own rights to more than 500,000 ac-ft of water from the Wind River (NRCE, 1999c), a portion of which could conceptually be diverted to the North Platte River system. Natural Resources Consulting Engineers, Inc. (NRCE) recently conducted the conceptual level studies for providing an additional water supply to the City of Casper. The NRCE study evaluated the continuous diversion of 20 cfs, or about 14,500 ac-ft per year, from the Wind River to the North Platte River. Under their conceptual design, water would be diverted by a pump diversion located on the Wind River, immediately downstream of the confluence of the Little Wind River, and conveyed via a pipeline approximately 30.5 miles over the Beaver Rim to the Sweetwater River. Once in the Sweetwater River, the water would be conveyed to the North Platte River and ultimately to the facilities owned by the City of Casper.

The alternative evaluated for this study assumed identical infrastructure as presented in the NRCE report for a 20 cfs pipeline, with the addition of a 40 cfs pipeline scenario. The evaluation of this alternative also assumed that the transbasin diversion would only occur during months exhibiting target flow shortages at the critical habitat.

Yield

To evaluate the yield associated with this alternative, the following methods and assumptions were applied:

1. It was assumed that the purchase of sufficient water rights to satisfy the target diversion could be negotiated with the Tribes. According to the Office of the Wyoming State Engineer, the Tribes currently own rights to approximately 515,000 ac-ft of water with an 1868 priority date. The Tribes are currently using approximately one half of this water with the other half available for future uses (Wyoming SEO, 1999a). Transfer of water would require an application and approval from the Wyoming State Engineer's Office.

2. Mean daily flow data were obtained for the USGS stream gaging stations located on the Wind River and the Little Wind River. These stations are both located immediately upstream of the confluence of the two rivers. The daily flow data were added to represent the mean daily flow of the Wind River downstream of the confluence.

3. Diversion of Wind River water would be physically constrained by available flows in the river. Only three times in the twenty-year study period has discharge in the river been less than 100 cfs and never has it dropped below 80 cfs. Diversions of 20 cfs and 40 cfs were determined to be physically possible based upon the minimum discharge evident in the Wind River.

The Sweetwater River joins the North Platte River at Pathfinder Reservoir, which is located approximately 6 miles upstream of the Alcova gage. Because evaporation, seepage and diversion loss factors were not developed for tributary channels, transbasin diversions from the Wind River are routed to the confluence of the Sweetwater River and the North Platte River in Reach 2 assuming no losses.

Tables 8.H.7 and 8.H.8 summarize the net hydrologic effects or additional flow added to Reach 2 for the 20 cfs diversion and 40 cfs diversion scenarios, respectively.

The water budget spreadsheet was used to route the net hydrologic effects downstream to the critical habitat. Two routing scenarios were

Table 8.H.7
Diversion of 20 cfs From Wind River
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1230	1190	1230	0	1111	1230	1190	1230	1190	1230	1230	1190	13250
1976	1230	1190	0	0	1111	1230	1190	1230	1190	1230	1230	1190	12020
1977	1230	1190	1230	1230	1111	1230	1190	1230	1190	1230	1230	1190	14479
1978	1230	1190	1230	1230	1111	0	1190	1230	1190	1230	1230	1190	13250
1979	1230	1190	1230	1230	1111	1230	1190	1230	1190	0	1230	1190	13250
1980	1230	1190	0	0	0	0	0	0	0	1230	1230	1190	6069
1981	1230	1190	0	0	1111	1230	1190	1230	1190	1230	0	1190	10790
1982	1230	1190	0	0	1111	1230	1190	1230	1190	1230	1230	1190	12020
1983	1230	1190	0	0	0	0	0	0	0	0	0	0	2420
1984	0	1190	0	0	0	0	0	0	0	0	1230	0	2420
1985	0	0	0	0	0	0	1190	1230	1190	1230	1230	0	6069
1986	1230	1190	0	0	0	0	0	0	0	0	0	0	2420
1987	0	0	0	0	0	0	0	0	0	0	1230	0	1230
1988	1230	0	0	0	0	1230	1190	1230	1190	1230	1230	1190	9719
1989	1230	1190	0	0	1111	1230	1190	1230	1190	0	1230	0	9600
1990	1230	1190	1230	0	1111	1230	1190	1230	1190	1230	1230	1190	13250
1991	1230	1190	0	0	1111	1230	1190	0	0	1230	1230	1190	9600
1992	1230	1190	0	0	1111	0	1190	1230	1190	1230	1230	1190	10790
1993	1230	1190	0	0	1111	0	1190	1230	1190	0	1230	1190	9560
1994	0	0	0	0	1111	1230	1190	1230	1190	0	1230	1190	8370
Average	984	952	307	184	722	676	893	861	833	738	1045	833	9029

Table 8.H.8
Diversion of 40 cfs From Wind River
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2460	2380	0	0	2221	2460	2380	2460	2380	2460	2460	2380	24040
1976	2460	2380	2460	2460	2221	2460	2380	2460	2380	2460	2460	2380	28959
1977	2460	2380	2460	2460	2221	0	2380	2460	2380	2460	2460	2380	26499
1978	2460	2380	2460	2460	2221	2460	2380	2460	2380	0	2460	2380	26499
1979	2460	2380	0	0	0	0	0	0	0	2460	2460	2380	12139
1980	2460	2380	0	0	2221	2460	2380	2460	2380	2460	0	2380	21580
1981	2460	2380	0	0	2221	2460	2380	2460	2380	2460	2460	2380	24040
1982	2460	2380	0	0	0	0	0	0	0	0	0	0	4840
1983	0	2380	0	0	0	0	0	0	0	0	2460	0	4840
1984	0	0	0	0	0	0	2380	2460	2380	2460	2460	0	12139
1985	2460	2380	0	0	0	0	0	0	0	0	0	0	4840
1986	0	0	0	0	0	0	0	0	0	0	2460	0	2460
1987	2460	0	0	0	0	2460	2380	2460	2380	2460	2460	2380	19438
1988	2460	2380	0	0	2221	2460	2380	2460	2380	0	2460	0	19200
1989	2460	2380	2460	0	2221	2460	2380	2460	2380	2460	2460	2380	26499
1990	2460	2380	0	0	2221	2460	2380	0	0	2460	2460	2380	19200
1991	2460	2380	0	0	2221	0	2380	2460	2380	2460	2460	2380	21580
1992	2460	2380	0	0	2221	0	2380	2460	2380	0	2460	2380	19121
1993	0	0	0	0	2221	2460	2380	2460	2380	0	2460	2380	16740
1994	0	0	0	0	2221	2460	2380	2460	2380	2460	0	2380	16740
Average	1845	1785	492	369	1444	1353	1785	1722	1666	1476	1968	1666	17570

evaluated. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diverters, in which case, additional flows are reduced by diversions.

Tables 8.H.9 and 8.H.10 summarize the results of routing the water downstream to the critical habitat for the 20 cfs alternative under the two scenarios, respectively. Tables 8.H.11 and 8.H.12 summarize corresponding results for the 40 cfs alternative. Based upon the study team's understanding of Wyoming water law, it is likely that a transbasin diversion from the Wind River can be protected from downstream diversions. Consequently, the estimated average annual reductions in target flow shortages for the 20 cfs and 40 cfs alternatives are 6,788 ac-ft and 9,727 ac-ft, respectively. If the water cannot be protected from downstream diversions, the average annual reductions in target flow shortages for the 20 cfs and 40 cfs alternatives are 2,086 ac-ft per year and 2,984 ac-ft per year, respectively. Information including the average annual additional flow at the top of the next downstream reach (Reach 4) and at Grand Island is provided in the yield summary section.

The analysis discussed above assumes that water is diverted only during months with target flow shortages at the critical habitat. If storage is available in the Lake McConaughy Environmental Account, a continuous diversion from the Wind River could further reduce flow shortages at the critical habitat accordingly.

Cost

The primary direct costs associated with this alternative involve the costs associated with construction of the diversion structure on the Wind River, the pipeline, and pump stations required to convey the water to the Sweetwater River. According to the NRCE conceptual design, the estimated capital costs of the pipeline and pump stations required to continuously convey 20 cfs would be approximately $18.6 million. Costs of approximately $5.5 million would be required for NEPA compliance, right-of-way acquisition, construction administration and final designs and specifications, thereby bringing the total capital costs to approximately $24.1 million for the 20 cfs diversion scenario. Operation costs were estimated to be

Table 8.H.9
Diversion of 20 cfs From Wind River
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	249	606	709	0	745	885	374	24	48	5	4	21	3670
1976	88	578	0	0	830	848	121	25	10	1	1	9	2511
1977	165	535	672	648	683	807	155	32	10	1	4	25	3738
1978	569	585	679	793	941	0	72	54	6	2	1	4	3707
1979	188	493	752	733	553	902	64	15	35	0	3	6	3744
1980	64	499	0	0	0	0	0	0	0	1	4	13	581
1981	98	512	0	0	703	785	23	3	2	8	0	8	2142
1982	114	755	0	0	861	861	27	9	7	2	4	19	2660
1983	175	667	0	0	0	0	0	0	0	0	0	0	841
1984	0	790	0	0	0	0	0	0	0	0	20	0	811
1985	0	0	0	0	0	0	265	34	32	4	5	0	341
1986	157	665	0	0	0	0	0	0	0	0	0	0	822
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	616	0	0	0	0	937	197	118	12	6	5	28	1920
1989	111	640	0	0	796	870	31	5	8	0	3	0	2465
1990	536	655	690	0	756	835	84	69	3	0	6	9	3644
1991	69	815	0	0	812	790	10	0	0	1	1	11	2508
1992	72	678	0	0	858	0	15	13	6	9	4	7	1662
1993	674	735	0	0	574	0	17	14	27	0	17	0	2059
1994	0	0	0	0	771	1015	47	18	8	0	3	18	1880
Average	197	510	175	109	494	477	75	22	11	2	5	9	2086

Table 8.H.10
Diversion of 20 cfs From Wind River
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	940	885	893	0	973	1128	1080	1077	1050	1046	736	947	10754
1976	777	841	0	0	1000	1104	1001	1075	806	397	138	469	7608
1977	984	868	903	947	983	1163	950	1079	947	614	748	948	11136
1978	981	955	958	840	1028	0	1042	1051	943	369	545	466	9177
1979	728	875	1026	972	817	1173	1049	1070	765	0	864	621	9959
1980	791	945	0	0	0	0	0	0	0	840	851	637	4066
1981	867	830	0	0	877	1061	956	1088	722	653	0	632	7686
1982	956	1117	0	0	1065	1076	997	1086	987	998	1055	797	10134
1983	1153	953	0	0	0	0	0	0	0	0	0	0	2106
1984	0	1107	0	0	0	0	0	0	0	0	764	0	1871
1985	0	0	0	0	0	0	1075	1098	1005	1064	1071	0	5312
1986	1161	1014	0	0	0	0	0	0	0	0	0	0	2175
1987	0	0	0	0	0	0	0	0	0	0	811	0	811
1988	898	0	0	0	0	1126	979	1003	868	870	901	892	7536
1989	962	1132	0	0	1024	1061	997	954	1005	0	835	0	7970
1990	1085	1025	961	0	1038	1156	1038	1072	765	513	979	627	10259
1991	747	906	0	0	1028	1109	934	0	0	377	460	521	6084
1992	689	1078	0	0	1054	0	1018	821	999	897	692	743	7990
1993	969	1016	0	0	681	0	1078	1082	1026	0	427	0	6280
1994	0	0	0	0	878	1157	1046	1040	938	0	1030	767	6856
Average	734	777	237	138	622	616	762	730	641	432	645	453	6788

Table 8.H.11

Diversion of 40 cfs From Wind River

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	498	1212	0	0	1490	1769	748	48	97	10	7	42	5922
1976	177	1156	0	0	1659	1697	241	50	21	2	1	18	5022
1977	330	1070	925	1296	1366	0	311	64	21	3	8	49	5443
1978	1137	1171	1357	1586	1883	0	145	109	11	0	3	9	7411
1979	376	986	0	0	0	0	0	0	0	0	6	11	1379
1980	128	998	0	0	0	0	0	0	0	2	0	26	1154
1981	196	1024	0	0	1406	1570	47	6	4	17	0	15	4284
1982	228	1511	0	0	0	0	0	0	0	0	0	0	1739
1983	0	1333	0	0	0	0	0	0	0	0	0	0	1333
1984	0	0	0	0	0	0	0	0	0	0	41	0	41
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	22	0	22
1988	1231	0	0	0	0	1875	394	237	24	0	10	0	3770
1989	223	1281	0	0	1593	1740	62	9	16	0	6	0	4930
1990	1071	1310	0	0	1513	1669	168	0	0	1	11	18	5762
1991	138	1630	0	0	1624	0	19	0	0	1	1	21	3435
1992	145	1355	0	0	1717	0	30	26	12	0	7	15	3306
1993	0	0	0	0	1148	0	33	28	54	0	35	0	1299
1994	0	0	0	0	1542	1700	95	36	16	0	0	36	3424
Average	294	802	114	144	847	601	115	31	14	2	8	13	2984

Table 8.H.12

Diversion of 40 cfs From Wind River

Reductions to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1879	1769	0	0	1947	2256	2160	2154	2100	2091	1471	1894	19722
1976	1554	1682	0	0	2001	2209	2002	2150	1611	793	276	938	15215
1977	1968	1735	925	1894	1966	0	1901	2159	1895	1229	1497	1896	19064
1978	1961	1910	1915	1680	2055	0	2085	2102	1886	0	1091	932	17618
1979	1456	1750	0	0	0	0	0	0	0	0	1728	1242	6176
1980	1582	1891	0	0	0	0	0	0	0	1680	0	1275	6429
1981	1733	1659	0	0	1755	2121	1911	2176	1445	1307	0	1265	15372
1982	1911	2235	0	0	0	0	0	0	0	0	0	0	4146
1983	0	1905	0	0	0	0	0	0	0	0	0	0	1905
1984	0	0	0	0	0	0	0	0	0	0	1527	0	1527
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	1621	0	1621
1988	1796	0	0	0	0	2252	1958	2006	1735	0	1801	0	11547
1989	1925	2265	0	0	2047	2122	1993	1909	2010	0	1669	0	15941
1990	2170	2051	0	0	2076	2311	2076	0	0	1025	1958	1255	14922
1991	1495	1813	0	0	2057	0	1868	0	0	755	921	1043	9950
1992	1378	2156	0	0	2108	0	2035	1642	1997	0	1384	1487	14187
1993	0	0	0	0	1362	0	2157	2165	2052	0	427	0	8163
1994	0	0	0	0	1757	1700	2092	2081	1876	0	0	1533	11039
Average	1140	1241	142	179	1056	749	1212	1027	930	444	869	738	9727

approximately $937,000 per year. Given the average expected operation period of eight months per year, prorated annual operation costs become $625,000. The total present value cost of this project based on a 20-year study period and a discount rate of 6 percent is about $31.3 million.

Based upon this estimate, the cost per ac-ft of target flow reductions at the critical habitat would be approximately $4,610 assuming that additional water can be protected from downstream diversions. These costs do not include the purchase or long-term lease of water rights from the Tribes. If these costs are included, the unit cost of this alternative would increase. There would be some economies of scale associated with the costs for the 40 cfs alternative. Given economies of scale, the cost of a 40 cfs pipeline may be less than twice the cost of the 20 cfs pipeline to a degree, however, the cost per ac-ft of target flow reductions will most likely not be less than $3,000. The cost per ac-ft of target flow reductions for either size diversion exceeds the economic screening criteria of $3,000, therefore, this alternative will not be evaluated further at this time.

Power Interference Charges

This evaluation focuses on the cost, yield, and associated issues of power interference as an alternative by itself. Although beyond the scope of this phase of study, it should be noted that hydrogeneration will be affected by other alternatives, creating a net gain or loss of generation from these facilities.

Region 1

The developed hydroelectric plants identified in Region 1 are presented in Table 8.H.13.

Table 8.H.13
Developed Hydroelectric Generation Facilities in Region 1

Plant or Site Name	Owner	Installed Capacity (Mw)	Average Annual Generation (Mwh)	Storage Dedicated to Power (ac-ft)
Alcova	USBR	36.0	128,000	184,200
Fremont Canyon	USBR	66.8	255,600	1,016,000
Glendo	USBR	38.0	87,600	512,000
Guernsey	USBR	6.4	22,500	41,000
Kortes	USBR	37.0	155,900	5,000
Seminoe	USBR	51.0	146,200	1,011,000

Sources: Federal Energy Regulatory Commission, Hydroelectric Power Resources of the United States as of January 1, 1992; and U.S. Bureau of Reclamation, Annual Operating Plans, North Platte River Area, North Platte River Power Plant Data, 1999.

There are no hydrogeneration facilities in Region 1 that are candidates for power interference charges, based on the operational definition of this alternative, which excludes USBR facilities. Further evaluation of this alternative in this region is unwarranted.

Region 2

Developed hydroelectric generation facilities identified in Region 2 are enumerated in Table 8.H.14.

Table 8.H.14
Developed Hydroelectric Generation Facilities in Region 2

Plant or Site Name	Owner	Installed Capacity (Mw)	Average Annual Generation (Mwh)	Storage Dedicated to Power (ac-ft)
Betasso	City of Boulder	3.0	8,238	<1,000
Big Thompson	USBR	4.5	15,000	<1,000
Boulder Canyon	Public Service Co.	20.0	26,635	<1,000
Cabin Creek	Public Service Co.	324.0	unknown	not applicable
Estes	USBR	45.0	107,800	<1,000
Flatiron 1 and 2	USBR	94.5	288,000	2,000
Idlywilde	City of Loveland	0.9	7,700	<1,000
Foothills Water Treatment Plant	City and County of Denver	3.1	11,000	<1,000
Georgetown	Public Service Co.	1.4	6,800	<1,000
Jerry B. Buckley	Jerry B. Buckley	0.3	2,430	<1,000
Kohler	City of Boulder	0.1	770	<1,000
Longmont	City of Longmont	0.3	4,340	<1,000
Mary's Lake	USBR	8.1	40,400	<1,000
Maxwell	City of Boulder	0.1	520	<1,000
North Fork	City and County of Denver	5.5	23,000	<1,000
Orodell	City of Boulder	0.2	1,310	<1,000
Pole Hill	USBR	38.2	207,300	<1,000
Strontia Springs	City and County of Denver	1.0	6,700	<1,000

Sources: Federal Energy Regulatory Commission, Hydroelectric Power Resources of the United States as of January 1, 1992; and U.S. Bureau of Reclamation, unpublished hydropower database, April 1999.

There are no hydroelectric facilities in Region 2 that are candidates for power interference charges. None of the reservoirs behind the hydroplants have sufficient water storage dedicated to power generation; each is less than 1,000 ac-ft. Almost all of the plants are small, and many are run-of-river. Among the larger hydrogeneration facilities, Flatiron, Pole Hill, and Estes are USBR facilities where irrigation is the primary project

Region 3

Hydrogeneration facilities found in Region 3 are identified in Table 8.H.15.

Table 8.H.15
Developed Hydroelectric Generation Facilities in Region 3

Plant or Site Name	Owner	Installed Capacity (Mw)	Average Annual Generation (Mwh)	Storage Dedicated to Power (ac-ft)
Columbus	Loup River Public Power District	39.9	115,000	5,000
Jeffrey	CNPPID	18.0	100,000	6,000
Johnson No. 1	Central Nebraska Public Power and Irrigation District (CNPPID)	18.0	100,000	39,000
Johnson No. 2	CNPPID	18.0	100,000	1,000
Kearney	Nebraska Public Power District (NPPD)	1.5	2,000	<1,000
Kingsley	CNPPID	50.0	89,000	1,690,000
Monroe	Loup River Public Power District	7.8	22,500	<1,000
North Platte	NPPD	24.0	100,000	11,000
Spaulding	City of Spaulding	0.1	700	<1,000

Sources: Federal Energy Regulatory Commission, Hydroelectric Power Resources of the United States as of January 1, 1992; U.S. Bureau of Reclamation, unpublished hydropower database, April 1999; and Personal Communication with Jeremie Kerkman, CNPPID, 1999.

Columbus is owned by the Loup River Public Power District, located in Columbus, Nebraska. The Loup River drains into the Platte River below Grand Island with no apparent benefit to the Three States Cooperative Program. The Kingsley generation facility is a feature of the Lake McConaughy-Kingsley Dam Project. Extraordinary re-licensing efforts have been undertaken on this project and its related facilities, Jeffrey Canyon, Johnson #1, and Johnson #2, in recent years that might discourage a re-examination of flow release schedules. A map of these facilities is provided in Figure 8.H.1.

Two hydrogeneration facilities in Region 3 are owned by the Nebraska Public Power District (NPPD). The Kearney plant does not offer storage as a run-of-river facility. The North Platte hydrogeneration facility is operated in close coordination with Lake McConaughy. Second, irrigation is the primary purpose. NPPD also has a broad concern about the cost and viability of this option, including accurate figures on the following:

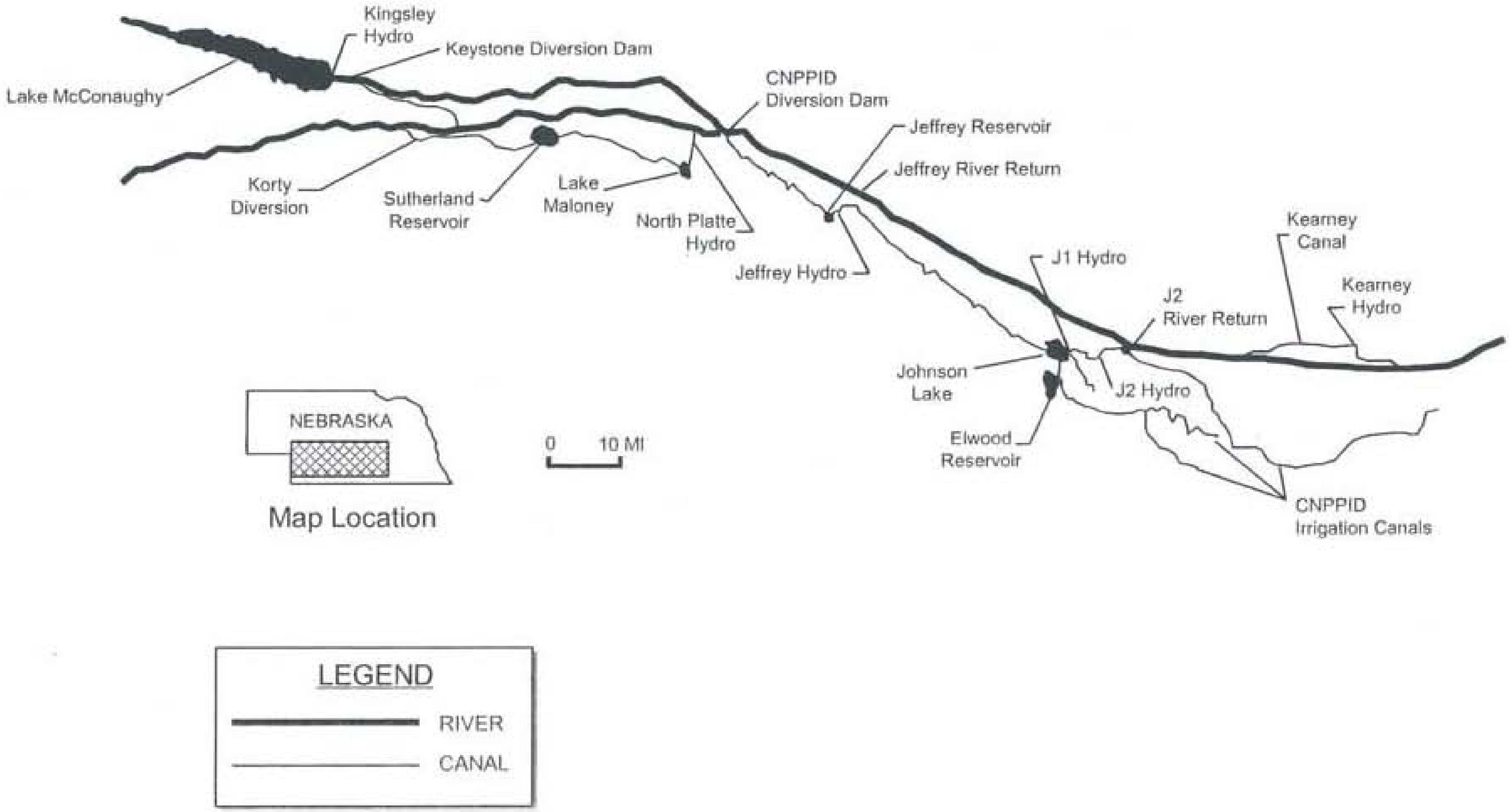
- Total cost of lost energy and capacity,
- Variable market values for this resource,
- Third party impacts, and
- An incentive to overcome the accumulated risks.

(personal communication with Frank Kwapnioski and Barry Campbell, NPPD, 1999)

Since Lake McConaughy storage is the principal constraint to the use of CNPPID facilities described below and Central has an interest in this option, their facilities are the focus of the remainder of this evaluation. Therefore, neither NPPD facility on its own is considered further as a candidate for this alternative, although the North Platte hydro plant could be impacted by a power interference alternative involving Central.

The two Johnson Units and Jeffrey are owned by the Central Nebraska Public Power and Irrigation District (CNPPID), which has expressed an interest in the power interference compensation program (personal communication with Mike Drain, CNPPID, 1999). Unlike a USBR project, federal laws or resource output priorities would not be violated

FIGURE 8.H.1
REGION 3 HYDROGENERATION FACILITIES



with this power interference option. Agreement of the two districts and care not to violate any physical or regulatory constraints must be evident for power interference to occur. Sufficient water for hydrogeneration may be present to merit Cooperative Program interest, focusing on operational changes within the license guidelines. For the purposes of this study, the focus of the Region 3 power interference charge program will be on facilities owned by CNPPID. These would include the two Johnson Units and the Jeffrey facility, with a combined 54 Mw power generation capacity. Although Central owns these facilities, it should be noted that any change to their operation will affect NPPD's operations and generation. It must be also remembered that this is a voluntary program and that the participants might choose not to participate because of hydrology, weather conditions or other circumstances which have not been identified thus far.

There is a set of agreements between CNPPID and NPPD, including a 1954 agreement and a recent power sales agreement between the two districts. These recognize the priorities agricultural deliveries and senior water rights along with mitigation responsibilities. A price for sale of power and the right to receive the resource is provided.

Yield

The water that might be made available to reduce shortages at the critical reach must reflect certain operational constraints and physical system relationships that define the maximum amount of water available. Based upon information from CNPPID, these issues include (written communication from Jeremie Kerkman, CNPPID,1999):

1. An ac-ft loss to Jeffrey amounts to an ac-ft loss at Johnson No. 1 (J-1) and Johnson No. 2 (J-2) because the same water passes through all three plants and also the North Platte Hydro.
2. Storage at Jeffrey or the two Johnson units is insufficient to effectively operate a power interference program. It is assumed that this alternative will rely upon Lake McConaughy storage without affecting total annual Kingsley generation.
3. Following its authority, CNPPID has confirmed the priority of water releases for its irrigation customers. CNPPID believes

that this priority can be accommodated with power interference.

4. Minimum stream flow requirements under the new Federal Energy Regulatory Commission (FERC) license proscribe a range of releases from Lake McConaughy, which will limit hydropower interference. These minimum flows change according to very wet to very dry conditions and are measured at the Keystone Diversion Dam and the CNPPID Diversion Dam in Nebraska. This constraint is reflected in the alternative described below.

5. Since the benefit of power interference lies not with increases in average annual flows but with timing of releases, the "yield" of this alternative is in balancing periodic water excess at Grand Island with periodic shortages. This consideration has been accounted for in the yield analysis.

The yield of the power interference charge program among the three regions in the Platte River Basin amounts to the yield of the program in Region 3 and, more specifically, from CNPPID. The calculation of average annual yield available for power interference at CNPPID generation facilities is quite complex, with the incorporation of minimum stream flows. Storage of excess water available for power interference could not be carried over from month to month due to storage limitations at Lake McConaughy unless excess storage capacity exists. Based upon Lake McConaughy storage constraints and outflows, monthly J-2 returns, actual historical monthly conditions for minimum stream flows at Keystone Diversion Dam, and monthly Grand Island excesses and shortages, the study team has estimated the average annual yield available for power interference to be about 41,000 ac-ft, as shown in Table 8.H.16.

Further study might be needed to confirm and refine the analysis. For instance, the analysis is performed using month end reservoir levels instead of continuous daily drops or rises to McConaughy. Further, the model assumes short term storage changes that might be too large to accommodate in actual operation. Also, the analysis assumes the FERC imposed reservoir elevation; if more storage could be identified or created at Lake McConaughy this would increase the yield of this alternative.

Table 8.H.16
Power Interference Charges
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	35270	0	0	0	0	0	0	0	35270
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	26996	0	26996
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	13271	13271
1982	0	0	0	0	3666	0	0	0	0	0	0	0	3666
1983	0	0	0	0	19436	0	0	0	0	0	0	0	19436
1984	18300	0	0	0	54240	0	0	0	70000	0	0	0	142540
1985	0	0	0	0	41080	8400	5158	1942	0	0	0	0	56580
1986	5943	0	0	0	4696	0	0	0	32000	0	0	0	42639
1987	13500	25000	19600	0	49568	0	0	0	0	0	40346	0	148014
1988	53328	0	0	0	15189	34200	14300	0	0	0	0	0	117017
1989	0	0	0	0	20690	0	0	0	0	0	368	0	21058
1990	9273	0	0	0	6098	0	0	0	0	0	0	0	15371
1991	0	0	0	0	10789	5726	0	0	0	31619	0	0	48134
1992	0	0	0	0	6727	0	2419	0	0	0	0	0	9146
1993	0	0	0	0	0	0	0	0	0	0	452	0	452
1994	0	0	0	0	63042	1737	47765	0	0	0	8200	0	120744
Average	5017	1250	980	0	16525	2503	3482	97	5100	1581	3818	664	41017

In addition, the yield of power interference might be different with actual operation of the facilities as compared with this retrospective model. The future, of course, is unknown in real time operations. All of the considerations which go into operations cannot necessarily be captured in a model.

The net hydrologic effects were routed downstream from Lake McConaughy using the water budget spreadsheet. Two routing scenarios were evaluated for the proposed project. The first scenario assumes additional flows can be protected from downstream diversions, in which case, additional flows are not reduced by diversions. The second scenario assumes additional flows cannot be protected from downstream diversions, in which case additional flows are reduced by diversions. Tables 8.H.17 and 8.H.18 summarize the reductions to target flow shortages at the critical habitat with and without diversion losses, respectively. The average annual reductions to target flow shortages are 10,407 ac-ft and 17,367 ac-ft with and without diversion losses, respectively. One explanation for the large difference in the 41,000 ac-ft of available yield and the ultimate reductions to target flows is the likelihood that McConaughy might spill the water before it is needed to reduce the shortage. Further study might allow for reduced purchase less than 41,000 ac-ft to achieve the similar yield.

The following steps and associated tables offer additional detail about the calculation of yields. The historical McConaughy outflow is set forth in Table 8.H.19. The derivation of yield proceeds through succeeding thresholds.

a. The maximum theoretical water available is the minimum of the J-2 River return flows and the maximum Kingsley Release, provided in Tables 8.H.20 and 8.H.21, respectively. By considering the J-2 returns, this avoids a negative impact on Central's irrigation customers since that water cannot be removed from the system by Central. Although Kingsley may not experience diminished annual generation, this retiming will result in losses to North Platte, Jeffrey, Johnson Nos.1 and 2.

Table 8.H.17
Power Interference Charges
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	26798	0	0	0	0	0	0	0	26798
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	784	0	784
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	1637	1637
1982	0	0	0	0	2912	0	0	0	0	0	0	0	2912
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	2684	643	0	0	0	0	3326
1986	4461	0	0	0	0	0	0	0	0	0	0	0	4461
1987	0	0	0	0	0	0	0	0	0	0	3882	0	3882
1988	29281	0	0	0	0	13999	7810	0	0	0	0	0	51089
1989	0	0	0	0	15096	0	0	0	0	0	24	0	15120
1990	4495	0	0	0	4265	0	0	0	0	0	0	0	8760
1991	0	0	0	0	8113	3838	0	0	0	417	0	0	12368
1992	0	0	0	0	5347	0	1385	0	0	0	0	0	6732
1993	0	0	0	0	0	0	0	0	0	0	65	0	65
1994	0	0	0	0	44565	1492	23798	0	0	0	343	0	70198
Average	1912	0	0	0	5355	966	1784	32	0	21	255	82	10407

Table 8.H.18
Power Interference Charges
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	32309	0	0	0	0	0	0	0	32309
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	19879	0	19879
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	7467	7467
1982	0	0	0	0	3602	0	0	0	0	0	0	0	3602
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	4889	1841	0	0	0	0	6730
1986	5782	0	0	0	0	0	0	0	0	0	0	0	5782
1987	0	0	0	0	0	0	0	0	0	0	29245	0	29245
1988	40720	0	0	0	0	13999	12560	0	0	0	0	0	67279
1989	0	0	0	0	19401	0	0	0	0	0	295	0	19697
1990	8704	0	0	0	5853	0	0	0	0	0	0	0	14557
1991	0	0	0	0	10273	5384	0	0	0	10728	0	0	26385
1992	0	0	0	0	6564	0	2273	0	0	0	0	0	8837
1993	0	0	0	0	0	0	0	0	0	0	427	0	427
1994	0	0	0	0	50790	1700	45141	0	0	0	7517	0	105148
Average	2760	0	0	0	6440	1054	3243	92	0	536	2868	373	17367

Table 8.H.19
Central Nebraska Public Power and Irrigation District
Historical Lake McConaughy Outflow
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	33700	25500	66600	42810	26820	25760	39140	63590	72120	226910	188060	111420	922430
1976	43970	30240	51320	39290	28150	25250	40750	53700	172120	238730	153120	77000	953640
1977	28010	49530	43340	42320	24560	29150	22310	62410	117510	241950	124510	65700	851300
1978	53310	50220	47210	42810	36290	25530	25390	85010	147670	240540	153060	87300	994340
1979	61720	52340	41380	44280	36790	24230	21510	28270	28400	125570	143170	42430	650090
1980	28230	24610	38420	42210	44160	55410	126370	86730	109700	247840	179310	61680	1044670
1981	45250	47890	37140	32010	29750	22040	21940	27810	70140	184620	74920	72850	666360
1982	29550	49910	45640	44100	29840	30320	26220	34230	45260	182900	156340	87130	761440
1983	14090	49200	54190	51330	44280	42900	45290	77750	440610	389980	487430	440650	2137700
1984	3660	21530	153300	128930	187470	285970	314560	335280	360890	210350	204460	164240	2370640
1985	106200	158650	167170	109460	82510	156550	66000	31870	84790	205960	124560	58020	1351740
1986	45930	48070	43890	46890	49700	116430	138960	122200	153460	261010	274910	199320	1500770
1987	161460	122100	97170	79470	45290	60110	83860	68430	66170	168210	176890	77420	1206580
1988	91370	72330	60690	43070	28930	39070	67040	85770	139310	184170	139480	61250	1012480
1989	48150	38410	39730	36300	30970	25260	30830	83650	105420	193980	172880	36040	841620
1990	30120	28980	30220	21470	19070	22310	72510	68090	105570	247580	155890	71160	872970
1991	22570	22890	27050	25180	15190	16220	24160	30170	60530	261190	195820	43010	743980
1992	2250	11770	19620	20270	14490	13690	13190	62160	63730	125110	136640	34220	517140
1993	22150	19310	21150	26630	21510	16360	6370	33870	55100	98720	62080	39640	422890
1994	42840	50080	51570	41930	33400	28260	20410	63710	122470	161480	163410	44030	823590
Average	45727	48678	56840	48038	41459	53041	60341	75235	126049	209840	173347	93726	1032319

Table 8.H.20
Central Nebraska Public Power and Irrigation District
Johnson Hydro #2 Discharge
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	56010	44800	58690	58100	55780	65460	62000	51930	69110	70510	62290	56980	711660
1976	49820	52750	57340	67620	71510	66030	62500	47390	41360	71080	66430	43030	696860
1977	38830	40080	49640	47300	45500	54700	58260	44470	43250	67540	42990	36670	569230
1978	40390	39820	43320	49460	45550	55900	40460	35910	36040	68370	50000	35190	540410
1979	39460	39160	50250	46150	42920	57960	38720	35020	68290	62150	51470	29840	561390
1980	22700	25130	85420	90260	86130	106970	96970	87450	78530	69360	57900	42660	849480
1981	29580	36790	54560	68570	62290	52550	26900	31780	33170	72600	43230	24440	536460
1982	38950	39640	59850	58940	64510	62280	22410	18140	16010	50060	44470	42220	517480
1983	20010	57670	74300	79600	89800	107500	93140	88980	52650	30570	45580	64030	803830
1984	53070	46110	44410	54240	86250	103340	84210	79690	81310	63780	60360	88240	845010
1985	38110	33760	44050	55180	64820	90880	66140	79520	66040	58990	37970	51860	687320
1986	82240	53510	73190	90480	88810	107970	97110	89750	72940	71990	74450	93920	996360
1987	101800	91250	102070	95310	93770	99660	88680	90590	76940	56490	60110	84580	1041250
1988	78940	74470	84220	57700	71200	101310	82120	82520	56620	53940	49730	45650	838420
1989	38850	31170	47270	74580	59560	72580	24850	28840	35680	44900	50460	30630	539370
1990	26690	28570	34140	58010	52380	68570	87810	52090	31160	58230	52490	26570	576710
1991	27300	34200	32130	42330	54910	42020	17970	30820	49120	65070	51370	18860	466100
1992	13710	31580	32660	52190	67860	98400	47020	26750	35830	49340	51480	27930	534750
1993	45330	37210	53850	60260	63630	98410	41200	22850	28650	43080	34400	63850	592720
1994	83240	76820	85410	80890	77580	77990	31660	40020	33380	53890	41150	33770	715800
Average	46252	45725	58339	64359	67238	79524	58507	53226	50304	59097	51417	47046	681031

Table 8.H.21
Hypothetical Maximum Kingsley Release
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1976	276698	267773	276698	276698	258847	276698	267773	276698	297525	307443	307443	267773	3358066
1977	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1978	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1979	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1980	276698	267773	276698	276698	258847	276698	267773	276698	297525	307443	307443	267773	3358066
1981	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1982	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1983	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1984	276698	267773	276698	276698	258847	276698	267773	276698	297525	307443	307443	267773	3358066
1985	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1986	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1987	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1988	276698	267773	276698	276698	258847	276698	267773	276698	297525	307443	307443	267773	3358066
1989	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1990	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1991	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1992	276698	267773	276698	276698	258847	276698	267773	276698	297525	307443	307443	267773	3358066
1993	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
1994	276698	267773	276698	276698	249921	276698	267773	276698	297525	307443	307443	267773	3349140
Average	276698	267773	276698	276698	252152	276698	267773	276698	297525	307443	307443	267773	3351371

b. The minimum stream flow requirements represent another constraint on power interference yield. Table 8.H.22 indicates the minimum release requirements below Keystone at the Sutherland Supply Canal. Because of minimum flow requirements at Keystone, minimum flow requirements at Central's North Platte Diversion are likely to met and so any changes would not have substantive effects upon yield. The difference between historical McConaughy releases and minimum flow release requirements are presented in Table 8.H.23. This represents potential storage without regard to Grand Island excesses, shortages or McConaughy storage restrictions.

c. Potentially retimed hydropower interference volume, or the total available water, is equal to the minimum of: (1) J-2 return flows; (2) historical McConaughy releases less McConaughy minimum release requirements; and (3) Grand Island excesses. This is shown in Table 8.H.24. These amounts exceed McConaughy storage restrictions.

d. To consider storage capacity, a release pattern will need to be developed. Releases are assumed to be the least of storage available or the shortage at Grand Island. Additional releases were also made if storage space was unavailable. Cumulative potential hydropower interference storage at end of each month in the period of record is found in Table 8.H.25. The months and amounts of excess flows at Grand Island must be considered as the sources of potential storage. This storage cannot exceed available McConaughy storage, nor can it carry over to the following month without available storage during that month. Together, constraints produce the 41,000 ac-ft yield below McConaughy.

Table 8.H.22
Minimum Release According to Year Type
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1976	27670	26777	27670	27670	25885	27670	26777	27670	26777	27670	27670	26777	326682
1977	27670	26777	27670	27670	24992	27670	26777	27670	26777	27670	27670	26777	325790
1978	27670	26777	27670	27670	24992	27670	26777	27670	26777	27670	27670	26777	325790
1979	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1980	43042	41654	43042	43042	40265	43042	41654	43042	41654	43042	43042	41654	508173
1981	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1982	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1983	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1984	53802	52067	53802	53802	50331	53802	52067	53802	52067	53802	53802	52067	635216
1985	53802	52067	53802	53802	48596	53802	52067	53802	52067	53802	53802	52067	633480
1986	43042	41654	43042	43042	38877	43042	41654	43042	41654	43042	43042	41654	506784
1987	53802	52067	53802	53802	48596	53802	52067	53802	52067	53802	53802	52067	633480
1988	27670	26777	27670	27670	25885	27670	26777	27670	26777	27670	27670	26777	326682
1989	27670	26777	27670	27670	24992	27670	26777	27670	26777	27670	27670	26777	325790
1990	15372	14876	15372	15372	13885	15372	14876	15372	14876	15372	15372	14876	180994
1991	15372	14876	15372	15372	13885	15372	14876	15372	14876	15372	15372	14876	180994
1992	15372	14876	15372	15372	14380	15372	14876	15372	14876	15372	15372	14876	181490
1993	27670	26777	27670	27670	24992	27670	26777	27670	26777	27670	27670	26777	325790
1994	27670	26777	27670	27670	24992	27670	26777	27670	26777	27670	27670	26777	325790
Average	35125	33992	35125	35125	31996	35125	33992	35125	33992	35125	35125	33992	413842

Table 8.H.23
Difference between Historical McConaughy Releases and Minimum Release Requirements
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	23558	0	0	0	0	20538	30467	183868	145008	69757	473195
1976	16310	3463	23650	11620	2265	0	13983	26030	145343	211070	125450	50223	629407
1977	340	22753	15670	14650	0	1470	0	34740	90733	214280	96840	38933	530409
1978	25650	23443	19550	15140	11298	0	0	57340	120893	212870	125400	60513	672097
1979	18678	10687	0	1238	0	0	0	0	0	82518	100118	767	214005
1980	0	0	0	0	3895	12358	84717	43688	68057	204798	136268	20027	573807
1981	2208	6237	0	0	0	0	0	0	28487	141578	31868	31197	241574
1982	0	8267	2608	1058	0	0	0	0	3597	139858	113298	45467	314152
1983	0	7547	11148	8288	5403	0	3637	34708	398967	346928	444388	399007	1660020
1984	0	0	99498	75128	137139	232168	262493	281488	308823	156548	150658	112173	1816113
1985	52408	106593	113368	55668	33914	102748	13933	0	32723	152148	70758	5943	740202
1986	2878	6427	848	3848	10833	73388	97307	79168	111807	217968	231878	157667	994016
1987	107668	70033	43368	25668	0	6308	31783	14628	14093	114418	123088	25363	576415
1988	63700	45563	33020	15400	3045	11400	40263	58110	112533	156500	111810	34483	685828
1989	20490	11633	12060	8630	5978	0	4053	55980	78633	166320	145210	9273	518260
1990	14738	14094	14848	6098	5186	6938	57634	52718	90694	232208	140518	56284	691956
1991	7198	8014	11678	9808	1306	848	9284	14798	45644	245818	180448	28134	562976
1992	0	0	4248	4898	110	0	0	46788	48864	109738	121258	19354	355257
1993	0	0	0	0	0	0	0	6190	28323	71050	34410	12863	152836
1994	15180	23293	23900	14260	8408	590	0	36040	95683	133820	135750	17263	504187
Average	17372	18402	22651	13570	11439	22411	30954	43148	92718	174715	138221	59734	645336

Table 8.H.24
Potential Hydropower Interference Volume that could be Retimed
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	23650	11620	0	0	0	0	0	0	0	0	35270
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	26996	0	0	26996
1980	0	0	0	0	3895	12358	84717	43688	48310	0	0	0	192968
1981	0	0	0	0	0	0	0	0	0	0	13271	0	13271
1982	0	0	2608	1058	0	0	0	0	0	0	0	0	3666
1983	0	0	11148	8288	5403	0	3637	34708	36940	480	5960	52830	159394
1984	0	0	44410	54240	86250	103340	84190	76200	67700	14200	0	75360	605890
1985	38110	33760	44070	55180	33914	90880	0	0	0	0	0	5943	301857
1986	0	0	848	3848	10833	7085	74251	32030	21308	12850	49750	93560	306364
1987	88056	67752	43368	25668	0	6308	31783	14628	14093	7590	0	25363	324608
1988	0	15269	33020	15400	3045	0	0	0	0	0	0	0	66735
1989	0	0	12060	8630	0	0	0	0	0	368	0	9273	30331
1990	0	0	0	6098	0	0	0	0	0	0	0	0	6098
1991	0	0	6707	9808	0	0	0	12579	19040	0	0	0	48134
1992	0	0	4248	4898	0	0	0	0	0	0	0	0	9146
1993	0	0	0	0	0	0	0	0	0	35780	0	12863	48643
1994	2900	23293	23900	14260	0	0	0	0	0	8200	0	0	72553
Average	6453	7004	12502	10950	7167	10999	13929	10692	10370	5323	3449	13760	112596

Table 8.H.25
Cumulative Hydropower Interference Storage at end-of-month
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	23650	35270	2075	0	0	0	0	0	0	0	60996
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	26996	0	0	26996
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	13271	0	13271
1982	0	0	2608	3666	0	0	0	0	0	0	0	0	6274
1983	0	0	11148	19436	0	0	0	0	0	0	5960	18300	54844
1984	0	0	0	54240	0	23900	30500	70000	0	0	0	0	178640
1985	0	0	1400	56580	15500	7100	2211	0	0	0	0	5943	88734
1986	0	0	848	4696	0	0	0	32000	0	0	49750	82000	169294
1987	68500	43500	23900	49568	0	6308	32000	46628	60721	68311	39066	64429	502929
1988	20517	35786	68806	84206	48500	14300	0	0	0	0	0	0	272115
1989	0	0	12060	20690	0	0	0	0	0	368	0	9273	42391
1990	0	0	0	6098	0	0	0	0	0	0	0	0	6098
1991	0	0	6707	16515	6242	0	0	12579	31619	0	0	0	73662
1992	0	0	4248	9146	2582	2582	0	0	0	0	0	0	18557
1993	0	0	0	0	0	0	0	0	0	35780	35353	48216	119349
1994	51116	74409	98309	112569	61779	60079	0	0	0	8200	0	0	466459
Average	7007	7685	12684	23634	6834	5713	3236	8060	4617	6983	7170	11408	105030

Cost

Two important facts distinguish this individual case of power interference. First, participation by any utility in the Three States Cooperative Program is presumed to be strictly voluntary with this and all other alternatives. Second, contracts between two parties normally carry a right to specific performance.

There are two elements of cost to consider with this individual case of power interference charges: payments to CNPPID for the lost revenue (since less energy will be sold to NPPD) and the net cost NPPD will incur to replace the energy it would have received from CNPPID, plus the value of associated capacity loss, encompassed by generation replacement costs. The latter is not simply a third party impact because NPPD has a multi-year contract with CNPPID to obtain energy under specified terms. NPPD and CNPPID also signed an operating agreement in 1954 which recognizes responsibilities of both parties with regard to Lake McConaughy operations (personal communication with Frank Kwapioski, 1999). NPPD might experience other losses associated with generation and capacity reductions at its North Platte hydro if Lake McConaughy is storing for power interference when North Platte is below capacity. Compensation for damages or losses to NPPD are likely to be required if the Program proceeds with the power interference charge program.

The first cost element can be derived by relating CNPPID's power revenues to net energy delivered and then to water released from the district's three hydrogenerating facilities. For the 1994 through 1998 period, this amounted to an approximate average of $12 per ac-ft released by the three plants.

It is noted that power generation will still occur with power interference, but it will be at different times or later in the year. CNPPID and NPPD point out that a loss in value may result from retiming. The retimed generation could be assumed to be the incentive for these districts to participate, but this deserves further study.

The second cost component, NPPD's losses, is more problematic to estimate (personal communication with Barry Campbell, NPPD, 1999). The concept for such a calculation would typically be the additional cost to replace the lost power. NPPD has indicated that it does, in fact, need this power and would need to replace it (personal communication with Brian Barels, 1999). Since NPPD needs the CNPPID resource, it would need to purchase outside power resources that would have the components of capacity charges, energy charges, transmission costs, and transmission losses. These costs would vary by peak, off-peak and season. The costs need to be projected in an electric industry marketplace that faces tightening supplies and is moving to market-based rates. These accumulated costs, less the payments to CNPPID, represent the avoided costs that NPPD faces and would seek to recover.

Avoided cost must be derived on a utility-specific and specific resource replacement basis. The value lost to NPPD in this circumstance depends on the nature of NPPD's system load over time, other generation capabilities within their system, and other opportunities to acquire power resources from other generators. A quantification of these costs was not made by NPPD, and is complicated by considering electric industry restructuring and other uncertainties. A study of NPPD power system requirements and sources by cost over time will be needed to confirm present power values of NPPD. As outlined, this cost estimate would require a considerable study to yield useful estimates, which is beyond the scope of this study. Under these conditions, the study team concluded that a detailed cost estimate of the avoided cost component could not be made.

The cost would be that amount necessary to complete the program with CNPPID. This would amount to about $12 per ac-ft or approximately $492,000 per year to redistribute approximately 41,000 ac-ft, excluding the unknown amount for NPPD costs. This cost does not include Central's increased costs of maintenance and administration associated with this alternative.

The capitalized cost to acquire this right would amount to $138 per ac-ft or $5.6 million for approximately 41,000 ac-ft, not accounting for the NPPD cost portion. The cost per ac-ft at the critical habitat would be approximately $325 assuming additional flows can be protected from downstream diversions and $540 assuming additional flows cannot be protected from downstream diversions.

The study team assumed, for the purpose of this reconnaissance level study, that NPPD's lost value would not exceed twice the power interference costs to CNPPID. This is based upon the opinion that Central would not have agreed to the sale price for the power if it were actually three times the price which NPPD is, in fact, paying. This is likely to be a conservative assumption that can be refined in later study phases.

As such, the study team believes the ultimate cost should be below $17 million. This amount excludes the multi-faceted, fully loaded costs it would bear under the alternative as described. Based on a total cost of $17 million, the cost per ac-ft at the critical habitat would be approximately $980 assuming additional flows can be protected from downstream diversions and $1,630 assuming additional flows cannot be protected from downstream diversions.

5. Yield Summary

Table 8.H.26 summarizes the yields associated with the alternatives evaluated. Projects have been analyzed independently of each other. Several projects rely on the same source of water, in which case, the yields of these projects combined may be less than simply adding the yields of the individual projects. The total yields described in this memo for each alternative are specific to the assumptions the study team has made for these projects.

The average annual net hydrologic effects at the site for alternatives that have not been deferred range from -85 ac-ft per year to 41,017 ac-ft per year. The net hydrologic effects at the top of the next downstream reach and net hydrologic effects at the critical habitat are also summarized in Table 8.H.26. The net hydrologic effects at the top of the downstream reach and at the critical habitat, and reductions to target flow shortages were not evaluated for Dodge Dam, Toltec Dam, Glendo Reservoir, Chatfield Reservoir, Cooper Creek diversion, and Middle Fork Powder River transbasin diversion because these projects were deferred from further evaluation at this time.

The reductions in shortages to target flows at the critical habitat for alternatives that have not been deferred range from 552 ac-ft per year to 17,367 ac-ft per year, without diversion losses. With diversion

TABLE 8.H.26

Alternatives Yield and Cost: Category 6 — Systems Integration and Management

Reach Alternative	Yield 20 year Average Annual Values (ac-ft/yr)							Capitalized Costs			
	Net Hydrologic Effect At Site	Net Hydrologic Effect at Top of Downstream Reach (w/diversion loss)	Net Hydrologic Effect at Top of Downstream Reach (w/o diversion loss)	Net Hydrologic Effect at Habitat (w/diversion loss)	Net Hydrologic Effect at Habitat (w/o diversion loss)	Reduction to Target Flow Shortages at Habitat (w/diversion loss)	Reduction to Target Flow Shortages at Habitat (w/o diversion loss)	Cost* w/ diversion loss ($ Million)	Cost* w/out diversion loss ($ Million)	Cost per Acre-Foot of Average Reduction in Target Flow Shortage At Habitat ($/ac-ft) (w/diversion loss)	Cost per Acre-Foot of Average Reduction in Target Flow Shortage At Habitat ($/ac-ft) (w/o diversion loss)
Region 1											
Reach 3											
La Prele Reservoir 5,000 ac-ft Pool	3,388	3,329	3,329	1,427	2,953	354	2,218	$1.9	$1.9	$1,990	$330
Wind River Transbasin Div. (20 cfs)	9,029	9,029	9,029	3,084	6,873	2,086	6,788	$31.3	$31.3	$15,090	$4,610
Wind River Transbasin Div. (40 cfs)	17,570	17,333	17,333	4,562	11,934	2,984	9,777	N/A	N/A	N/A	N/A
Middle Fork Powder River Transbasin Diversion	15,000	N/A	N/A	N/A	N/A	N/A	N/A	$115.0	$115.0	Cost at Site $7,670	Cost at Site $7,670
Reach 4											
Glendo Reservoir: Reallocation of Flood Pool	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Reach 6											
Leiber Dam and Reservoir	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Grayrocks Reservoir	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dodge Dam and Reservoir	970 - 3742	N/A	N/A	N/A	N/A	N/A	N/A	14.5 - 29.4	14.5 - 29.5	Cost at Site $3,700 - $16,500	Cost at Site $3,700 - $16,500
Cooper Creek Diversion	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Region 2											
Above Reach 7											
Chatfield Reservoir Reoperation	3,500	N/A	N/A	N/A	N/A	N/A	N/A	N/A	$13.5	N/A	Cost at Site $4,050
Region 3											
Reach 17											
Power Interference Charges	41,017	41,017	41,017	25,274	55,081	10,407	17,567	$17.0	$17.0	$1,630	$980
B-1 Reservoir Reoperation	(85)	(85)	(85)	(57)	4	455	252	$1.5	$1.5	$2,590	$2,510

* Present value of sum of implementation cost, capital costs and operating costs over 20 year period using 6 percent discount rate.

N/A: Not Analyzed

losses, reductions in shortages to target flows at the critical habitat range from 954 ac-ft per year to 10,407 ac-ft per year.

6. Cost Summary

Table 8.H.26 also summarizes the costs associated with the alternatives evaluated. Under the programs evaluated in this memo, the total net present value costs for alternatives that have not been deferred range from about $1.3 million to $17 million for B-1 Reservoir and power interference charges, respectively. For alternatives that have not been deferred the cost per ac-ft of shortage reduction at the critical habitat without diversion losses ranges from $850 to 2,310, respectively. With diversion losses, the costs would rise to $1,630 and $2,590 per ac-ft, respectively.

Several alternatives, including Dodge Dam, Chatfield Reservoir, Middle Fork Powder River transbasin diversion, and Wind River transbasin diversion were deferred from further evaluation because the cost per ac-ft of yield (additional water to route downstream) at the site exceeded the economic screening criteria of $3,000 per ac-ft or the total cost exceeded $50 million. The cost per ac-ft of yield at the site for these alternatives ranged from $5,700 to $16,500.

The costs associated with the Glendo Reservoir, Toltec Reservoir, and Cooper Creek alternatives were not evaluated because these alternatives were screened from further evaluation at this time.

7. Associated Issues

The only alternatives that have not been screened out are La Prele Reservoir, Grayrocks Reservoir, B-1 Reservoir, and paying power interference charges. These projects were evaluated according to the criteria established in concert with the Water Management Committee. The evaluation of paying power interference charges refers only to Region 3, Reach 17, since this was the only location where such a program might be envisioned at this time. The five categories of associated issues are physical, legal/institutional, economic, social, and environmental. Each of the five characteristics is examined for these projects in the categories below. Tabular scoring for these projects according to each sub-criterion is presented at the end of this section in Tables 8.H.27 and 8.H.28. Scoring has been provided for both the with

TABLE 8.H.27
Scoring Table - With Diversions in Wyoming, Colorado and Nebraska
Category 6 - Systems Integration and Management

	Region 1 Reaches							Region 2 Reach	Region 3 Reaches	
	3a	3b	3c	4	6a	6b	6c	7	17a	17b
Physical										
Net Reduction in Shortage to Target Flows	1			0	0		0		0	5
Sustainability	4									5
Scalability	1									5
Technically Implementable	5									5
Time to Yield Realization	4									4
Ability to Monitor and Measure	4									4
Third Party Hydrologic Impacts	3									3
Subtotal	22									31
Subtotal Average	3									4
Legal/Institutional										
Ease of Permitting	3									3
Consistent with Interstate Compacts, Federal Laws & Decrees	5									5
Consistent with State Laws	3									5
Potential for Institutional Consensus	4									2
Can be Mitigated	2									3
Administrative Ease	4									4
Consistent with Existing Contract, Facility & Land Ownership	3									1
Subtotal	24									23
Subtotal Average	3									3
Social										
Effects on Customs and Culture	3									3
Equity of Impacts	3									3
Impacts on Community Organizations and Support Structures	3									3
Effects on Community Sustainability	3									3
Public Acceptability	3									2
Subtotal	15									14
Subtotal Average	3									3
Economic										
Initial Implementation and Capital Cost	5		0							4
Average Annual Total Cost per ac-ft Reduction	5	0	0			0		0		3
Direct Economic Impacts	3									3
Secondary Economic Impacts	3									2
Fiscal Impacts	3									2
Effects on Economic Development Potential	3									3
Subtotal	22									17
Subtotal Average	4									3
Environmental										
Impacts to Wetlands	3									3
Impacts to Habitat	3									3
Impacts to Water Quality	3									3
Impacts to Prime and Unique Farmlands	5									5
Visual Impacts	3									3
Impacts to Amenities	3									3
Subtotal	20									20
Subtotal Average	3									3
Overall Total (Sum of Averages)	17	0	0	0	0	0	0	0	0	17

Legend:
3a - La Prele Reservoir 5,000 ac-ft Pool
3b - Wind River Transbasin Diversion
3c - Middle Fork Powder River
Transbasin Diversion
4 - Glendo Reservoir: Flood Pool Reallocation
6a - Toltec Dam and Reservoir
6b - Dodge Dam and Reservoir
6c - Cooper Creek Diversion
7 - Chatfield Reservoir
17a - B-1 Reservoir
17b - Power Interference Charges

TABLE 8.H.28
Scoring Table - No Diversions in Any State
Category 6 - Systems Integration and Management

	Region 1 Reaches								Region 2 Reach	Region 3 Reaches	
	3a	3b	3c	4	6a	6b	6c	6d	7	17a	17b
Physical											
Net Reduction in Shortage to Target Flows	1			0	0					1	5
Sustainability	4									3	5
Scalability	1									1	5
Technically Implementable	5									5	5
Time to Yield Realization	4									5	4
Ability to Monitor and Measure	4									4	4
Third Party Hydrologic Impacts	2									3	3
Subtotal	21									22	31
Subtotal Average	3									3	4
Legal/Institutional											
Ease of Permitting	2									4	3
Consistent with Interstate Compacts, Federal Laws & Decrees	5							0		5	5
Consistent with State Laws	3									4	4
Potential for Institutional Consensus	3									4	2
Can be Mitigated	2									5	3
Administrative Ease	4									4	4
Consistent with Existing Contract, Facility & Land Ownership	3									5	1
Subtotal	22									31	22
Subtotal Average	3									4	3
Social											
Effects on Customs and Culture	3									3	2
Equity of Impacts	3									3	3
Impacts on Community Organizations and Support Structures	3									3	3
Effects on Community Sustainability	3									3	3
Public Acceptability	2									4	2
Subtotal	14									16	14
Subtotal Average	3									3	3
Economic											
Initial Implementation and Capital Cost	5		0							5	4
Average Annual Total Cost per ac-ft Reduction	5	0	0			0			0	3	5
Direct Economic Impacts	3									3	3
Secondary Economic Impacts	3									3	2
Fiscal Impacts	3									3	2
Effects on Economic Development Potential	3									3	3
Subtotal	22									20	19
Subtotal Average	4									3	3
Environmental											
Impacts to Wetlands	3									3	3
Impacts to Habitat	3									4	3
Impacts to Water Quality	3									3	3
Impacts to Prime and Unique Farmlands	5									5	5
Visual Impacts	3									4	3
Impacts to Amenities	3									3	3
Subtotal	20									22	20
Subtotal Average	3									4	3
Overall Total (Sum of Averages)	16									18	17

Legend:
3a - La Prele Reservoir 5,000 ac-ft Pool
3b - Wind River Transbasin Diversion
3c - Middle Fork Powder River
Transbasin Diversion
4 - Glendo Reservoir: Flood Pool Reallocation
6a - Toltec Dam and Reservoir
6b - Dodge Dam and Reservoir
6c - Cooper Creek Diversion
6d - Grayrocks Reservoir
7 - Chatfield Reservoir
17a - B-1 Reservoir
17b - Power Interference Charges

diversions and without diversions scenarios. Differences under the scenario with diversions are discussed at the close of each criteria category.

B-1 Reservoir

Physical

B-1 Reservoir, confined by the surrounding topography, cannot be enlarged and is therefore not scalable. The reductions to target flow shortages for this alternative are sustainable over time. Contracts with CPNRD and NPPD may need to change if surrounding ground water levels decrease dramatically. The life span of the B-1 project could last beyond 10 to 13 years. Reoperation of B-1 Reservoir is technically implementable. The time to yield realization is dependent on the length of time required to develop an operating plan with CPNRD and NPPD and to rehabilitate the reservoir outlet structure. The time to yield realization would be on the order of 1 to 2 years. The yield from this alternative is easily quantified. Third-party hydrologic impacts associated with controlling releases from B-1 Reservoir could most likely be mitigated.

Legal and Institutional

The B-1 Reservoir project is consistent with interstate compacts, federal laws, and decrees and is easy to administer and enforce. Reservoir projects in Nebraska are consistent with state laws. Re-operation of the conservation pool in B-1 Reservoir for Program purposes would require contract negotiations with CPNRD and NPPD. In the future, re-negotiation with CPNRD may be necessary if ground water levels in the surrounding area approach the lower limits defined in the CPNRD Ground Water Management Plan. Institutional consensus should be attainable because of the broad support for this alternative. No undesirable impacts are envisioned with this alternative.

Social

The social effects of this alternative are generally positive. Any adverse effects on cultural resources could most likely be mitigated.

There will be no impact on customs and culture, community organizations and support structures or community sustainability. A B-1 Reservoir project would not be expected to encounter resistance from neighboring property owners.

Economic

Most of the costs of this alternative are capital costs up front. No direct, secondary, or fiscal impacts are envisioned with this alternative. The project should not have any impact on business sales, employment and employee wages and wealth. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and should not effect existing users.

Environmental

This alternative should not impact existing wetlands. Potential positive impacts would occur from the creation of wildlife habitat in the reservoir through frequent fills. Reservoir projects could have both negative and positive impacts on water quality and on aquatic habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when flows are reduced due to diversions to storage. The visual quality of the surrounding area would not be significantly impacted. The B-1 project would have no impact to impact to prime and unique farmlands or locale amenities.

La Prele Reservoir

Physical

Any agreement with the PEPL to purchase or lease their water and storage would require the approval of the District. It is possible that obtaining the approval of the District could impact the yield of PEPL water and storage and corresponding net reductions to target flow shortages. The La Prele Reservoir alternative is not scalable because PEPL's storage right that is be available for lease or sale is only 5,000 ac-ft. The maximum additional flow at the top of Reach 4 to be routed downstream is already only 3,579 ac-ft. Any reduction in the amount of storage leased or purchased would make this alternative less desirable from a physical yield standpoint.

This alternative is sustainable for the next 27 years based on the current agreement between PEPL and the District. Currently, 12 years remain on PEPL's original agreement, with the option to renew the agreement for another 15 years. After 27 years (the year 2026), the status of PEPL's storage account in La Prele Reservoir is uncertain and would depend on whether the agreement can be further extended. Therefore, the life span of the project can be extended beyond 10 to 13 years, however, the agreement must be renewed. This alternative is technically implementable at the scale proposed. The time to yield realization would be dependent primarily on legal and institutional issues. For the La Prele Reservoir alternative to be implemented a change of use would be required for water to be stored under the La Prele Reservoir storage right and used for the benefit of the critical habitat in Nebraska. In addition, approval from the Wyoming legislature would be required for this water to be exported to Nebraska. These legal obstacles could require a minimum of one to two years and possibly up to four years for resolution.

This alternative could be easily monitored and measured in terms of the amounts stored and released, however, there is some uncertainty regarding the seepage out of the reservoir that is accounted for as storage and charged and delivered to PEPL. There would be some negative third-party hydrologic effects on the District because the District is currently using PEPL's storage right for irrigation. Irrigation return flows are eventually stored in Glendo Reservoir and subsequently released for hydropower and irrigation use. Returns flows from this irrigation use are either reused by downstream irrigators or eventually stored in Lake McConaughy and subsequently used for hydropower and irrigation. Protecting releases from LaPrele from diversion will affect the timing and quantity of these return flows, which would result in negative third-party impacts on downstream irrigators, the EA in Lake McConaughy, and hydropower diverters.

The only change in scoring from scenario 1 to scenario 2 is under third party hydrologic impacts. The hydrologic impacts on the District would be greatly reduced if the District is allowed to divert releases from La Prele Reservoir for the critical habitat.

Legal and Institutional

The primary legal/institutional obstacle associated with use of PEPL's storage right in La Prele Reservoir is the inability to export water out of state for use at the critical habitat under existing state water law. An in-state beneficial use must be decreed or approved by the Wyoming legislature for water to be exported to the critical habitat. This issue has been addressed with the Tamarack Project by decreeing in-state wildlife enhancement benefits associated with the recharge sites. The District may object to the sale or lease of PEPL's water or may object to changing the use of this water right as they are currently using water stored under PEPL's right. This alternative could be difficult to permit and is currently not consistent with State laws. While not consistent with current State laws, this alternative is consistent with interstate compacts, federal laws and decrees. This alternative has the potential for institutional consensus, however, depending on the conditions of the agreement, the District may or may not object. Depending on the provisions of obtaining the District's approval of a transaction it may be necessary to mitigate irrigators that are currently using water stored under PEPL's right. Administratively, this alternative would not be difficult to operate or maintain, however, it must be administered on a monthly basis. This alternative has some contract issues including obtaining the District's approval of a transaction and changing the use of the water right, however, these issues can be dealt with.

The changes in scoring from scenario 1 to scenario 2 are under ease of permitting and potential for institutional consensus. This project would be more acceptable to the District if they are allowed to divert releases from La Prele Reservoir for the critical habitat. The District would be less inclined to object to the transaction.

Social

The social effects of this alternative are likely to be neutral to minimal. There will be no impact on customs and culture, community organizations and support structures or community sustainability. This alternative would also have no adverse effects on cultural resources.

There may be some public opposition to acquiring PEPL's water for the critical habitat because it is currently being used by the District. Some irrigators could be negatively impacted depending on how reliant they are on PEPL's storage water.

The only change in scoring from scenario 1 to scenario 2 is under public acceptability. This project would be more acceptable to the District if they are allowed to divert releases from La Prele Reservoir for the critical habitat.

Economic

The cost of this alternative consists primarily of the cost associated with purchasing PEPL's storage right, which is the remaining principal on an existing loan, and an additional cost for obtaining the District's approval of the transaction. In addition, there would be some minimal annual operations and maintenance costs. It is possible that obtaining the approval of the District could impact the cost of PEPL water and storage. The direct economic impacts, including direct third-party impacts, as well as, secondary economic impacts and fiscal impacts would be minimal. Any direct economic impact would be on the District, which is currently using PEPL's storage right for irrigation, however it is unlikely that this amount of water and storage would have a measurable economic impact. The negative impact on the District is dependent on how often and to what extent the District relies on PEPL's storage right. This project will have minimal direct, indirect and induced impacts on business sales, employment, employee wages and wealth. There are potentially negative effects on economic development, since this water will be unavailable for other future uses. The effects on economic development potential would be a limitation on future development and would not impact existing economic conditions. There would be no measurable effect on revenues and expenditures of governmental entities resulting from this alternative.

The sub-criteria are scored equally for both scenarios 1 and 2.

Environmental

This alternative would have no impact on wetlands, habitat, water quality, and prime and unique farmlands. In addition, there would be no visual impacts or impacts to amenities as a result of this alternative.

The sub-criteria are scored equally for both scenarios 1 and 2.

Power Interference Charges

The associated issues refer only to Region 3, Reach 17, since this was the only location where such a program might be envisioned at this time.

Physical

This program does offer a significant net reduction in shortages to target flows. The program to pay power interference charges also scores high in other physical categories; it is fully sustainable, technically implementable, and there is a clear opportunity to monitor and measure the water savings. The available water varies with hydrologic conditions, but not more than other alternatives. Technically, power interference simply requires a change of operations for the CNPPID hydrogeneration facilities to follow new criteria. Releases by day and by month are obviously measurable. The scalability of this program rests with CNPPID's interest in gaining as little or as much from this program as it wishes, assuming this is a voluntary program, and further assuming that NPPD is agreeable. There is a clear upper limit to the available water from this program. Time to realization will likely be delayed by the resolution of NPPD's losses in this transaction. The resolution of NPPD's losses could mean waiting until the current contract expires, thought to be 2013 or earlier, if mutual accommodations are found. Third party hydrologic impacts might occur with irrigation storage converted to this program alternative. CNPPID intends to minimize this impact upon irrigators within its district. The Study Team believes third party hydrologic impacts will be modest, given the nature of this program and its proximity to Grand Island. Some impacts during the non-irrigation season are possible.

Under the with diversions scenario, there might be certain downstream losses, but these should be modest. These waters are backed by Lake McConaughy storage and stand a better chance of protection, perhaps similar to the Environmental Account. First, those diversions would have to be below Reach 14. Second, the monthly changes focus on the non-irrigation season. The ability to monitor would be reduced, but third party hydrologic impacts could be eliminated.

Legal and Institutional

From a legal and institutional perspective, the power interference program is quite negative according to two sub-criteria, but little or no constraints are evident with the other sub-criteria. Permitting issues relate to Lake McConaughy operating and release criteria. These appear to be surmountable, but further study of affected permits and licenses is warranted. Power interference does not conflict with compacts, federal laws, or decrees, nor with Nebraska law, except for the protection of conserved waters in the river. Institutional consensus is problematic, and contractual conflicts are evident. CNPPID has an existing contract to deliver energy to NPPD, and NPPD desires those resources and views the power interference charge program questionable from its own perspective. The contractual rights, remedies and potential mitigation available to NPPD are uncertain at this point, but affected sub-categories must receive a low ranking for the purposes of this reconnaissance study. If these obstacles can be overcome, administration of this option will not be difficult. One possibility for simplifying institutional constraints would be to add this water to the Environmental Account.

Social

The social impacts of the power interference alternative are mostly quite modest, with the possible exception of public acceptability and irrigator concerns. A contract dispute might have broad ramifications. Neutral effects are likely.

Economic

Major unknowns are evident in assessing the economic evaluation criteria for the power interference charge program. The initial implementation and capital costs depend upon the resolution of the NPPD contract issue and the development of an administrative and management plan to implement this alternative. The average annual total cost per ac-ft of reduction to shortages at the critical habitat also cannot be determined until the settlement with NPPD is known. Even so, the ultimate cost should be below $17 million overall. The Study Team believes, without more data but based on past experience, that the value of the lost power resource to NPPD is unlikely to exceed three times the lost value to CNPPID.

It is important to note that the power interference charge program does not result in a net increase in average annual flows, but offers a timing benefit to reduce months where shortages are evident. The cost per ac-ft must be interpreted in that context, and the actual yield determined at the critical habitat, including the possible disruption of historic storage patterns.

There are unlikely to be any appreciable economic impacts, fiscal impacts or impacts upon economic development, unless useful replacement power is unavailable, in which case substantial economic impacts might occur. If left unmitigated, higher power costs to NPPD might occur, and NPPD intends to minimize such effects. Economic impacts would be unaffected by the "diversions on" scenario. Third party impacts to power consumers will remain the same.

Environmental

This power interference charge program would result in different operational criteria for the three impoundment facilities known as Johnson No. 1, Johnson No. 2, and Jeffrey and for Lake McConaughy. Storage levels are likely to change, which could affect various environmental resources and also recreation. Given the size of these facilities, it is unlikely that these impacts would be severe, although further study of the environmental impacts of these operational changes would be required. A third party environmental impact might occur with this alternative: replacement generation is likely to be fossil-fuel based and therefore cause greater impact than hydrogeneration. The protection of conserved waters from downstream diversions will not affect this evaluation criteria.

8.I. Watershed Management

I. Watershed Management

1. Introduction

This section examines the yields, costs and associated issues of watershed management alternatives to reduce shortages to target flows at the critical habitat. A number of watershed management alternatives identified in the long list of alternatives were previously deferred from further analysis, as documented in Chapter 6. The remaining alternatives fall into one category:

Forest Management

A brief description of each of the representative projects and how they might be implemented is provided, followed by estimates of yields and cost for each project. Finally the evaluation of each project in terms of physical, legal and institutional, economic, social, and environmental effects is provided to conclude the watershed management alternatives evaluation.

2. Conceptual Definition

With respect to water yield, forest management involves patch-cutting, selective harvest, and other forest clearing methods designed to increase streamflow. Considerable research has been conducted pertaining to forest management and associated streamflow responses. Research has shown that removal of trees in the watershed can increase streamflow quantities by reducing evapotranspiration and by increasing the snowpack accumulation in the openings that result from harvest (Leaf, 1975; Callaham, 1990; Stednick, 1996 among others). The additional runoff created varies with the drainage basin, the types of forest involved, the area of forest cleared, the manner in which the forest is harvested, and climatic factors. These effects diminish over time as the trees are reestablished and original evapotranspiration and snow distribution conditions are approached. Research conducted at the Fraser Experimental Forest in Colorado shows that water yield increases from timber harvest are attenuated over approximately 80 years in subalpine lodgepole pine, and in approximately 100 years in spruce/fir. Aspen reaches complete hydrologic utilization in about 30 years (Leaf, 1999). Continued maintenance of the cut condition through prescribed burns or selective cutting could result in longer-term, higher yields. Because the water yield generated from these techniques results from changes in the use of precipitation and snowmelt by the forest, the effects upon water yield generated by forest management alternatives would vary with climatic cycles.

3. Operational Definition

Some limitations and basic assumptions must be applied to forest management alternatives to adequately evaluate the feasibility, physical yield, legal implications, costs and benefits, and other aspects of each alternative. The following operational definition describes the assumptions and methodologies used to define forest management alternatives.

- Only areas that have been previously investigated and considered for forest management programs were reviewed and evaluated. The review of information associated with these areas was limited to that information presented in forest management plans of the USDA Forest Service (USFS). Other non-timber lands could be managed to increase water yield through prescribed fire or other means; however, these alternatives were not analyzed.

- The estimates of water yield and associated costs were extracted from Final Environmental Impact Statements associated with the various forest management plans. Factors considered by the USFS in the generation of estimates of water yield include the type of forest cleared, the size of the drainage basins involved, and precipitation. The timing of additional runoff was extracted from studies conducted at the Fraser Experimental Forest (Troendle, et al., 1998). Leaf (1999) presented estimates of additional yield that could be gained through forest management. Those estimates fall within the range of those alternatives evaluated following review of the USFS documents.

- Estimated hydrologic effects at the critical habitat were evaluated for both the "protected" and "unprotected" conditions. Any additional water yield that is generated by forest management alternatives was assumed to be subject to appropriation under state water law and not available to a new water right. The estimates resulting from the "protected" condition are considered hypothetical and may not be realized without changes to current water laws. They are presented in this chapter for the purposes of comparison with other alternatives.

- Losses due to evaporation, seepage, and historical diversions en route to the critical habitat were accounted for using the water budget spreadsheet. Appendix E presents detailed discussions of the spreadsheet model, assumptions, and methodologies.

4. Alternatives

Regions 1 and 2

Regional Forest Management

"Virtually all of the water available to the Platte is generated from snowmelt on densely forested land, most of which is controlled by the USDA, Forest Service" (Leaf, 1999). Therefore, management of these lands has obvious importance to the Platte River system. Forest Plans (Plans) and accompanying Final Environmental Impact Statements (FEISs) for each National Forest (NF) within the Platte River drainage were reviewed. Only those National Forests within Regions 1 and 2 that contribute runoff to the Platte River drainage basin were studied. Forest lands within Region 3 were not included because of a lack of potentially treatable acreage. Therefore, the forests evaluated include:

- Medicine Bow National Forest (Region 1),
- Arapaho/Roosevelt National Forest (Region 2),
- Routt National Forest (Region 2), and
- Pike/San Isabel National Forest (Region 2)

Forest management plans and accompanying FEISs are primary sources of information for this study, accordingly, the following explanation of these documents is provided.

Forest management plans are prepared by the USFS in accordance with the 1976 National Forest Management Act (NFMA), the 1969

National Environmental Policy Act (NEPA), and other laws and regulations. The NFMA regulations state that a forest plan should ordinarily be revised on a 10-year cycle or at least every 15 years (36 CFR 219.10). The purpose of a Forest Plan is to provide guidance for all resource management activities within the National Forest. Briefly, the forest plan

- establishes forest-wide standards and guidelines,
- establishes management area direction (management area prescriptions) applying to future activities in a management area (resource integration and minimum, specific management requirements),
- designates lands as suited or not suited for timber production or other resource management activities,
- establishes monitoring and evaluation requirements, and
- provides recommendations to Congress for the establishment of wilderness, wild and scenic rivers, and other special designations, as appropriate (USFS, 1997a).

NFMA regulations (Code of Federal Regulations 36 Part 219 (36 CFR 219.10)) set forth a procedural framework to planning activities subject to the requirements of NEPA. With respect to the formulation of forest management alternatives, the regulations state:

"The interdisciplinary team shall formulate a broad range of reasonable alternatives according to NEPA procedures. The primary goal in formulating alternatives, besides complying with NEPA procedures, is to provide an adequate basis for identifying the alternative that comes nearest to maximizing net public benefits…Alternatives shall provide different ways to address and respond to the major public issues, management concerns, and resource opportunities identified during the planning process."

Each forest develops its own Forest Plan and accompanying Draft Environmental Impact Statement (DEIS) which are published for public review and comment. Following the review and comment period, the Revised Plan, Final Environmental Impact Statement, and Record of Decision (ROD) are issued. Following the completion of the NEPA process, an alternative is selected and documented in the ROD.

This plan will then remain in effect until the plan is revised again in 10 to 15 years.

Given the wide spectrum of resources and uses available within these lands, the Plans must truly be multi-disciplinary in nature. The needs and requirements of various resources and uses must be balanced against each other, often with one suffering at the other's expense. Therefore, the USFS includes the analysis of several alternative management plans at the time each Forest Plan is revised. Table 8.I.1 summarizes the various categories that the USFS includes within any alternative (USFS, 1997a). Each alternative emphasizes a different balance of these categories. For example, one alternative may emphasize development of forest products (Category 5) with relatively little emphasis on wilderness areas (Category 1). Another alternative may emphasize optimization of recreational opportunities (Category 4) with less emphasis placed on forest products (Category 5), and so on. With respect to water yield, those forest management alternatives which place a higher emphasis on Category 5 (forest products) will tend to generate correspondingly higher increases in water yield.

Recently, the Coalition for Sustainable Resources, Inc. brought suit against the USFS (Coalition for Sustainable Resources v. USFS, et al., Civil Action No. 98CV 174, Wyoming District Court). Their claim argued that the USFS has not managed National Forest lands to generate higher water yield. This suit was dismissed because U.S. District Court Judge Clarence Brimmer ruled that the suit was premature, citing this reconnaissance study investigation (Billings Gazette, May 23, 1999).

The study team evaluated three forest management scenarios for each National Forest to estimate the potential benefits associated with the watershed management alternative. These were designated the "USFS Selected Alternatives", the "Water Yield", and "Benchmark" scenarios. Each of these scenarios assumes that similar management strategies are imposed in each of the National Forests. Descriptions of these alternatives and the assumptions associated with each are as follows:

- USFS Selected Alternatives Scenario. This scenario consists of the combination of the specific alternatives from each of the four National Forests that have been selected in the respective RODs (i.e., the Preferred Alternatives). This scenario

Table 8.I.1
USFS Management Area Prescription Categories

Category	Description	Example
Category 1	Preservation lands with very little human influence	Wilderness areas
Category 2	Conservation lands that represent rare ecosystems	Research Natural Areas
Category 3	Areas with limited use but more human activities allowed	Motorized backcountry areas
Category 4	Recreation areas	Scenery, dispersed recreation
Category 5	Forested ecosystems providing timber and range products	General forest and rangelands
Category 7	Forest Service land adjacent to private land	Intermixed areas of Forest Service land and private cabins
Category 8	Ski areas and utility corridors	Steamboat Ski Area

Source: US Forest Service, 1997a

represents the current management strategy of the USFS. Table 8.I.2 summarizes the individual alternatives selected for each of the respective National Forests. This scenario is evaluated to determine the additional water yield associated with forest management plans selected for implementation by the USFS but as yet not fully implemented.

- Water Yield Scenario. This scenario consists of the combination of the specific alternatives from each of the four National Forests that generated the greatest increase in water yield over baseline conditions. Table 8.I.2 summarizes the individual alternatives selected for each of the respective National Forests.

- Benchmark Scenario. In previous Forest Plans, the USFS presented estimates of maximum increases in water yield, which could be developed without degradation of water quality. For the purposes of this evaluation, these estimates were considered to be theoretical values and were utilized as "benchmark" values upon which to compare alternatives.

The Benchmark scenario was included by the study team to provide an upper limit to the yield that could theoretically be generated by forest management techniques. For example, the estimated 240,000 ac-ft increase in water yield from the Arapaho/Roosevelt National Forest was considered a theoretical benchmark. According to the USFS, it did not include consideration of constraints such as provisions for sustainable timber production or viable wildlife habitat (USFS, 1997b).

To put the areal extent of the Benchmark scenario into perspective, the following example and conclusion are extracted from responses to comments on the Arapaho/Roosevelt National Forest FEIS (USFS, 1997a). Using the USFS estimate, an average of 0.912 ac-ft of water produced per acre of forest harvested, approximately 263,000 additional acres would need to be maintained in a clear cut condition in the Arapaho/Roosevelt National Forest to generate an increased water yield of 240,000 ac-ft per year. According to Leaf, approximately 1,500,000 acres of forest lands would need to be maintained in a patch cut condition to generate an approximately equivalent yield (Leaf, 1999).

Yield

The assumptions, procedures, and results related to water yield estimates associated with forest management alternatives are as follows:

1. Increased water yield generated from forest management activities (i.e., timber harvest) increases with time assuming a constant rate of timber harvest. The water yields reported in this chapter represent the *average* increased yield associated with a given forest management plan *at full implementation level*. According to the respective FEISs, the plans are implemented over a planning period of 50 years. Use of the average increased yield at full implementation represents a conservatively high estimate of additional water associated with the forest management scenarios. There were insufficient data to support the analysis of forest management for the 20-year study period.

2. All water associated with a given forest management plan was used as input to the water budget analysis. This assumption gives full accreditation of increased water yield over the baseline condition (i.e. the existing condition) to each alternative evaluated.

3. Baseline conditions were assumed to be those presented in the respective FEISs. These values represent the estimated mean annual yield generated within the National Forests at the time the FEIS was prepared. Stream gaging records for the evaluation period (1975-1994) which are incorporated within the water budget model would, therefore, reflect these conditions. It should be noted that research conducted by Leaf (1999) shows that water yield from the National Forests has declined since the turn of the century due to changes in USFS management strategies.

4. The increased water yield associated with the management alternatives discussed above was tabulated for each of the four National Forests (Table 8.I.3).

Table 8.I.2
Forest Management Alternatives Incorporated In USFS Selected Alternatives and Water Yield Scenarios

National Forest	USFS Selected Alternatives Scenario	Water Yield Scenario	Source
Medicine Bow (Region 1)	Alternative A Multiple Resource Objectives	Alternative H Increased water	Final Environmental Impact Statement for the Medicine Bow National Forest Land and Resource Management Plan, 1984
Arapaho / Roosevelt (Region 2)	Alternative B Multiple Resource Objectives	Alternative C Emphasis on forest products	Final Environmental Impact Statement for the Arapaho / Roosevelt National Forest Land and Resource Management Plan, 1997
Pike / San Isabel (Region 2)	Alternative A Multiple Resource Objectives	Alternative D Market Opportunities	Final Environmental Impact Statement for the Pike / San Isabel National Forest Land and Resource Management Plan, 1982
Routt (Region 2)	Alternative C Multiple Resource Objectives	Alternative E Emphasis on timber and resource production	Final Environmental Impact Statement for the Routt National Forest Land and Resource Management Plan . 1998

Table 8.I.3
Summary of National Forest Incremental Water Yield

National Forest	USFS Selected Alt. Scenario (ac-ft)	Water Yield Scenario (ac-ft)	Benchmark Scenario (ac-ft)
Medicine Bow National Forest			
Increased Yield Over Baseline	9,172	36,000	53,500
Routt National Forest			
Increased Yield Over Baseline	727	1,255	103,000
Arapaho / Roosevelt National Forest			
Increased Yield Over Baseline	777	2,256	240,000
Pike / San Isabel National Forest			
Increased Yield Over Baseline	745	2,000	4,849
Total Increased Yield Over Baseline	11,421	41,511	401,349

For the USFS Selected Alternatives scenario, which evaluates the increased yield associated with the suite of alternatives that have been selected by the USFS, the annual increments in water yield over baseline conditions were 9,172 ac-ft (Medicine Bow NF), 727 ac-ft (Routt NF), 777 ac-ft (Arapaho/Roosevelt NF), and 745 ac-ft (Pike/San Isabel NF). These values represent the additional water yield over existing baseline conditions as estimated by the USFS.

For the Water Yield scenario, which evaluates the National Forest management alternatives generating the greatest increase in water yield, the annual increments in water yield over baseline conditions were 36,000 ac-ft (Medicine Bow NF), 1,255 ac-ft (Routt NF), 2,256 ac-ft (Arapaho/Roosevelt NF), and 2,000 ac-ft (Pike/San Isabel NF). These values represent the additional water yield over existing baseline conditions as estimated by the USFS.

For the Benchmark scenario, which represents the *theoretical maximum* increase in water yield for each of the National Forests, the annual increases in water yield over baseline conditions were 53,500 ac-ft (Medicine Bow NF), 103,000 ac-ft (Routt NF), 240,000 ac-ft (Arapaho/Roosevelt NF), and 4,849 ac-ft (Pike/San Isabel).

Each forest covers multiple drainage basins, including basins not tributary to the Platte River. Approximately 80% of the Routt NF, 21% of the Arapaho/Roosevelt NF, and 14% of the Medicine Bow NF are tributary to the Colorado River Basin. Likewise, approximately 59% of the Pike/San Isabel National Forest is tributary to the Arkansas River Basin. Therefore, the annual increases in water yield were reduced by these factors (Table 8.1.4). Therefore, the total additional yield associated with the USFS Selected Alternatives scenario was 8,952 ac-ft per year. Total additional yield associated with the Water Yield scenario was 33,813 ac-ft per year .

The total additional yield to the Platte River basin associated with the Benchmark scenario was 258,198 ac-ft per year. This value is consistent with Leaf's estimate of nearly 250,000 ac-ft per year of additional water yield, which could be achieved through patch cut methods within the Platte River Basin.

Table 8.I.4
Distribution of Additional Water Yield

National Forest	Study Reach	Distribution of Yield	USFS Selected Alt. Scenario (acre-feet)	Water Yield Scenario (acre-feet)	Benchmark Scenario (acre-feet)
Medicine Bow National Forest					
Incremental Yield			9,172	36,000	53,500
Platte River System					
North Platte River	Reach 1	56%	5,136	20,160	29,960
Laramie River	Reach 6	30%	2,752	10,800	16,050
Colorado River System	Out of Basin	14%	1,284	5,040	7,490
Routt National Forest					
Incremental Yield			727	1,255	103,000
Platte River System					
North Platte River	Reach 1	20%	145	251	20,600
Colorado River System	Out of Basin	80%	582	1,004	82,400
Arapaho / Roosevelt National Forest					
Incremental Yield			777	2,256	240,000
Platte River System					
Cache La Poudre River	Reach 11	30%	233	677	72,000
Laramie River	Reach 6	11%	86	248	26,400
South Platte River	Reach 7	38%	295	857	91,200
Colorado River System	Out of Basin	21%	163	474	50,400
Pike / San Isabel National Forest					
Incremental Yield			745	2,000	4,849
Platte River System					
South Platte River	Reach 7	41%	305	820	1,988
Arkansas River System	Out of Basin	59%	440	1,180	2,861
Reach Summary					
Reach 1			5,281	20,411	50,560
Reach 6			2,838	11,048	42,450
Reach 7			600	1,677	93,188
Reach 11			233	677	72,000
Total In Basin			8,952	33,813	258,198
Total Out of Basin			2,468	7,698	143,151
Total			11,421	41,511	401,349

The in-basin runoff (tributary to the Platte River) was apportioned in a similar manner between the four reaches affected. These reaches were Reach 1 (North Platte River), Reach 6 (Laramie River), Reach 7 (South Platte River), and Reach 11 (Cache la Poudre River).

5. The water yield increases reported by the USFS represent mean annual changes. Studies indicate that changes in streamflow resulting from forest management practices in the snow zone occur in May and June during the rising limb of the hydrograph (Troendle, et al., 1998). Based upon this finding, the additional runoff was distributed to May and June, on a reach by reach basis, in the same proportion as the long-term average discharge for the two months (Table 8.I.5).

Table 8.I.6 summarizes the on-site net hydrologic effects for Reaches 1, 6, 7, and 11, for the three forest management scenarios. The National Forests are generally located upstream of the study reaches in the Platte River headwaters. Losses or gains may exist in the river reaches between the Forests and the study reach. However, for consistency with the scope and constraints of this study, it was assumed that these effects were realized at the upstream end of study reaches 1, 6, 7, and 11.

The water yield increases attributed to the three forest management scenarios were routed downstream using the water budget spreadsheet. Results of the USFS Selected Alternatives scenario analyses are summarized in Table 8.I.7 assuming additional water can be diverted; and in Table 8.I.8 assuming additional water cannot be diverted. The average annual reductions to target flows shortages at the critical habitat were 184 ac-ft in the first case and 5,025 ac-ft in the second case. Total increased flows at the critical habitat were 939 ac-ft for routing with diversions and 7,274 ac-ft for routing without diversions. Given the modeling constraints and assumptions, all of this benefit would be realized during the months of May and June of each year.

Results of the Water Yield scenario analyses are summarized in Table 8.I.9 assuming additional water can be diverted; and in Table 8.I.10 assuming additional water cannot be diverted. The average annual reductions to target flows shortages at the critical habitat were 698 ac-ft in the first case and 18,956 ac-ft in the second case. Total increased

Table 8.I.5
Monthly Distribution of Increased Water Yield Attributed to Forest Management Alternatives

		Mean Monthly Water Yield		Total	Percent for Period	
Gage	Reach	May	June	May - June	May	June
North Platte at Northgate	1	68,344	77,438	145,782	46.9%	53.1%
Laramie River at Fort Laramie	6	26,804	26,520	53,324	50.3%	49.7%
South Platte at Henderson	7	66,905	64,475	131,380	50.9%	49.1%
Cache La Poudre at Mouth of Canyon	11	46,666	95,186	141,852	32.9%	67.1%

Table 8.I.6
Forest Management
Summary of Net Hydrologic Effects: Watershed Management Scenarios
(ac-ft)

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
USFS Selected Alternatives													
Reach 1	0	0	0	0	0	0	0	2476	2805	0	0	0	5281
Reach 6	0	0	0	0	0	0	0	1427	1411	0	0	0	2838
Reach 7	0	0	0	0	0	0	0	305	295	0	0	0	600
Reach 11	0	0	0	0	0	0	0	77	156	0	0	0	233
Water Yield													
Reach 1	0	0	0	0	0	0	0	9569	10842	0	0	0	20411
Reach 6	0	0	0	0	0	0	0	5554	5495	0	0	0	11048
Reach 7	0	0	0	0	0	0	0	854	823	0	0	0	1677
Reach 11	0	0	0	0	0	0	0	223	454	0	0	0	677
Benchmark													
Reach 1	0	0	0	0	0	0	0	23703	26857	0	0	0	50560
Reach 6	0	0	0	0	0	0	0	21338	21112	0	0	0	42450
Reach 7	0	0	0	0	0	0	0	47456	45732	0	0	0	93188
Reach 11	0	0	0	0	0	0	0	23686	48314	0	0	0	72000

Table 8.I.7
Forest Management: USFS Selected Alternatives Scenario Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	169	280	0	0	0	449
1976	0	0	0	0	0	0	0	161	60	0	0	0	221
1977	0	0	0	0	0	0	0	206	66	0	0	0	273
1978	0	0	0	0	0	0	0	236	38	0	0	0	273
1979	0	0	0	0	0	0	0	135	247	0	0	0	382
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	42	13	0	0	0	54
1982	0	0	0	0	0	0	0	54	38	0	0	0	93
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	277	178	0	0	0	455
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	589	68	0	0	0	656
1989	0	0	0	0	0	0	0	32	35	0	0	0	67
1990	0	0	0	0	0	0	0	214	17	0	0	0	232
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	40	31	0	0	0	71
1993	0	0	0	0	0	0	0	104	178	0	0	0	282
1994	0	0	0	0	0	0	0	124	45	0	0	0	170
Average	0	0	0	0	0	0	0	119	65	0	0	0	184

Table 8.I.8
Forest Management: USFS Selected Alternatives Scenario Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	3775	4144	0	0	0	7918
1976	0	0	0	0	0	0	0	3767	3181	0	0	0	6948
1977	0	0	0	0	0	0	0	3777	3829	0	0	0	7606
1978	0	0	0	0	0	0	0	3669	3750	0	0	0	7419
1979	0	0	0	0	0	0	0	3648	2942	0	0	0	6590
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	3674	2712	0	0	0	6386
1982	0	0	0	0	0	0	0	3696	3772	0	0	0	7468
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	3832	3973	0	0	0	7805
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	3458	3563	0	0	0	7020
1989	0	0	0	0	0	0	0	3335	3619	0	0	0	6954
1990	0	0	0	0	0	0	0	3635	3039	0	0	0	6674
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	2738	3777	0	0	0	6516
1993	0	0	0	0	0	0	0	3770	4047	0	0	0	7817
1994	0	0	0	0	0	0	0	3644	3742	0	0	0	7386
Average	0	0	0	0	0	0	0	2521	2505	0	0	0	5025

Table 8.I.9
Forest Management: Water Yield Scenario
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	652	1039	0	0	0	1692
1976	0	0	0	0	0	0	0	624	232	0	0	0	855
1977	0	0	0	0	0	0	0	800	256	0	0	0	1056
1978	0	0	0	0	0	0	0	913	145	0	0	0	1058
1979	0	0	0	0	0	0	0	506	878	0	0	0	1384
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	159	46	0	0	0	206
1982	0	0	0	0	0	0	0	211	148	0	0	0	359
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	1005	665	0	0	0	1670
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	2247	259	0	0	0	2506
1989	0	0	0	0	0	0	0	123	134	0	0	0	257
1990	0	0	0	0	0	0	0	828	67	0	0	0	895
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	154	118	0	0	0	273
1993	0	0	0	0	0	0	0	400	690	0	0	0	1090
1994	0	0	0	0	0	0	0	482	175	0	0	0	657
Average	0	0	0	0	0	0	0	455	243	0	0	0	698

Table 8.I.10

Forest Management: Water Yield Scenario

Reductions to Target Flow Shortages, without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	14261	15624	0	0	0	29886
1976	0	0	0	0	0	0	0	14233	11995	0	0	0	26228
1977	0	0	0	0	0	0	0	14270	14418	0	0	0	28688
1978	0	0	0	0	0	0	0	13866	14146	0	0	0	28012
1979	0	0	0	0	0	0	0	13890	11172	0	0	0	25062
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	13861	10174	0	0	0	24035
1982	0	0	0	0	0	0	0	13956	14190	0	0	0	28146
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	14481	14996	0	0	0	29476
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	13058	13406	0	0	0	26464
1989	0	0	0	0	0	0	0	12593	13591	0	0	0	26184
1990	0	0	0	0	0	0	0	13708	11367	0	0	0	25075
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	10299	14209	0	0	0	24508
1993	0	0	0	0	0	0	0	14243	15255	0	0	0	29498
1994	0	0	0	0	0	0	0	13763	14093	0	0	0	27856
Average	0	0	0	0	0	0	0	9524	9432	0	0	0	18956

flows at the critical habitat were 3,552 ac-ft for routing with diversions, and 27,458 ac-ft for routing without diversions. As previously discussed, all of this benefit would be realized during the months of May and June of each year.

Following the same procedure as described for the USFS Selected Alternatives and Water Yield scenarios, the average annual reductions to target flows shortages at the critical habitat for the Benchmark scenario were estimated. Tables 8.I.11 and 8.I.12 summarize the results of routing additional water to the critical habitat, assuming it is subject to diversion (Table 8.I.11) and not subject to diversion (Table 8.I.12). The average annual reductions to target flows shortages at the critical habitat were 4,708 ac-ft and total increased flows at the critical habitat were 25,990 ac-ft assuming the water can not be diverted. Reductions to target flows shortages would be 143,217 ac-ft and total increased flows at the critical habitat would be 212,812 if the water could be protected.

These estimates were made assuming that all four of the National Forests were to manage their respective forests to generate runoff in accordance with their benchmark forest planning analyses.

Additional variations of the forest management alternative could be evaluated during the Action Plan phase of the Project. The forest management alternative has potential for optimization. For example, individual forest management plans could be modified in lieu of the regional approach considered in this analysis.

Cost

The study team estimated the costs of the USFS Selected Alternatives and Water Yield scenarios based upon information provided in the four FEIS documents for the National Forests included in the study. These documents presented the Present Net Value (PNV) of costs associated with each of the alternatives evaluated by the USFS (based on a discount rate of 4 percent over a 50-year period). From these values, annualized costs were computed. The annualized costs were then prorated based upon the relative area of the forests draining to the Platte River Basin.

Based upon the values presented in these documents, the total cost of implementing the USFS Selected Alternatives scenario would be

Table 8.I.11
Forest Management: Benchmark Scenario
Reductions to Target Flow Shortages, with Diversions All States
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	3071	10541	0	0	0	13612
1976	0	0	0	0	0	0	0	2387	786	0	0	0	3173
1977	0	0	0	0	0	0	0	3069	883	0	0	0	3952
1978	0	0	0	0	0	0	0	3096	627	0	0	0	3723
1979	0	0	0	0	0	0	0	4656	16774	0	0	0	21431
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	952	531	0	0	0	1483
1982	0	0	0	0	0	0	0	788	590	0	0	0	1378
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	13285	5839	0	0	0	19124
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	12556	1461	0	0	0	14018
1989	0	0	0	0	0	0	0	471	585	0	0	0	1056
1990	0	0	0	0	0	0	0	2773	309	0	0	0	3082
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	524	812	0	0	0	1336
1993	0	0	0	0	0	0	0	1658	2637	0	0	0	4296
1994	0	0	0	0	0	0	0	1871	615	0	0	0	2486
Average	0	0	0	0	0	0	0	2558	2150	0	0	0	4708

Table 8.I.12

Forest Management: Benchmark Scenario

Reductions to Target Flow Shortages, without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	104112	128591	0	0	0	232702
1976	0	0	0	0	0	0	0	103954	98317	0	0	0	202271
1977	0	0	0	0	0	0	0	99651	123459	0	0	0	223109
1978	0	0	0	0	0	0	0	100461	115638	0	0	0	216099
1979	0	0	0	0	0	0	0	82939	76289	0	0	0	159228
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	81817	88821	0	0	0	170638
1982	0	0	0	0	0	0	0	102811	122226	0	0	0	225037
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	86067	120780	0	0	0	206847
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	96105	116499	0	0	0	212604
1989	0	0	0	0	0	0	0	93485	120219	0	0	0	213705
1990	0	0	0	0	0	0	0	103768	111467	0	0	0	215235
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	82647	52868	0	0	0	135515
1993	0	0	0	0	0	0	0	104278	126031	0	0	0	230309
1994	0	0	0	0	0	0	0	101521	119526	0	0	0	221048
Average	0	0	0	0	0	0	0	67181	76037	0	0	0	143217

approximately $31.6 million per year (Routt NF: $2.1 million per year, Arapaho/Roosevelt NF: $15.7 million per year, Medicine Bow NF: $8.2 million per year, and Pike/San Isabel NF: $5.6 million per year). Note that these values have been prorated to reflect only that portion of the Forest that lies within the Platte River drainage. Because the Existing USFS Management scenario represents that suite of forest management plans which have been selected and are currently being implemented by the USFS, no cost to the Project was assumed for the additional water yield associated with them. Consequently, the cost per ac-ft associated with this alternative would be $0 for both the "with diversions" and "without diversions" scenarios (Table 8.I.13).

The total cost of implementing the Water Yield alternative would be approximately $35.2 million. (Routt NF: $2.4 million per year, Arapaho/Roosevelt NF: $14.8 million per year, Medicine Bow NF: $12.0 million per year, and Pike/San Isabel NF: $6.0 million per year).

Assuming that the USFS has already committed to spending approximately $31.6 million per year to implement the selected alternatives (i.e., the Existing USFS Management scenario), the additional cost that could be incurred by the Project was assumed to be the incremental difference between the costs of the USFS Selected Alternatives and Water Yield scenarios. Consequently, the cost of implementing the Water Yield scenario would be approximately $3.6 million per year. The present value of this cost over the next 20 years, using a six percent discount rate, is approximately $41.0 million.

Based upon the average annual reduction to target flow shortages from the Water Yield scenario, the total cost per ac-ft associated with this alternative would be approximately $58,740 assuming the water is not protected and $2,160 assuming it is protected (Table 8.I.13). The cost per ac-ft of average target flow reductions for the "with diversions" scenario exceed the economic screening criteria; therefore, associated issues presented below do not reflect this scenario.

The costs associated with the forest management alternatives include costs associated with management, administration, construction, etc. Financial benefits would be gained from revenue derived from timber sales, campground receipts, oil and gas leases, etc. Additional economic benefits of the regional water yield alternative would also be gained. These benefits include items that do not involve the actual transaction of money. Examples of economic benefits would include

Table 8.1.13

Alternatives Yield and Cost: Category 7 -- Watershed Management: USFS Selected Alternatives and Water Yield Scenarios

	Yield 20-year Average Annual Values (ac-ft/yr)							Capitalized Costs			
Reach Alternative	Net Hydrologic Effects At Site	Net Hydrologic Effects at Top of Downstream Reach (w/diversion loss)	(w/o diversion loss)	Net Hydrologic Effects at Habitat (w/diversion loss)	(w/o diversion loss)	Reduction to Target Flow Shortages at Habitat (w/diversion loss)	(w/o diversion loss)	Cost* w/ diversion loss ($ Million)	Cost* w/o diversion loss ($ Million)	Cost per Acre-Foot of Average Reduction in Target Flow Shortage At Habitat ($/ac-ft) (w/diversion loss)	(w/o diversion loss)
Regions 1 and 2											
USFS Selected Alternatives											
Reach 1	5,281	5,281	5,281	453	4,278	68	2,950				
Reach 6	2,838	2,838	2,838	401	2,304	101	1,585				
Reach 7	600	600	600	70	499	13	354				
Reach 11	233	233	233	16	194	2	137				
Total	8,952	8,952	8,952	940	7,275	184	5,026	$0 **	$0 **	$0 **	$0 **
Regions 1 and 2											
Regional Water Yield											
Reach 1	20,411	20,411	20,411	1,749	16,532	265	11,400				
Reach 6	11,048	11,048	11,048	1,563	8,968	392	6,168				
Reach 7	1,677	1,677	1,677	195	1,396	36	991				
Reach 11	677	677	677	46	562	5	397				
Total	33,813	33,813	33,813	3,553	27,458	698	18,956	$41.0	$41.0	$58,740	$2,160

* Present value of sum of implementation cost, capital costs, and operating costs over 20 year period using 6 percent discount rate.

** Yield associated with this alternative will be gained with no costs incurred by the Project.

recreational uses such as hiking, fishing, etc. Consideration of these benefits is included in the Associated Issues section of this chapter.

As previously discussed, the "benchmark" scenario represents a theoretical upper limit to the amount of water yield that could be generated by forest management techniques. None of the FEISs evaluated impacts or costs associated with this forest management strategy. Therefore, the cost of implementing this alternative could not be estimated based on the information available.

In a manner similar to that discussed in the Yield section of this chapter, additional variations of the forest management alternative could be evaluated during the Action Plan phase of the Project to optimize costs. It is evident that there is a variation in costs associated with implementation of a "Water Yield" management plan between National Forests. For example, the "Water Yield" management plan for the Arapaho/Roosevelt NF results in less costs than the USFS Selected Alternative for that National Forest.

Associated Issues

The Regional Forest Management alternatives were evaluated according to the associated issues evaluation criteria previously reviewed by the Water Management Committee. Chapter 6 of this report contains a detailed discussion of these criteria. The associated issues are physical, legal and institutional, social, economic and environmental. Tabular scoring of these alternatives according to each sub-criteria is presented in Tables I.8.14 and I.8.15 for the "with diversions" and "without diversions" conditions, respectively. Scores assigned to each alternative were derived following review of modeling results, cost estimates and review of the pertinent sections of the respective FEISs.

Physical

Assuming additional water associated with the forest management alternatives is subject to diversion, reductions to target flows shortages at the critical habitat are low. These alternatives are sustainable, however, continued maintenance of the harvested condition would be required or the effects of the alternative would be attenuated with time as the forest rejuvenates. Forest management alternatives are scalable

Table 8.I.14
Scoring Table - With Diversions in Wyoming, Colorado, and Nebraska
Category 7 - Watershed Management Scenarios

	Regions 1 and 2 Reaches 1, 6, 7 and 11 A	Regions 1 and 2 Reaches 1, 6, 7 and 11 B
Physical		
Net Reduction in Shortage to Target Flows	0	
Sustainability		
Scalability		
Technically Implementable		
Time to Yield Realization		
Ability to Monitor and Measure		
Third Party Hydrologic Impacts		
Subtotal		
Subtotal Average		
Legal/Institutional		
Ease of Permitting		
Consistent with Interstate Compacts, Federal Laws & Decrees		
Consistent with State Laws		
Potential for Institutional Consensus		
Can be Mitigated		
Administrative Ease		
Consistent with Existing Contract, Facility & Land Ownership		
Subtotal		
Subtotal Average		
Social		
Effects on Customs and Culture		
Equity of Impacts		
Impacts on Community Organizations and Support Structures		
Effects on Community Sustainability		
Public Acceptability		
Subtotal		
Subtotal Average		
Economic		
Initial Implementation and Capital Cost		
Average Annual Total Cost per Acre Foot Reduction		0
Direct Economic Impacts		
Secondary Economic Impacts		
Fiscal Impacts		
Effects on Economic Development Potential		
Subtotal		
Subtotal Average		
Environmental		
Impacts to Wetlands		
Impacts to Habitat		
Impacts to Water Quality		
Impacts to Prime and Unique Farmlands		
Visual Impacts		
Impacts to Amenities		
Subtotal		
Subtotal Average		
Overall Total (Sum of Averages)	0	0

Legend:

A. USFS Selected Alternatives Scenario
B. Water Yield Scenario

Table 8.I.15
Scoring Table - No Diversions in Any State
Category 7 - Watershed Management

	Scenarios	
	Regions 1 and 2 Reaches 1, 6, 7 and 11	Regions 1 and 2 Reaches 1, 6, 7 and 11
Physical	A	B
Net Reduction in Shortage to Target Flows	4	5
Sustainability	4	4
Scalability	2	3
Technically Implementable	5	5
Time to Yield Realization	1	1
Ability to Monitor and Measure	1	1
Third Party Hydrologic Impacts	3	3
Subtotal	20	22
Subtotal Average	3	3
Legal/Institutional		
Ease of Permitting	5	1
Consistent with Interstate Compacts, Federal Laws & Decrees	3	3
Consistent with State Laws	1	1
Potential for Institutional Consensus	4	2
Can be Mitigated	3	3
Administrative Ease	3	3
Consistent with Existing Contract, Facility & Land Ownership	5	4
Subtotal	24	17
Subtotal Average	3	2
Social		
Effects on Customs and Culture	3	3
Equity of Impacts	3	3
Impacts on Community Organizations and Support Structures	4	4
Effects on Community Sustainability	4	4
Public Acceptability	3	2
Subtotal	17	16
Subtotal Average	3	3
Economic		
Initial Implementation and Capital Cost	5	1
Average Annual Total Cost per Acre-Foot Reduction	5	2
Direct Economic Impacts	3	5
Secondary Economic Impacts	5	5
Fiscal Impacts	2	2
Effects on Economic Development Potential	4	4
Subtotal	24	19
Subtotal Average	4	3
Environmental		
Impacts to Wetlands	3	3
Impacts to Habitat	3	3
Impacts to Water Quality	3	3
Impacts to Prime and Unique Farmlands	5	5
Visual Impacts	2	2
Impacts to Amenities	3	3
Subtotal	19	19
Subtotal Average	3	3
Overall Total (Sum of Averages)	17	15

Legend:

A: USFS Selected Alternatives Scenario
B: Water Yield Scenario

in size; the scenarios discussed in this study incorporate four forest management scenarios involving thousands of acres of forest managed by the US Forest Service. Limitations to the size of the alternative may be imposed by factors such as financial costs, forest multiple use policies and environmental issues. Forest management alternatives of the scale evaluated are technically implementable. Increased yield from forest management practices could initially occur within one year following harvest, assuming there is sufficient precipitation. However, the National Forest management plans incorporated in this alternative represent a 50-year time period. For the purposes of this investigation, it was assumed that implementation of the alternatives could be accelerated to be implemented within 10 years. While research shows that the effects of timber management are predictable, the ability to measure and monitor the additional water yield associated with these alternatives may be problematic. Increased streamflow generated under either scenario may generate third party hydrologic impacts in the form of benefits to downstream water users.

Legal and Institutional

The principal legal and institutional issue associated with these alternatives concerns the ownership of additional water. According to current water law, additional water generated by these alternatives would be subject to appropriation. To fully realize the benefits of forest management alternatives at the critical habitat, institutional changes would be required. Changes to state laws regarding protection of this water will be problematic. With respect to the Water Yield scenario, the potential for institutional consensus is considered to be low. Objections may be made by environmental groups with respect to increasing the timber harvest activities in the National Forests.

The USFS Selected Alternatives scenario is being implemented by the USFS. Permitting issues may make changes to forest management activities difficult. During the permitting process, opposition to this alternative is likely to exist, particularly with alternatives of the scale associated with the benchmark scenario. The Water Yield scenario conflicts with existing programs that have previously been implemented by the USFS. Change of the forest management plans to implement the Water Yield or Benchmark alternatives would require revisions to the Forest Plan, subsequent environmental reevaluation and compliance (NEPA), and may involve a lengthy public approval process. The public interest in management of the National Forests may be intense, particularly when management activities affect timber-related issues. The CSR contends that the USFS has not fulfilled its responsibilities required by the Organic Act of 1897 and the Multiple Use-Sustained Yield Act of 1960. It is evident from the lawsuit promulgated by the Coalition for Sustainable Resources, Inc. that redirection of current forest management philosophy may involve protracted litigation. Although this case was dismissed, its existence is evidence of the disagreement over consistency of USFS forest management activities with state and federal laws. If implemented, administration of water generated by forest management alternatives may be difficult. Timber management activities would be administered by existing entities, however, a mechanism to quantify the additional water yield associated with forest management activities on a seasonal basis is not readily apparent. Estimates of water yield over long-term baseline conditions can be made. However, it may be difficult to quantify the increases attributable to these alternatives in any given year. Without knowledge of the quantities of water involved, administration of water associated with these alternatives may be difficult. Also, without the ability to quantify additional streamflows attributable to these alternatives, mitigation of physical, environmental, and economic impacts would be difficult.

Social

In relation to the existing baseline conditions, a greater degree of social benefit would be gained by those communities relying upon the timber industry in terms of community sustainability, community organizations and support structures. Benefits would be primarily in the form of employment opportunities related to increased timber management activity. Additional benefit would be gained through increased recreational opportunities (USFS, 1984).

Implementation of either alternative at the proposed scale may have negligible effects on customs and culture. Given the increased magnitude of timber harvest and the accelerated schedule with respect to that presented in the FEIS, implementation of this alternative may tend to further polarize public groups with already opposing views. Those favoring amenity values over commodities would be most strongly opposed to this alternative (USFS, 1997a). Equity of impacts may be offsetting as those opposing the alternative may feel harmed while those dependent upon the timber industry would benefit.

Economic

The USFS has initiated implementation of the USFS Selected Alternatives scenario; there would be no cost to the Project for this scenario. Initial implementation and capital costs of the Water Yield Scenario would include costs associated with forest plan revision, environmental compliance, and permitting. Financial benefits associated with the scenario may offset costs resulting in possible net financial benefit. Fiscal impacts to governmental entities resulting from the alternative measured in dollars may be positive.

Based upon the USFS economic analyses, which includes values associated with activities such as hiking, fishing, etc., the benefits of the alternative would be high on an per ac-ft basis. Direct economic benefits of the alternative would be positive and include employee wages and wealth associated with the timber industry and recreation activities (USFS, 1997a, USFS, 1984). Additional employment opportunities and earnings would result in positive secondary economic impacts through increased sales and spending (USFS, 1997a).

Economic development would be mostly positive with some negative effects. Maintenance of the forest in a patch-cut condition to extend the number of years additional flow is realized would continue to generate economic benefits through employee wages and wealth. Expansion of the timber harvesting activities in the forest at the accelerated schedule evaluated in this chapter would reduce the portion of the forest available for future harvest.

Environmental

The forest management alternatives evaluated have the potential to degrade environmental quality if proper safeguards are not properly implemented and administered. Degradation of water quality, wetlands, wildlife habitat, and vegetation may result if the alternative proceeds without adequate supervision of operators. The forest management plans call for adherence to the USFS Watershed Conservation Practices (WCP) Handbook (USFS, 1991). This manual contains standards and design criteria to protect water quality in compliance with the Clean Water Act (CWA). If these standards are properly applied, surface water degradation would be minimized. The alternative would require compliance with NEPA, therefore full environmental consequences of the proposed activities would be defined at that time.

The forest management alternatives would have immediate impacts on the habitat structure and often the composition of the treated area. Timber management can result in positive and negative effects on wildlife. Positive aspects of timber management include the retention of diversity of habitats and vegetative composition, structure, and pattern. Negative aspects can be a loss of habitat effectiveness, increased wildlife disturbance and displacement, and degradation of aquatic habitat (USFS, 1984). At the scale of timber harvest evaluated under the water yield alternative, these effects are assumed to be neutral. With the implementation of the benchmark scenario, these effects could be more severe.

Additional flows resulting from the water yield alternatives would likely be within the range of natural variability in the hydrologic system. Changes to existing flow regimes would be limited to the May/June time period when the hydrograph is dominated by snowmelt (Troendle, et al., 1998). However, effects of added headwater supplies would likely be observed beyond June due to return flows from diversions to storage and diversions for irrigation. The water budget spreadsheet is not capable of modeling return flows because it is operated under the assumption that diversions are 100 percent consumptive. Because return flows do occur, more water would likely arrive at the critical habitat than is accredited to this alternative by the spreadsheet model.

Increased timber harvest activity may adversely affect the quality of surface runoff in the affected areas (headwater regions). During timber harvest activities, sediment delivery to surface waters may be increased due to construction of roads, disturbance of soils, and removal of vegetation (USFS, 1984; Harr, 1988; Madej and Ozaki 1996). Following the harvest, erosion can occur in the form of streambank erosion, channel scour, or mass wasting (Wolfe and Williams, 1986). Research conducted at the Fraser Experimental Forest (Troendle, et al., 1998) and other forests (Ciliberti, 1986) has shown that timber harvest can occur without observable degradation of surface water quality given adequate environmental safeguards.

Increased peak discharges and duration of higher flows following timber harvest may cause additional streambank erosion, channel degradation, and overbank flooding during the summer runoff period. Sedimentation from timber harvest activities and erosion and channel degradation could be detrimental to aquatic biota and aquatic habitat (Ringler and Hall, 1975; USFS, 1984). The relative impacts of the benchmark scenario would likely be more severe than those of the water yield alternative.

Changes in flow-duration relationships could potentially impact wetlands and aquatic habitat. The added water associated with this alternative may result in the formation of new wetlands in some locations. Likewise, additional water may at least partially offset detrimental impacts to aquatic life by increasing instream flows during dry and average years.

Both scenarios would result in changes in the scenic condition of the forest. They would result in fewer forested acres and more open areas. Vegetation treatments change characteristic landscapes and would "enhance viewing opportunities in some areas or dominate the landscape in other areas" (USFS, 1984).

Implementation of a forest management scenario, which emphasizes timber harvest, will result in a lower emphasis being placed on other forest activities. Therefore, amenities such as campgrounds, hiking trails, and other recreational resources may be negatively impacted by the alternative.

9. THIRD PARTY IMPACTS

A. Introduction

A workshop was held with the WMC on September 17, 1998 to define third party impacts in the context of this study and establish the level of detail required for the analysis of these impacts. The definition of third party impacts with respect to this study is as follows:

> "Third party impacts include significant positive or negative hydrologic, economic, environmental, and/or other effects on parties in the Platte River study area that are not the direct Recovery Program participants."

The study team was instructed to identify and discuss potential impacts associated with the alternatives identified. The analysis is qualitative as opposed to quantitative and does not include the development of methods to mitigate third party impacts. In addition, the discussion of third party impacts has been limited to the Platte River Basin.

Third party impacts are primarily a result of hydrologic and economic impacts of an alternative. Potential sources of third party impacts related to hydrologic effects include 1) Changes in Platte River streamflows both in terms of timing and quantity, 2) Changes in canal flows, 3) Changes in return flows, 4) Changes in groundwater/surface water connections, and 5) Changes in water quality. Potential sources of third party impacts related to economic effects include 1) Changes in the scale or nature of water-use operations, 2) Changes in expenditure patterns, 3) Changes in related industries, 4) Changes due to construction activities, 4) Changes in the tax base, and 5) Impacts on economic development. It is noted that third party environmental effects are also evident with certain alternatives. For example, replacement power can produce effected related to fossil fuel generation.

Third party impacts have been identified and discussed for each of the categories of alternatives in the following sections. Only third party impacts associated with the alternatives that have been scored are addressed.

B. Reservoirs

There are several third party impacts that could occur as a result of almost any reservoir alternative due to similarities in the types of hydrologic and economic effects associated with these types of projects. As such, third party impacts are discussed generally for all reservoir projects.

Diversions to storage may reduce available flows for new water users in the future or potentially existing users if they are not protected through the water rights administration process. Diversions, releases and return flows from reservoir seepage will also alter the timing of water available to downstream users. There are potential negative economic and hydrologic third party impacts due to changes in the quantity and timing of water. For example there may be impacts on water users who rely upon return flows or groundwater recharge for eventual pumping. There may be surface water irrigators that use runoff or return flows that are reused several times by other surface diverters. Different crops require different water amounts at different times during the growing season. Changing the timing and quantity of water available to downstream users could impact this balance.

Diversions to storage through existing canals will reduce the opportunity for the owner to use that conveyance capacity. For example, the Julesburg Irrigation District fills Julesburg Reservoir by the Harmony Ditch. If excess ditch capacity is used to fill an enlargement to Julesburg Reservoir for the Recovery Program Harmony Ditch capacity will no longer be available to the Julesburg Irrigation District for potential future operations including enlargements or potential recharge projects.

Reservoir alternatives could generate employment opportunities on a short-term basis during construction, which is a third party economic benefit. The projected employment can range from 100 to 750 people depending on the magnitude of the project.

Some reservoir alternatives would provide a significant increase in recreational opportunities, which is a third party benefit. Recreational opportunities associated with reservoir enlargements and/or new storage construction consist of swimming, picnicking, fishing, nature study, sightseeing, hiking, and boating. The extent to which recreational opportunities are enhanced depends to a large degree on the size of the project and whether there are other reservoirs with similar opportunities in the vicinity.

Third party environmental impacts can be both positive and negative. There could be negative impacts to wetlands from reservoir impoundment and positive impacts resulting from the creation of additional wildlife habitat. These impacts can be significant depending on the size of the project. Reservoir projects could also have both negative and positive impacts on water quality and downstream aquatic habitat. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when river flows are reduced and temperatures change due to diversions to storage.

Reservoir seepage could impact groundwater levels in the vicinity. Increased groundwater levels could have both positive and negative third party impacts. Increased groundwater levels could reduce pumping costs for nearby groundwater irrigators. Alternatively, increased groundwater levels could result in waterlogging of nearby irrigated lands resulted in decreased productivity and yields. This is particularly a problem in the Central Platte River region where groundwater levels are already too high in several areas.

Reservoir projects can also modify the flood risk for downstream properties. For example, reservoir projects on Plum Creek could potentially decrease the flood risk for downstream properties by providing more control of flows during flood events. Decreasing the flood risk is a third party benefit.

C. Agricultural and Municipal Water Conservation

Municipal conservation has been deferred from further evaluation, therefore, third party impacts have not been discussed.

Third party impacts that were identified for agricultural conservation apply to the specific types of programs evaluated, which include conservation cropping, deficit irrigation, irrigation district structural measures, and water district non-structural measures.

For conservation cropping, third party hydrologic impacts could occur to farmers that have traditionally relied on return flows or runoff from participating farms for a portion of their water supply because different crops require different water amounts at different times during the growing season. Diminished return flows change the quantity and timing of water in the river, which can be a negative hydrologic third party impact on downstream users if they are not protected through the water rights administration process. Reduced deliveries to participating farms may result in reductions in canal company revenues for companies that have volumetric rates and could, in the extreme, require increases in water delivery rates.

Third party economic impacts may also effect farm workers and input suppliers because of differing requirements between traditional crops and alternative crops grown as a result of the conservation cropping program. Changes in the farm product can have negative impacts on processors, shippers, and purchasers of farm products as well as local livestock growers. Changes in water quality, either positive or negative, as a result of changes in cropping are also possible.

For deficit irrigation, third party hydrologic impacts may occur on neighboring farms because participating farms will divert less and produce less runoff and return flow. If conserved water from deficit irrigation is to be protected from downstream diversions, downstream existing water rights holders will likely be protected through the water rights administration process. Deficit irrigation would result in reduced yields, potentially impacting processors, shippers, livestock growers and others relying on this production. If water deliveries are significantly reduced within an individual canal company or irrigation district's service area, company or district revenues may be impacted if the entity uses volumetric rates. Water quality improvements can occur with reduced irrigation.

For irrigation district structural measures there may be substantial third party hydrologic impacts from reduced groundwater recharge and surface water return flows resulting from smaller conveyance losses. These supplies are relied upon by some farmers "under the canals" as a principal component of their water supplies. In both cases, the third party hydrologic impacts may result in negative third party economic impacts due to diminished yields as a result of reduced water supplies. In areas prone to high water tables and flooding, such as the groundwater mound area in central Nebraska, reduced canal seepage may provide a third party hydrologic and economic benefit.

For all the agricultural conservation measures, third party hydrologic benefits may occur if the conserved water is not protected from downstream diversions. Each of these measures will ultimately leave more water in the river at the location where it is implemented, which may improve the supplies available for junior water rights holders downstream under this scenario.

D. Reuse

The third party impacts that were identified generally apply to all projects that involve the relocation of return flows such as the project currently being implemented by the Tri-Basin Natural Resources District (NRD) at Funk Lagoon.

Similar to reservoir and conservation projects there are potential negative economic and hydrologic third party impacts on downstream users due to changes in the quantity and timing of water in the river if they are not protected through the water rights administration process.

Projects that relocate return flows in the Central Platte region could provide third party benefits to homeowners and landowners in areas where groundwater levels are lowered. Waterlogging in several areas throughout the Central Platte has resulted in decreased agricultural productivity and yield. Lowering the groundwater table could improve productivity, and in some cases bring waterlogged land back into production. Lowering groundwater levels could also have negative third party impacts if pumping costs are increased for nearby groundwater irrigators.

There are specific potential third party benefits associated with the Funk Lagoon project to downstream homeowners and landowners. The channel capacity of Lost Creek is currently not sufficient to handle irrigation return flows and storm events, therefore, diversions from Lost Creek would free up additional channel capacity.

There are also potential third party environmental impacts on water quality if water is diverted from Lost Creek to North Dry Creek. Water quality could improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when river flows are reduced and temperatures change due to diversions to storage .

E. Incentive Based Reductions in Agricultural Water Use

The third party impacts that were identified for incentive based reductions in agricultural water use apply to the specific types of programs evaluated, which include the purchase of irrigated lands, acquisition of water rights, land fallowing, temporary leasing of water rights, and dry year leasing.

In general all of these programs can alter the timing and quantity of water in the river. As such, there are potential hydrologic and corresponding economic third party impacts on downstream users. If water conserved through these alternatives is not protected from downstream diversion, these third party benefits would likely be positive. Additional flows under this scenario may allow junior water rights holders downstream to make greater use of their water rights. If the water is protected from downstream diversion, existing downstream water right holders would likely be protected through the water rights transfer process.

Negative third party hydrologic impacts from these alternatives are most likely to occur to nearby farmers who have traditionally relied on tailwater runoff or groundwater recharge from participating farms for a portion of their water supply.

Third party impacts for purchasing irrigated lands and the acquisition of water rights are similar. Apart from the potential third party hydrologic impacts identified above, there could also be third party economic impacts on agricultural input and equipment suppliers, farm workers, processing industries and local communities that depend on agriculture. These impacts can potentially be mitigated by dispersing land purchases geographically. Third party fiscal impacts may also result from land purchases or water right purchases. Public entities are generally not subject to local property taxes, so irrigated lands purchased by the program may be removed from the local tax role. If only the water rights are sold, the land may still be reclassified as dryland and have reduced value for tax purposes. If water deliveries are significantly reduced within an individual canal company or irrigation district's service area, company or district revenues may be impacted if the entity uses volumetric rates.

For land fallowing third party impacts are more modest but similar to purchasing agricultural lands. Since land fallowing can be temporary for any particular land parcel, changes in participating properties and geographic dispersion can help mitigate third party impacts.

Third party impacts associated with temporary leasing of water rights are similar but more modest than third party impacts associated with land fallowing. Because water right leasing would allow participating farms to either spread remaining water supplies or convert a portion of their land to grazing or dryland crop production, indirect economic impacts on related agricultural industries would be less than for land fallowing.

Dry year leasing third party impacts are similar to an on-going water right leasing program but are potentially substantial on a site-specific basis in the dry years when the leases are activated. Since the value of water in agriculture is greatest during dry years, third party economic impacts during these years could be substantial.

F. Groundwater

There are several third party impacts that could occur as a result of almost any groundwater alternative due to similarities in the types of hydrologic and economic effects associated with these types of alternatives. Therefore, third party impacts were discussed generally for groundwater projects.

In general, diversions to recharge will reduce available flows for new water users in the future. Diversions to recharge and return flows from canals and recharge basins will alter the timing and quantity of water in the river. There are potential negative economic and hydrologic third party impacts on downstream users due to changes in the quantity and timing of water in the river if they are not protected through the water rights administration process.

Diversions to recharge through existing canals will reduce the opportunity for the owner to use that conveyance capacity, which is a negative third party impact. If excess ditch capacity is used to fill a recharge basin that capacity will no longer be available for potential future operations and/or development.

Third party environmental impacts may be primarily positive. Similar to the Tamarack Recharge Plan, recharge projects can generate wetlands and wildlife habitat, particularly for waterfowl. Impacts on water quality can be both positive and negative. Recharge projects could improve water quality on-site due to the creation of wetlands. Water quality could also improve during the summer months when additional flows resulting from these projects return to the river. However, water quality could be degraded and fish and aquatic habitat negatively impacted during the winter months when river flows are reduced and temperatures change due to diversions to storage.

Alternatives that involve pumping from the groundwater mound could lower groundwater levels in the Central Platte region. Lower groundwater levels could have both positive and negative third party impacts. Negative impacts include increased pumping costs for nearby groundwater irrigators due to lower groundwater levels. Alternatively, lower groundwater levels would decrease waterlogging of nearby irrigated lands and alleviate problems with flooded basements, both of which are positive impacts. Alternatives that involve pumping from the groundwater mound also require the use of drains to return groundwater pumped from the mound to the Platte River. These projects could have negative third party impacts on landowners adjacent to the drains if waterlogging problems are increased.

Recharge projects that involve pumping groundwater or diverting water via an existing canal to a recharge basin could result in higher groundwater levels due to increased return flows. Raising groundwater levels would have the opposite positive and negative third party impacts as lowering groundwater levels.

G. Systems Integration and Management

Third party impacts that result from systems integration and management projects are site specific because the conditions of each of these projects vary considerably.

The same third party impacts that apply to reservoirs regarding changes in the timing and quantity of flow available to downstream users and water quality also apply to La Prele Reservoir. Third party impacts associated with La Prele Reservoir are related primarily to impacts on the La Prele Irrigation District. The District is currently using water stored under PEPL's right for irrigation. If this water is purchased or leased for the Recovery Program it will no longer be available for use by the District, which is a potential negative third party economic impact depending on how reliant the District is on PEPL's water.

Protecting minimum flow releases from Grayrocks Reservoir will have impacts on downstream irrigators. Minimum flow releases are considered natural flow at the confluence of the Laramie and North Platte Rivers. Therefore, downstream irrigators are entitled to divert that water according to the provisions of the 1945 Decree. If minimum flow releases are protected downstream to the critical habitat there will be negative third party economic impacts on downstream irrigators that currently divert that water. These negative impacts could include changes in agricultural production and farm labor. There will also be third party impacts associated with lower reservoir levels in Reclamation's North Platte River facilities. Less natural flow available between Whalen Dam and Tri-State Dam will result in a greater demand on storage. Lower reservoir levels in these facilities could have negative impacts on recreation and fish and wildlife habitat.

A transbasin diversion from Wind River could have positive third party environmental impacts on water quality in the Platte River Basin but negative impacts on the Winder River Basin. Water quality could improve during the summer months when additional flows are diverted into the Platte River basin. Negative impacts on water quality are unlikely because this is a transbasin diversion and reductions in Platte River flows will not occur.

Third party impacts associated with B-1 Reservoir are similar to those associated with groundwater recharge projects. B-1 Reservoir will be operated as a recharge reservoir similar to a project involving diversions through an existing canal to a recharge basin. B-1 Reservoir could potentially raise groundwater levels along the Gothenburg Canal and in the area of the reservoir. Higher groundwater levels could increase waterlogging problems and problems with flooded basements in the area, which are negative impacts. Conversely, higher groundwater levels could decrease pumping costs for groundwater irrigators in the area.

Power interference will likely produce third party hydrologic, economic and environmental effects. Water release schedules from Lake McConaughy will differ from the historical pattern, primarily in non-irrigation months. There will also be changes in the timing and quantity of water available downstream of the J-2 return. Changes in release schedules and J-2 returns could have potential negative economic and hydrologic third party impacts on downstream water users in Region 3, possibly municipal and industrial users, that rely on these flows. Economic effects might stem from modified stream flows, but more likely from the diverse impacts associated with securing replacement power. Both CNPPID and NPPD will seek compensation under the power interference alternative; NPPD will experience direct impacts associated with power replacement. However, NPPD customers will likely experience higher electricity costs because of more expensive non-hydro power or, worse, experience a reduction in power availability that could produce economic constraints. The loss of system generating capacity will be evident for the Mid-America Power Pool. Third party environmental consequences are likely as hydro generation, usually very low in environmental impacts, is replaced by fossil fuel generation, which often affects air quality and other environmental resources. Fluctuating reservoir pools are a detriment to recreation if they occur.

H. Watershed Management

There are several third party impacts that could occur as a result of watershed management alternatives. The third party impacts associated with forest management are as follows.

Additional water generated by forest management projects will alter the quantity and timing of water available to downstream users. There are potential positive effects on economic development if flows are increased since this water will be available for other existing and future uses. Additional water generated by these projects may improve the supplies available for downstream junior water rights holders.

A forest management alternative would increase the rate of timber harvest and generate additional employment opportunities in the logging industry, which is a third party economic benefit for communities that depend on the timber industry. Employee wages and wealth would be expected to increase.

Forest management alternatives would have both positive and negative third party environmental impacts. Impacts to vegetation would be substantial as a result of timber harvest. There could be negative third party impacts on wildlife habitat where certain species rely on forests as refuge sites, breeding habitat, and for feeding. Certain species could be sensitive to habitat changes. There could also be negative impacts on aquatic resources. Less stable streams with low gradients and unstable banks could be impacted by increased runoff. Potential increased sediment loads could result in loss of fisheries. Conversely, increased flows due to forest management could potentially improve aquatic habitat and water quality.

There would be significant positive third party impacts related to recreation. A portion of the roads constructed for timber cutting would provide access into areas that are currently inaccessible. Increased accessibility would subsequently increase public and private developed recreation use and dispersed recreation use including camping, hiking, biking, snowmobiling, skiing, hunting, and fishing. Forest management could result in a greater number of recreation days.

10. DEMONSTRATION PROJECTS

A. Purpose and Methodology

The purpose of this effort was to illustrate the feasibility of potential demonstration projects. Properly selected and designed demonstration projects can build credibility for the overall Cooperative Agreement, help demonstrate progress beyond "paper" evaluations, show the applicability of existing research and techniques to the Platte River situation, and help reduce uncertainty regarding many aspects of the alternatives discussed previously.

Concepts for demonstration projects were developed by reviewing the assumptions and data limitations associated with each of the water conservation and supply alternatives and by discussing the timing, objectives, scale, scope and other aspects of potential demonstration projects with WMC members and other Platte River Basin water users. Based on this review and input from the WMC, three types of demonstration projects were suggested, which include small-scale projects that are constructed to test both the feasibility of larger scale projects and the assumptions used in their evaluation, projects that are not physically constructed, but provide further data through field investigations and measurements, and projects that focus on refining assumptions and methodologies used to analyze an alternative by developing more sophisticated analytic tools.

Therefore, the study team used a very broad definition of demonstration projects that includes construction of smaller-scale facilities, data acquisition efforts, and refinement of analysis assumptions and methodologies. The study team incorporated its prior experiences with similar efforts in the Platte River Basin or other areas to help identify potential demonstration projects.

In many cases, the evaluation of alternatives did not result in one alternative scoring significantly better than other similar alternatives in other reaches. Therefore, no single alternative is readily apparent as being a better candidate for a demonstration project than others. Demonstration projects must then focus on any additional information needed to further refine the evaluation, which can help confirm or reject the highest ranking alternative(s). In other words, what information would be of enough significance that it could change the scoring enough to make the alternative more or less desirable? The first step was identifying assumptions made in each evaluation that, if additional information was available, could potentially adjust the scoring of the alternative. Some items listed may not be as significant as others; however they are included to stimulate the consideration, evaluation, and selection of demonstration projects by the WMC and Governance Committee.

The study team also participated in several WMC meetings that included the discussion of potential demonstration projects. The concepts included groundwater management projects and groundwater and water reuse projects such as those suggested by a WMC subcommittee headed by Mike Drain of CNPPID. These potential projects are discussed in context with others identified in the subsections that follow.

B. Evaluation Criteria

The following criteria are included for potential use by the Governance Committee in the selection of suitable demonstration projects that might be funded through the Cooperative Agreement. These criteria were considered in the identification of the candidate demonstration projects presented under Section 10.C.

- ***Substantial upside potential for the technique*** - Supply and conservation techniques to be further examined through demonstration projects should have considerable potential for success and broader implementation beyond the demonstration. The technique being demonstrated should also have the capability of providing sufficient water supplies, in a broader application beyond the small-scale demonstration, to make a substantial contribution to the ultimate flow objectives.

- ***Limited downside risk from the demonstration project*** - The demonstration projects should be relatively low risk in terms of financial commitment and the reputation of the overall program. In addition, the demonstration should be structured so that there is minimum potential for irreversible damage if the demonstration project is not completely successful. The study team assessed the magnitude of the financial requirements for demonstration projects and the potential downside if a project is not successful.

- ***Demonstration can help resolve uncertainties*** - The demonstration projects may be designed to provide further clarification of aspects of the technique which are uncertain, such as how water users will respond to financial incentives to change their behavior. For each alternative considered for possible inclusion as a demonstration project, the study team will indicate key issues and information, which can be resolved or developed through the demonstration.

- ***Results can be extrapolated to a larger program*** - The demonstration projects should be designed so that the findings can be utilized in the context of larger programs. This does not mean that the conditions or results will necessarily be the same in every location, but that the information from the program can be used to better predict the outcomes of a broader application of the supply or conservation technique. The study team sought to either identify representative demonstration projects, or identify how the demonstration project application and results would vary in a broader application to other areas based on the characteristics of those areas compared to the demonstration area.
- ***Demonstration project itself is readily feasible*** - Demonstration projects should not require overwhelming financial investment or protracted and complex resolution of legal, institutional, environmental, or other problems in order for a limited-scale demonstration project to be implemented.

C. Potential Projects

Presented below are potential demonstration projects and the results of their evaluation. Discussed first are general purpose projects that apply to several categories of alternatives and are aimed at confirming the assumptions on which the overall Study is based. The remainder of this section covers demonstration projects that are specific to the categories of alternatives presented in Chapter 8. Two categories, Incentive Based Reductions in Agricultural Water Use and Agricultural Water Conservation are discussed together (under the title of Agricultural Water Use) because certain demonstration projects could serve alternatives under both categories.

General Purpose Projects

Three of the most promising areas for useful demonstration projects relate to: 1) resolving uncertainties in calculating the net reductions to target flow shortages, 2) estimates of participation levels and costs to induce participation in incentive-based programs, and 3) legal/institutional issues related to management of Program waters within the context of each States' water laws.

1. Calculating Net Reductions to Shortages - As discussed in Chapter 7, net reductions in shortages to target flows were estimated with the use of a simplified water budget spreadsheet. This was entirely appropriate for a large reconnaissance evaluation of many types of alternatives. Further definition of the attractiveness of selected alternatives may be enhanced by demonstration projects focused on the types of assumptions inherent to the spreadsheet's calculations. Demonstration projects could focus on refined analysis of gains and losses and diversions, refinement of the reach definitions, explicit accounting for return flows in selected reaches, extension of the study period or evaluation of another (probably shorter) period to evaluate an alternative's response in relation to a particular Program need, or many other factors or issues.

2. Participation and Inducement Cost Survey - Many of the comments received on the draft evaluations of Program alternatives regarded agricultural water use and estimates of participation rates and costs required to induce participation. There were also comments suggesting that the Governance Committee send out an RFP soliciting communities to participate in municipal conservation demonstration projects. Therefore, a survey of all water users in each of the 19 reaches may provide useful data and help gage public acceptability of the alternatives. In addition, a demonstration program to support the Governance Committee's outreach program might provide specific information on potential modifications to existing water uses. The program could also provide information to state rule-makers on the acceptability of potential statutory modifications.

3. Legal and Institutional Issues Related to Management of Program Waters – The potential for each state to assure delivery of any Program water downstream was a continuing point of discussion throughout the Study. Demonstration projects designed to test each State's ability to deal explicitly with this issue may provide very pragmatic information in the development of an Action Plan, especially if the projects were structured to delineate specific statutory restrictions such as the acceptability of various types of in-state beneficial uses including instream flows and habitat/wildlife enhancement.

Reservoir Projects

Reservoir construction does not lend itself to the typical definition of demonstration projects. Since dams are capital intensive construction, it is generally not economically (or environmentally) feasible to construct a small reservoir to determine whether or not this type of project meets expectations before the full-size project is constructed. Therefore, the most likely candidates for demonstration projects related to reservoir alternatives will further define the assumptions used to evaluate representative projects in Region 2 and more precisely define the physical parameters or the institutional constraints on reservoir operations in all the regions. These projects generally fall within the second and third categories of demonstration projects, which focus on data acquisition and refinements to the analyses. Potential demonstration projects could be structured as follows:

1. Reservoir Operations, Evaporation, and Area-Capacity Relationships - In general, reservoirs were assumed to fill to maximum capacity with available supplies during months of excess flows at the critical habitat. A demonstration project or study could provide information on whether selected reservoirs could be operated differently (for example, without a one-fill rule) and help refine the estimates of average annual reductions to target flow shortages and associated unit costs. Demonstration projects consisting of more site specific analyses could also help refine estimates of evaporation and area-capacity relationships.

2. Reservoir Seepage - Generalized reservoir seepage rates were based on a percent of monthly storage volume for an off-channel reservoir and return flows were estimated based on the SDF methodology. A demonstration project could refine the seepage values and SDF values for selected reservoirs by analysis or measurement and help establish confidence in the ability to monitor and measure reservoir projects.

3. Observation Wells - Observation wells may need to be installed and hydrogeologic investigations conducted to measure recharge water returning to the river. A demonstration project could refine the costs associated with observation wells and hydrogeologic studies.

4. Replacement of Sand Dam Diversions - Some reservoir alternatives would require improvements to existing diversions

accomplished with sand dams. A demonstration project consisting of more detailed analysis could address which sand dams would need replacement and refine the costs using structural layouts of new facilities and wasteways to return flows back to the river immediately downstream of the dam.

Agricultural Water Use

For the purpose of presenting demonstration projects, two categories of alternatives from Chapter 8, Incentive Based Reductions in Agricultural Water Use and Agricultural Water Conservation Projects have been combined since several potential demonstration projects could fall under both categories. The shortlisted alternatives in these two categories include:

- Acquisition and Dry-Up of Irrigated Lands,
- Permanent Acquisition of Agricultural Water Rights,
- Land Fallowing Programs,
- Dry Year Leasing,
- Deficit Irrigation,
- Conservation Cropping Patterns, and
- Structural Modifications to Irrigation District Facilities.

Demonstration projects or pilot programs should be considered for each of the seven bulleted alternatives shown above for the following reasons:

- The alternatives have the potential to meet a substantial portion of the flow objective, but public acceptance and institutional issues are key to their implementation. Smaller scale testing allows all parties to witness the results without making a premature commitment to a long-term program.
- The pilot test allows for the opportunity to refine approaches and to optimize the larger scale programs, if the pilot tests show significant promise.

- Similar pilot projects have been successfully tried in other areas. For example, cost sharing arrangements to implement irrigation system improvements have been implemented both within and outside of the Platte River Basin.
- As a purely market based approach, the responsiveness of water users is somewhat difficult to predict. Field experience with a demonstration project could assist greatly in refining the program and predicting its results.

Demonstration projects could be configured to enhance data on physical attributes and consumptive use; test the legal/institutional issues; better define the costs, benefits, and financing issues; address environmental effects; and judge public involvement and acceptance of the alternatives. Efforts separate from the Cooperative Agreement and this Study, including those of the research universities, state and federal agencies, and local water users and districts, focus on many types of agriculturally related demonstration projects. These efforts have, and may continue, to provide most of the data related to physical and environmental effects and cost and benefit data. It may be advantageous for the Program to support and/or participate in these projects considering that the most valuable scientific data must be collected using established protocols over several seasons, if not years. Therefore, the promising demonstration projects for the Program presented below focus on institutional and public acceptance aspects of programs relating to agricultural water use.

One challenging aspect of these demonstration projects will be selecting locations. Areas should be chosen so that results of the demonstration project can be extrapolated to other parts of the study regions. The selected area should have an agricultural economy which is sufficiently diversified, both in terms of direct crop production and support industries, so that results of the demonstration can shed light on broader programs.

Some insights into possible mechanisms can be drawn from prior experience in other locations. For example, the Edwards Aquifer Authority near San Antonio, Texas implemented a one-year test of an irrigation suspension pilot program last year. In this test program, voluntarily participating farmers were compensated for foregoing irrigation on portions of their lands for a year, without permanently sacrificing their water rights. Forty farmers, representing more than 10,000 irrigated acres agreed to participate. Members of the Palo

Verde Irrigation District in California have participated in two-year land fallowing programs, with compensation from the Metropolitan Water District. Examples of farm and irrigation system conservation improvements in exchange for cost sharing are more common.

Pilot projects or small scale tests in selected areas could be configured to address the following Study assumptions and the questions they raise:

1. Management Agency - The study team assumed that an agency would be identified to purchase and own water rights and irrigated land. Who will this agency consist of? Federal, state, and/or local officials or landowners? What are the funding sources to cover any salary and non-salary operating costs or will costs be born by existing agencies and budgets? In addition to the costs associated with creating and staffing an agency to manage the lands, what other costs should be included in the management costs? On-going management costs were assumed to be partially offset by revenues obtained from leasing the lands for dryland production, grazing or other uses. What is the magnitude of the revenues that may be obtained.

2. Economic Incentives - It was assumed that the prices paid to farmers would reflect a premium to induce participation. What level of inducement would be required? This demonstration project would focus on analysis of current economic conditions in the agricultural sector so that it would not duplicate the effort of the General Project above, "Participation and Inducement Cost Survey". To evaluate economic and social impacts, baseline information for the area should be collected and participants required to keep records that will provide data on how their operations changed as a result of the project. Further evaluations would be conducted at the conclusion of the demonstration to assess indirect impacts of this technique.

3. Transaction Costs - It was assumed that the transaction costs (legal and administrative) would be a significant percentage of the real property acquisition costs. Is this value realistic and what factors would affect it? The costs associated with water right transfers would be investigated focusing on purchases of, and changes to existing agricultural water rights.

4. Water Use Reductions - It was estimated that certain alternatives would result in broad percentage reductions in water use (for example, deficit irrigation could reduce water use on hay fields by an average of 25%). Pilot programs could help define low-end and high-end estimates of reductions in water use and determine how significantly they affect the net reduction to target shortages at the critical habitat.

5. Participation Rates - Estimated participation was expressed in general percentages. What are the best case and worst case scenarios? How receptive are the irrigators? This demonstration project would need to go beyond the survey on participation in the General Purpose Projects section. It would focus specifically on agricultural participation and utilize information from other programs in the western U.S.

6. Conveyance System Improvements - It was estimated that system improvements could result in efficiency improvements expressed in average terms, however, this will vary significantly on a reach by reach basis. Is it significant enough to influence the results of the analyses? One or more demonstration projects could be conducted to complement other existing studies of conveyance losses if alternatives with significant conveyance components are considered further in the Action Plan phase.

Reuse Projects

Presented below are four potential reuse demonstration projects. The reuse projects identified are pilot projects that involve construction of smaller-scale facilities to test the feasibility of expanded projects. A subcommittee of the WMC identified five potential demonstration projects, four of which involve reuse of Lost Creek flows and/or utilization of the Fort Kearny Improvement Project Area (IPA) and Funk Lagoon facilities (WMC, 1999). The fifth project, involving pumping groundwater along Plum Creek, is presented under groundwater demonstration projects.

The WMC proposal cites the following the benefits of the proposed projects:

- Serve to reduce uncertainty in potential or estimated costs and yields for these and similar projects.

- Test Nebraska State laws, specifically Statute 46-252, related to protecting "new water"

- Increase local public support for the Cooperative Agreement by demonstrating that Program water can be developed through "win-win" alternatives.

- Test the willingness of local communities, landowners, and agencies to partner/collaborate in the process of developing Program water.

- Most of the recommended projects are "scalable", in that there exists the potential for larger or smaller projects of the same type, should the demonstrations show that the projects are feasible alternatives.

The four proposed pilot projects are as follows:

1. Fort Kearny IPA Connection - Lost Creek is a perennial tributary to the Platte River, flowing approximately parallel and south of the river, and entering the river near the downstream end of the critical habitat reach. The Fort Kearny IPA includes a drainage ditch maintained by the Tri-Basin Natural Resources District. This demonstration project would involve the construction of a connection that is approximately ¾ mile from Lost Creek to the Fort Kearny IPA, which returns to the Platte River further upstream. The connection would allow water to be diverted from Lost Creek to the Platte River via the IPA ditch. The result of this connection would be increased flow through approximately twenty miles of the critical habitat area. The connection could be operated to maintain a relatively steady rate of diversion, with an estimated 3,000 ac-ft/yr of improvement to FWS target flows (WMC, 1999). The project could also potentially serve as a means to get other Program water or water to offset new depletions to the river from the Lost Creek area.

2. Fort Kearny IPA Pump Station - This project may potentially be necessary for the operation of the previously mentioned Fort Kearny IPA Connection project if capacity limitations of the IPA connection prove to be too restrictive to fully realize the yield from the project. The inclusion of a pump station may also be necessary to allow expansion of projects in the vicinity of Lost Creek. This project would consist of a pump station and pipeline for the

purpose of conveying water from the IPA connection to the river at a rate greater than is possible through the ditch under gravity-flow conditions. The pump station would likely be located along Crooked Creek, which is a waterway that intersects the IPA connection approximately one mile from the river. There is no specific yield associated with this, but this project may be necessary to fully realize the yield from other related projects.

3. Lost Creek Pumping - This project would involve the use of a well in an area where the groundwater table is high to pump water into Lost Creek. The water would then be routed to the Platte River either through the existing connection between Lost Creek and North Dry Creek, or through the proposed Fort Kearny IPA connection. Operation of the well would be made to coincide with shortages to target flows. The demonstration project would involve the use of single well, with an estimated annual average reduction in target flow shortages of approximately 500 ac-ft (WMC, 1999).
4. Funk Lagoon Operations - Funk Lagoon Wildlife Protection Area (WPA) is a FWS wildlife refuge located on Lost Creek south of the Platte River. Water for the WPA comes predominantly from precipitation runoff and irrigation return flows from surface water deliveries from the CNPPID system. The FWS manager of the WPA has indicated that reduced water contents in the summertime would be beneficial for active management of the lagoon, but currently there is hesitation to release water from the lagoon because of the uncertainty of a replacement supply prior to the start of migration. This project would involve a summertime release of water from the lagoon in exchange for a reliable source of replacement water. The water released from the lagoon would be routed to the Platte River via the existing connection between Lost Creek and North Dry Creek. The replacement water would come from the CNPPID system at the end of the irrigation season, but ahead of the fall migration. The WPA would benefit by being able to reduce capacity for summertime maintenance without threatening water levels for the migration season, surrounding landowners may benefit from lower irrigation season groundwater levels in an area that currently has problems with high groundwater, and the Program would benefit from increased summertime river flows. Average reductions in shortages to target flows are estimated at 500 ac-ft/yr (WMC, 1999).

Groundwater Projects

Presented below are eight potential groundwater demonstration projects. The first one presented is from the same WMC draft proposal (WMC, 1999) as the four reuse projects discussed above.

1. Plum Creek Pumping - This demonstration project wold involve pumping water from a nuisance high groundwater area into Plum Creek for delivery to the Platte River. The land is currently managed for wildlife under an agreement with the Rainwater Basin Joint Venture (RBJV), and the RBJV has indicated that removal of groundwater in the summertime would be beneficial for the active management of the land. Specifically, this project would involve pumping water through a combination of a single existing well and a new sump pit with a quick-cycle pump. The water would be conveyed from the well and pit to the creek via a pipe. The RBJV would benefit from lower irrigation season groundwater levels in an area that currently has problems with high groundwater, and the Program would benefit from increased summertime river flows. Average reductions in shortages to target flows are estimated at 600 ac-ft/yr (WMC, 1999).

2. Central Platte Pumping - A project similar to the demonstration project outlined for Plum Creek could be implemented at a site located approximately ¼ mile upstream from the Odessa Bridge on the south side of the Platte River. This site also has problems with high groundwater levels. In this case three irrigation wells are located within 1,000 feet of the Platte River channel. These wells could be pumped back to the river to increase summertime river flows and lower groundwater levels in the area.

3. Pratt-Ferris Recharge Project - The Pratt-Ferris site is representative of potential recharge projects in Region 1, therefore, it is considered a good potential demonstration project site. Surface water diversions would be made to the Pratt-Ferris canal to deliver water to recharge ponds. Diversions during the months of May through September would most likely not be possible because Pratt-Ferris is diverting for irrigation and there would be limited excess capacity available for recharge. Issues associated with whether excess capacity exists and/or the types of arrangements that would be required to provide sufficient capacity could be evaluated. The costs of canal enlargement in light of the amount of water available for diversion could also be addressed.

4. Loss Sensitivity - Groundwater returns to the Platte River from surface water diversions into recharge ponds were computed as inflows minus evaporation. Evaporation was estimated to be one percent (1%) of gross diversions, consistent with the Tamarack Plan. Demonstration projects could be implemented to further the analysis of evaporation estimates along with any site-specific conveyance losses and deep percolation, throughout the study area.

5. Return Flow Timing - For the purposes of the Study, the SDF method is appropriate for comparison of widely varying alternatives. Demonstration projects could implemented to further refine analyses by evaluating the sensitivity of return flow timing, factors affecting the variability, and the resulting effects on reducing shortages to target flows in the critical habitat.

6. Recharge Costs & Credits - Recharge credits could be shared in lieu of expenses paid to a canal owner for delivering water to recharge ponds. This and other compensation methods could be evaluated with a demonstration project that focuses on data acquisition and involves a survey of irrigation districts that could potentially deliver water to recharge basins. This demonstration project could also be expanded to provide information to refine or update cost estimates for the implementation and operation of recharge projects.

7. Scalability - A demonstration project could help identify the practical lower limit of a cost-effective recharge project.

8. Groundwater Mound - This alternative encompasses both additional surface water and/or groundwater re-regulation opportunities and reduction of natural groundwater exports from the basin. A demonstration project could help test or calibrate existing computer models, estimate growth rates associated with the mound, incorporate field data collection, and test the Study's assumptions regarding the location of wells.

Systems Integration and Management

Demonstration projects related to systems integration and management are primarily related to refining assumptions and methodologies used to evaluate alternatives.

1. Integrated Reservoir Operations - It might be possible to configure a "paper" demonstration project related to integrated operation of the North Platte reservoirs that could concisely document the constraints of the existing authorizing legislation and subsequent public laws on any modified reservoir operations. If this paper exercise showed promise, the demonstration project could then document what changes would be required to implement a test operational pilot program that would have to address the required statutory changes as well as modifications to reservoir operations.

2. La Prele Reservoir - A demonstration project could be configured to refine the analysis of La Prele Reservoir by providing additional information related to the following questions. What compensation would need to be provided to the district for them to agree to a transaction between PEPL and the Program? To what extent does the District currently use PEPL's storage right? What are the legal hurdles that would need to be surmounted with a change in use or place of use associated with PEPL's storage right?

3. Grayrocks Reservoir - A demonstration project could be configured to refine the analysis of Grayrocks Reservoir by providing additional information related to the following questions. Could minimum flow releases be increased without impacting BEPC's operations? The state of Wyoming has been unofficially administering the Laramie River according to the terms of the Agreement of Settlement and Compromise. However, they do not administer the minimum flow releases past the mouth of the Laramie River. What are the legal and institutional barriers to setting the extent of the reach from downstream of the reservoir or from the mouth of the Laramie River to the state line or the critical habitat?

4. Power Interference Charges – A "paper" demonstration project related to power interference charges could help refine the analysis of this alternative. There are numerous uncertainties associated with this alternative, which include willingness to participate on the part of CNPPID and NPPD, the amount of water available for power interference, the operation of Lake McConaughy as it relates to power interference, and the costs to CNPPID and NPPD to conduct power interference. A "paper" project would help resolve several of these key issues without incurring any capital construction costs. A "paper" study could be conducted which tracks how much water is available for power interference and

identifies reasonable replacement costs based on open market purchases for energy and costs of replacement capacity such as gas turbine generation. Alternatively, a paper study could use historical records to identify the amount of water available for power interference. A "paper" demonstration project would provide valuable information, which is necessary to fully evaluate a large-scale power interference project.

Watershed Management Projects

No demonstration projects for this category of alternatives were identified. The key factors in the applicability of these alternatives for the Program are related to the legal/institutional and environmental constraints to implementation.

D. Summary

Presented below is a summary of how each of the potential demonstration projects fares in the context of the evaluation criteria. The "Upside Potential" criterion relates to the potential of a demonstration project generating a certain amount of shortage reduction to be expanded to provide greater reductions. Therefore, the criterion is not applicable to many projects shown below because the projects do not specifically result in reduced shortages. Rough estimates of costs based on engineering judgement and experience with similar types of projects are provided as an indication of the relative effort associated with each project. These costs could be significantly more or less depending on the final scope of work adopted.

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
			General		
1. Calculating Net Reductions to Shortages	Not Applicable	Potential conflicts w/ current modeling	Yes, but could delay CA process	Not Applicable	Further scoping needed
2. Participation and Inducement Cost Survey	Not Applicable	Minor	Strong Potential	General input on acceptability	Feasible- $20,000 to design & conduct
3. Legal/ Institutional Issues Related to Management of Program Waters	Not Applicable	Minor	Yes, facilitates agency communication	Not Applicable	Feasible, but scoping needed, allow $20,000

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
Reservoirs					
1. Reservoir Operations	May show greater reductions to shortages	Minor	Yes, provides more explicit information	Yes, but primarily limited to specific state	Feasible, schedule impacts likely, may conflict with site-specific analysis of alternatives
2. Evaporation	Very limited	Minor	Yes, but probably won't have major effect	Yes	Feasible, $5,000.
3. Area-Capacity Relationships	Very limited	Minor	Yes, but probably won't have major effect	Yes	Feasible, allow $5,000 per site (w/ field surveys, allow $30,000)
4. Seepage	Very limited	Minor	Yes, but probably won't have major effect	Yes	Feasible, allow $5,000 per site (w/ field surveys, allow $15,000)
5. Observation Wells	Very limited	Minor	Yes, but probably won't have major effect	Yes	Feasible, allow $5,000 per site (w/ field work, allow $10,000)
6. Sand dam replacement	Limited	None identified	Yes, and could help mitigate potential opposition	Yes, a generalized layout could be scaled to suit other locations	Feasible, allow $15,000 total

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
Agricultural Water Use					
1. Management Agency	Not Applicable	Very minor	Clarifies agency roles and potential management costs	Yes, could cover a variety of types of management structures	Feasible, allow $20,000.
2. Economic Incentives	Not Applicable	Very minor	Helps reinforce the incentive-based program & provides needed data for several alternatives	Yes, the project would need to address a wide range of economic issues in the ag sector	Feasible, allow $30,000.
3. Transaction Costs	Not Applicable	Very minor	Helps refine the cost of several alternatives	Yes	Feasible, allow $15,000
4. Water Use Reductions	Not Applicable	Very minor	Yes, but tends to duplicate the demonstration projects of others	Yes	Feasible, allow $50,000
5. Participation Rates	Not Applicable	Very minor	Narrows the range and provides more defensible data	Yes, if the research is properly structured	Feasible, allow $20,000
6. Conveyance System Improvements	Not Applicable	Very minor	Yes	Yes, within similar areas and conditions	Feasible, but scoping is important to avoid duplication with other efforts. Allow $20,000 without field work.

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
Reuse Projects					
1. Fort Kearny IPA Connection	Some, but limited by water availability and location of return within the critical habitat	Limited	Technically straightforward	To some extent, but other sites are limited	May be feasible, but may require environmental review/permitting. WMC subcomm. Est. $110,000 – Allow $125,000 for gaging, management, and unlisted items.
2. Fort Kearny IPA Pump Station	This project helps achieve the upside potential of the preceding project	Limited	Technically straightforward	No, single site application	May be feasible, but may require environmental review/permitting. WMC subcomm. Est. $95,000 – Allow $110,000 for gaging, management, and unlisted items.
3. Lost Creek Pumping	Potentially large groundwater supply available, conveyance capacity issue and location of return within the critical habitat limit the upside potential	Limited	Technically straightforward; Could help in the evaluation / implementation of other GW diversions to the Platte in Region 3	Limited to areas where groundwater table is high	Feasible, but permitting issues are similar to the preceding two projects since joint facilities may be used. WMC subcomm. Est. $50,000 – Allow $70,000 for gaging, management, and unlisted items.
4. Funk Lagoon Operations	Limited by physical properties of the lagoon and its existing uses	Potential conflicting agency interests	Yes, but only for this project	Could help in the evaluation / implementation of other small surface water storage opportunities especially in Region 3	Uncertain, potential conflicts with other purposes. WMC subcomm. Est. $65,000 – Allow $80,000 for gaging, management, and unlisted items.

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
Groundwater Projects					
1. Plum Creek Pumping	Good, initial project could be expanded	Limited – project is technically straightforward	Good test for a variety of GW alternatives	Excellent potential to help quantify feasibility	Some permitting issues. WMC subcomm. Est. $40,000 – Allow $70,000 for gaging, management, and unlisted items.
2. Central Platte Pumping	Good, initial project could be expanded	Limited – project is technically straightforward	Good test for a variety of GW alternatives	Excellent potential to help quantify feasibility	Some permitting issues. Wells already constructed, allow $40,000 for gaging, management, and unlisted items.
3. Pratt-Ferris Recharge Project	Good, representative project in Region 1	Limited – project is technically straightforward	Good test for a variety of GW alternatives	Excellent potential to help quantify feasibility	Permitting issues. WMC subcomm. Allow $70,000 per Plum Creek estimate
4. Loss Sensitivity	Helps reliability of estimates	Very minor	Enhance perceptions on reliability	Yes, but only to similar sites	Feasible, allow $25,000 including limited fieldwork
5. Return Flow Timing	Helps reliability of estimates	Very minor	Enhance perceptions on reliability	Yes, but only to similar sites	Feasible, allow $25,000 including limited fieldwork
6. Recharge Costs & Credits	Helps reliability of estimates	Very minor	Enhance perceptions on reliability	Yes, but only to similar sites	Feasible, allow $15,000.
7. Scalability & Phasing	Helps set practical approach	Very minor	Enhance perceptions on reliability and helps define implementation schedule	Yes	Feasible, allow $15,000.
8. Groundwater Mound	Very high given the large volume of water potentially available	Minor	Addresses multiple issues	Yes, but may duplicate other on-going studies	Feasible, allow $30,000 to $150,000.

Potential Demonstration Projects	Upside Potential	Downside Risk	Resolves Uncertainties	Results can be Extrapolated	Demo Project is Feasible (cost & barriers to implementing)
Systems Integration and Management					
1. Integrated Reservoir Ops	Moderate	Agency relationships	May enhance general knowledge of legal constraints	Likely restricted only to facilities being reviewed	Feasible, allow $20,000
2. La Prele Reservoir	Moderate	Minor	Yes	Not applicable	Feasible, allow $5,000
3. Grayrocks Reservoir	Moderate	Minor	Yes	Not applicable	Feasible, allow $5,000.
4. Power Interference	Good, helps reliability of estimates	Minor	Yes	Not applicable	Feasible, allow 20,000.

11. SUMMARY AND CONCLUSIONS

This report begins with an Executive Summary that provides a broad overview of the Study. Chapters 2 through 7 document the study process, characteristics of the Platte River study area, the development of the alternatives considered in the Study and the analytic techniques used to evaluate them. Chapters 8 through 10 present the detailed alternatives evaluations and findings, third party impacts, and suggestions regarding potential demonstration projects. This Chapter summarizes the Study and provides general conclusions that may be useful in preparing an Action Plan for the Cooperative Agreement.

Many river basin planning studies end in the recommendation or selection of a single combination of projects that comprise an overall plan. This study provides basic information on which to formulate a plan, but stops short of a recommendation or selection. An Action Plan will be prepared under the auspices of the Governance Committee of the Platte River Cooperative Agreement and its designated Water Action Plan Committee. Therefore, the primary outputs of this Study are the following:

- Reductions to Target Flow Shortages from Specific and/or Representative Projects
- Unit Costs of Specific and/or Representative Projects
- Multi-attribute Scoring of the Specific and/or Representative Projects (according to physical, legal and institutional, social, economic, and environmental criteria)

These topics are presented in the following sections.

A. Reductions to Target Flow Shortages from Specific and/or Representative Projects

A primary output of the detailed alternatives analysis presented in Chapter 8 are the yield and cost summary tables. These tables are organized first by the major categories of alternatives (for example, reservoirs, groundwater, etc.) and second by location (study Region and Reach of the river). The tables present seven types of hydrologic information:

- net hydrologic effects at each alternative site,

- net hydrologic effects at the top of the next downstream reach, with and without diversions,
- net hydrologic effects at the critical habitat, with and without diversions, and
- reductions to target flow shortages, with and without diversions.

The tables also provide four types of cost information:

- capitalized cost, with and without diversions, and
- cost per ac-ft of average annual reduction to target flow shortages, with and without diversions.

The tables cover 190 specific and/or representative projects with 61 additional variations on those projects.

Tables 11.1 through 11.4 summarize alternatives capable of providing significant potential to reduce target flow shortages and projects that cost less than $1,000 per ac-ft of reductions to target flow shortages. It is important to note that there is uncertainty associated with the costs and yields of these alternatives because they have been evaluated at a reconnaissance level. In addition, projects have been analyzed independently of each other. The yield of projects combined may be less than simply adding the yields of the individual projects because several projects rely on the same source of water.

The yield and cost summary tables indicate that there are 15 projects capable of reducing shortages to target flows by at least 10,000 ac-ft/yr on average if the resulting flows can be protected from downstream diversions. The projects are listed in Table 11.1. In some instances, ranges of reductions in target flow shortages are presented in Table 11.1 because a number of these alternatives have variations of similar projects within the same reach. Table 11.1 also summarizes the potential reductions to target flow shortages if the resulting flows cannot be protected from diversion. The "with diversions" scenario assumes the majority of these diversions are 100 percent consumptive with no return flows to the river. Therefore, the range of flows presented in Table 11.1 should conservatively bracket shortage reductions that would occur at the critical habitat.

There are also an additional 20 alternatives capable of reducing shortages to target flows by 5,000 to 10,000 ac-ft/yr on average if the resulting flows can be protected from downstream diversions, as

Table 11.1
Projects with Greatest Potential to Reduce Target Flow Shortages (More than 10,000 ac-ft per year w/o diversions)

Project	Region	Reductions in Target Flow Shortages (ac-ft/yr)	
		w/o Diversions	w/ Diversions
50,000 ac-ft Reservoir (Reaches 8,9)	2	20,000-30,000	8,000-15,000
30,000 ac-ft Plum Creek Reservoir	3	26,000	25,000
Power Interference	3	17,400	10,400
Forest Mngt. Water Yield (Reaches 1,6,7,11)	1&2	19,000	700
Land Purchase Program in Reach 8	2	12,600	No Shortage Reduction
Land Fallowing Program in Reach 8	2	12,600	No Shortage Reduction
21,900 ac-ft Julesburg Enlargement	2	12,500	6,900
GW Re-Regulation in Reach 19	3	12,600-38,000	12,600-38,000
GW Re-Regulation in Reach 17	3	12,000-38,000	12,000-37,000
GW Re-Regulation in Reach 18	3	12,000-36,000	12,000-36,000
GW Re-Regulation in Reach 10	3	12,000-36,000	5,700-17,000
Riverview Reservoir	3	12,000	5,800
Groundwater Recharge in Reach 7	2	11,000-12,000	1,000-1,100
Groundwater Recharge in Reach 9	2	11,000-12,000	4,000-5,000
Groundwater Recharge in Reach 8	2	11,000-12,000	2,100-2,250

Table 11.2
Projects with Significant Potential to Reduce Target Flow Shortages
(Between 5,000 and 10,000 ac-ft per year w/o diversions)

Project	Region	Reductions in Target Flow Shortages (ac-ft/yr)	
		w/o Diversions	w/ Diversions
10,000 ac-ft Lined Res. (Reaches 8,9)	2	9,700 – 9,900	2,900 – 5,300
10,000 ac-ft New Res. (Reaches 8,9)	2	9,600 - 9,700	2,800 – 5,200
USFS Selected Alternatives (Reaches 1,6,7,11)	1&2	5,000	200
Groundwater Re-Regulation (Reaches 17,18,19)	3	7,600 – 8,100	7,000 – 8,100
Land Purchase in Reach 12	1	8,700	No Reductions
Land Fallowing in Reach 12	1	8,700	No Reductions
Groundwater Recharge in Reach 10	3	7,900 – 10,000	3,900 – 4,500
Land Purchase in Reach 9	2	7,400	No Reductions
Land Fallowing in Reach 9	2	7,400	No Reductions
Groundwater Recharge in Reach 13	1	7,500 – 9,200	3,900 – 4,300
Purchase Rights (Reach 12)	1	5,600	No Reductions
Lease Rights (Reach 12)	1	5,600	No Reductions
Beebe Draw	2	5,400	250
Conservation Cropping in (Reaches 8,9)	2	6,400 – 9,900	No Reductions
Groundwater Recharge Reaches (7,8,9)	2	5,600 – 10,000	400 – 4,400
Jeffrey Canyon Res.	3	6,100	5,000
4,800 ac-ft J-2 Re-Regulating Res.	3	5,300	5,200
Lease Rights (Reaches 8,9)	2	5,200 – 8,800	No Reductions
Purchase Rights (Reaches 8,9)	2	5,200 – 8,800	No Reductions
Conservation Cropping in Reach 12	1	5,000	No Reductions

Table 11.3
Projects which Cost Less than $1,000/ac-ft of Average Reductions in Target Flow Shortages (w/o Diversions Scenario)

Project	Region	Cost ($/ac-ft)	
		w/o Diversions	w/ Diversions
10,000 ac-ft Reservoir at Bottom of Reach 9	2	940	1,770
Conservation Cropping (Reaches 12,13)	1	810 – 940	No Reductions
Conservation Cropping (Reaches 16,19)	3	870 – 990	870 – 3,540
Relocation of Return Flows	3	95 – 130	No Reductions
Lease Water Rights (Reaches 1,2,3,4,6,12,13)	1	710 – 930	11,900 – 30,700
Lease Water Rights (Reach 16)	3	960	3,410
USFS Selected Alternative (Reaches 1,6,7,11)	1&2	0	0
GW Recharge in Reach 9	2	900 – 950	2,170 – 2,180
GW Recharge in Reach 13	1	740	1,850
GW Re-Regulation in Reach 10	2	470 – 590	1000 – 1,250
Gothenburg Canal Recharge Project (Reach 16)	3	640	1,050
Dawson Canal Recharge Project (Reach 17)	3	600	620
GW Re-Regulation in Reach 17	3	590 – 840	610 – 920
GW Re-Regulation in Reach 18	3	390 – 940	400 – 950
GW Re-Regulation in Reach 19	3	380 – 900	380 – 900
La Prele Res. 5,000 ac-ft Pool	1	850	1,990
Power Interference	3	980	1,630

Table 11.4
Projects which Cost Less than $1,000/ac-ft of Average Reductions in Target Flow Shortages and Reduce Target Flow Shortages More than 5,000 ac-ft per Year (w/o Diversions Scenario)

Project	Region	Cost ($ac-ft/yr)	Reductions in Shortages (ac-ft/yr)
10,000 ac-ft Reservoir at Bottom of Reach 9	2	940	9,700
Conservation Cropping (Reach 12)	1	940	5,000
GW Recharge in Reach 9	2	900 – 950	11,000-12,000
GW Re-Regulation in Reach 10	2	470 – 590	27,000 –36,000
GW Re-Regulation in Reach 17	3	590 – 840	7,600 – 38,000
GW Re-Regulation in Reach 18	3	390 – 940	7,700 – 36,000
GW Re-Regulation in Reach 19	3	380 – 900	8,100 – 38,000
USFS Selected Alternative (Reaches 1,6,7,11)	1 & 2	0	5,000
Power Interference	3	980	17,400

shown in Table 11.2. In some instances, ranges of reductions in target flow shortages are presented in Table 11.2 because a number of these alternatives have variations of similar projects within the same reach or in other reaches. Table 11.2 also summarizes the potential reductions to target flow shortages if the resulting flows cannot be protected from diversion. The "with diversions" scenario assumes that the majority of these diversions are 100 percent consumptive with no return flows to the river. Therefore, the range of flows presented in Table 11.2 should conservatively bracket shortage reductions that would occur in the critical habitat.

In general, reservoir projects and groundwater re-regulation (pumping from the groundwater mound) were the most effective in reducing target flow shortages. This is primarily a result of the control that is afforded from these types of alternatives. Agricultural projects and groundwater recharge projects were also effective in reducing target flow shortages due to the magnitude of additional flows that remain, or are added back, in the river system from these alternatives. Alternatives in all categories that were evaluated at a smaller size due to cost limitations did not result in significant reductions to target flow shortages.

There are opportunities to re-regulate all alternatives evaluated through the Lake McConaughy Environmental Account (EA). Although Lake McConaughy EA operations have not been modeled for this reconnaissance level study, the EA can be used to re-regulate additional water generated by any given alternative. Therefore, estimates of net reductions to target flow shortages could potentially increase if additional water is re-regulated through the Lake McConaughy EA account.

B. Unit Costs of Specific and/or Representative Projects

In the process of selecting screening criteria for the Study, it was decided with WMC input and concurrence that projects with a total capital cost of more than $50 million or unit costs for reduction to target flow shortages or more than $3,000 per ac-ft on average would be set aside and not evaluated further in the Study. If a combination of projects are selected in the Action Plan that average $3,000 per ac-ft, the minimum funding needed would be $180 million for the minimum average shortage reduction of 60,000 ac-ft; this greatly exceeds the current funding of the Cooperative Agreement. Therefore, to facilitate the reader's review of the study's results, a summary table of the lowest unit cost projects was prepared using $1,000 per ac-ft as the upper limit. This results in a list of 15 most cost-effective alternatives as shown in Table 11.3. In some instances, ranges of reductions in target flow shortages are presented in Table 11.3 because a number of these alternatives have variations of similar projects within the same reach or in other reaches. This table also shows that these projects would cost considerably more than $1,000 per ac-ft if Program water is not protected from downstream diversion. Conversely, unit costs could decrease for the "with diversions" scenario if more detailed analyses of the magnitude and timing of return flows indicate that the assumption of 100 percent consumptive use of the diversion can be reduced to a smaller percentage.

Table 11.4 summarizes alternatives that are both the most affordable and provide the most reduction in target flow shortages. Table 11.4 includes alternatives that cost less than $1,000 per ac-ft of average reductions in target flow shortages and have the potential to reduce target flow shortages by more than 5,000 ac-ft if the resulting flows can be protected from downstream diversions. This results in a list of nine alternatives that are both cost-effective and provide the most reduction in target flow shortages. These projects would cost considerably more than $1,000 per ac-ft if Program water is not protected from downstream diversion.

Based on a review of Tables 11.1 through 11.4 there are alternatives, that when combined, could yield 60,000 to 80,000 ac-ft of average annual reductions to target flow shortages. However, there are physical, legal and institutional, economic, social and environmental issues that could constrain implementation and must be considered when preparing the Action Plan.

C. Compatibility of Water Conservation/Supply Alternatives

The goal of 60,000 to 80,000 ac-ft of shortage reduction on average will likely be accomplished through a combination of water conservation/supply alternatives. Certain projects are mutually exclusive while others are compatible or partially compatible for combination.

Table 11.5 summarizes the compatibility of alternatives on the short-list that have not been deferred. As shown in Table 11.5, certain

Table 11.5
COMPATIBILITY OF SHORT LISTED ALTERNATIVES THAT HAVE NOT BEEN DEFERRED

Alternative	No.	1 New storage/reservoirs	2 Enlarge Existing Reservoirs	3 Lining reservoirs/gravel pits	4 Conservation cropping patterns	5 Deficit Irrigation practices	6 Water district structural alternatives	7 Relocation of return flows	8 Acquisition and dry-up of irrigation	9 Permanent acquisition of ag water	10 Land fallowing programs	11 Temporary leasing of agricultural water	12 Dry year leasing	13 Drought water banking	14 Groundwater recharge/return flow	15 Reduction of groundwater export	16 Additional groundwater reregulation	17 Modification to water rights	18 Modification to reservoir operation	19 Power interference charges	20 Forest management
New storage facilities or equalizing reservoirs	1	/																			
Enlarge existing reservoirs	2	/	/																		
Lining existing reservoirs and gravel pits	3	/	/	/																	
Conservation cropping patterns	4	/	/	/																	
Deficit irrigation practices	5	/	/	/																	
Water district structural alternatives	6	/	/	/																	
Relocation of return flows	7	/	/	/																	
Acquisition and dry-up of irrigated lands	8	/	/	/																	
Permanent acquisition of agricultural water rights	9	/	/	/																	
Land fallowing programs	10	/	/	/																	
Temporary leasing of agricultural water supplies	11	/	/	/																	
Dry year leasing	12	/	/	/																	
Drought water banking	13	/	/	/																	
Ground water recharge/return flow projects	14	/	/	/	/	/	/		/	/	/	/	/	/	/						
Reduction of groundwater export	15															/					
Additional groundwater reregulation opportunities	16																/				
Modification to existing water rights (LaPrele, Grayrocks)	17	/	/	/											/						
Modification to reservoir operations (B-1 Reservoir)	18	/	/	/	/	/	/		/	/	/	/	/	/	/			/	/		
Power interference charges	19	/	/	/	/	/	/		/	/	/	/	/	/	/			/	/		
Forest management	20																				

KEY	
	Compatible
/	Partially Compatible
■	Not Compatible

Note:
Partially compatible refers to alternatives that could be combined but probably not at the scale proposed because they rely on the same source of water.

alternatives are fully compatible while others are only partially compatible. Alternatives may be partially compatible because the yields of these projects combined may be less than simply adding the yields of the individual projects. This table is intended to identify which alternatives require further investigation to evaluate their compatibility with other alternatives. Alternatives that are compatible may not require further investigation, whereas, alternatives that are partially compatible require additional investigated to evaluate their compatibility. To fully address the compatibility of specific projects they must be evaluated together. The evaluation of alternative combinations will be done during the Action Plan phase if so directed.

A major component of the Program will be re-regulating water from periods of excess at the critical habitat to periods of shortage. This can be facilitated in large part if storage space is available so that water can be retimed. In general, the construction of new storage facilities, dredging or enlarging existing reservoirs, removing storage restrictions, and groundwater recharge projects are compatible or partially compatible with all other types of alternatives. All of these alternatives create additional surface water and groundwater storage space. Alternatives such as forest management, the reduction of groundwater export, and additional groundwater re-regulating opportunities are compatible with all other alternatives because they do not result in any flow reductions. The relocation of return flows, which refers to the Lost Creek/North Dry Creek Cutoff, is also compatible with all other alternatives because it is located downstream in Reach 19 and does not interfere with any other projects that were evaluated. Alternatives that involve agricultural water conservation and incentive based reductions in agricultural water use are fully compatible with each other, however, only partially compatible with most surface and groundwater storage alternatives. Typically, flows would increase during the irrigation season from May through September, and flows would decrease during October through April due to reductions in return flows. Flow reductions during the non-irrigation season would reduce the amount of water available to storage rights. Power interference relies on storage in Lake McConaughy, therefore, its compatibility with other alternatives is similar to new storage.

It is important to note that while some projects may be compatible the yields of these projects combined may be less than simply adding the yields of the individual projects because projects have been analyzed independently of each other. In addition, Table 11.5 addresses categories of alternatives in general. There may be some specific projects that have been evaluated that are mutually exclusive, which is not captured in Table 11.5. For example, additional groundwater re-regulation projects are generally partially compatible with other groundwater re-regulation projects. However, this depends on the extent to which these types of projects are implemented. For example, pumping from the mound up to 51,000 ac-ft/yr and discharging back to the Platte River and pumping from the mound up to 51,000 ac-ft/yr for irrigation of lands previously irrigated by surface water may be mutually exclusive if the total pumping of these projects combined exceeds the growth rate of the mound. Generally, groundwater recharge projects, surface water storage projects, and groundwater re-regulation projects are partially compatible with similar projects in other reaches but mutually exclusive with similar projects in the same reach.

D. Level of Uncertainty

There are varying degrees of uncertainty associated with the alternative evaluations presented in Chapter 8. Because the study was conducted at a reconnaissance level, the assumptions and methods used to evaluate alternatives were simplified. The level of uncertainty associated with costs and yields varies considerably based on the assumptions and methods used and the amount of existing information available for specific projects. For example, the SDF method was used to evaluate the timing of return flows for groundwater recharge projects. As explained in Chapter 5, several of the underlying simplifications of a stream-aquifer system that are relied on by the SDF method are violated in the Platte River system. As such, there is considerable uncertainty regarding the SDF model's predictions of return flows and the related assessment of a recharge project's ability to reduce target flow shortages.

In general, there is a high level of uncertainty associated with the yields of groundwater recharge and re-regulation alternatives due primarily to the use of the SDF method and the uncertainty related to the growth rate of the mound. Generally, there is less uncertainty associated with surface water storage projects because diversions to storage and releases can be more accurately modeled and there is a considerable amount of information available on reservoir construction costs. A considerable amount of information was available for several surface water storage projects, which reduced the uncertainty associated with the yields and costs of those projects. There is a high degree of uncertainty associated with forest management both in terms of yield and cost. There is considerable uncertainty associated with the amount and timing of additional water that would be generated from timber harvest. There is also a high degree of uncertainty associated with power interference charges. The costs associated with power interference are complicated by numerous uncertainties including electric industry restructuring, peak versus base load power values, and replacement power costs including capacity charges, energy charges, transmission costs, and transmission losses.

Incentive-based reductions in agricultural water use and agricultural water conservation strategies also have a high level of uncertainty. Many of these alternatives would require participation from a large number of individual farmers. While there is precedent for many of these alternatives in other locations, the magnitude of farmer response to varying levels of financial incentives to modify existing practices cannot be predicted with great accuracy within the Platte River basin. Hydrologic effects of these alternatives are also subject to additional uncertainty because the precise location of the farms that would participate would be determined by market driven decisions of individual farmers. Estimated yields and costs of structural improvements to irrigation district facilities were based upon prior studies and projects. The extent to which similar results can be obtained for facilities that have not been previously subject to engineering studies is also subject to uncertainty.

E. Multi-attribute Scoring of Specific and/or Representative Projects

As discussed in Chapter 6, the alternatives received scores ranging from zero to 25 based on five general criteria and 31 secondary sub-criteria. All scores fell in the 14 to 19 range. Several of the groundwater projects earned scores at the upper end of this range and several of the incentive based reductions to agricultural water use, systems integration, and new reservoir projects were at the lower end of the range. The reader is cautioned that, at this Study's reconnaissance level of detail, that there may be no significant difference in overall ability to implement a project based on a two to three point difference. Each of the five general criteria were weighted equally and the reader may want to review which types of projects scored best in both the general and sub-criteria. Figures 11.1 through 11.22 facilitate this review. Any differences between the total scores presented in the Chapter 8 scoring tables and Figures 11.1 through 11.2 are due to rounding of the individual screening criteria averages.

F. Third Party Impacts

Third party impacts associated with alternatives that were not deferred were identified and discussed. Third party impacts are primarily a result of hydrologic and economic impacts of an alternative. Third party hydrologic impacts are related primarily to changes affecting the timing and quantity of Platte River flows, which may affect existing downstream users or future water users. Third party economic impacts are related primarily to agricultural alternatives and focus on changes in the scale or nature of operations, changes in expenditure patterns, and changes in related industries.

G. Demonstration Projects

Concepts for demonstration projects were developed by reviewing the assumptions and data limitations associated with each of the water conservation and supply alternatives and by discussing the timing, objectives, scale, scope and other aspects of potential demonstration projects with WMC members and other Platte River basin water users. The study team defined three types of demonstration projects, which include construction of smaller-scale facilities, data acquisition efforts, and refinement of analysis assumptions and methodologies. Several demonstration projects were identified that are intended to reduce uncertainty and refine many aspects of the alternative analyses discussed previously.

Figure 11.1

Scoring for Reservoir Alternatives with Diversions

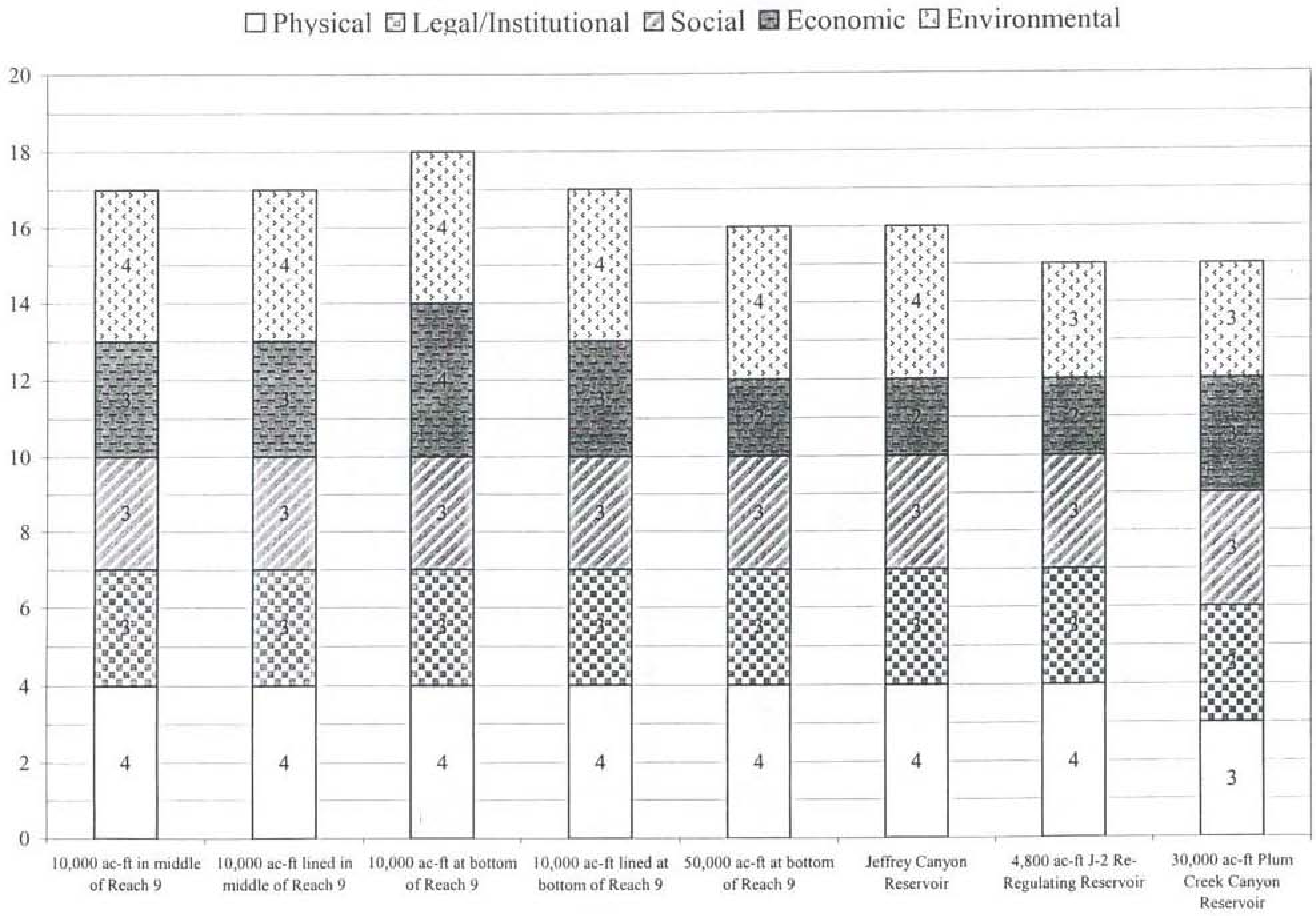


Figure 11.2

Scoring for Reservoir Alternatives with No Diversions in Any State

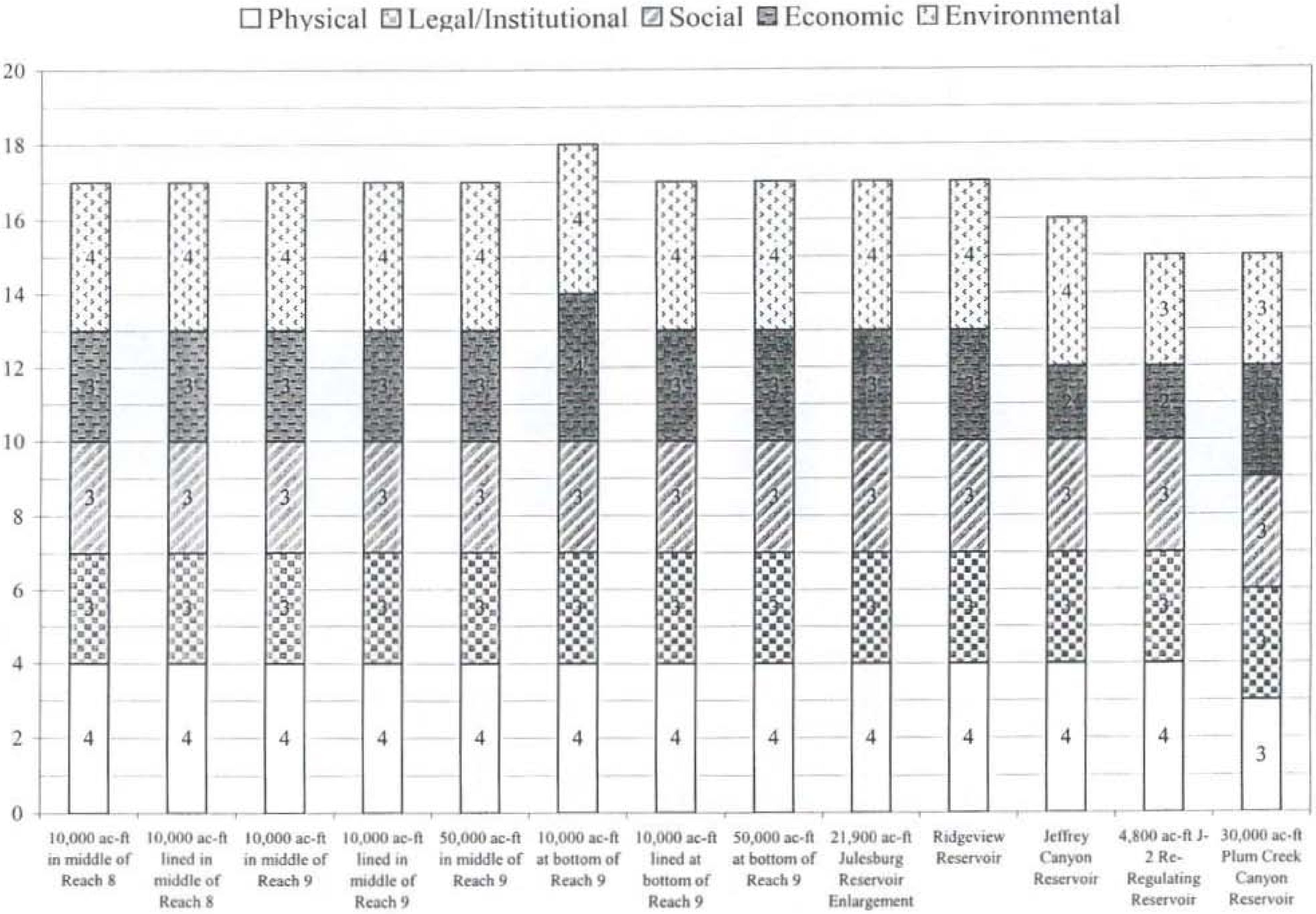
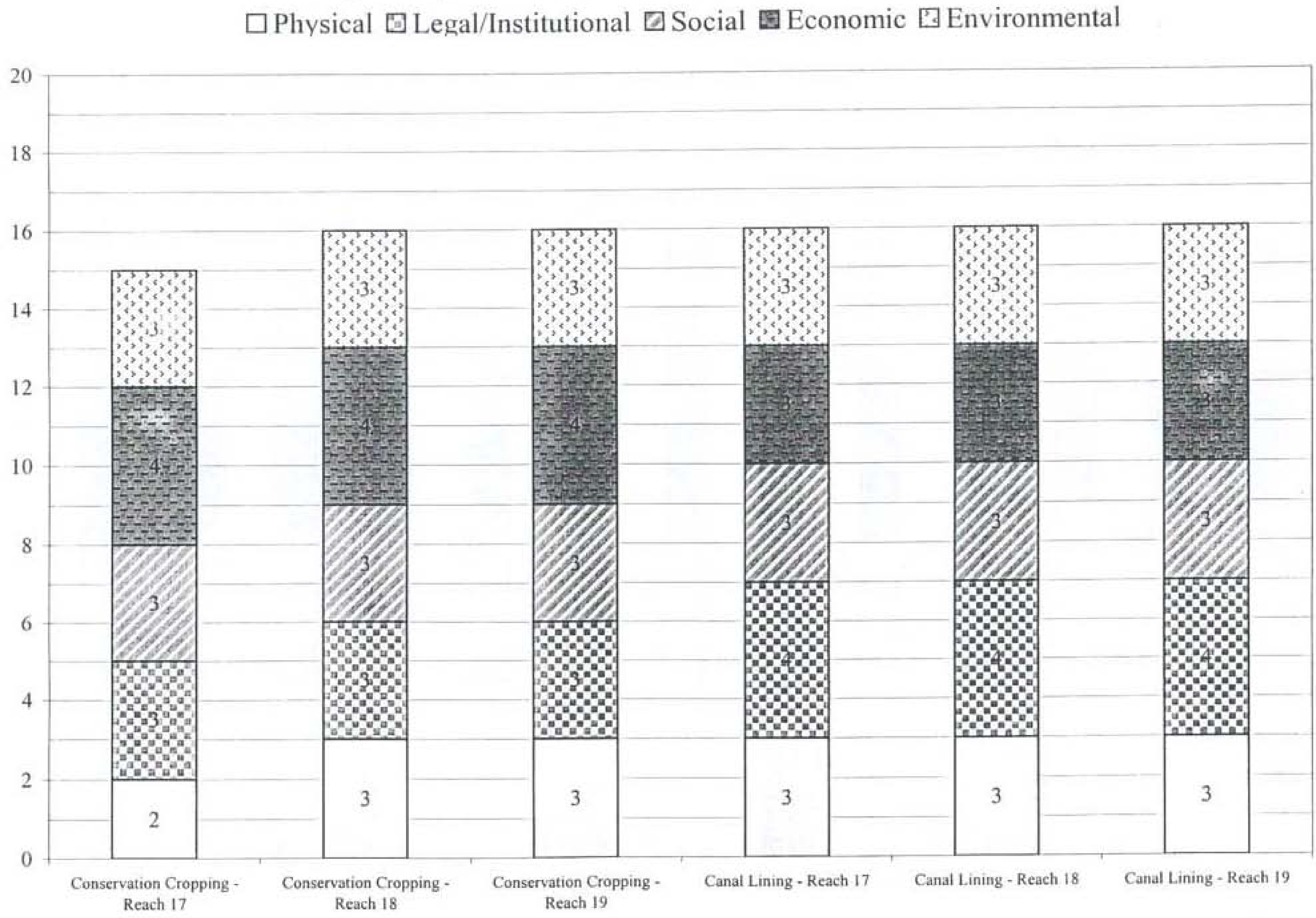


Figure 11.3

Scoring for Agricultural Conservation Projects with Diversions



	Physical	Legal/Institutional	Social	Economic	Environmental
Conservation Cropping - Reach 17	2	3	3	4	3
Conservation Cropping - Reach 18	3	3	3	4	3
Conservation Cropping - Reach 19	3	3	3	4	3
Canal Lining - Reach 17	3	4	3	3	3
Canal Lining - Reach 18	3	4	3	3	3
Canal Lining - Reach 19	3	4	3	3	3

Figure 11.4

Scoring for Agricultural Conservation Projects with No Diversions in Any State

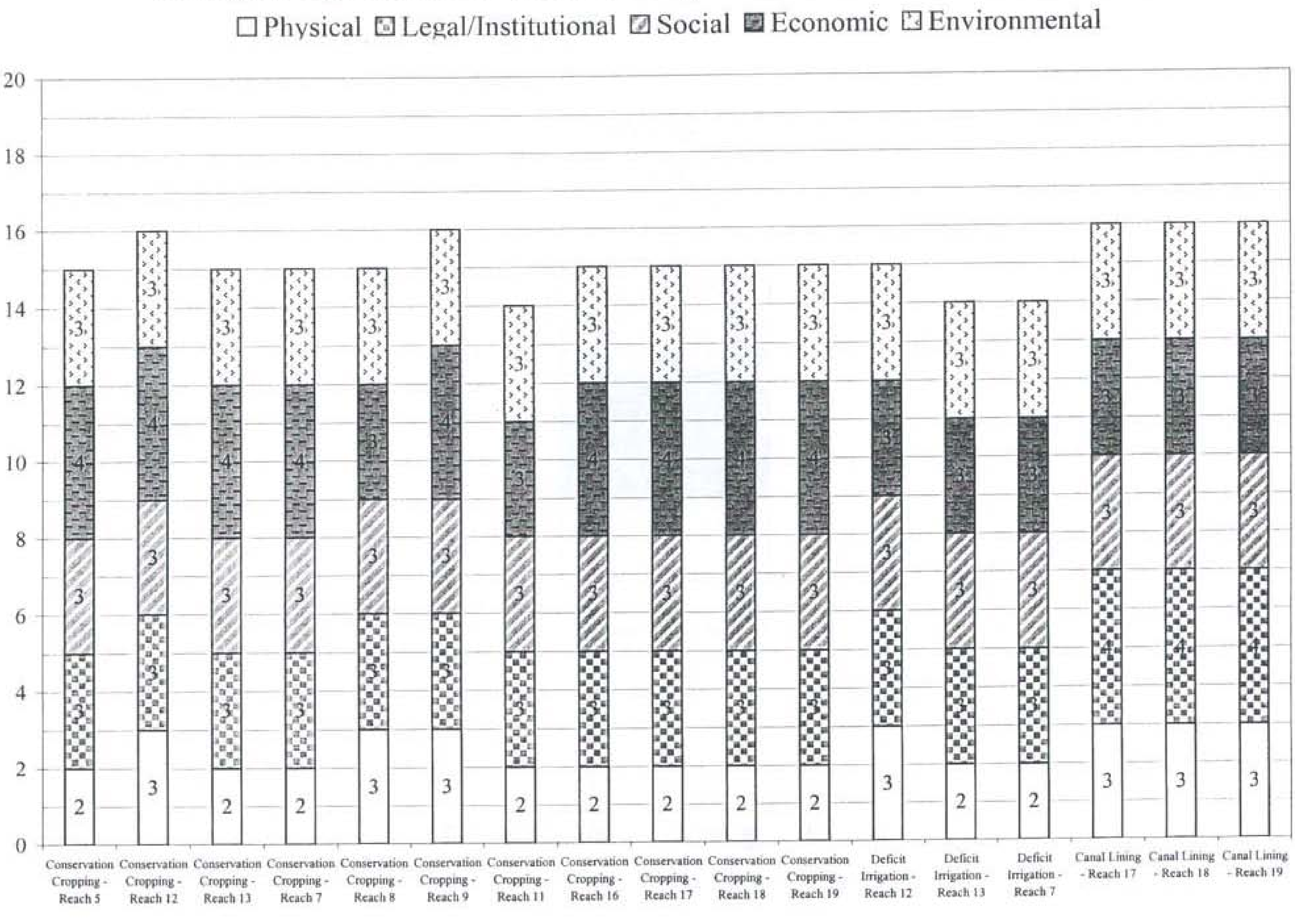


Figure 11.5

Scoring for Reuse Alternatives with No Diversions in Any State

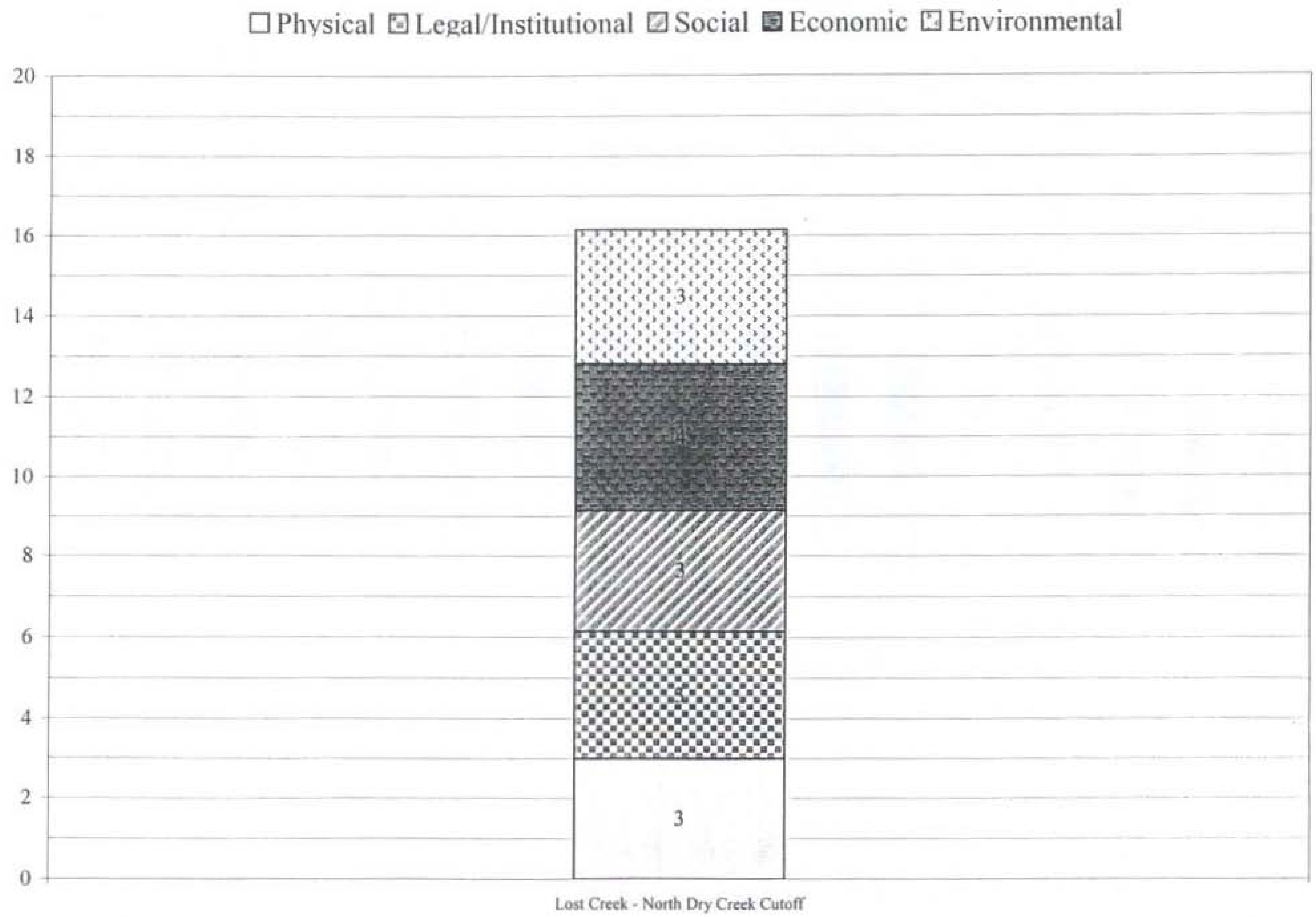


Figure 11.6

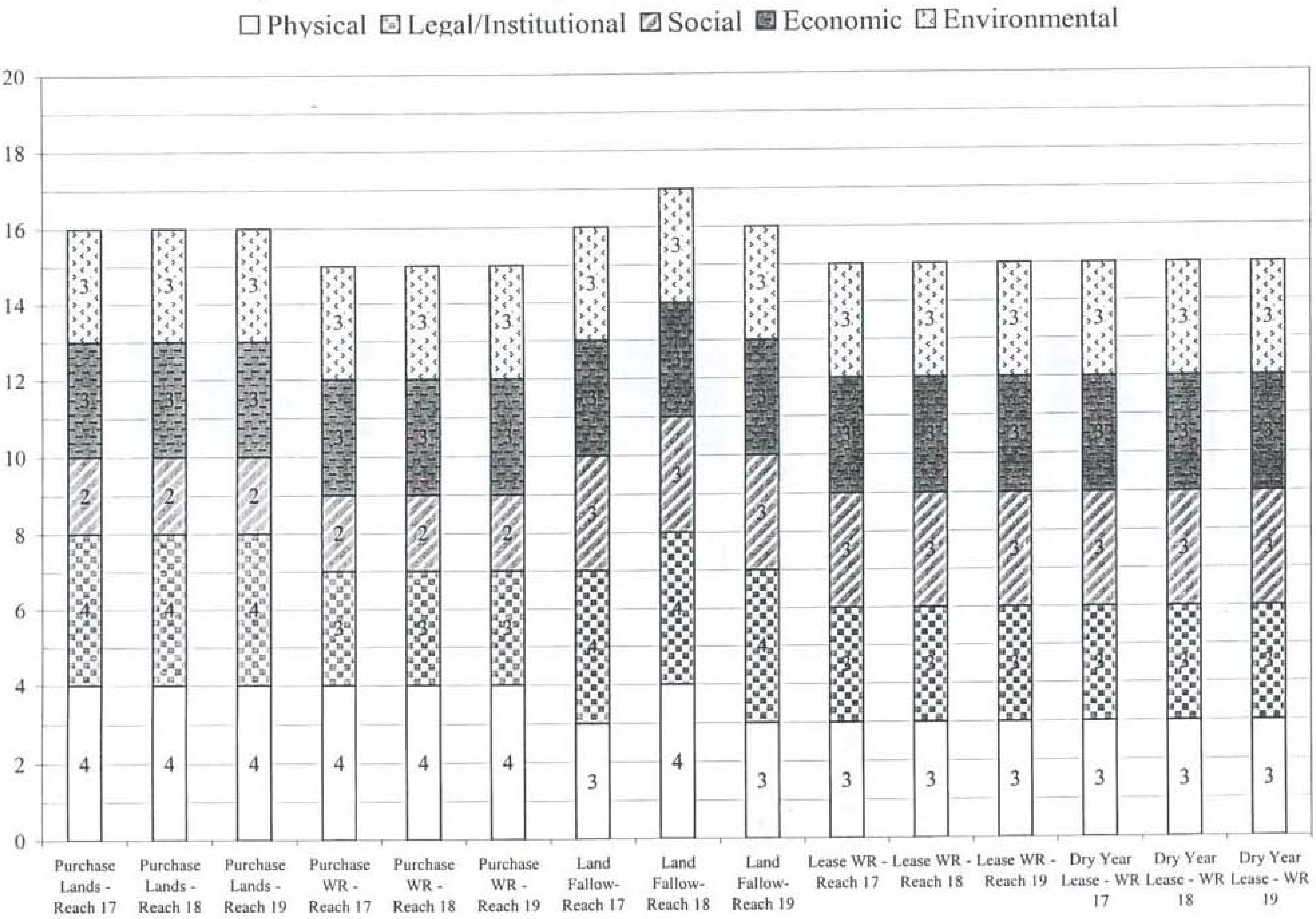

Scoring for Incentive Based Agricultural Water Use Projects with Diversions

Figure 11.7

Scoring for Land Purchase and Irrigation Retirement Projects with No Diversions in Any State

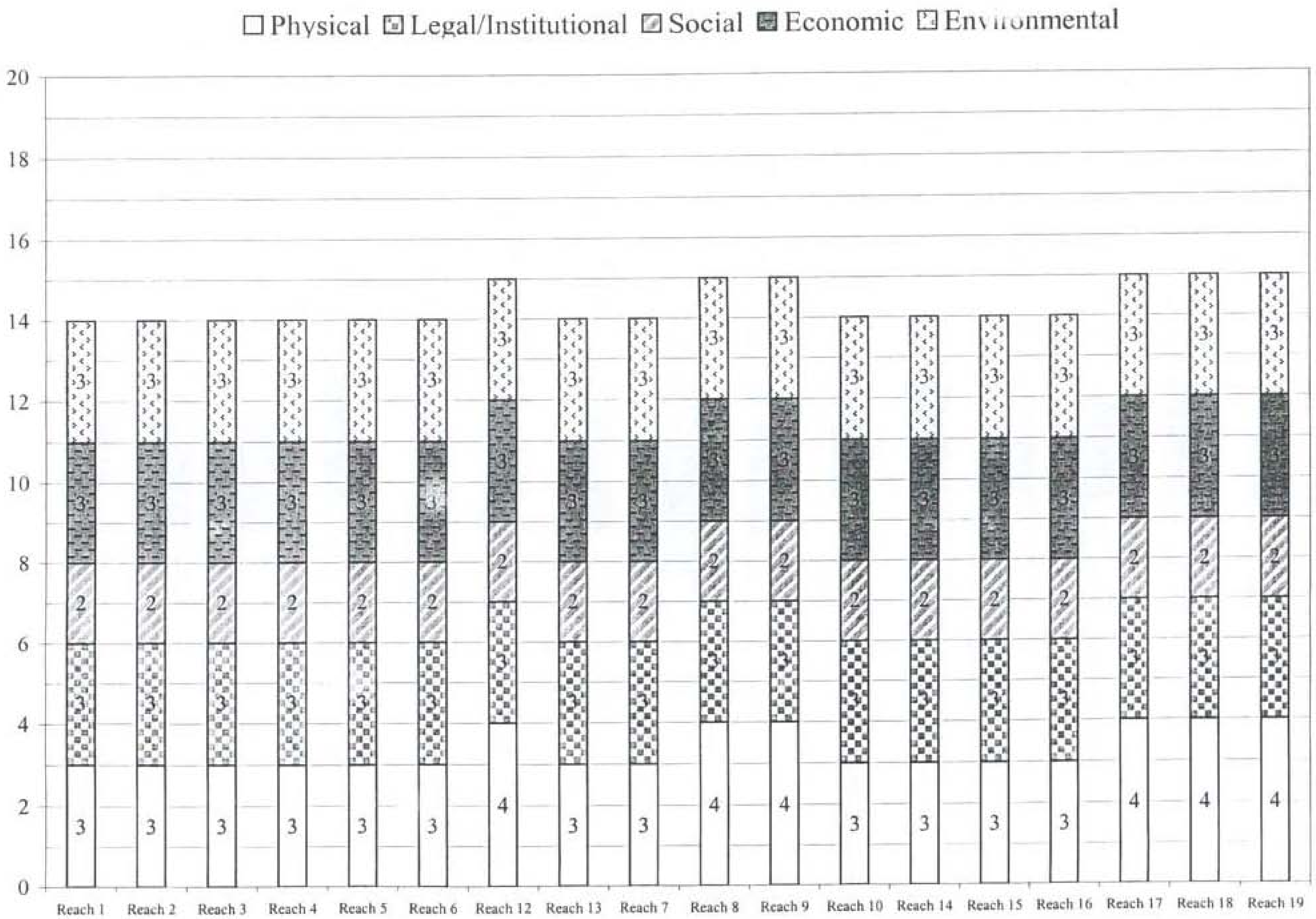


Figure 11.8

Scoring for Purchase Agricultural Water Rights Projects with No Diversions in Any State

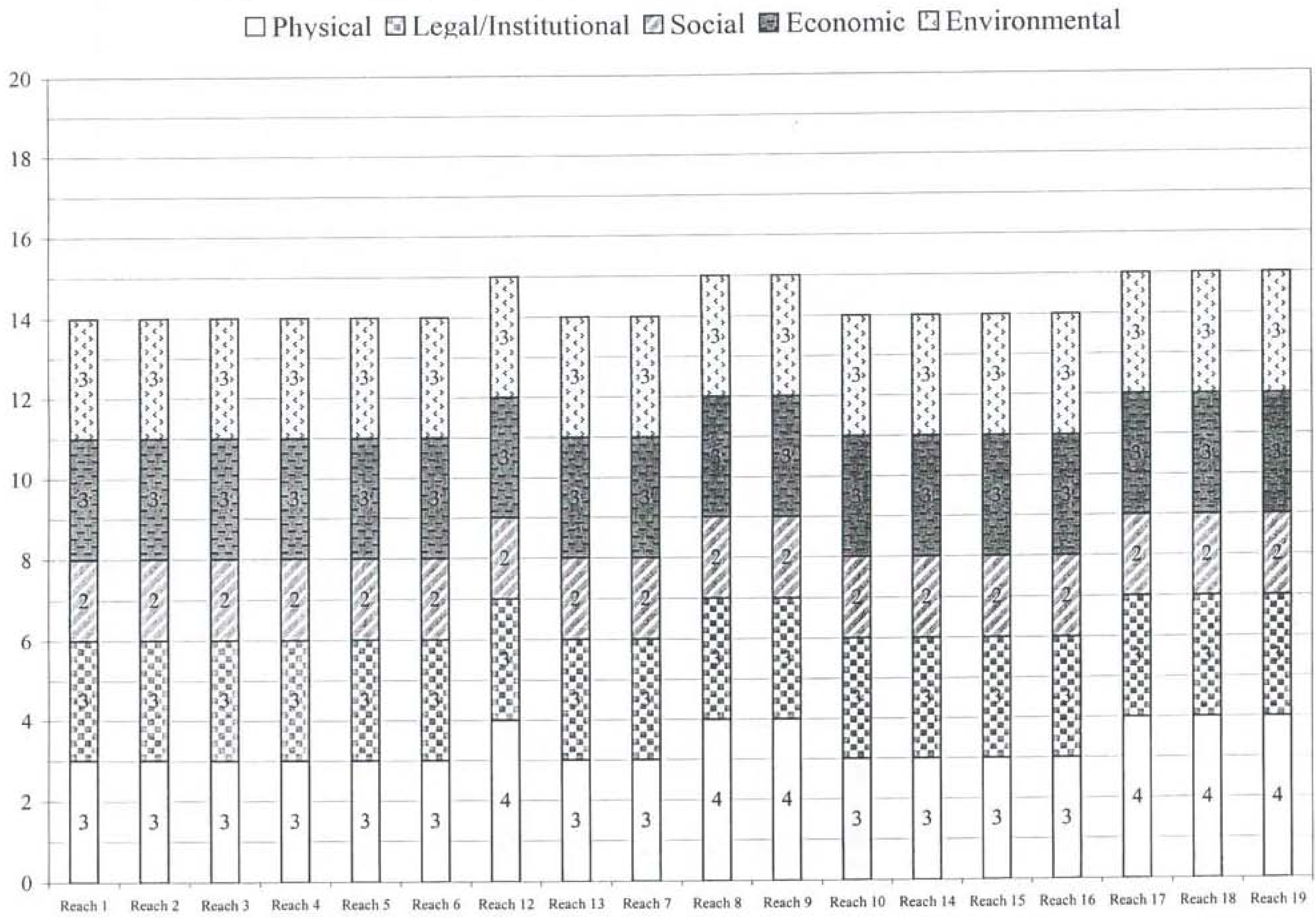
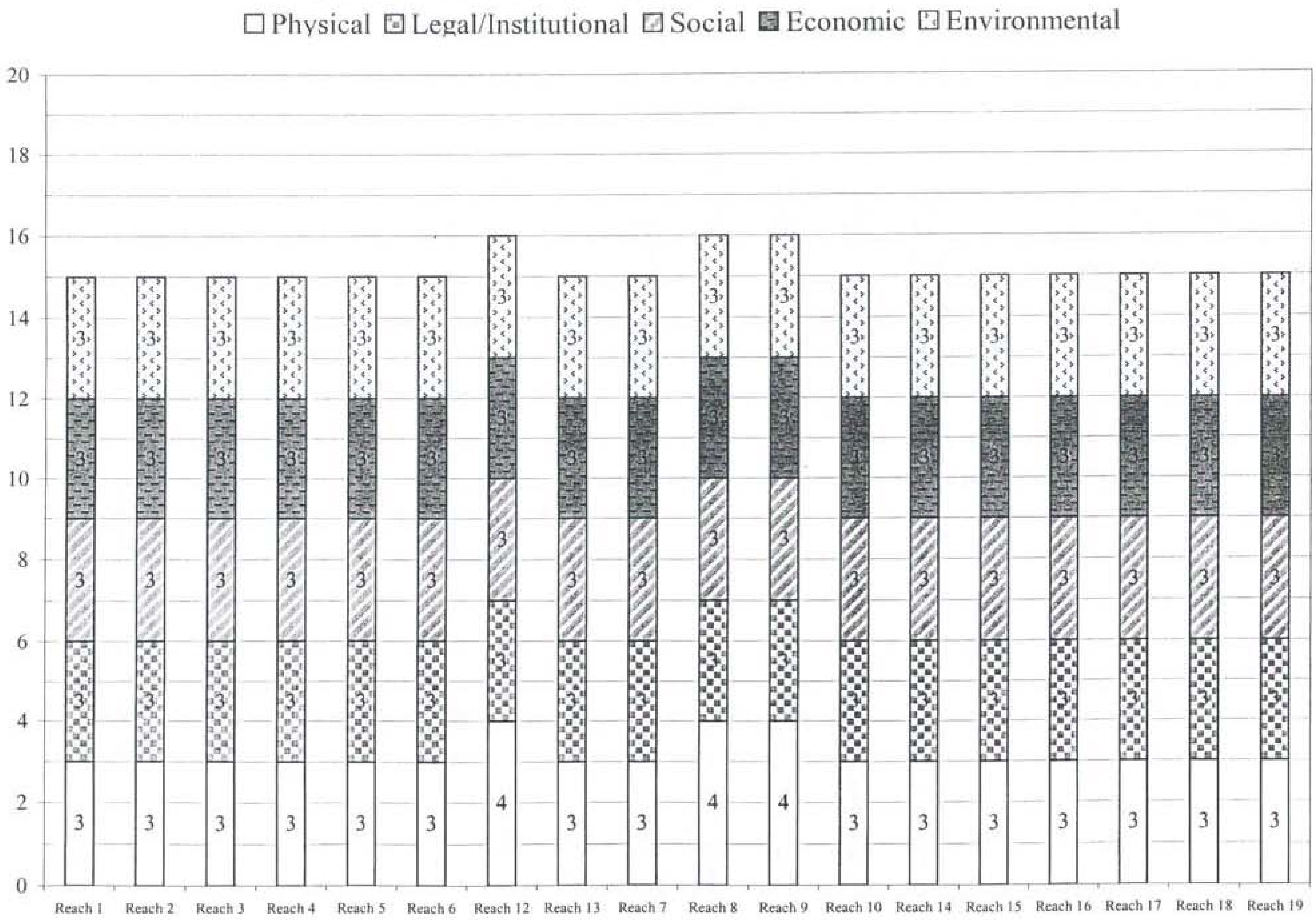


Figure 11.9

Scoring for Land Fallowing Projects with No Diversions in Any State



Scoring for Temporary Leasing of Agricultural Water Supplies Projects with No Diversions in Any State Figure 11.10

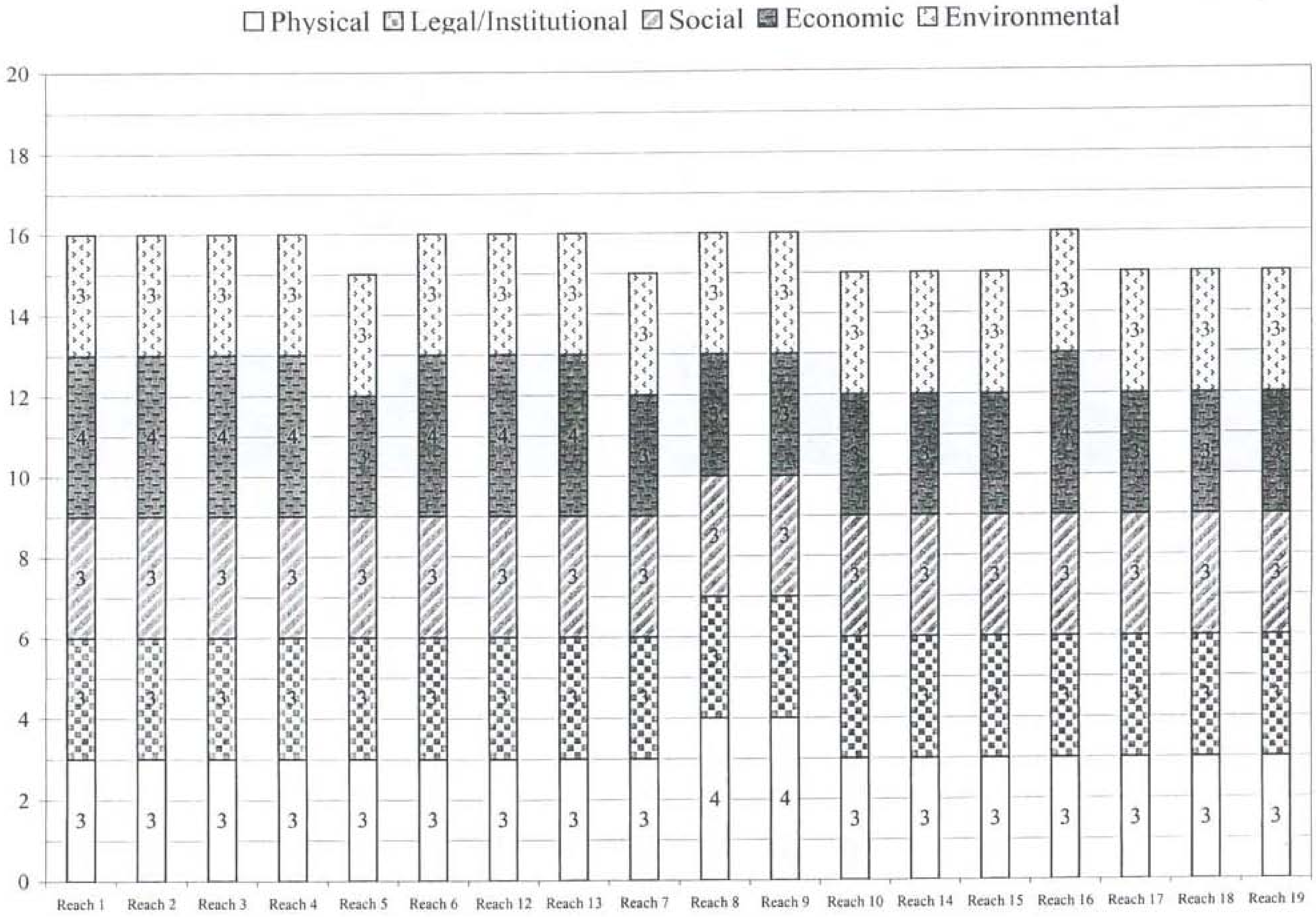


Figure 11.11

Scoring for Dry Year Leasing Projects with No Diversions in Any State

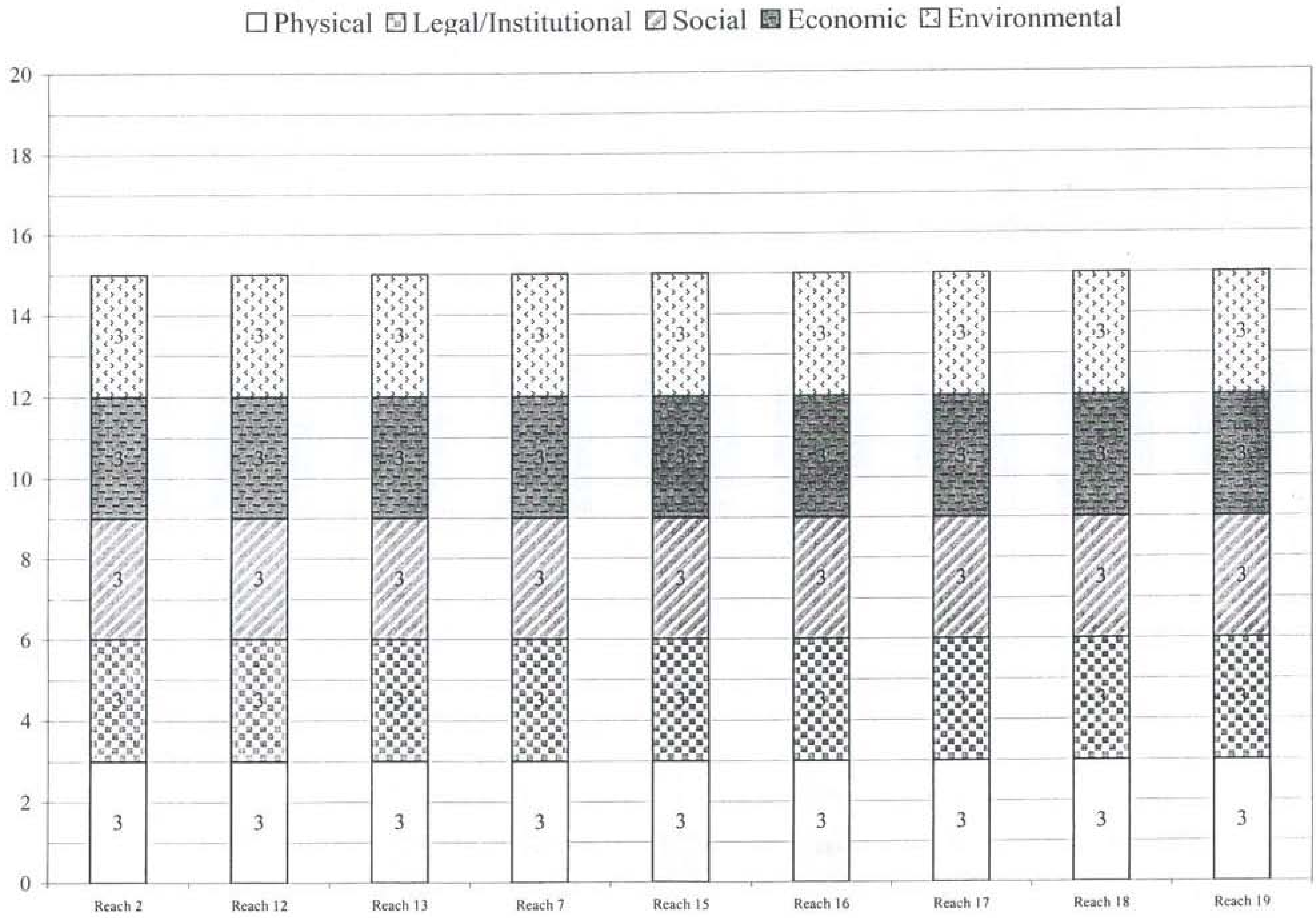


Figure 11.12

Scoring for Recharge/Return Flow Projects in Regions 1 and 3 with Diversions

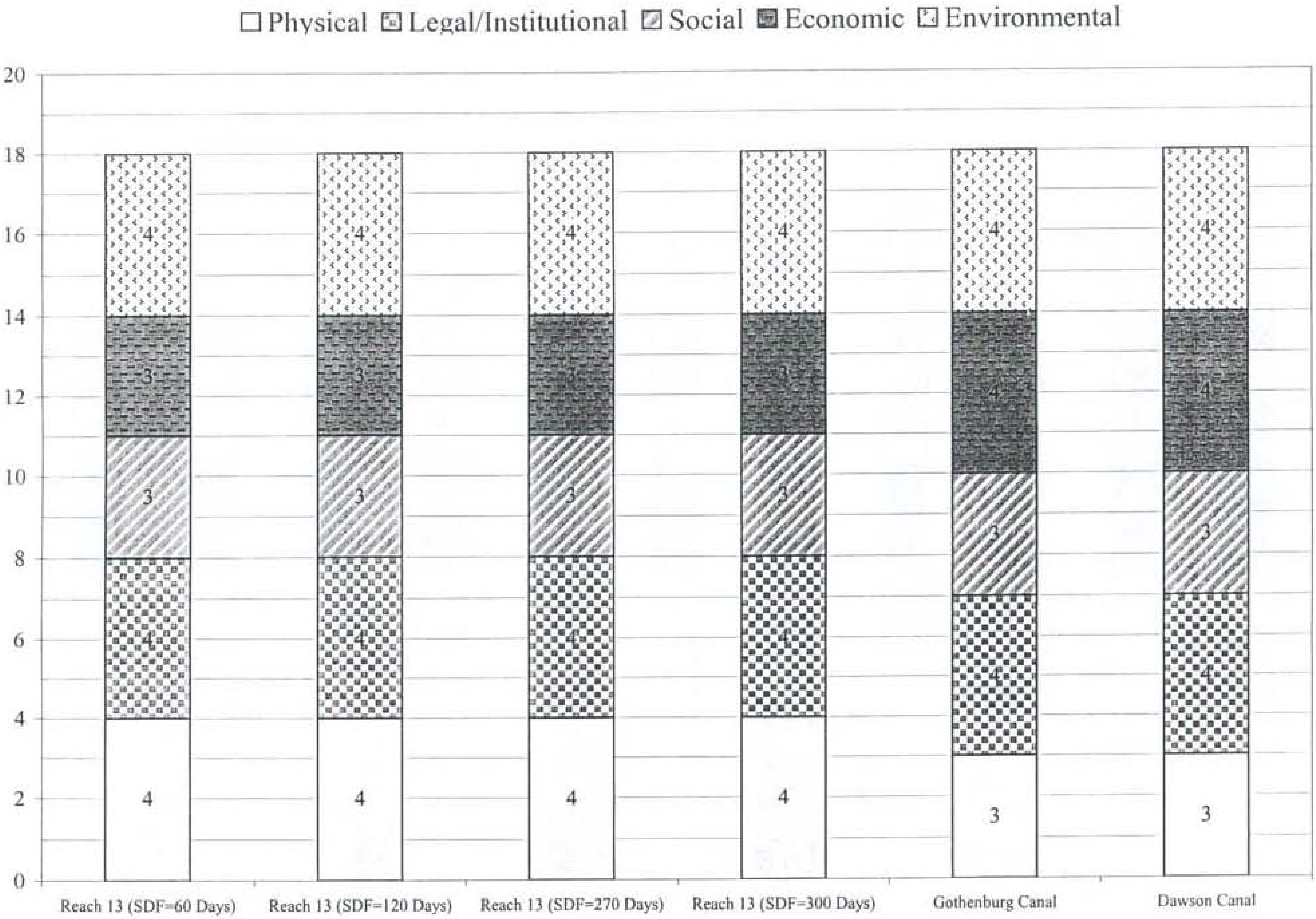


Figure 11.13

Scoring for Recharge/Return Flow Projects in Region 2 with Diversions

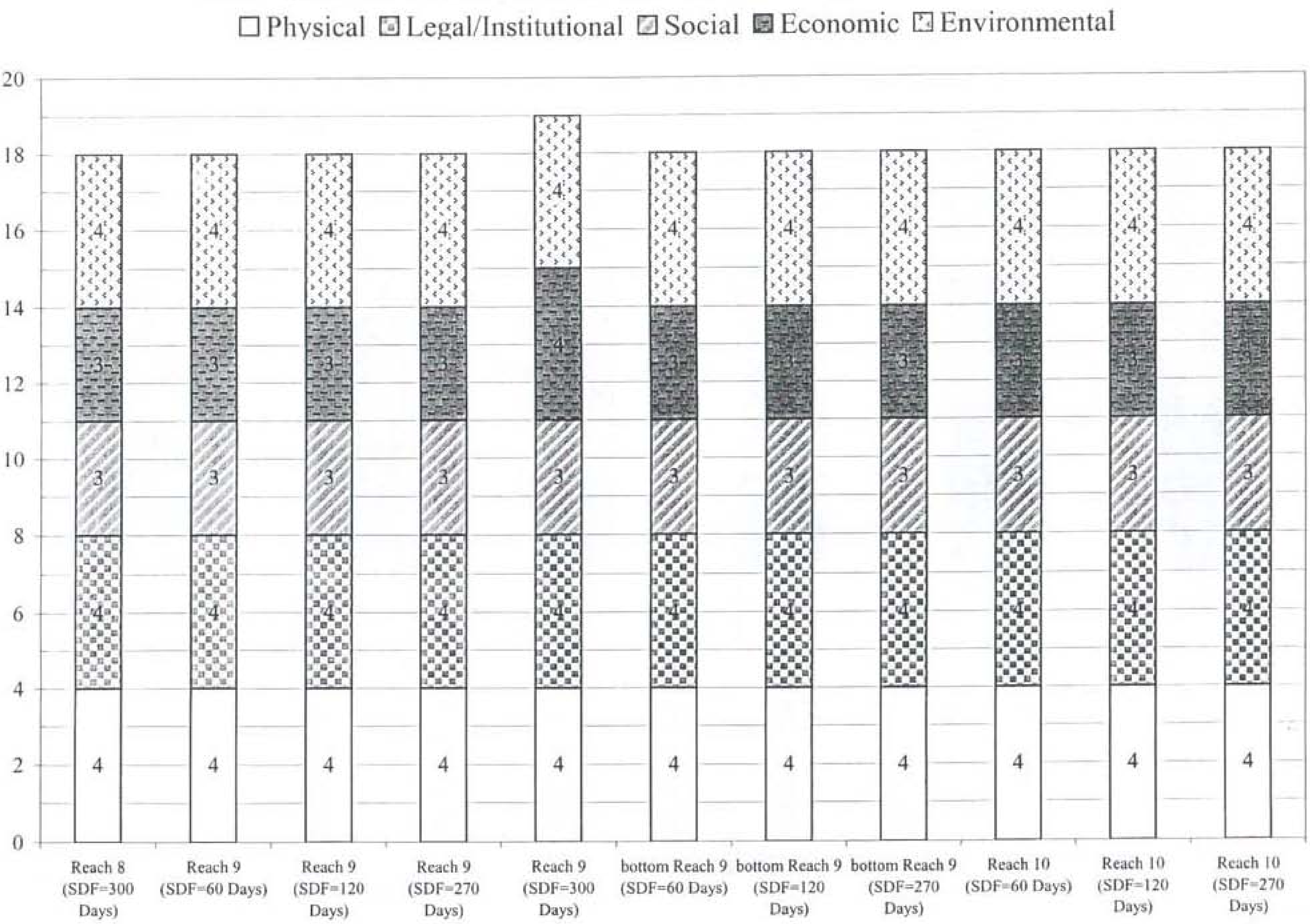


Figure 11.14

Scoring for Groundwater Re-Regulation Projects with Diversions

Scenario 2 (3) - Pump from the mound up to 36,500 ac-ft/yr (14,500 ac-ft/yr) and discharge water directly to the Platte River
Scenario 4 (5) - Pump from the mound up to 14,500 ac-ft/yr (51,000 ac-ft/yr) for irrgation of lands previously irrigated by surface water

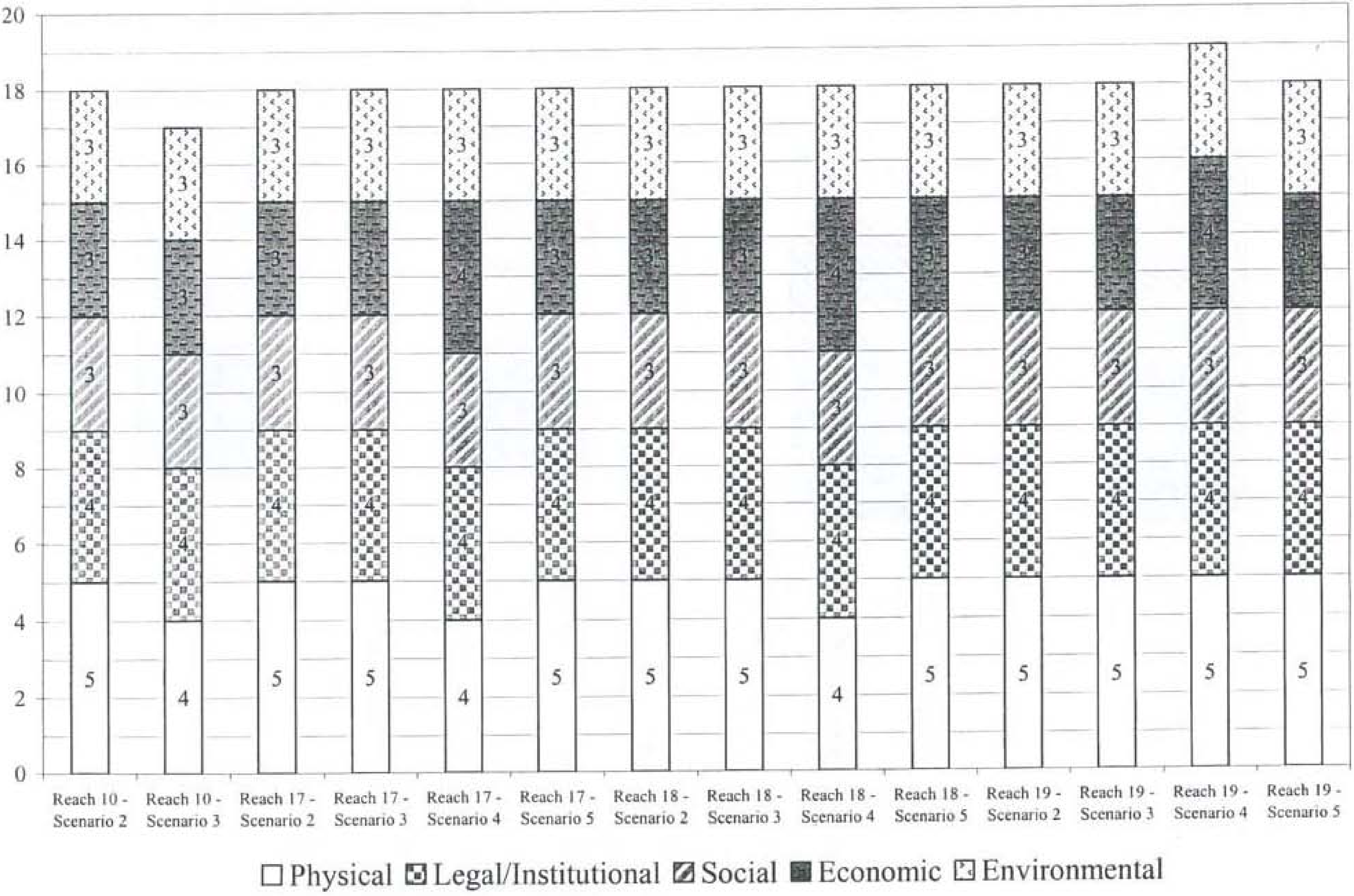


Figure 11.15

Scoring for Reduction of Groundwater Export Projects with Diversions

Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River

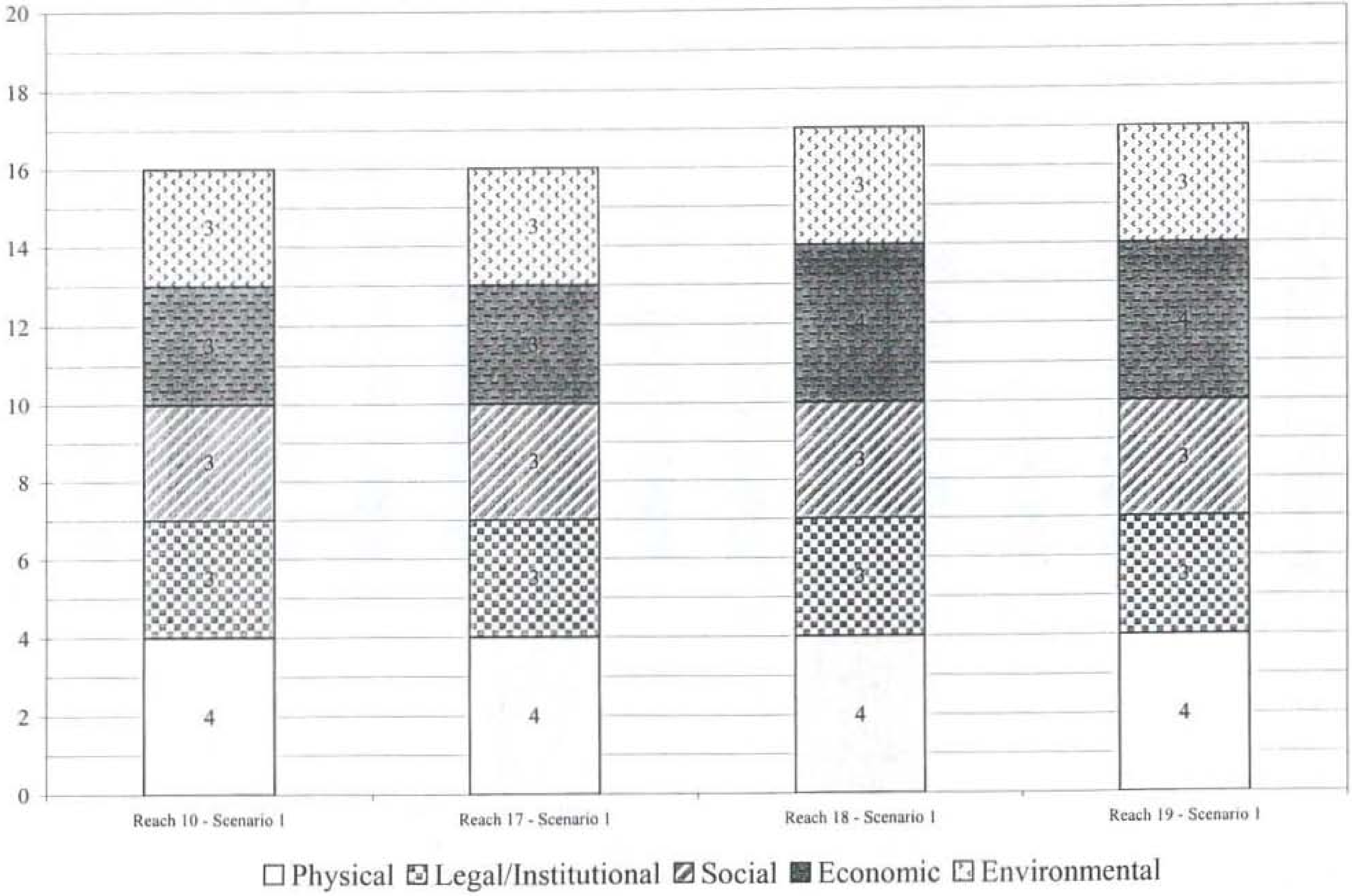


Figure 11.16

Scoring for Recharge/Return Flow Projects in Regions 1 and 3 with No Diversions in Any State

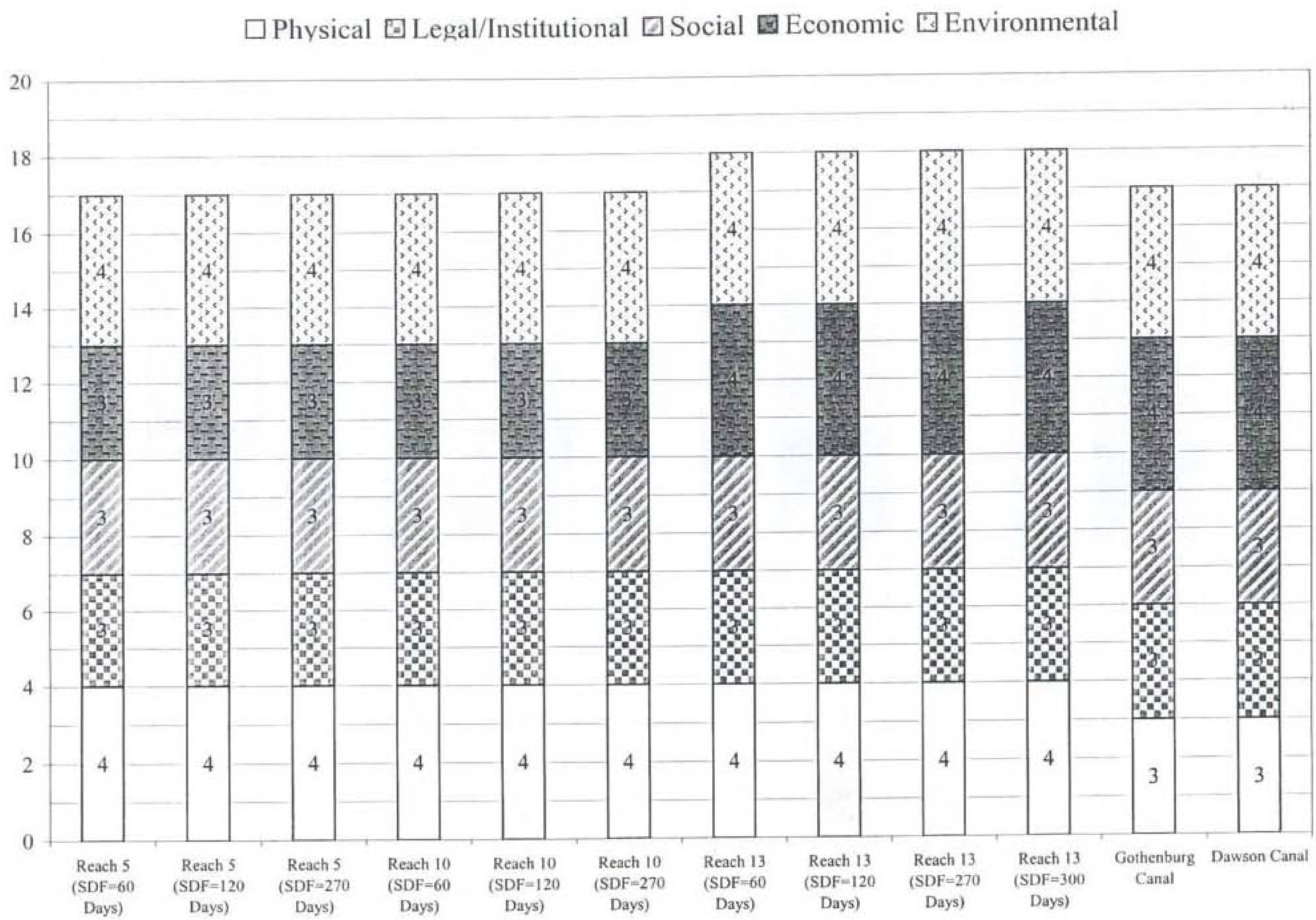


Figure 11.17

Scoring for Recharge/Return Flow Projects in Region 2 with No Diversions in Any State

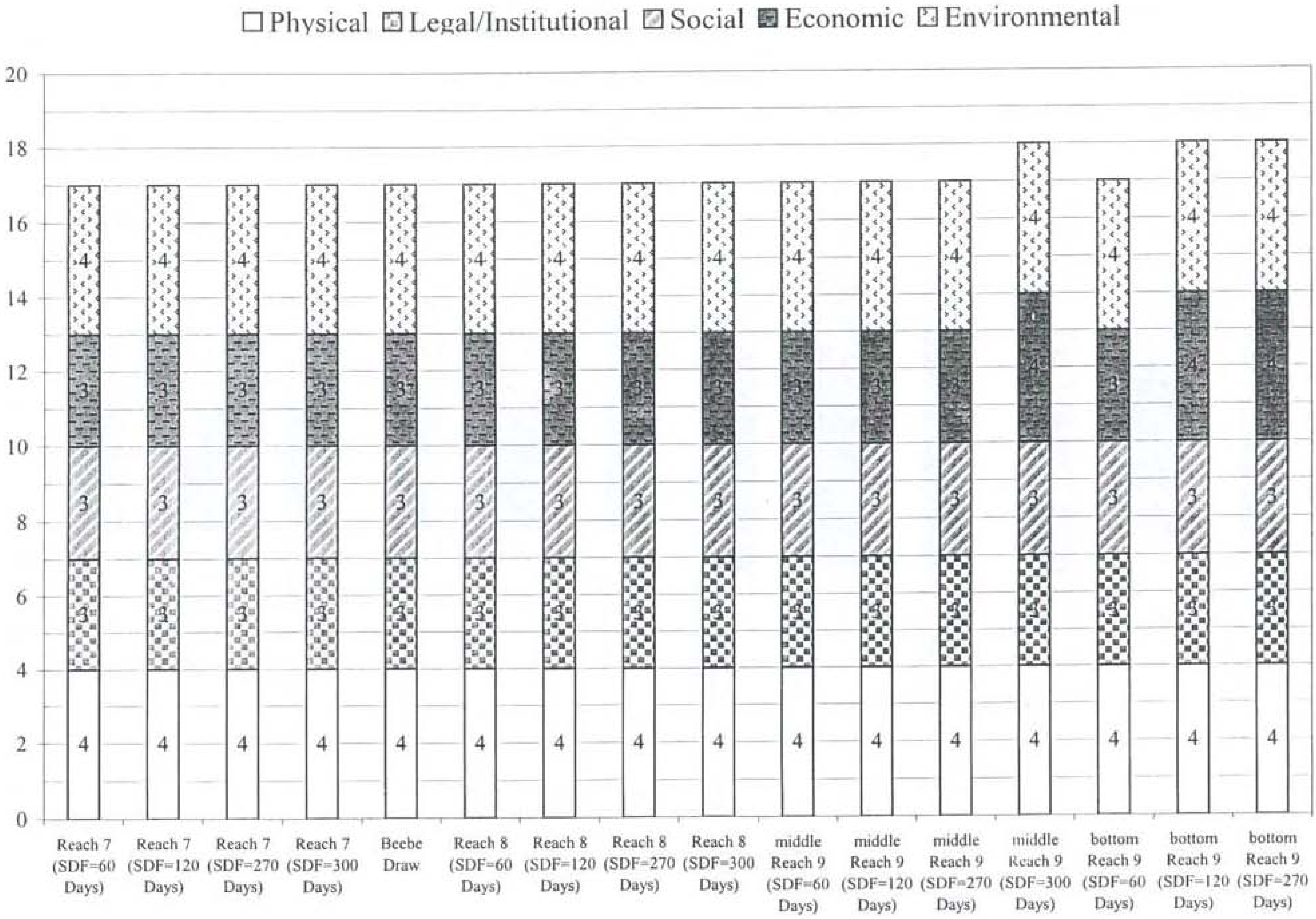
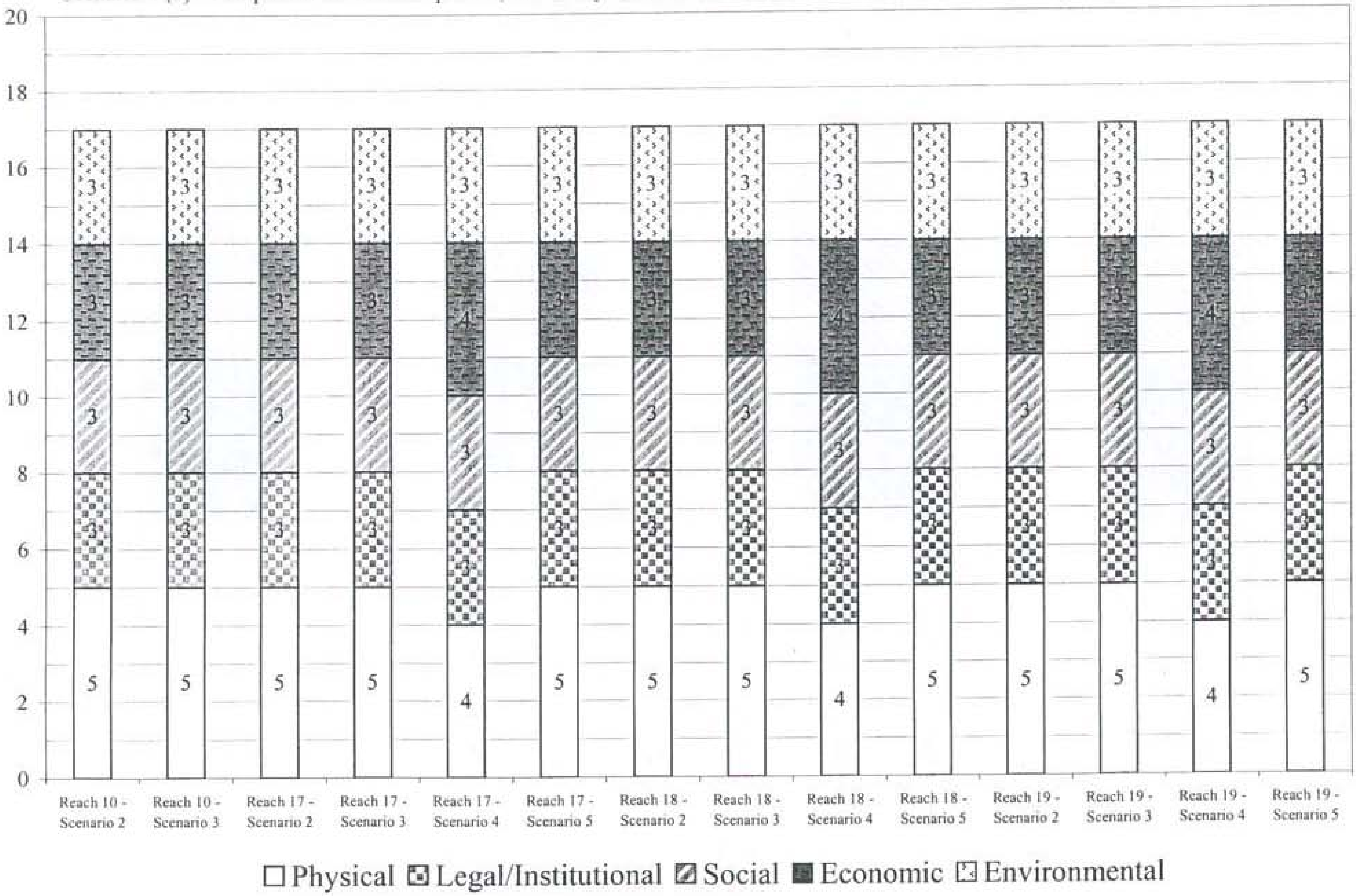


Figure 11.18

Scoring for Groundwater Re-Regulation Projects with No Diversions in Any State

Scenario 2 (3) - Pump from the mound up to 36,500 ac-ft/yr (14,500 ac-ft/yr) and discharge water directly to the Platte River
Scenario 4 (5) - Pump from the mound up to 14,500 ac-ft/yr (51,000 ac-ft/yr) for irrgation of lands previously irrigated by surface water



Scoring for Reduction of Groundwater Export Projects with No Diversions in Any State

Figure 11.19

Scenario 1 - Pump from the groundwater mound up to 51,000 ac-ft/yr and discharge water directly to the Platte River

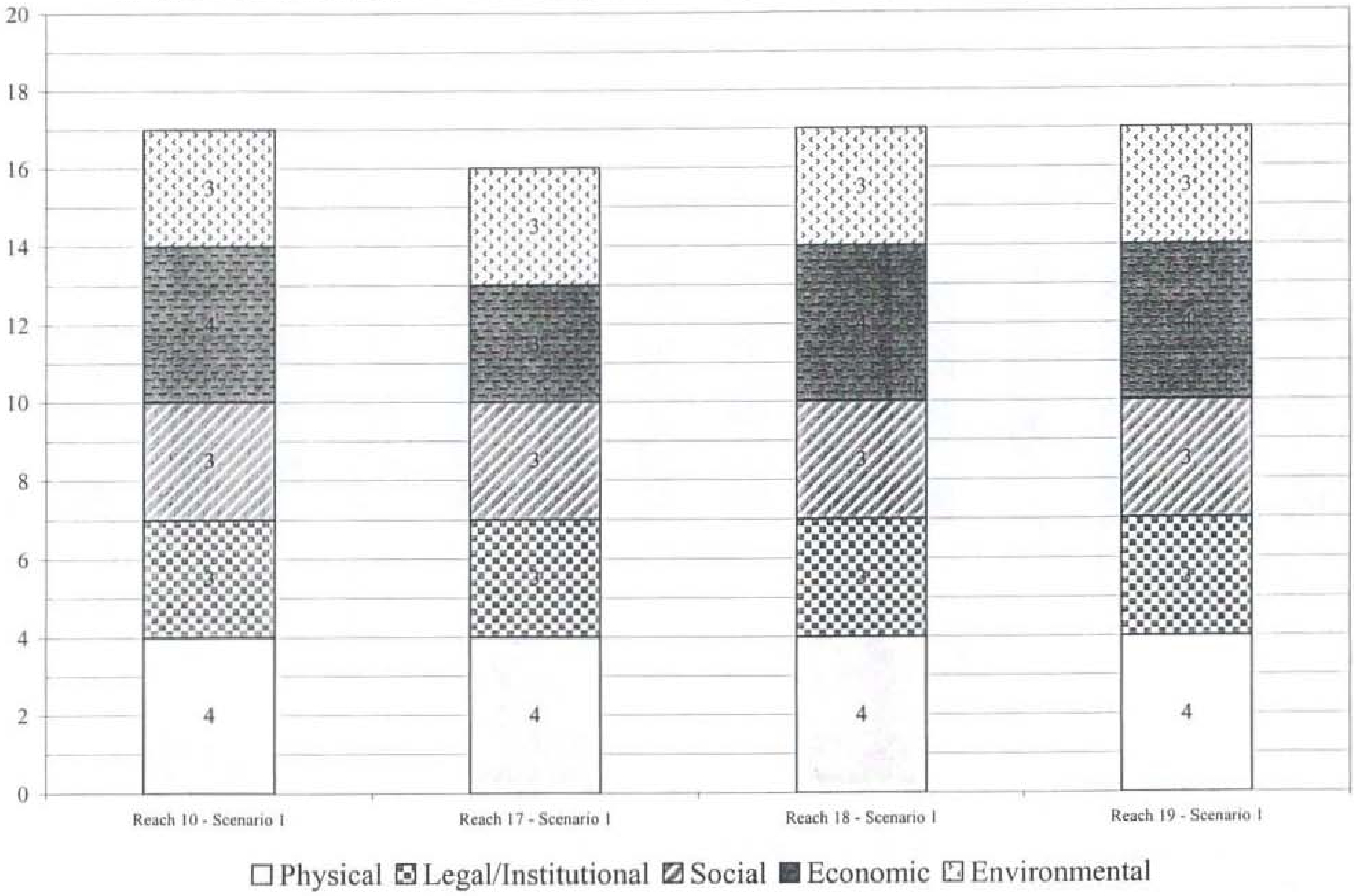


Figure 11.20

Scoring for Systems Integration and Management Alternatives with Diversions

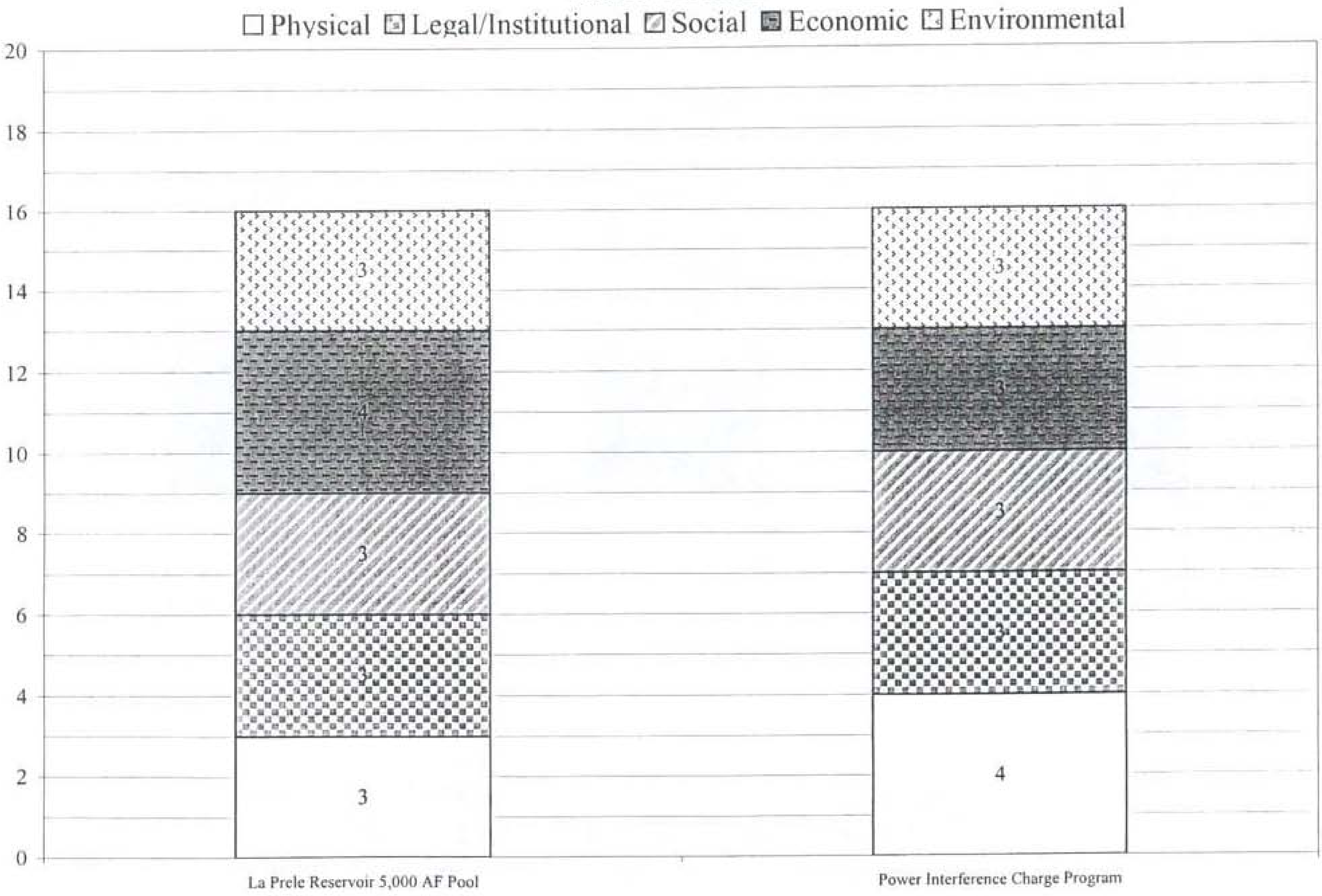


Figure 11.21

Scoring for Systems Integration and Management Alternatives with No Diversions in Any State

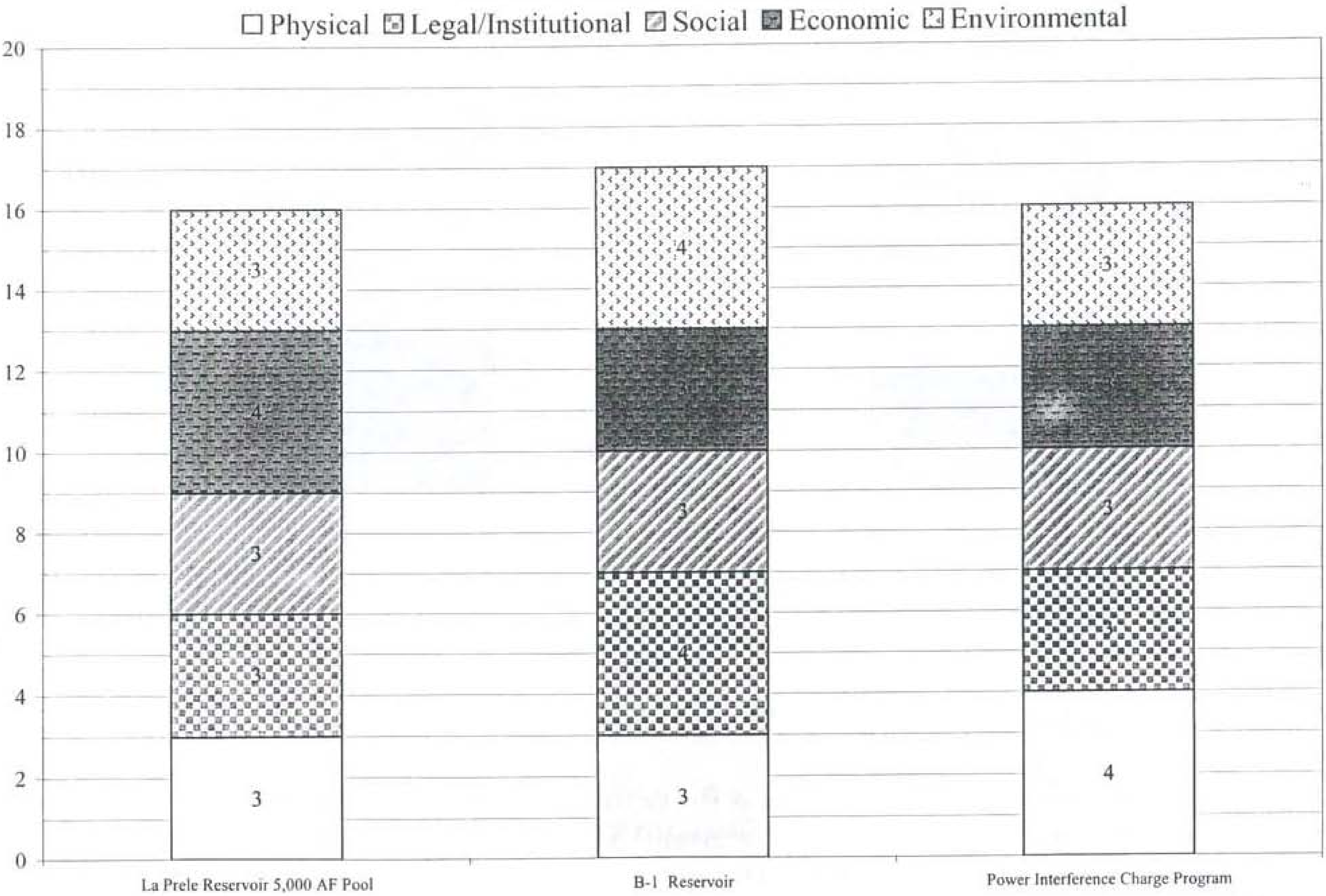
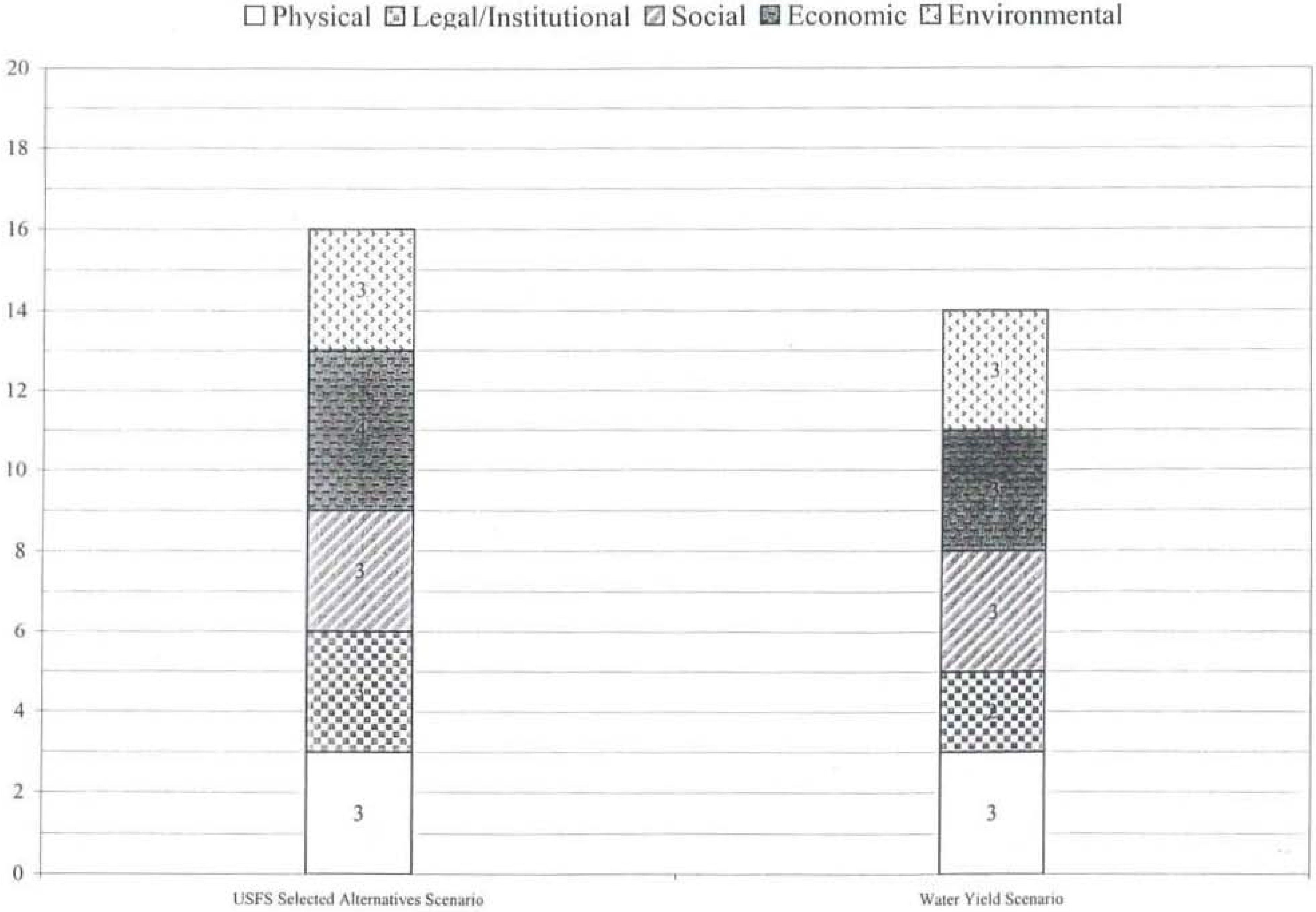


Figure 11.22

Scoring for Watershed Management Alternatives with No Diversions in Any State



12. References

Adelman, Don, *Potential Water Conservation by Center Pivot and Furrow Irrigators in Nebraska*, American Water Resources Association, 1995.

Allen, Richard G.,et al., "Water Conservation From a Hydrologic Viewpoint" *Choices*, 4th Quarter, 1995.

American Water Works Association, *Dual Water Systems*, 1983.

------, *Before the Well Runs Dry: A Handbook for Designing a Local Water Conservation Plan*, Volume 1, 1984.

------, *Water Audits and Leak Detection*, 1990.

------, *Alternative Rates*, 1992.

Banner Associates, Inc., *Preliminary Technical Data Report: Wyoming Coal Gas Project Water System*, January 1981a.

------, "Laramie River Operations Model," 1981b.

------, "Basin Electric Power Cooperative, Monthly Excel Spreadsheet Model," unpublished data, 1994.

BBC Research and Consulting, *Social and Economic Impacts of Water Transfers*, Texas Water Development Board, 1996.

Bentall, Ray, "Nebraska's Platte River: A Graphical Analysis of Flows" *Nebraska Water Survey Paper 53*, Conservation and Survey Division, Lincoln, NE, July 1982.

The Billings Gazette, "Suit Seeking Increased Logging Dismissed," May 23, 1999.

Billings, R. Bruce and W. Mark Day, "Water Rates as a Conservation Policy Option" *Presentation to the Arizona Section, American Water Resources Symposium*, October 1983.

Bishop-Brogdan Associates, Inc., *Contemplated Draft and Storage Yield of a Portion of La Prele Reservoir*, May 1995.

Bjorklund, L.J. and R.F. Brown, "Geology and Ground-Water Resources of the Lower South Platte River Valley Between Hardin, Colorado, and Paxton, Nebraska" *USGS Water Supply Paper 1378*, 1957.

Bleed, Ann, et al., "Environmental and Financing Optimization Analysis of Platte River Development Alternatives" *Economic*, June 1986.

Boyle Engineering Corporation, *San Miguel Water Supply Study: Phase I, Final Report*, Colorado Water Conservation Board, June 1989.

------, *Drought Analysis and Water Supply Study*, City of Greeley, CO, May 1994.

------, *Lake Powell Pipeline Feasability Study*, March 1995.

------, "Modeling and Schematic Design Technical Memorandum" *Denver Water Nonpotable Resuse Project*, 1999.

Bredehoeft, John, and Bern Hinckley, *The Impact of NPPD and CNPPID on the Platte River: Nebraska's Ground-Water Mound,* July 1998.

Brendecke, Charles M. and John J. Cassidy, *Mitigation Opportunities in Nebraska,* July 1998.

Bridges, Chris and Terry Moulton, "Monitoring Conservation Effectiveness in Pilot Demonstration Projects" *Water Conservation in the 21st Century: Conservation, Demand, and Supply*, American Water Resources Association, 1995.

"Bringing the River Back to the Future" *Proceedings of the 1996 South Platte Forum, Urban and Rural Watershed Management*, CWRRI, Northglenn, CO, October 29-30, 1996.

Brown and Caldwell, *Water Conservation Study*, City of Colorado Springs, April 1988.

Brown, F. Lee, et al., *Transfers of Water Use in New Mexico: New Mexico Water Resources Research Institute Technical Completion Report,* August 1992.

Burns, Alan W., "Hydrologic Analysis of the Proposed Badger-Beaver Creeks Artificial Recharge Project, Morgan County, Colorado" *USGS Water Resources Investigations*, 80-46, 1980.

Cady, Ralph E. and Marilyn Ginsberg, *Interpretive Study and Numerical Model of the Hydrogeology Upper Bib Blue Natural Resources District*, Conservation and Survey Division, Lincoln, NE, May 1979.

California Department of Water Resources, *A Guide to Water Transfers in California, Draft,* 1989.

------, *The 1991 Drought Water Bank,* January 1992.

------, *Final Drought Water Bank Environmental Impact Report*, November 1993a.

------, *The 1992 Drought Water Bank*, 1993b.

Callaham, R.Z. (ed.), "Case Studies of Watershed Projects in Western Provinces and States", *Wildland Resources Association*, Report 22, University of California, Berkeley, 1990.

Cappock, Ray, et al., "California Water Transfers: The System and the 1991 Drought Water Bank" *Sharing Scarcity Gainers and Losers in Water Marketing*, University of California Agricultural Issues Center, 1994.

Cassidy, John J., *The Central Nebraska Public Power and Irrigation District and the Nebraska Public Power District: Description of the Projects, Water Utilization, and Operations,* July 1998.

Cech, Thomas V., "Conjunctive Use of Ground Water and Surface Water in the South Platte" *Proceedings of the NWWA Western Regional Conference on Ground Water Management*, San Diego, CA, October 23-26, 1983.

------, "Conjunctive Use of Surface and Ground Water in the South Platte River Basin: A Case Study of the Central Colorado Water Conservancy District" *Ground Water Quality and Management Practices*, Deborah M. Fairchild, 1987.

Central Nebraska Public Power and Irrigation District (CNPPID), *U-2 Application for a Permit for Incidental Underground Water Storage & Recovery for Gosper, Phelps & Kearney Counties*, October 1984.

------, *U-12 Application for a Permit for Incidental Underground Water Storage & Recovery for Lincoln, Dawson & Frontier Counties*, June 1988.

------, *Surface Water Quality & Irrigation Management Field Demonstration Projects, 1996*, January 20, 1996.

------, *Surface Water Quality & Irrigation Management Field Demonstration Projects, 1997*, January 12, 1997.

------, *Comments on Kingsley Riprap Proposal*, Memorandum from Mike Drain to Kevin Boyd, February 12, 1999a.

------, Personal communication with Mike Drain and the Boyle team, 1999b.

------, Personal communication with Don Shepler and the Boyle team, 1999c.

------, Personal communication with Mike Duran, J. Kerkman, and the Boyle team, 1999d.

------, Written communication from Jeremie Kerkman, 1999e.

------, *Comments on Draft Water Conservation/Supply Study*, November 1999f.

Central Nebraska Public Power and Irrigation District (CNPPID) et al., Personal communication with CNPPID, NPPD, Nebraska Department of Water Resources, Tri-County NRD, and the Boyle team, February 2 and 3, 1999.

Central Nebraska Regional Water Conservation Task Force, *Comprehensive Water Conservation Plan*, 1994.

------, *Supplement to the Comprehensive Water Conservation Plan*, December 1996.

------, *Supplement II to the Comprehensive Water Conservation Plan*, 1998.

------, Personal communication with the Boyle team, 1999

Central Platte Natural Resources District (CPNRD), *Groundwater Management Plan*, Volume 1, 1993.

------, Personal communication with Duane Woodward and the Boyle team, 1999.

Central Platte Natural Resources District (NRD) and U.S. Department of the Interior (DOI), *Wood River Artificial Groundwater Recharge Demonstration Project Summary: High Plains States Groundwater Demonstration Program*, March 1998.

Chaney, Alberta H. and Gary C. Woodard, "Socioeconomic Impacts of Water Farming on Rural Areas of Origin in Arizona" *American Journal of Agricultural Economics*, December 1990.

Chisholm, Roderick A. II and Ronald L. Grimes, *Snowpack Augmentation by Cloud Seeding in Colorado and Utah*, 1979.

Ciliberti, V.A., "Sediment Yield and Runoff after Timber Harvest" *Proceedings of the Fourth Federal Interagency Sedimentation Conference, Volume I*, Las Vegas, NV, March 24-27, 1986.

Colorado Notebook - not dated, not titled.

Colorado State University, *Evaluations of Direct and Extra Area Effects of Utah Weather Modification Programs to Increase Water Supplies: Final Report and Supplemental Appendices to State Engineer's Office*, December 1992.

------, "SDF View" *Integrated Decision Support Group*, a model, 1999.

Colorado Water Resources Research Institute (CWRRI), "Weekly Crop Consumptive Use and Precipitation in the Lower South Platte River Basin, 1947-1975" *Technical Report No. 15*, February 1979.

------, *Proceedings: Colorado Water Engineering and Management Conference*, Fort Collins, CO, February 1989.

------, "Irrigation Water Conservation: Opportunities and Limitations in Colorado" *Completion Report No. 190*, October 1996.

------, "Colorado Water" *Water Partnerships - 22nd Annual Colorado Water Workshop*, October 1997.

Colorado Water Conservation Board, *An Analysis of Water Salvage Issues in Colorado*, Denver, CO. 1992.

Committee on Western Water Management, *Water Transfers in the West: Efficiency, Equity and the Environment*, National Academy Press, 1992.

"Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered Species Habitats Along the Platte River, Nebraska," July 1997.

Cummings, Ronald G. and Vahram Nercissiantz, "The Use of Water Pricing as a Means for Enhancing Water Use Efficiency in Irrigation: Case Studies in Mexico and the United States" *Natural Resources Journal*, Fall 1992.

Cuthbert, Richard W. and Pamela R. Lemoine, "A Review of Effective Conservation-Oriented Rate Structures" *American Water Resources Association*, 1995a.

------, "The Pricing of Reclaimed Water: Effective Strategies for Developing Reclaimed Water Charges" *American Water Resources Association,* 1995b.

Dennehy, Kevin F. and Jorge R. Ortiz-Zayas, "Bibliography of Water-Related Studies, South Platte River Basin-Colorado, Nebraska, and Wyoming" *Open File Report 93-106*, U.S. Geological Survey, Denver, CO, 1993.

Dennehy, Kevin F. et al., "South Platte River Basin-Colorado, Nebraska, and Wyoming" *Water Resources Bulletin*, V29, No.4, American Water Resources Association, August 1993.

Denver Water Department, *Annual Report,* 1997.

Dixon, Lloyd S. and Larry L. Dale, *The Impact of Water Supply Reductions on San Joaquin Valley Agriculture*, Rand, December, 1994.

Dixon, Lloyd S., et al., *California's 1991 Drought Water Bank: Economic Impacts in the Selling Regions*, Rand, 1993.

ECI, *City of Greeley Draft Water Conservation Technical Report*, December 1994.

Ellinghouse, Carol and George McCoy, "The Effects of Water Conservation on New Water Supply for Urban Colorado Utilities" *Completion Report No. 120*, CWRRI, December 1982.

"Endangered Species Management: Planning For Our Future" *Proceedings of the 1995 South Platte Forum*, CWRRI, Greeley, CO, October 25-26, 1995.

Engelbert, Ernest A. and Ann F. Scheuring, *Water Scarcity, Impacts on Western Agriculture,* 1984.

Farmer's Reservoir and Irrigation Company (FRICO), Personal communication with John Akolt and the Boyle team, 1999.

Federal Energy Regulatory Commission, *Hydroelectric Power Resources of the United States as of January 1992*, 1992.

Flack, J. Ernest, et al., "Achieving Urban Water Conservation: A Handbook" *Completion Report No. 180*, Colorado Water Resources Research Institute, September 1977.

Flowerday, Charles A., (ed.), "Flat Water: A History of Nebraska and Its Water" *Resource Report No. 12*, Conservation and Survey Division, Lincoln, NE, March 1993.

Fredericks, Jeffrey W., et al., "Decision Support System for Conjunctive Stream-Aquifer Management" *Journal of Water Resources Planning and Management*, March/April 1998.

Gilliland, Martha W., et al., "Water and Water Rights Transfers: A New Policy for Nebraska" *Water Resources Bulletin*, American Water Resources Association, February 1989.

Goecke, J.W., et al, "Hydrogeology of Parts of the Twin Platte and Middle Republican Natural Resources Districts, Southwestern Nebraska" *Nebraska Water Survey Paper No. 70,* April 1992.

Greeley Water Department, Personal communication with the Boyle team, April 5, 1999.

"Ground Water Recharge Projects in the Western United States - Economic Efficiency, Financial Feasibility and Legal/Institutional Issues (Part II), Draft Report High Plains States Groundwater Demonstration Program," Western States Water Council and U.S. Bureau of Reclamation, December 1997.

"Grow with the Flow; Growth and Water in the South Platte Basin" *Proceedings of the 197 South Platte Forum*, CWRRI, Longmont, CO, October 29-30, 1997.

Harvey, M.D., et al., "Gully Erosion" *U.S. Bureau of Land Management Technical Note 366,* March 1985.

Harr, R.D. and R.L. Fredriksen, "Water Quality after Logging Small Watersheds within the Bull Run Watershed, Oregon" *Water Resources Bulletin*, vol. 24, no. 5, October 1988, pp 1103-1111.

Harza Engineering Company, et al., *Middle Fork Powder River Dam and Reservoir Project, Conceptual Design Report*, Executive Summary, January 1986a.

------, *Middle Fork Powder River Dam and Reservoir Project, Conceptual Design Report, Volume II Appendix A, B, and C*, January 1986b.

------, *Summary Report, Cache La Poudre Basin Study, Water and Hydropower Resources Management Study*, Colorado Water Resources and Power Development Authority, January 1987.

------, *Final Report, Cache La Poudre Basin Study Extension,* Colorado Water Resources and Power Development Authority, December 1990.

------, *Water Utilization Study for the Sutherland Project, FERC Project No. 1835,* Volume I and Volume II-Appendices, NPPD, December 1993.

HDR Engineering, Inc., *Horse Creek Reservoir Level II Study Executive Summary,* November 1986a.

------, *Horse Creek Reservoir Level II Study,* November 1986b.

------, *Winter Stock Water Replacement Program, Tri-County Water Conservancy District*, March 1986c.

HDR Engineering, Inc., et al., *Final Report, Upper Gunnison-Uncompahgre Basin, Phase I, Feasibility Study, Volume I,* Colorado Water Resources and Power Development Authority, May 1989a.

------, *Summary Report, Upper Gunnison-Uncompahgre Basin, Phase I, Feasibility Study, Volume I,* Colorado Water Resources and Power Development Authority, May 1989b.

------, *Final Report, Upper Gunnison-Uncompahgre Basin, Phase I, Feasibility Study, Appendices,* Colorado Water Resources and Power Development Authority, May 1989c.

HDR Infrastructure, Inc., *Horse Creek Reservoir Level II Study, Final Report,* November 1986.

Hibbert, Alden R., "Managing Vegetation to Increase Flow in the Colorado River Basin" *U.S. Forest Service Rocky Mountain Forest and Range Experiment Station General Technical Report RM-66,* November 1979.

Hinckley, Bern S., *NPROAM Return Flow Parameters and Demand Adjustments*, July 1998.

Horton, Jerome S. and C.J. Campbell, "Management of Phreatophyte and Riparian Vegetation for Maximum Multiple Use Values" *U.S. Forest Service Rocky Mountain Forest and Range Experiment Station Research Paper RM-117*, April 1974.

Howe, Charles W., et al., "The Economic Impacts of Agriculture to Urban Water Transfers on the Area of Origin: A Case Study of the Arkansas River Valley in Colorado" *American Journal of Agricultural Economics*, December 1990.

Howitt, Richard, et al., *A Retrospective on California's 1991 Emergency Drought Water Bank*, California Department of Water Resources, March 1992.

Huffaker, Roy G. and Noremn K. Whittlesay, "Agricultural Water Conservatoin Legislation – Will It Save Water?" *Choices*, 4th Quarter, 1995.

Huntzinger, Thomas L. and Michael J. Ellis, "Central Nebraska River Basins, Nebraska" *Water Resources Bulletin*, V29, No.4, American Water Resources Association, August 1993.

Hurr, R.T. and P.A. Schneider, "Hydrogeologic Characteristics of the Valley – Fill Aquifer in Reaches of the South Platte River Valley, Colorado" *U.S. Geological Survey Open File Report*, Denver, CO, 1972.

Hydroscience Associates, Inc., *Depletions to the North Platte River Resulting from Groundwater Withdrawals for Irrigation from Whales Dam to the Nebraska – Wyoming State Line*, May 1997.

Hydrosphere Resource Consultants, *Systems Integration as a Water Supply Source for the Denver Metropolitan Area, Draft Report*, Colorado Department of Natural Resources, September 1992.

------, *Achieving Efficient Water Management: A Guidebook for Preparing Agricultural Water Conservation Plans*, U.S. Department of the Interior, December 1996.

------, *Incentive Pricing Handbook for Agricultural Water Districts*, U.S. Bureau of Reclamation, April 1997.

------, *Final Report Evaluating South Platte Storage Alternatives*, 1999.

Hydrosphere Resource Consultants and Colorado Division of Water Resources, *Denver Basin and South Platte River Basin Technical Study, Senate Bill 96-074, Technical Addendum 1 and Technical Addendum 2*, prepared for the Special Water Committee, April 1988.

Hydrosphere Resource Consultants, et al., *Metropolitan Water Supply Investigation Final Report (TAC Review Draft)*, Colorado Water Conservation Board, October 19, 1998.

Hydro-Triad, LTD., *Beebe Draw Diversion and Augmentation Program: Report No. 1, The Water Resources of Beebe Draw*, January 1985.

Jenkins, C. T., "Techniques for Computing Rate and Volume of Stream Depletion by Wells" *U.S. Geological Survey Open File Report*, 1967.

Jensen, Marvin E., *Estimated Consumptive Use in the North Platte River Basin in Wyoming*, Fort Collins, CO, July 1998.

Johns, Eldon L. (ed.), "Water Use by Naturally Occurring Vegetation (including an annotated bibliography)" *ASCE Committee on Irrigation Water Requirements, Irrigation and Drainage Division*, New York, NY, 1989.

Keifer, Jack C. and Jeffrey DeWitt, "Isolating the Impact of a Change in Rate Structure" *Water Conservation in the 21st Century: Conservation, Demand, and Supply*, American Water Resources Association. April 1995.

Kromm, David E. and White, Steven E., *Conserving Water in the High Plains*, Kansas State University Department of Geography, 1990a.

------, "Adoption of Water-Saving Practices by Irrigators in the High Plains" *Water Resources Bulletin*, December 1990b.

Labadie, John W. and John M. Shafer, *Exploring Ways of Increasing the Use of South Platte Water*, CWRRI.

Leaf, Charles F., "Potential Water Yield Increases from Cloud Seeding in the North Platte River Basin" *Platte River Hydrologic Research Center Research Paper*, PRHRC-4 Review Draft, June 1998.

Leaf, Charles I., "Watershed Management in the Rocky Mountains Subalpine Zone: The Status of our Knowledge" *U.S. Dept. Of Agriculture Forest Service Res. Paper RM-137*, Rocky Mountain Forest and Range Exp. Station, Fort Collins, CO, 1975, 31 pp.

------, *Potential Water Yield Increases from Cloud Seeding in the North Platte River Basin*, September 1998.

------, "Cumulative Hydrologic Impacts of U.S. Forest Service Management Practices on the Routt, Arapaho-Roosevelt, Pike, and Medicine Bow National Forests: Potential for Water Yield Improvement" *Platte River Hydrologic Research Center, Research Paper PRHRC-3*, January 1999.

League of Women Voters of Nebraska Education Fund (LWV), *Nebraska's Water, Nebraska's Wealth - Choices and Challenges*, 1997.

Lidstone and Anderson, Inc., *Goshen Irrigation District Rehabilitation Project, Level II Final Report*, December 1991.

------, *Goshen Irrigation District Rehabilitation Project-Siphons, Tunnels and Canals*, October 1992.

------, *Analysis of Guernsey Reservoir Silt Run, Final Report*, January 1993a.

------, *Instream Flow Evaluation for the North Platte River Drainage*, September 1993b.

------, *Goshen Irrigation District Horse Creek Re-regulating Reservoir Level*, December 1993c.

------, *Hill Irrigation District Improvements Project, Final Report*, October 1997.

Lund, Jay R. and Morris Israel, "Optimization of Transfers in Urban Water Supply Planning" *Journal of Water Resources Planning and Management,* January/February 1995.

MacDonnell, Lawrence J., *The Water Transfer Process as a Management Option for Meeting Changing Water Demands*, U.S. Geological Survey Grant 14-08-0001-G 1538, April 1990.

Maddaus, William O., *Water Conservation*, American Water Works Association, 1987.

Madej, M.A. and V. Ozaki, *Earth Surface Processes and Landforms*, vol. 21, no. 10, 1996, pp 911-927.

Mathiesen, Rebecca, *Policies and Opportunities for Water Conservation and Water Supply in the Platte River Basin in Wyoming*, Wyoming State Engineer's Office, January 1998.

McCarl, Bruce A., et al., "Evaluation of Dry Year Option Water Transfers from Agricultural to Urban Use" *Technical Report No. 175*, Texas Water Resources Institute, April 1997.

McHaney, Steven J., *Maximizing Recycled Water Use Through Market Assessment and Product Marketing*, American Water Resources Association, 1995.

McLaughlin Water Engineers, Ltd., *Platte River Basin Study*, Prepared for Western Water Policy Review Advisory Commission, July 1997.

Metropolitan Water District (MWD), *Regional Impacts of the Palo Verde Test Land Fallowing Program*, Cubed, M., December 1994.

------, *Palo Verde Test Land Fallowing Program—Final Report*, Great Western Research, August 1995.

Michelsen, Ari M. and Robert A. Young, "Optioning Agricultural Water Rights for Urban Water Supplies During Drought" *American Journal of Agricultural Economics,* November 1993.

Miller, K., "Current Status and Future Trends" *Municipal Wastewater Reuse: Selected Readings on Water Reuse,* U.S. Environmental Protection Agency, 1991.

Missouri Basin States Association (MSBA), "Ground Water Depletion" *Technical paper supplement to Missouri River Basin Hydrology Study,* 1982a.

------, "Transmissivity and Stream Depletion Factor Maps" *Appendix II of Ground Water Depletions Technical Paper,* 1982b.

Morel-Seytoux, H.J., et al., *The Impacts of Improving Efficiency of Irrigation Systems on Water Availability in the Lower South Platte River Basin*, CWRRI.

Moore, Nancy Y., et al., *Assessment of the Economic Impacts of California's Drought on Urban Areas*, Rand, 1993.

Morris, John R. and Clive V. Jones, *Water for Denver: An Analysis of the Alternatives*, Environmental Defense Fund, 1980.

Morrison-Knudsen Engineers, Inc., *Final Report, Cherry Creek Water Resources Project, Phase I Feasibility Study*, Colorado Water Resources and Power Development Authority, December 1987.

National Water Company, Personal communication with Dale Shaffer and the Boyle team, 1999.

Natural Resources Consulting Engineers, Inc. (NRCE), *Woodward-Clyde and NRCE, Background Hydrological and Economic Data for the Platte River EIS*, 1999a.

------, *Draft Design Summary: Transfer of Water from the Big Wind River to the North Platte River*, unpublished report, 1999b.

------, Personal communication with the Boyle team, 1999c.

Nebraska Department of Water Resources (DWR), Personal communication with the Boyle team, 1999.

Nebraska Natural Resources Commission (NNRC), "Potential Projects" *State Water Plan Publication No. 301-4, Status Summary Volume 1*, March 1979.

------, *State Water Planning and Review Process, Transferability of Surface Water Rights*, May 1983.

------, *Policy Issue Study on Supplemental Water Supplies*, January 1984.

------, *State Water Planning and Review Process, Policy Issue Study on Water Use Efficiency*, April 1985.

------, *Policy Issue Study on Integrated Management of Surface Water and Groundwater*, April 1986.

------, *Report on the South-Central Area Ground Water Planning Study*, August 1990.

------, *Estimated Water Use in Nebraska*, 1995.

Nebraska Public Power District (NPPD), Personal communication with Barry Campbell and the Boyle team, 1999a.

------, Personal communication with Frank Kwapnioski, Barry Campbell, and the Boyle team, 1999b.

------, Personal communication with Frank Kwapnioski and the Boyle team, 1996c.

Nebraska Wildlife Federation, Personal communication with D. Hovorka and the Boyle team, 1999.

Northern Colorado Water Conservancy District (NCWCD), Personal communication with the Boyle team, 1999a.

------, Personal communication with Eric Wilkerson and the Boyle team, 1999b.

Oad, Ramchand and Michael DiSpigno, "Consumptive Use and Return Flows" *Completion Report No. 189*, Colorado Water Resources Research Institute, December 1996.

Office of Water Conservation and the Citizen's Advisory Committee Master Plan Task Force, *1997 Denver Water Conservation Master Plan,* 1997.

Olsson Associates, *North Platte Natural Resources District Groundwater Management Plan,* November 1993.

Palumbo, Mark R. and Jeffrey S. Foster, *Whalen to Lewellen Surface Water Irrigation Groundwater Return Flow Analysis,* July 1998.

Platte River Modeling, *Surface Water Models Application for North Platte and Platte River Operations,* February 1998.

Pochop, Larry, et al., "Consumptive Use and Consumptive Irrigation Requirements in Wyoming" *WWRC Publication #92-06,* October 1992.

PRC Engineering, Inc., *Grand Mesa Water Supply Study, Final Report,* Colorado Water Conservation Board, December 1986.

Purcell Consulting, P.C., *Changes in Municipal and Industrial Water Use in Portions of the Platte River Basin in Wyoming and Nebraska,* July 1998a.

------, *Deer Creek Dam and Reservoir: Report for the Wyoming Attorney General's Office,* July 14, 1998b.

Resource Consultants, Inc., *Droughts and Their Effects on the Water Supplies for the City of Fort Collins, Colorado,* July 1985.

Rice, Teresa A. and Lawrence J. MacDonnell, "Agricultural to Urban Water Transfers in Colorado: an Assessment of the Issues and Options" *Completion Report No. 177,* Colorado Water Resource Research Institute at Colorado State University, December 1993.

Richard P. Arber Associates, *Denver Water Non-Potable Reuse Project NPRP/SWC Schematic Design Report*, 1999.

Ringler, N.H. and J.D. Hall, "Effects Of Logging On Water Temperature And Dissolved Oxygen In Spawning Beds" *Transactions of the American Fisheries Society*, vol. 104, no. 1, 1975, pp 111-121.

Rowe, L.K. and C.H. Taylor, "Hydrology And Related Changes After Harvesting Native Forest Catchments And Establishing *Pinus radiata* Plantations, Part 3, Stream Temperatures" *Hydrological Processes*, vol. 8, no. 4, 1994, pp 299-310.

Rozaklis, Lee, *What Water Crisis?*, 1997.

------, *Final Report Evaluating South Platte Storage Alternatives,* 1998.

R.W. Beck and Associates, Inc., *Deer Creek Project Feasibility Study Calculation Book 3 of 4 Feasibility Report Reservoir Yield Studies,* 1984.

R.W. Beck and Associates, Inc. and Dames & Moore, *St. Vrain Basin Reconnaissance Study, Summary Report, Colorado Water Resources and Power Development Authority*, February 1986.

Sando, Steven K., et al., "Hydrologic Impacts of Improved Irrigation Efficiencies" *Journal of Irrigation and Drainage Engineering*, May 1988.

Schroeder, Dewayne R., "Analytical Stream Depletion Model" *Ground Water Software Publication No. 1*, Office of the State Engineer, Colorado Division of Water Resources, 1987.

Sear-Brown Group, *Expanded Reconnaissance Study Lower South Platte River Sustainment Project*, March 1997.

"Seeking an Integrated Approach to Watershed Management in the South Platte Basin" *Proceeding of the 1993 South Platte Forum*, CWRRI, Fort Collins, CO, October 67-28, 1993.

Simons & Associates, Inc., *Platte River System Hydrologic Analyses, Appendix IV*, January 1990.

Simpson, Hal D. and Chuck Lile, *Denver Basin and South Platte River Basin Technical Study, Senate Bill 96-074*, prepared for the Special Water Committee, April 1998.

Sharpe, William E., et al., *The Impact of Mass Distribution of Water Conservation Devices and a Water Conservation Rate Structure on Residential Water Use*, Institute for Research on Land and Water Resources, 1982.

Smith, D.H., et al., "Irrigation Water Conservation: Opportunities and Limitations in Colorado" *Completion Report No. 190*, Colorado Water Resources Research Institute, 1996.

South Platte Natural Resources District, *South Platte Natural Resources District Groundwater Management Plan*, June 1994.

States West Water Resources Corporation, *Irrigated Lands Mapping North Platte River Basin, Wyoming*, July 1998.

State of Wyoming, *Compacts, Treaties, and Court Decrees*, compiled under the direction of G. Christopulos, State Engineer, 1982.

"Statutes, Policies and Selected References Pertinent to Water Conservation and Water Supply in Nebraska's Platte River Basin, Cooperative Agreement on Platte River Research," December 1987.

Stednick, John D., "Monitoring The Effects Of Timber Harvest On Annual Water Yield" *J. of Hydro.*, 176: 79-95, 1996.

Steppuhn, H. and J. Waddington, "Conserving Water and Increasing Alfalfa Production Using A Tall Wheatgrass Windbreak System" *Journal of Soil and Water Conservation*, 51(5). September-October, 1996.

Taylor, R. Garth and Robert A. Young, "Economic Impacts of Rural to Urban Water Transfers: A Colorado Case Study" *Colorado Water Engineering and Management Conference*, February 27-28, 1991.

Teegarden, Travis P., *Quantification of Evapotranspiration and Irrigation Water Requirements for Wyoming*, M.S. thesis for U. of Wyoming Dept. of Agricultural Engineering, May 1992.

Troendle, C.A. and R.M. King, "The Effect Of Timber Harvest On The Fool Creek Watershed, 30 Years Later" *Water Resources Bulletin,* 21: 12 (1915-1933), 1985.

Troendle, C.A, et al., "The Coon Creek Water Yield Augmentation Pilot Project" *Proceedings 66th Western Snow Conference*, Colorado State University, Ft. Collins, Snowbird, UT, April 21-23, 1998, pp. 123-130.

Tudor Engineering Company, et al., *Final Report, Clear Creek Project Phase I – Feasibility Study, Volume I,* Colorado Water Resources and Power Development Authority, November 1987.

------, *Final Report, Clear Creek Project Phase I, Step 2 – Feasibility Study*, Colorado Water Resources and Power Development Authority, June 1989.

Tuttle Applegate, Inc., *Feasibility Study for Sedgwick Reservoir*, Groundwater Appropriators of the South Platte River Basin Inc., February 1998.

Twin Platte Natural Resources District, personal communication with Kent Miller and the Boyle team, 1999.

U.S. Army Corps of Engineers (USACOE), *The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Illustrative Examples,* February 1981.

------, *Metropolitan Denver Water Supply Final Environmental Impact Statement (EIS), Draft Appendix 4A: Water Sources Not Selected for Use in Alternative Scenarios*, Omaha, NE, May 1986.

------, *Final Environmental Impact Statement for Regulatory Permits,* September 1987.

------, *Metropolitan Denver Water Supply Final Environmental Impact Statement (EIS) Summary*, Omaha, NE, March 1988.

U.S. Bureau of the Census Web Page, *Annual Time Series of Population Estimates 1991 to 1996 and 1990 Census Population for Places,* 1997.

U.S. Bureau of Reclamation (USBR), *Silting and Seepage Investigations, North Platte Project - Wyoming - Nebraska, Final Report*, March 1963.

------, *Area Capacity Tables for Glendo Reservoir,* March 1975.

------, *Special Report on the North Platte Project: Rehabilitation and Betterment Program Investigations Wyoming - Nebraska,* August 1983.

------, *Section 79-SOD2-C of Memorandum No. DEC-GL-3620-1,* June 1992.

------, *North Platte River Water Utilization Model Documentation*, June 1997.

------, Unpublished hydropower database, April 1999.

U.S. Bureau of Reclamation Great Plains Region, Prairie Bend Unit P-S MBP, *Nebraska Regional Director's Planning Report/Draft Environmental Statement Hydrology Appendix Volume 1 of 3*, Grand Island, NE, May 1989.

U.S. Bureau of Reclamation Lower Missouri Region, *Water Use Management in the Upper Platte River Basin*, August 1982a.

------, *Water Use Management in the Upper Platte River Basin, Appendix 2 - Hydrology, Vol. 1 of 2*, August 1982b.

------, *Water Use Management in the Upper Platte River Basin, Appendix 2 - Hydrology, Vol. 2 of 2*, August 1982c.

U.S. Bureau of Reclamation Nebraska-Kansas Office, *South Divide Canal Project Report*, Grand Island, NE, October 1982.

U.S. Congressional Office of Technology Assessment, *Water-Related Technologies for Sustainable Agriculture in U.S. Arid/Semi-Arid Lands, OTA-F-212*, October 1983b.

U.S. Department of Agriculture (USDA) Farm Service Agency, *Fact Sheet: Conservation Reserve Program, February 1997*, 1999a.

------, Personal communication with Ed Buck, Price Support Programs, and the Boyle team, 1999b.

U.S. Department of Agriculture National Agricultural Statistics Service (USDA-NASS), *Agricultural Land Values and Agricultural Cash Rents*, April 1999a.

------, *Census of Agriculture—State Data, 1997* (via Internet), 1999b.

U.S. Department of Agriculture (USDA) Soil Conservation Service, *Upper North Laramie River Watershed, Albany County, Wyoming: Final Environmental Impact Statement*, 1980.

U.S. Department of the Interior (USDOI), *Water and Power Resources Data, Project Data*, 1981.

------, *Summary Report, Upper Platte River Study*, September 1983.

U.S. Fish and Wildlife Service (USFWS), *Volume I – Biological Opinion on the Federal Energy Regulatory Commission's Preferred Alternative for the Kingsley Dam Project (Project No. 1417) and North Platte/Keystone Dam Project (Project No. 1835)*, Grand Island, NE, July 1997a.

------, *Volume II: Appendix A – Cooperative Agreement for Platte River Research and Other Efforts Relating to Endangered habitats Along the Central Platte River, Nebraska (with Attachments and Appendices)*, July 1997b.

U.S. Forest Service (USFS), *Final Environmental Impact Statement for the Pike - San Isabel National Forest Land and Resource Management Plan*, Rocky Mountain Region, Denver, CO, 1982.

------, *Final Environmental Impact Statement for the Medicine Bow National Forest Land and Resource Management Plan*, Rocky Mountain Region, Denver, CO, 1984.

------, *Forest Service Handbook and Draft Supplements, Soils Management Handbook,* 1991a.

------, *Watershed Conservation Practices Handbook*, 1991b.

------, *Final Environmental Impact Statement for the Arapaho - Roosevelt National Forest Land and Resource Management Plan,* Rocky Mountain Region, Denver, CO, 1997a.

------, *Final Environmental Impact Statement for the Arapaho - Roosevelt National Forest Land and Resource Management Plan, Appendix A,* Rocky Mountain Region, Denver, CO, 1997b.

------, *Final Environmental Impact Statement for the Routt National Forest Land and Resource Management Plan,* Rocky Mountain Region, Denver, CO, 1997c.

U.S. Geological Survey (USGS), *Estimated Use of Water in the United States*, electronic database, 1990.

------, *Estimated Water Use in Nebraska 1990,* Nebraska District and Nebraska Natural Resources Commission, 1994.

------, *Estimated Use of Water in the United States,* electronic database, 1995.

------, Personal communication with Bob Swanson and the Boyle team, 1999.

University of Nebraska Extension Service, Personal communication with Joel Schneekloth and the Boyle team, 1999.

University of Nebraska, Lincoln, *Groundwater Atlas of Nebraska, Resource Atlas No, 4,* Conservation and Survey Division, 1986.

------, *1997/1998 Nebraska Farm Real Estate Market Development Guide,* 1999.

Vaux, Henry J., et al., "Thoughts for Future Water Policy" *Sharing Scarcity Gainers and Losers in Water Marketing,* University of California Agricultural Issues Center, 1994.

Waddington, Ralph, "Water Supplies for the West" *Water Conservation in the 21st Century: Conservation, Demand, and Supply*, American Water Resources Association, 1995.

Wahl, Richard W. and Frank H. Osterhoudt, *Voluntary Transfers of Water in the West, National Water Summary,* 1985.

Warner, James W., et al., "Recharge as an Augmentation Plan" *Groundwater Program Technical Report No. 21*, CWRRI, March 1994.

Water Management Committee (WMC), *Cooperative Agreement Demonstration Projects Proposal Draft,* July 13, 1999.

"Water Partnerships: Can Competing Users Cooperate to Manage A Vital Resource…And Live Happily Ever After?" *Proceedings of the 22nd Annual Colorado Water Workshop*, Western State College, Gunnison, CO, July 30-August 1, 1997.

"Water and Related Land Resources of the Green River Basin, Wyoming" *Wyoming Water Planning Program Report No. 3*, September 1970.

"Water and Related Land Resources of the Platte River Basin, Wyoming" *Wyoming Water Planning Program Report No. 9*, September 1971.

West Water Engineering, *Ute Water Pipeline EIS*, 1997.

Western Water Consultants, Inc., *Report on Upper Laramie River Storage Projects - Level II, Volume II Dodge Dam and Reservoir*, 1993.

Western Water Policy Review Advisory Commission, *Water in the West: The Challenge for the Next Century*, June 1998.

Wolfe, M.D. and J.W. Williams, "Rates of Landsliding as Impacted by Timber Management Activities" *Northwestern California. Bulletin of the Association of Engineering Geologists*, vol. 23, no. 1, February 1986, pp 53-60.

W.W. Wheeler and Associates, *Riverside Water Study, Riverside Irrigation District*, December 1979.

------, *Feasibility Study, Enlargement of Julesburg Reservoir, Logan and Sedgwick Counties, Colorado*, May 14, 1998.

Wyoming State Engineer's Office (SEO), *Wyoming Water Planning Program, The Wyoming Framework Water Plan*, May 1973.

------, 100-Page Bibliography received from Becky Mathisen, December 1998.

------, Personal communication with John Barnes and the Boyle team, 1999a.

------, Personal communication with the Boyle team, 1999b.

------, Personal communication with Rod Oliver and the Boyle team , 1999c.

Wyoming Water Development Commission, State of Wyoming, *1998 Water System Survey Report*, 1998a.

------, *1998 Legislative Report*, 1998b.

------, *1998 Water System Survey Report The Platte River Basin in Wyoming and Nebraska, (1940-1996)*, 1998c.

APPENDIX A

Summary of Flow Conditions for the Platte River for the Historical 1975-1994 Water Year Period

January 5, 1999

SUMMARY OF FLOW CONDITIONS FOR THE PLATTE RIVER FOR THE HISTORICAL 1975-1994 WATER YEAR PERIOD

As required by Milestone W14-1 of the Cooperative Agreement, the Water Management Committee (WMC) has summarized flow conditions in the associated habitats in central Nebraska and at the state lines for the historical water year period of 1975 through 1994. It is important to note that these summaries of flow conditions for the historical period are for a monthly planning analysis to evaluate, screen, and compare water conservation/supply alternatives.

The attached tables list the monthly values in acre-feet obtained from USGS records for this historical period for the following river gage locations:

Table 1: North Platte River near Northgate, Colo. (Near Colo.-Wy. State line); USGS #06620000
Table 2: North Platte River at Wyoming-Nebraska State line; USGS #06674500
Table 3: South Platte River at Julesburg, Colo. (Near Colo.-Nebr. State line); USGS #06764000
Table 4: North Platte River at Lewellen, Nebr. (Inflow to Lake McConaughy); USGS #06687500
Table 5: Platte River near Overton, Nebr. (Start of Big Bend Habitat); USGS #06768000
Table 6: Platte River near Grand Island, Nebr. (End of Big Bend Habitat); USGS #06770500

In the performance of the Water Conservation and Supply Study, the Consultant will utilize the historical monthly river loss factors developed by the WMC per Milestone W14-1 when routing different water conservation/supply alternatives in order to compare an alternative's impact on historic flows at the above listed locations.

The objective of developing and implementing a water conservation/supply component for the first increment of a Program is to produce annually on average at least 60,000 acre-feet of net hydrologic benefits ("reducing shortages to the target flows as measured at Grand Island") in the associated habitats. Tables 7 and 8 list the monthly shortages and excesses in flows at the Grand Island Gage for the historic 1975-94 period with respect to the USFWS (July 1997) weighted average monthly species instream flow recommendations or targets which are given in Table 9. The designation of wet, average, and dry years in Tables 7, 8, and 9 are based on USFWS biological recommendations; wet year flows are recommended to occur 33% of the time, average year flows to occur 42% of the time, and dry year flows to occur no more than 25% of the time.

Tables 1 through 8 are contained in a spreadsheet called "PRgage2" currently located on the CNPPID's FTP site. Access to this FTP site is as follows:
Host Name: 164.119.100.4
Host Type: Automatic detect
User ID: anonymous
Password: guest
Directory: /pub/data/mad/w14-1

The most important locations for the Consultant to compare the impacts on river flows are at Overton and Grand Island in the habitat in order to judge if a net reduction in shortages to the target flows would have occurred historically if an alternative had been implemented. For example, the best water conservation/supply alternative would increase flows at Grand Island over historic conditions during months of shortage while reducing flows from historic conditions at Grand Island only during months of excess.

The actual operations of implemented water conservation/supply alternatives as with the operations of the states' water plans (Lake McConaughy Environmental Account, Pathfinder Modification Project, and Tamarack Plan) will be tracked by an accounting system developed by the WMC in accordance with Milestone W14-1. Although these Program waters will be accounted for, tracked, and compared to modeled yields and historic flow conditions and trends, the modeled annual yields of water conservation/supply projects and the states' water plans will not be used as a Program compliance criteria or milestone. As stated in the October 5, 1998 Memorandum from USFWS on Milestones for the First Program Increment, yields will vary over time due to hydrologic swings through wet and dry cycles. It is impossible to verify with flow measurements what "really" would have happened if the projects and plans did not exist. Differences in flow caused by the projects and plans could be well within the error band of making flow measurements at river gage locations and well within the variability of hydrologic cycles.

The October 5, 1998 memorandum states that the milestones for water conservation/supply projects and the three states' water plans will be based on the construction and implementation of the agreed upon projects and plans. The USFWS memorandum indicates that the actual yield of the projects and plans as determined by the tracking and accounting system will be compared against previous model results and analysis and any concerns generated by widely differing expectations will be brought to the attention of the Governance Committee for discussion and possible Program modification.

Further analysis by the WMC of trends and the variations due to hydrologic cycles in the historical 1975-94 data presented for the above locations will assist in future discussions on yields resulting from the three states' plans and the water conservation/supply projects. The comparison of yields from the future accounting system to yields from previous models and analysis must recognize historical hydrologic trends and cycles in order to see if differences are within natural variations and not under the control of project operators.

TABLE 1

NORTH PLATTE RIVER NEAR NORTHGATE, COLO. (Near Colo.-Wy. State line); USGS #06620000

Water Year

ACRE-FEET

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	7040	7020	4960	4280	3990	6250	14380	66780	76510	86070	20340	7030	304640
1976	5820	4960	5300	4380	4610	8830	28660	41690	42610	26920	15760	7130	196650
1977	6390	5230	2090	1690	2340	3820	13180	15560	14710	7550	7680	4750	84990
1978	5180	4190	5140	5930	5440	8630	33970	61000	126200	80560	19020	7670	362930
1979	5610	5270	4410	4920	4990	6260	56850	111700	114200	62250	23260	7270	405990
1980	5670	5860	5130	5100	4880	9040	69220	131600	80030	40640	10060	6380	373610
1981	6110	5690	5380	3570	3440	7860	7810	13010	31130	17090	7510	5820	114420
1982	6720	7210	11450	5940	3770	14100	26930	60560	81310	84620	31310	17190	351110
1983	15790	10760	7390	5610	5350	10560	32300	83690	196100	140600	46890	12750	567790
1984	13340	13530	11810	10870	7700	9130	35300	224400	140700	87220	39470	20990	614460
1985	20020	17230	10430	9970	8390	16400	75120	98980	71900	37690	16500	8950	391580
1986	17300	11970	10860	9580	11050	44410	90290	116900	164200	77000	25000	14930	593490
1987	17890	18440	10120	4870	5870	9850	37810	40550	30910	15190	8620	4060	204180
1988	5030	4860	4750	4580	5400	7160	77110	82030	72100	20500	7170	3620	294310
1989	3980	6400	6140	3830	3800	18730	29210	16320	28080	14310	8850	4650	144300
1990	4270	5900	4360	4230	4120	8550	28920	14390	48570	30880	9400	4650	168240
1991	7400	7040	4270	3810	4080	7370	17010	41440	74700	21520	10000	4950	203590
1992	3330	4690	4720	2820	3970	10440	16000	22910	33710	19810	8600	4180	135180
1993	3970	5940	4230	4680	4950	10320	30650	85290	91950	44310	15560	8870	310720
1994	10620	11030	7480	5340	4920	10340	32300	38020	29090	10750	5940	2930	168760
AVG	8574	8161	6521	5299	5153	11403	37650	68341	77436	46274	16847	7939	299597

TABLE 2

NORTH PLATTE RIVER AT WYOMING-NEBRASKA STATE LINE; USGS #06674500

Water Year

ACRE-FEET

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	33020	23860	21330	18570	15850	18120	25820	29310	50410	105900	74760	42510	459460
1976	31300	22560	20590	17940	17030	15470	18650	33470	39970	88720	71240	42860	419800
1977	33810	19810	18690	15880	13170	13070	13860	30960	37340	80520	54910	36620	368640
1978	20280	16920	16630	14090	12670	14770	15960	61400	40250	79720	65190	40150	398030
1979	27350	20650	17900	15050	14540	15820	17200	20510	48190	84140	70530	32780	382660
1980	22750	17680	16910	16220	19750	18400	97420	166100	102500	91840	82140	41660	693370
1981	23340	16970	13850	11460	9390	9530	8570	7570	38180	93090	74980	38640	345570
1982	24530	16750	13530	10500	8290	8650	8840	23020	14910	81980	85580	44700	341280
1983	29510	15790	13830	12100	9720	8800	61380	285100	418300	440900	353600	283600	1932630
1984	44950	30730	28700	27000	61170	218400	249000	413500	449400	232200	202400	120800	2078250
1985	56960	45130	46060	40190	22910	121900	41990	40490	77480	92470	80670	59880	726130
1986	30980	19480	16450	17610	15400	34380	124200	126300	235600	248000	95900	87690	1051990
1987	102500	86520	47000	22070	13320	15720	45010	37320	46390	80910	61330	46430	604520
1988	26270	17100	14550	12520	11330	12410	28290	54340	43320	85960	73520	45580	425190
1989	27900	17080	13560	11970	10270	11210	10860	17500	34950	79350	65250	40780	340680
1990	18420	15020	12830	11540	9470	11780	11520	2700	10200	85030	63080	35690	287260
1991	20500	14810	11750	10390	8580	8640	8410	10830	56680	72870	67740	44660	335860
1992	22340	15290	13450	11750	10160	10390	9180	9520	2920	64450	72600	39320	281370
1993	18930	15730	12510	10220	8240	13250	9950	25540	30020	78890	76590	41440	341310
1994	25000	16600	13660	11540	10120	10680	9430	25850	43680	80270	70260	39320	356390
AVG	32032	23224	19189	15931	15069	29569	40777	71067	90934	117351	93114	60256	608520

TABLE 3

SOUTH PLATTE RIVER AT JULESBURG, COLO. (Near Colo.-Nebr. State line); USGS #06764000

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	ACRE-FEET												
1975	8233	7900	19275	28899	31283	15082	11115	14515	81644	4772	4776	7882	255376
1976	8396	11760	26547	35474	25944	30900	3834	5708	3033	1414	1123	2836	161969
1977	4582	3779	7434	9878	12793	25012	20001	10358	7948	2432	3295	2817	110329
1978	5885	5088	6448	7900	10116	11780	4336	3610	13585	1930	1043	803	72524
1979	5387	4963	6317	9531	29476	14856	17613	44225	260826	19704	42599	19341	474838
1980	16927	32079	50523	69513	97091	89236	129620	610056	253964	8348	2214	10346	1369917
1981	8764	17488	29488	43037	22090	19948	23645	22241	41419	2817	2698	1327	232962
1982	5793	6018	12411	15215	23147	10982	5462	5558	15439	21995	3880	11839	138739
1983	7946	16336	48258	91458	69779	94268	167088	418393	726208	311048	82740	63287	2086809
1984	51352	51546	60635	95405	106017	66807	163575	340939	165788	13494	54454	116866	1286878
1985	149256	140291	84278	74162	91379	33816	9142	119453	53693	8660	7593	30972	802695
1986	45759	28731	58344	32354	53137	21600	111273	21346	161752	6829	3727	46929	641781
1987	28245	35288	55851	52387	45053	96099	57477	192075	132873	10965	6395	26959	740667
1988	12873	17568	20896	59119	95683	56747	30492	48077	38676	3925	3138	5629	392823
1989	8279	6407	29109	48734	41016	33435	9963	2803	8577	1864	3221	18474	211882
1990	7646	4427	8733	55150	40344	59068	61960	8263	5798	1821	4854	8727	266791
1991	10616	9483	27745	49240	43745	23740	15388	6278	53363	3064	3677	17990	264329
1992	9594	6268	15483	49113	57834	77718	42397	3191	28247	16814	28741	37557	370957
1993	24678	11849	48345	52810	52931	64247	37724	9136	10251	2878	2908	41895	359652
1994	32670	16040	36010	48240	42380	32950	13900	5270	3430	1560	1230	1240	234920
AVG	22594	21715	32607	48881	49562	43415	48050	94575	103326	22317	13115	23686	523842

TABLE 4

NORTH PLATTE RIVER AT LEWELLEN, NEBR. (Inflow to Lake McConaughy); USGS #06687500

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
	ACRE-FEET												
1975	120418	95248	94474	89912	81800	78008	94216	81800	76234	59735	37536	65134	972514
1976	107208	97092	96596	93919	85905	73112	73102	71467	57791	25194	51797	72316	905501
1977	110263	88444	85449	67935	75631	75909	71198	65505	54816	28479	47187	61310	832126
1978	88464	78923	73132	69423	69224	87968	68187	99449	84824	59578	56558	73836	909566
1979	101892	83347	93621	66447	100425	91975	71049	63020	59049	51186	67812	91205	941028
1980	97192	80451	92971	74857	97410	85330	129602	228063	135723	40701	43808	71208	1177314
1981	97449	83347	78209	67495	59941	63881	56268	52035	30435	44434	59073	62718	755285
1982	92153	77396	71525	73469	68173	61798	49649	59223	48550	54852	81446	97136	835371
1983	106197	84576	76603	74937	55822	69488	91733	313413	438691	396224	328428	322755	2358865
1984	127638	92372	97489	103142	127083	257498	337493	425461	505376	215051	147434	167130	2603165
1985	144121	114131	103261	93720	75512	158700	93324	61978	70720	36917	47558	101085	1101027
1986	117919	83287	89773	86183	87393	85429	175936	193847	254681	243098	84933	155744	1658226
1987	176075	148564	113635	83188	69026	88524	94296	114369	83049	48118	89178	102567	1210588
1988	99631	82950	73350	67360	73885	76464	74738	131189	60513	33910	38859	74778	887626
1989	100682	80966	73191	83704	62163	64250	54957	47612	23370	10169	23637	54853	689574
1990	82038	73707	56688	71313	52400	62175	60517	53906	26779	15920	35604	39626	630672
1991	74560	69363	59326	52563	50490	53578	46081	52075	112623	29276	19940	58537	678413
1992	76127	67657	57502	56869	47312	56151	42695	14981	27360	39251	25514	46860	558280
1993	64160	63139	49964	61409	50897	76147	60398	47390	61863	41074	73322	93641	743404
1994	98656	81502	79340	71170	60360	68460	48720	42920	40450	62030	40420	66190	758218
AVG	104042	86324	80805	75451	72543	86642	89708	110985	112645	76760	70002	94431	1080338

TABLE 5

PLATTE RIVER NEAR OVERTON, NEBR. (Start of Big Bend Habitat in Central Nebraska); USGS #06768000

Water
Year

ACRE-FEET

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	69047	55466	80166	35091	81045	92093	90327	52754	108188	29700	33737	54199	852813
1976	69283	82731	93203	107008	105263	102645	103954	57529	23205	18454	12272	46826	822373
1977	56350	62503	80608	70830	73051	91787	130552	93400	41004	19464	24637	54865	799051
1978	63132	55185	73958	63570	58750	100403	85468	47385	21739	22338	23917	34241	660086
1979	60002	54641	70017	58830	61309	110043	66682	44735	175896	88707	26963	36042	863867
1980	37878	44210	122422	140926	157924	185911	291846	602321	320170	15306	22693	51560	1993169
1981	49932	55164	71572	84555	78803	79129	41651	40070	19371	59429	38015	46887	664578
1982	57640	55303	78420	60992	85468	98122	51999	36734	23407	15400	19111	51919	634515
1983	51656	102611	117937	161316	167722	184046	233177	491028	1128595	699868	407941	478433	4224330
1984	161355	88185	198387	263207	387114	443088	598235	774149	564873	105217	43918	244701	3872429
1985	259517	343061	308152	204555	200668	259855	111035	120536	70213	34959	29730	75731	2018012
1986	117719	38757	116152	179683	184699	155663	231749	175438	203960	86840	153560	237501	1941921
1987	241230	177302	175279	174347	153322	185296	170241	211636	197341	52665	49131	117203	1904993
1988	115125	122011	137712	134182	187379	158598	116529	133547	29250	65014	45927	58992	1304266
1989	65770	48728	73002	95405	97428	131375	40574	27489	42565	35058	36028	58903	752325
1990	45802	44719	54058	79398	77990	97646	114783	74783	24454	15814	45310	30940	705697
1991	41867	50872	46768	62297	80152	72030	45116	79539	53421	21118	24706	31787	609673
1992	32951	55275	62902	74329	85289	144119	68676	27404	29966	46116	38696	24982	690705
1993	66161	57059	78940	107802	90962	164886	76919	38444	41615	72290	41524	70409	907011
1994	106800	98140	111300	98210	102200	114000	63390	48960	28970	55190	26500	46670	900330
AVG	88461	89146	107548	115327	125837	148537	136645	158894	157410	77947	57216	93140	1356107

TABLE 6

PLATTE RIVER NEAR GRAND ISLAND, NEBR. (End of Big Bend Habitat in Central Nebraska); USGS #06770500

Water
Year

ACRE-FEET

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	55630	48774	58814	74420	73131	102764	91359	59175	108541	38210	22128	53441	786387
1976	44235	58984	96694	79716	109805	106691	98698	66385	19543	9311	1310	18478	709850
1977	45719	46413	60575	55706	71881	92628	137455	111729	57663	10635	16493	47147	754044
1978	54924	54266	59286	46889	56608	219888	107068	56553	19404	6438	10106	13583	705013
1979	38379	47827	59802	50896	49745	165382	102704	74364	122313	100796	25146	20301	855655
1980	25353	42821	123451	104013	164231	225640	289190	532026	348952	23363	19987	28673	1927700
1981	36250	39701	66783	71286	65117	82711	48619	45094	16586	37077	62471	25890	597585
1982	49039	61930	82155	69421	103438	117501	58879	62410	40130	21513	24214	36902	727532
1983	61987	84559	118413	139537	168139	191425	213362	489382	1011273	664641	360635	391260	3894613
1984	166215	92648	208959	304661	406393	433547	589448	749355	541388	170057	30274	197720	3890665
1985	220780	312417	283260	176132	208463	281950	137911	146598	81429	43325	50053	90902	2033220
1986	139220	88721	131107	171074	190691	174585	217051	202830	180008	86650	123947	207015	1912899
1987	235656	168952	158261	154969	146579	225025	220919	205111	231907	81390	44555	96536	1969860
1988	103688	116469	105620	113355	192516	153501	114664	127636	30655	68420	48028	50610	1225160
1989	52210	53982	75519	95901	93779	123828	44624	25144	57739	74168	34626	93229	834949
1990	55682	54643	44602	120099	92658	124344	112185	105927	40820	8902	35375	16334	811571
1991	30071	48137	43607	48456	85527	75158	42171	79579	82721	8057	10305	15098	568887
1992	20265	51658	59002	81045	89236	141243	75465	23220	34383	47970	28282	21784	673553
1993	56580	51277	73448	76423	72774	275246	97890	69340	65119	174889	73373	93223	1179582
1994	113800	110000	112500	88540	92210	165800	79940	51100	46070	82000	31660	37140	1010560
AVG	80674	81709	101093	108127	126646	173943	143980	164148	156632	87891	52658	77763	1353464

TABLE 7

GRAND ISLAND SHORTAGE with respect to USFWS (July 1997) Weighted Average Monthly Species Target Flows (Table 9) for Wet, Average, and Dry Year Classifications

ACRE-FEET

Year Type	Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVG	1975	55070	34526	2886		69869	64736	51441	90825	50159	35590	51872	12059	518633
AVG	1976	66465	24316			33195	60809	44102	83615	139157	64489	72490	47022	635660
AVG	1977	64981	36887	925	5794	71119	74872	5345	38271	101037	63165	57307	18353	538056
AVG	1978	55776	29034	2214	14811	86392		35732	93447	139296	67362	63694	51917	639475
AVG	1979	74321	35473	1698	10604	93255	2118	40096	75636	38387		48654	45199	463441
WET	1980	122247	58379								50437	53813	36827	321703
DRY	1981	43650	16799			30683	31289	52581	21906	31014	12123		15810	255855
AVG	1982	61661	21370			39562	49999	83921	87590	118570	52287	49586	28598	593144
WET	1983	85613	16641											102254
WET	1984		8552									43526		52078
WET	1985							4889	24202	77271	30475	23747		160584
WET	1986	8380	12479											20859
WET	1987											29245		29245
WET	1988	43912					13999	28136	43164	128045	5380	25774	14890	303300
AVG	1989	48490	29318			49221	43672	98176	124856	100961		38974		533668
AVG	1990	55018	28657	16898		50342	43156	30615	44073	117880	64898	38425	49166	539128
DRY	1991	49829	8363			10273	38842	59029			41143	38895	26602	272976
DRY	1992	59635	4842			6564		25735	43780	13217	1230	20918	19916	195837
WET	1993	91020	49923			70226		44910	101460	93581		427		451547
AVG	1994					50790	1700	62860	98900	112630		42140	28360	397380
	AVG	49303	20773	1221	1550	33075	21260	33378	48586	62960	24429	34964	19736	351241

TABLE 8

GRAND ISLAND EXCESS with respect to USFWS (July 1997) Weighted Average Monthly Species Target Flows (Table 9) for Wet, Average, and Dry Year Classifications

ACRE-FEET

Year Type	Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
AVG	1975				12920									12920
AVG	1976			35194	18216									53410
AVG	1977													0
AVG	1978						52388							52388
AVG	1979										26996			26996
WET	1980			61951	42513	21231	58140	146390	361226	190252				881703
DRY	1981			29883	34386							13271		77540
AVG	1982			20655	7921									28576
WET	1983			56913	78037	25139	23925	70562	318582	852573	590841	286835	325760	2629167
WET	1984	18615		147459	243161	263393	266047	446648	578555	382688	96257		132220	2575043
WET	1985	73180	211217	221760	114632	65463	114450						25402	826104
WET	1986			69607	109574	47691	7085	74251	32030	21308	12850	50147	141515	566058
WET	1987	88056	67752	96761	93469	3579	57525	78119	34311	73207	7590		31036	631405
WET	1988		15269	44120	51855	49516								160760
AVG	1989			14019	34401						368		27729	76517
AVG	1990				58599									58599
DRY	1991			6707	11556				12579	35121				65963
DRY	1992			22102	44145		27243							93490
WET	1993			11946	14923		107746				101089		27723	263429
AVG	1994	2900	26700	51000	27040						8200			115840
	AVG	9138	16047	44504	49867	23801	35727	40799	66864	77757	42210	17513	35569	459795

TABLE 9:
USFWS (July 1997) Weighted Average Monthly Species Instream Flow Recommendations or Targets

Table 1. "Wet" instream flow recommendation hydrograph.

Month	Begin	End	cfs	No. Days	Kaf	Total Kaf	Average cfs
Jan	1	31	1,000	31	61.5		
Jan						61.5	1,000
Feb	1	14	1,800	14	50.0		
Feb	15	28	3,350	14	93.0	143.0	2,575
Mar	1	15	3,350	15	99.7		
Mar	16	22	1,800	7	25.0		
Mar	23	31	2,400	9	42.8	167.5	2,724
Apr	1	30	2,400	30	142.8		
Apr						142.8	2,400
May	1	10	2,400	10	47.6		
May	11	19	1,200	9	21.4		
May	20	26	4,900	7	68.0		
May	27	31	3,400	5	33.7	170.8	2,777
Jun	1	20	3,400	20	134.9		
Jun	21	30	1,200	10	23.8	158.7	2,667
Jul	1	31	1,200	31	73.8		
Jul						73.8	1,200
Aug	1	31	1,200	31	73.8		
Aug						73.8	1,200
Sep	1	15	1,200	15	35.7		
Sep	16	30	1,000	15	29.8	65.5	1,100
Oct	1	31	2,400	31	147.6		
Oct						147.6	2,400
Nov	1	15	2,400	15	71.4		
Nov	16	30	1,000	15	29.8	101.2	1,700
Dec	1	31	1,000	31	61.5		
Dec						61.5	1,000
Total Kaf						1,367.3	

Table 2. "Average" instream flow recommendation hydrograph.

Month	Begin	End	cfs	No. Days	Kaf	Kaf	cfs
Jan	1	31	1,000	31	61.5		
Jan						61.5	1,000
Feb	1	14	1,800	14	50.0		
Feb	15	28	3,350	14	93.0	143.0	2,575
Mar	1	15	3,350	15	99.7		
Mar	16	22	1,800	7	25.0		
Mar	23	31	2,400	9	42.8	167.5	2,724
Apr	1	30	2,400	30	142.8		
Apr						142.8	2,400
May	1	10	2,400	10	47.6		
May	11	19	1,200	9	21.4		
May	20	31	3,400	12	80.9	150.0	2,439
Jun	1	20	3,400	20	134.9		
Jun	21	30	1,200	10	23.8	158.7	2,667
Jul	1	31	1,200	31	73.8		
Jul						73.8	1,200
Aug	1	31	1,200	31	73.8		
Aug						73.8	1,200
Sep	1	15	1,200	15	35.7		
Sep	16	30	1,000	15	29.8	65.5	1,100
Oct	1	31	1,800	31	110.7		
Oct						110.7	1,800
Nov	1	15	1,800	15	53.6		
Nov	16	30	1,000	15	29.8	83.3	1,400
Dec	1	31	1,000	31	61.5		
Dec						61.5	1,000
Total Kaf						1,291.9	

Table 3. "Dry" instream flow recommendation hydrograph.

Month	Begin	End	cfs	No. Days	Kaf	Total Kaf	Average cfs
Jan	1	31	600	31	36.9		
Jan						36.9	600
Feb	1	14	1,200	14	33.3		
Feb	15	28	2,250	14	62.5	95.8	1,725
Mar	1	15	2,250	15	66.9		
Mar	16	22	1,200	7	16.7		
Mar	23	31	1,700	9	30.3	114.0	1,853
Apr	1	30	1,700	30	101.2		
Apr						101.2	1,700
May	1	10	1,700	10	33.7		
May	11	31	800	21	33.3	67.0	1,090
Jun	1	30	800	30	47.6		
Jun						47.6	800
Jul	1	31	800	31	49.2		
Jul						49.2	800
Aug	1	31	800	31	49.2		
Aug						49.2	800
Sep	1	15	800	15	23.8		
Sep	16	30	600	15	17.9	41.7	700
Oct	1	31	1,300	31	79.9		
Oct						79.9	1,300
Nov	1	15	1,300	15	38.7		
Nov	16	30	600	15	17.9	56.6	950
Dec	1	31	600	31	36.9		
Dec						36.9	600
Total Kaf						775.8	

NOTE: See Tables 1, 2, and 3 in "Pulse Flow Requirements For The Central Platte River," by David Bowman and Dave Carlson, August 3, 1994, for additional detail concerning the magnitude, timing, and long term average of pulse flow recommendations.

APPENDIX B

Methodology for Analyzing Surface Water/Groundwater Interaction

REPORT ON METHODOLOGY FOR ANALYZING HYDROLOGICALLY CONNECTED GROUNDWATER FOR THE PLATTE RIVER WATER CONSERVATION AND SUPPLY STUDY
(Adopted January 5, 1999 by WMC)

Introduction

At the Water Management Committee (WMC) workshop No. 1 on August 11, 1998, different methodologies were reviewed for the analysis of groundwater related impacts to the Platte River associated with various water conservation and supply alternatives. Each methodology was reviewed in the context of the following overall objectives:

1. The methodology should provide consistent, reliable results independent of the alternative being evaluated.

2. The methodology should reflect physical aspects of the hydrologic system to the extent practical.

3. The methodology should have the flexibility to analyze both point stresses (such as well pumping) as well as distributed stresses (such as deep percolation of irrigation water over broad areas).

4. Given the potentially large number of alternatives to be analyzed, the adopted methodology should be relatively simple to develop and apply.

5. The methodology should be based on data which is readily obtainable or reliably estimated.

The study requires quantitative results which are defensible, and consistent with a planning level analysis of the three-state area. The methodology will rely on data which already exists in published form, or which can be gathered relatively easily. No raw data collection is contemplated as part of this undertaking. The analysis of impacts will be limited to the area specifically affected by an alternative. The adopted methodology will be used to evaluate alternative-specific *changes* in the stream-groundwater interaction. Therefore, it will not be necessary to incorporate hydrologic stresses (such as pumping, deep percolation, return flow, etc) which are unchanged by the project alternative. Instead, only those hydrologic changes which are anticipated as part of the alternative need to be addressed.

A preliminary listing of the alternative methodologies identified for this study is shown in the following table:

Alternative Methodologies for Analyzing Stream/Groundwater Interactions	
Method Description	**Remarks**
Fixed distance from river, uniform impact.	Prior studies [1] have shown that a fixed distance of about 7 miles from the river is sufficient to capture the majority of impacts. Wells within this bandwidth were estimated to cause a river depletion of about 75% of consumed pumping [1] after a long term period of years. Advantages: Simple to apply, consistent results. Disadvantages: lacks quantitative basis. Method provides virtually no opportunity to check/verify results. Does not compute river depletions on a short term monthly basis.
Variable distance from river, uniform impact (area of impact delimited by boundaries of irrigated lands, alluvial channel boundaries, density of wells, topography)	See comments above. Advantages: Simple to apply, consistent results. Disadvantages: lacks quantitative basis. Requires data on irrigated lands, channel morphology, well locations, and topography. Method provides virtually no opportunity to check/verify results. Does not compute river depletions on a short term monthly basis.
Stream Depletion Factor (SDF) (analytical solution of groundwater flow)	Mapping of SDF values is available for most of the study area [1,2]. Advantages: method based on quantitative solution to ground water flow. Method widely accepted in scientific community. Relatively easy to review for purposes of developing consensus on assumptions. Disadvantages: Requires modest level of effort, SDF coverage not universal. Method does not provide solution for multiple aquifer environment. Method does not allow for explicit calibration.
Numerical Modeling	Method provides the most quantitative solution possible. Numerical models have become commonplace with advances in computer technology providing ease of model use. Advantages: capable of simulating complex stream-groundwater systems. Near-universal acceptance of method in scientific community. Disadvantages: Requires significant level of effort, even in locations where models have already been constructed. Relatively difficult to review for purposes of developing consensus on modeling assumptions.

Fixed Distance From River Method

This method is based on the premise that the hydrologically connected aquifers can be approximated as having uniform width and centered on the present active channel of the river. It further assumes that all river impacts and timing of those impacts can be represented using a single relationship for any groundwater stress occurring within the hydrologically connected aquifer, independent of the location of the stress. Prior studies [1] have shown that a fixed distance of about 7 miles from the river is sufficient to capture the majority of impacts. Wells within this bandwidth were found to cause a river depletion of about 75% of consumed pumping on average [1] after a long term period of years.

It is likely that some refinement of the estimated bandwidth and depletion factor would be needed prior to implementing this approach. It would also be desirable to evaluate the relative timing of impacts of wells lying within the resulting bandwidth. Such an analysis could be based on a uniform distribution of wells. Based on that analysis, a time-distribution of depletions would be developed.

Application of this method would require delineation of the pre-defined bandwidth at the site of each alternative. This is readily accomplished using existing topographic mapping.

This method, while simple in application, generally lacks a quantitative basis. The method does not consider the distribution of groundwater stresses within the hydrologically connected aquifer. While this method may provide gross estimates of river depletions and accretions for average, long-term conditions, it will not provide reliable estimates on a short-term, monthly basis.

Variable Distance From River Method

This methodology is similar in concept to the fixed distance approach described above. It incorporates a minor refinement in that it recognizes that the hydrologically connected aquifers will have irregular geometries. In this approach, the geometry of the hydrologically connected aquifer is inferred from one of several sources, such as topographic evidence, areas of irrigated agriculture, or locations and density of wells. It is expected that one or more of these sources would be selected as the primary measure of the geometry of the aquifer, and systematically applied to each alternative. Information on topography, distribution of irrigated lands and/or distribution of wells is generally available throughout the study area, at a scale suitable for this type of analysis.

As with the fixed distance approach, the method assumes a constant factor in estimating river depletion and a single relationship defining the timing of river impacts.

Limitations of this method are similar to those described above for the fixed distance methodology.

SDF Method

The SDF method is derived from the basic analytical equations describing groundwater flow to and from a well. These have been modified to include the interaction between a river or stream and the groundwater flow system. The method is based on the following important assumptions:

- For a water-table aquifer, drawdown (or rise) of the water table is negligible in comparison to the aquifer's saturated thickness.
- The aquifer is isotropic, homogeneous, and semi-infinite in areal extent, with a straight, fully penetrating stream boundary.
- Water is released instantaneously from storage.
- The well fully penetrates the aquifer.

- The pumping (or recharge) rate can be represented as steady over a fixed period of analysis.

The stream depletion factor (SDF) is defined as:

$$SDF = a^2S/T,$$

Where; SDF is defined as the time from the beginning of steady pumping or recharge within which the volume of stream depletion or accretion is 28 percent of the volume pumped or recharged [3]; a is the distance between the well and the river; S is the specific yield, a property of the aquifer; and T is transmissivity, a property of the aquifer. With this information, the rate, volume and timing of stream depletion/accretion can be estimated. There are also solutions for determining the cumulative effects of multiple wells, and the cumulative effects of these wells over time [4]. As described in the MBSA study [1], SDF values developed by MBSA and USGS were calibrated by finite difference modeling at intervals along the river.

Maps of SDF values have been published for most of the study area where there is a significant stream-groundwater interaction [1,2]. Map coverages do not include most tributary areas, nor do they extend into headwater areas. In these areas, the hydraulically connected alluvial aquifers are relatively small in extent and depth. Stream-groundwater impacts in these areas could be assumed to impact the stream on a 1:1 basis, i.e. all of the groundwater pumped (or added) within these areas will translate to a loss (or gain) to the stream. Further, the impacts to the stream could be assumed to occur in the same month as the pumping or recharge occurs.

One limitation of the SDF method is that it is intended primarily for use in analyzing "point" stresses, such as those produced by a well. Several supply/conservation alternatives will likely involve "regional" stresses, such as might be produced when a large irrigated tract is removed from production, thereby eliminating deep percolation over a broad area. In that case, such an impact might be evaluated by representing the condition using evenly distributed "point" stresses, to which the overall impact has been allocated in proportion to the area represented by the "point" stress. The extent to which the regional stresses are distributed could be judged on a case-by-case basis, with the objective of retaining a level of accuracy consistent among the alternatives.

A second limitation of the SDF method is that it is unsuitable for evaluating stream-groundwater interaction in multi-layered aquifer systems, such as are found in portions of the Nebraska study area, where an alluvial aquifer overlies the regional High Plains aquifer. In cases where alternatives are located in areas of multi-layered aquifers, supplemental analyses, such as the use of analytical solutions for the exchange of water between aquifers may be needed.

Numerical Modeling

Numerical approaches are a family of computer-based techniques for solving the partial differential equations that govern groundwater flow. Numerical models discretize the underlying aquifer(s) and solve the flow equations based on user-defined hydrogeologic parameters and boundary conditions.

The numerical model most often applied for the types of analyses required here is the U.S. Geological Survey's MODFLOW model. The model is capable of simulating either transient or steady-state groundwater flow in two or three dimensions. The model can simulate relatively complex hydrologic systems involving leakage between multi-layered aquifers, wells, drains, river seepage, evapotranspiration, and areal recharge. The numerical modeling approach provides the most quantitative solution possible for the analysis of stream/groundwater interactions.

The principal disadvantage of the numerical modeling approach is the extensive input data requirements and the effort required for model construction and calibration. The model operates on a user-defined grid that requires detailed information on aquifer properties, boundary conditions, distribution and timing of deep percolation from applied water, location, geometry, and hydrologic properties of river channels, canals, and drains, and detailed information on the locations of wells within the area to be modeled.

There is a great deal of flexibility in the selection of the scale for the model's construction. This provides some opportunity for averaging of conditions needed for the modeling, and greatly simplifies the model construction process. Such re-scaling would need to balance the need for reliable results with the effort required for the tool's development. It may be possible, through the selection of appropriate modeling scales, to implement a numerical model with relatively minor additional effort over that required for the SDF alternative. This may be desirable in cases where the SDF method is unable to adequately represent hydrologic conditions of a particular alternative.

Selection of Methodology

The SDF methodology will be adopted for the analysis of hydrologically connected groundwater. This method is founded on sound scientific principals, and provides a level of analytical detail which is commensurate with the level of analysis required by this study. The method is relatively simple, and lends itself to application to a large number of alternatives.

SDF mapping coverages are shown in [1] and [2]. Mapping contained in [1] covering portions of Wyoming and Colorado and all of the Nebraska portion of the study area is at a scale of one inch to four miles. Mapping contained in [2] covering portions of Colorado is at a scale of one inch to one mile.

There are several limitations to this methodology. These will be handled on a case-by-case basis as particular alternatives are singled out for analysis. The principal limitations are:

Extent of Coverage of SDF Mapping

Mapping of SDF values is available for most of the mainstem area. Mapping does not extend into the upstream tributary areas of Wyoming and Colorado, nor does it extend into tributary reaches of the mainstem in Nebraska. In the case where an alternative is identified in an area lacking SDF mapping, SDF values will be estimated using indirect means. This will require information on aquifer properties (transmissivity, saturated thickness, hydraulic conductivity) which will be estimated using the best available data. Such data may include well logs, reported well yields, or other data from which these properties may be inferred.

Analysis of Multiple-Layered Aquifers

Among the conditions necessary to the SDF solution is the assumption of a single water-bearing layer, bounded below by an impermeable layer. There are several regions within the study area where multiple aquifers exist, and where these aquifers are hydrologically connected. Most notable are regions along the Platte River in Central Nebraska where the surface alluvial aquifer overlies the

High Plains regional aquifer. In such areas, it is reasonable to expect that changes in river conditions may be translated to both the alluvial aquifer and to the deeper, High Plains aquifer. Analysis of alternatives located in areas underlain by multi-layered aquifers will need to consider both the interaction between the river and the hydrologically connected alluvial groundwater, as well as the interaction between aquifers. This will be accomplished using separate analytical and/or simplified numerical models to predict responses between aquifers. It will be necessary to collect additional hydrologic data for the affected aquifers, including prevailing water level elevations and hydrologic properties. Information will also be needed on the hydrologic properties of layers which may separate the aquifers.

References and Key Documents

[1] Missouri Basin States Association, 1982. *Technical Paper - Ground Water Depletion.* Technical paper supplement to Missouri River Basin Hydrology Study.

[2] Hurr, R. T. and P. A. Schneider, 1972. *Hydrogeologic Characteristics of the Valley-Fill Aquifer in the South Platte River Valley.* U.S.G.S. Open-File Report.

[3] Jenkins, C. T., 1967. *Techniques for Computing Rate and Volume of Stream Depletion by Wells.* U.S.G.S. Open File Report.

[4] Schroeder, Dewayne R., 1987. *Analytical Stream Depletion Model.* Ground Water Software Publication No. 1, Office of the State Engineer, Colorado Division of Water Resources.

APPENDIX C

Methodology for Estimating Consumptive Irrigation Requirements

MEMORANDUM

TO: Water Management Committee

August 10, 1998

FROM: Boyle Engineering Corporation

SUBJECT: **Platte River Study - Consumptive Use**

Introduction

The goal of the Platte River Study is to identify conservation measures or new supplies that will result in additional water reaching the critical habitat. Conservation through reduction of consumptive use will be an important element in many of the alternatives investigated as consumptive use is a very important component of most water budgets, particularly in arid regions such as the Platte Basin. Consumptive use of water by plants, evapotranspiration, will be an especially important component. The magnitude of this term is anticipated to generally be in the range of 50 to 75 percent of the total water in any given budget. Methods for estimating evapotranspiration are needed to evaluate this term. The purpose of this memorandum is to present a number of alternative methods for estimating evapotranspiration, briefly discuss their strengths and weaknesses, evaluate the methods for use in this study, and develop a recommendation for the methodology to be used.

Comparison of Evapotranspiration Estimation Methods

The evapotranspiration process involves a balance of energy and a balance of mass. Energy drives the process of converting the water mass from one form to another, liquid to vapor. A number of climatic factors are important in this process, key among these are temperature, radiation, relative humidity, and wind speed. These factors can be classified into two basic categories, an energy category and an aerodynamic or transport category. The energy category includes climatic factors that focus on the energy available to drive the phase change aspect of the evapotranspiration process, while the aerodynamic or transport category includes climatic factors that focus on the transport of water vapor out of the system. Temperature and radiation are measures of available energy while relative humidity and wind speed are measures of the transport capacity of the atmosphere.

Various methods for estimating evapotranspiration have been developed which focus on one or more of the climatic factors. These methods can be categorized by the factor(s) keyed on in the estimation approach. The commonly used classification categories are pan evaporation, temperature, radiation, and combination methods. Pan evaporation methods use measured evaporation from an open water surface as the basis of estimating evapotranspiration. Temperature methods use air temperature as the measure of available energy, while radiation methods use solar or net radiation as the measure of available energy. Combination methods use both energy and aerodynamic terms for estimating evapotranspiration. Within each of these categories a range of different approaches have been developed.

The basic approach was to represent the different categories considering use of the methodology in the study area and general acceptability within the engineering and scientific community. The Christiansen Method was selected to represent the Pan Evaporation Category. The Blaney-Criddle Method was selected to represent the Temperature Category. The Jensen-Haise Method was selected to represent the Radiation Category. The Penman Method was selected to represent the Combination Category. In each case, the methodology used to develop an estimate of evapotranspiration for a reference crop (well-watered, short-cropped grass) is presented. In each case, this value can then be translated into the potential evapotranspiration of other crops through multiplication by specific crop coefficients. These methods are discussed in the sections that follow.

Comparison of Evapotranspiration Estimation Methods

Christiansen – Pan Evaporation Method

Pan evaporation measures evaporation from an open water surface with respect to radiation, wind, temperature and humidity (Burman et al., 1983). This measurement can be adjusted to estimate reference evapotranspiration using a proportional relationship which evaluates pan size and environment (Jensen et al., 1990).

Christiansen's method estimates reference crop evapotranspiration by adjusting USWB Class A pan evaporation with weather parameters as follows (Jensen et al., 1990):

$$E_{to} = 0.775 E_v C_{T2} C_{W2} C_{H2} C_{S2}$$

Where the coefficients are defined based upon temperature, wind speed, relative humidity, and percentage of possible sunshine.

Pan evaporation data is sensitive to site conditions as well as operation and maintenance of the site. Therefore, the data must be carefully evaluated to determine its reliability based on the knowledge of site conditions. It has also been noted that strong winds (Pruitt, 1986) and other climatic forces affect the proportion of pan evaporation to reference crop evapotranspiration. For these reasons, using pan evaporation to estimate evapotranspiration has been suggested as a method of supporting or confirming data from other estimating techniques rather than as a primary source (Jensen, 1995). This method should be used for longer periods of time because of the varying reactions of pans and plants to climatic data on a daily basis (Burman et al., 1983).

Blaney-Criddle – Temperature Method

The original Blaney-Criddle method estimated the consumptive use factor (f) from mean temperature (T) and percentage (p) of total daylight hours. This factor is then multiplied by an empirically determined consumptive use crop coefficient (K) to determine consumptive use (CU) as follows (Doorenbos and Pruitt, 1977):

$$CU = Kf = K(pT/100)$$

This original Blaney-Criddle equation has been replaced by two modifications, the FAO-24 Blaney-Criddle method and the SCS Blaney-Criddle. The modifications result from the idea that temperature and day length are not representative of the effects of climate on crop water requirements nor are they related to reference crop evapotranspiration.

The FAO-24 method adjusts the original Blaney-Criddle method by including a factor for humidity, sunshine and wind. Doorenbos and Pruitt (1977) established the FAO-24 equation for evapotranspiration as follows:

$$E_{to} = c[p(0.46T + 8)]$$

The Soil Conservation Service incorporated a composite climate and crop coefficient (k) in the following revision to the Blaney-Criddle method (Jensen et al., 1990):

$$CU = kf$$

The Blaney-Criddle method of calculating evapotranspiration is popular because it only requires data which are readily available for long periods of time in most areas.

Disadvantages of this method result from the single climatic parameter of temperature used to calculate evapotranspiration. Therefore, results should be carefully evaluated in equatorial regions where temperatures are constant but other parameters change, on small islands and coastal areas where temperatures are affected by sea temperature rather than radiation, at high altitudes which have low mean daily temperatures due to cold nights but receive high radiation levels during the day, and in climates which have a variability of sunshine hours during autumn and spring (Doorenbos and Pruitt, 1977). Only the last two concerns generally apply to the Platte Basin.

A study performed for the American Society of Civil Engineers (Jensen et al., 1990) explored different methods of evaluating evapotranspiration and concluded that the SCS Blaney-Criddle method was found to underestimate values in arid climates and overestimate values in humid climates. The FAO Blaney-Criddle method performed well in arid locations, but also overestimated evapotranspiration in humid climates by 15 to 25%.

The suggested use of the Blaney-Criddle method is for periods of one month or longer when air temperature data is the only climatic data available. Additionally, due to its dependence on mean temperature, the Blaney-Criddle method should be calibrated to local conditions to account for local terrain features that influence the relationship between night-time minimum temperatures and daytime maximum temperatures. Further, the calculation should be made for each month of a year as opposed to using mean temperatures from several years of record (Doorenbos and Pruitt, 1977).

Jensen-Haise Alfalfa–Reference Radiation Method

Radiation methods of evaluating evapotranspiration are based on energy balance variables latent heat of vaporization (Λ) and mean air temperature (T). Jensen and Haise presented the following method for calculating evapotranspiration (Jensen et al., 1990):

$$\Lambda E_{tr} = C_T(T - T_x)R_s$$

The other terms are defined as functions of vapor pressure, elevation, and temperature.

The ASCE (Jensen et al., 1990) study of evapotranspiration evaluation methods found the Jensen-Haise method to underestimate daily evapotranspiration in humid locations. ASCE Irrigation Water

Requirements Committee recommended this method be used only for periods of 5 days to one month (Burman et al., 1983).

1963 Penman – Combination Method

Combination equations depend on energy balance and mass transport or aerodynamic terms. The 1963 Penman equation depends only on climatic forces such as vapor pressure (D_a), net radiation (R_n), soil heat flux (G), atmospheric density (ρ) and wind ($F(u)$) (Pereira et al., 1996):

$$ET_p = (\Delta(R_n - G) - \rho c_p F(u) D_a)/(\Delta+\gamma)$$

The 1990 ASCE study (Jensen et al., 1990) found that the Penman method underestimated peak monthly evapotranspiration in arid locations and overestimated in humid locations. The 1963 Penman equation also fails to include effects of surface resistance for water vapor transfer or leaf resistance on evapotranspiration. The 1963 Penman method is reliable for periods of 1 day to 1 month and can be modified to produce reliable hourly estimates (Burman et al., 1983).

Penman-Monteith – Combination Method

The Penman-Monteith equation modified the 1963 Penman equation to account for aerodynamic and surface resistance, specifically surface roughness and canopy resistance (Jensen et al., 1990):

$$\Lambda E_t = (\Delta/(\Delta+\gamma^*)(R_n - G) + (\gamma/(\Delta+\gamma^*)K_1(0.622\Lambda\rho/P)(1/r_a)(e^o{}_z - e_z)$$

With terms as defined previously for the 1963 Penman Equation and additional terms and coefficients which are determined based on humidity, wind speed, canopy height, and canopy resistance.

The Penman-Monteith equation ranked first in all aspects of the ASCE 1990 study (Jensen et al., 1990). The study also found this method to be the only method that did not overestimate evapotranspiration in humid locations.

The Penman-Monteith equation has an advantage over other methods in that it incorporates the influence of the reference plant on evapotranspiration and can account for changes in plant height over time as well as the influence of elevation. Additionally, the Penman-Monteith equation is physically based as opposed to empirically based and thus does not necessitate local calibration (Allen, 1995). The Penman-Monteith equation is most accurate when used to calculate evapotranspiration in hourly values and summing them to obtain daily values or monthly values.

Evaluation of Estimation Methods

Following a review of the methods previously described, each method was evaluated with respect to its potential for use during this study. Evaluation criteria were developed to facilitate this process and assist in the selection of a method for estimating evapotranspiration. These criteria included the following:

- Data Input Requirements/Simplicity
- Data Availability
- Applicability
- Accuracy
- Acceptability
- Cost/Work Effort

Each criterion is briefly described below.

Data Input Requirements/Simplicity. This criterion evaluated the simplicity of the methodology with respect to the data input requirements. A methodology was considered more favorable if the equation utilized to predict evapotranspiration relied on fewer input parameters.

Data Availability. The availability of the data required to predict evapotranspiration was evaluated given that the period of record for the hydrologic analyses will be 20 years (1975 to 1994). In addition, the regional availability of the data was evaluated, e.g., will the data be available at sufficient locations to promote the estimation of evapotranspiration and the evaluation of alternatives.

Applicability. Each methodology was evaluated with respect to its application throughout the three regions. For example, some methods were better suited to estimating evapotranspiration in humid versus semi-arid climates. Such limitations were specifically evaluated due to the variation in climatic variables from Region 1 to Regions 2 and 3.

Accuracy. The capability of each methodology to give a more accurate estimation of evapotranspiration was evaluated. Consideration was also given to the fact that monthly accounting of evapotranspiration will be utilized during the study. Consequently, each methodology was investigated with respect to its capability to provide reasonable estimates on a monthly basis. In some cases, additional parameters may provide for better estimation on evapotranspiration on a daily or hourly basis; however, using monthly averages of these parameters may alter the results and reduce the accuracy of the estimate.

Acceptability. This criterion evaluated the widespread acceptability of each methodology. Several of the methodologies for estimating evaporation have been utilized within each region in recent years. A qualitative evaluation of the utilization of each methodology by local, state and federal agencies within each region became an indicator of acceptability. A methodology that was more widely utilized throughout each region received a more favorable rating.

Cost/Work Effort. The work effort and costs associated with application of each methodology was considered. Given the schedule and budget for this study, a methodology that will promote the evaluation of more alternatives was considered the most favorable.

Recommendation

The capability of each methodology with respect to the criteria is determined on a scale which ranged from 1 (least favorable) to 3 (most favorable). Table 1 presents the results of the evaluation. As indicated in the table, the Blaney-Criddle Method was identified as the most favorable during the evaluation process. The justification for the selection of this method is provided below.

- The Blaney-Criddle Method required less data input parameters and was considered favorable from a standpoint of simplicity.
- The availability of the climatic data throughout each region was also considered the most favorable with the Blaney-Criddle Method.
- Limitations associated with the application of the Blaney-Criddle Method resulted in a moderately favorable rating with this criterion.
- Due to the input parameters, the Blaney-Criddle Method will provide a reasonably accurate estimate of evapotranspiration given the monthly accounting which is anticipated for this study. Although other methodologies may provide more accurate estimates for hourly or daily time periods, extrapolation of the parameters associated with these methodologies to a monthly time step will reduce the accuracy.
- In reviewing the methodologies utilized within the three regions, the Blaney-Criddle Method was considered to be the most widely acceptable.
- Based on the simplicity and availability of data, the Blaney-Criddle Method was considered the most favorable with respect to cost/work effort.

Table 1. Evaluation Matrix

Methodology	Data Input Requirements	Data Availability	Applicability	Accuracy	Acceptability	Cost/ Work Effort	Total Score
Christiansen Pan Evaporation	1	2	2	1	1	2	9
Blaney-Criddle	3	3	2	2	3	3	16
Jensen-Haise Radiation	2	2	2	2	2	2	12
1963 Penman Combination	1	1	2	2	2	2	10
Penman-Monteith Combination	1	1	3	2	2	1	10

References

Allen, R.G. 1995. *Introduction to Evapotranspiration*. Proceedings from Conference on Evapotranspiration and Irrigation Efficiency. Aurora, CO.

Burman, R.D., Nixon, P.R., Wright, J.L., and Pruitt, W.O., *Design and Operation of Farm Irrigation Systems*; Chapter 6: Water Requirements. Edited by M.E. Jensen. American Society of Agricultural Engineers. St. Joseph, MO.

Doorenbos, J. and Pruitt, W.O. 1977. *Guidelines for Predicting Crop Water Requirements*. Food and Agricultural Organization of the United Nations. Rome, Italy.

Jensen, M.E. 1995. *ASCE Manual 70: Evapotranspiration and Irrigation Requirements*. Proceedings from Conference on Evapotranspiration and Irrigation Efficiency. Aurora, CO.

Jensen, M.E., Burman, R.D., Allen, R.G. 1990. ASCE Manuals and Reports on Engineering Practice No. 70. *Evapotranspiration and Irrigation Water Requirements*. American Society of Civil Engineers. New York, NY.

Pereira, L.S., Perrier, A., Allen, R.G., and Alves, I. 1996. *Evapotranspiration: Review of Concepts and Future Trends*. Proc. EVAPOTRANSPIRATION AND IRRIGATION SCHEDULING. American Society of Agricultural Engineers. San Antonio, TX.

APPENDIX D

1975-1994 Time Period Justification

September 1, 1998

1975 TO 1994 TIME PERIOD JUSTIFICATION
Report to Platte River Cooperative Agreement Governance Committee From Water Management Committee, September 1998

The Water Management Committee (WMC) has selected a time period of Water Years 1975 through 1994 for developing the hydrologic information required by Milestone W14-1 of the Cooperative Agreement as the Milestone pertains to the Consultant's performance of the Water Conservation and Supply Study. For this time period, the WMC will provide information on (1) existing flow conditions on a monthly basis at important river points in the Platte Basin and (2) monthly loss factors for use in conveying estimated depletions and accretions throughout the basin to the critical habitat.

The Consultant will use this information to screen water conservation and supply alternatives for the average amount of water produced by an alternative over the 1975-94 period. As stated in Attachment II (Water Conservation/Supply Component) of the Cooperative Agreement, the objective for the first increment of a basin-wide Program ".... is to produce annually on average at least 60,000 acre-feet of net hydrologic benefits in the associated habitats for the benefit of the target species."

The analysis to screen alternatives for the amount of water produced on an average annual basis is less sensitive to the length of time period than a dry year yield analysis. If the average yield for the 1975-94 period screens out an alternative, it is likely the alternative will produce even less in an analysis using a longer period of record such as 1944-94 which includes the drought of the 1950s. In the final development of the Water Conservation/Supply Action Plan, the ability of alternatives to perform well during drought periods must be considered.

An advantage of using the 1975-94 period for screening hydrologic benefits is that this period represents river flow conditions that are reflective of current development. River flows using a longer time period would have to be adjusted in early years in order to reflect the effects that newer projects would have on river flows before the projects were built. Such adjustments are often problematic and making such adjustments is beyond the time frame available to the WMC. When using the hydrologic information for the 1975-94 period for screening water conservation/supply alternatives, it is the consensus of the WMC that adjustments to the record are not necessary.

The following examples illustrate that the 1975-94 period is sufficient to represent the current level of development in the basin. Total reservoir capacity in the basin has increased by less than 6% during the 1975-94 period. This difference is relatively small compared to the accuracy with which the river system can be either measured or modeled. In contrast, reservoir capacity has increased by about 25% in the 1944-94 period, which would require complicated modifications to the record in order to reflect current development. Also in the four years prior to 1944, total basin wide reservoir storage more than doubled from 3 MAF to over 6 MAF. Significant adjustments would be necessary in the early part of the 1944-94 period to adjust for the major changes this large increase in storage capacity produced. Increases in total basin reservoir capacity are shown in Figure 1.

Changes in river return flows or gains are a good indication of the effect of project development. New surface water irrigation projects raise groundwater levels that contribute to increased river gains. For example, river return flows have increased substantially over the time period of 1944-94 in some of the reaches below Lake McConaughy, principally because of the development of the Central Nebraska Public Power and Irrigation District system. As an example, Figure 2 shows historic river gains for the reach from North Platte to Overton beginning at the river gages on the North Platte River and South Platte River at North Platte and going downstream to Overton. This plot shows the increase in river gains over time. Figure 2 also illustrates that the river gains from the early 1944-74 period would have to be increased significantly to reflect the higher current river gains that have resulted from project development. River return flows have fairly stabilized at the higher values which indicates the 1975-94 time period is more representative of current development conditions.

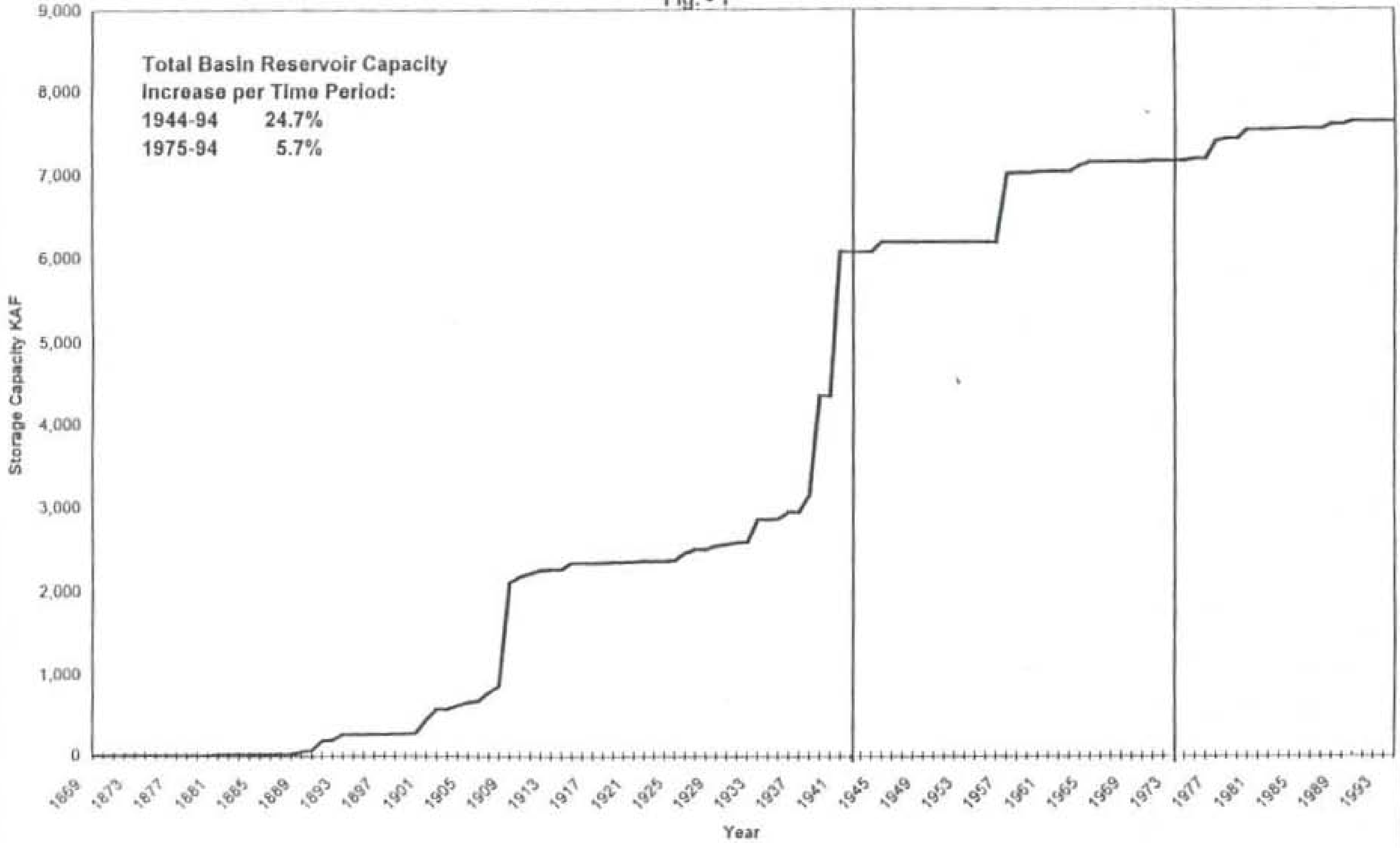
Increases in the minimum daily river flow by year are another indicator of increases in river return flows or gains which result from project development. Table 1 shows that the increase over time in minimum daily flows has been substantial but the changes over the more current 1975-94 period are much smaller than they are over the 1944-94 period, especially in the areas of greatest concern downstream of Lake McConaughy. Figure 3, for example, plots the minimum daily flow values, by year, at the Overton gage. As given in Table 1 and Figure 3, the 10-year running average for minimum flow at Overton for 1944-74 increased from 12 cfs to 189 cfs, a change of 177 cfs or 94%, while from 1975-94, the 10-year running average increased from 188 cfs to 213 cfs, a change of only 25 cfs or 12%. This also indicates that river return flows or gains resulting from new project development have fairly stabilized for the 1975-94 period. The changes at Lewellen and Julesburg shown in Table 1 are less dramatic due to the fact that the effects on river return flows of the much earlier irrigation development upstream of these two gages had stabilized before 1944.

Climatic records for the selected 1975-94 time period were compared to both the 1944-94 period used in much of the earlier OPSTUDY modeling and a longer 1931-94 period which includes the drought of the 1930s. Table 2 lists annual precipitation for ten selected stations throughout the basin. These ten stations range from Dillon, Colorado in the west (actually located just outside the Platte Basin in the Colorado River Basin) to Minden, Nebraska in the east. Precipitation at these ten locations is representative of the hydrologic conditions which influence river baseflows and local gains and losses. The average annual precipitation for these stations is 16.81 inches for the 1975-94 period, compared to 16.35 inches for the 1931-94 period, a difference of only 0.46 inches or 2.8%. Furthermore, the difference between the annual average of 16.81 inches for the 1975-94 period and 16.70 inches for the 1944-94 period is only 0.11 inches, or less than 1%. It should be noted that a mountain-weighted distribution of stations would be more appropriate for representing snow-based precipitation, which provides much of the water to the basin during spring and early summer runoff, but is not as relevant when local gains are being considered. To get an indication of the differences in snowmelt runoff between periods, stream flow records for runoff above Pathfinder Reservoir in Wyoming were reviewed. Average annual snowmelt runoff above Pathfinder Reservoir was only 2.7% greater for the 1975-94 period than the 1944-94 period.

These records indicate that the 1975-94 period is not significantly different on average from the longer periods, and indicate that the previously mentioned increases in river gains are not the result of a significantly climatically wetter period. It should be noted that the 1975-94 period includes representative years of both water surpluses (1983-84) and drought (1988-91).

In conclusion, the WMC selected the 1975 through 1994 time period for developing hydrologic information because it represents river flow conditions that are reflective of current development. This time period is a satisfactory screening period for average water yields of water conservation/supply alternatives proposed by the Consultant.

Platte River Basin
Total Reservoir Storage Capacity
Fig. - 1

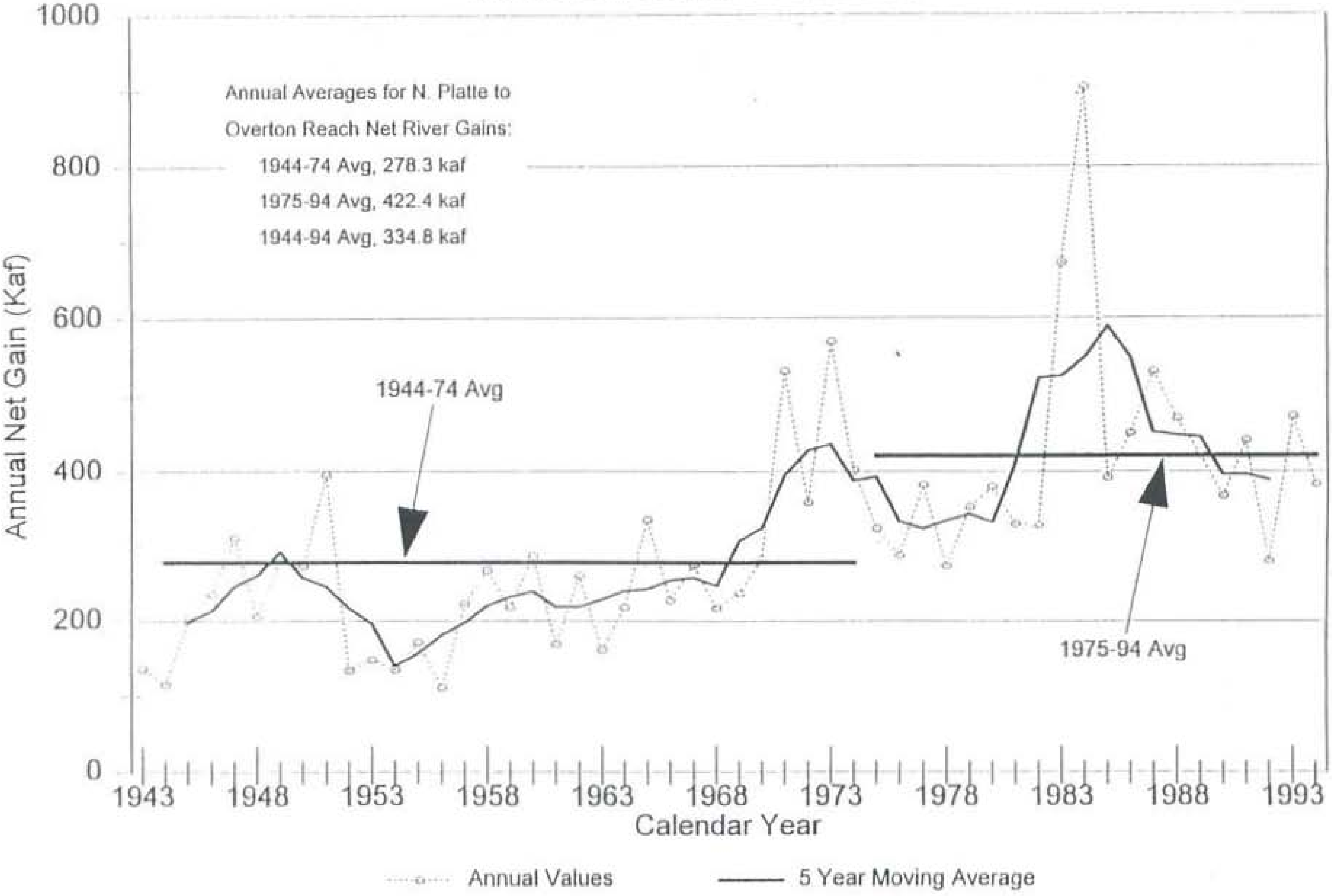


File:precip/storcap.xls
Date:7/7/98
phs

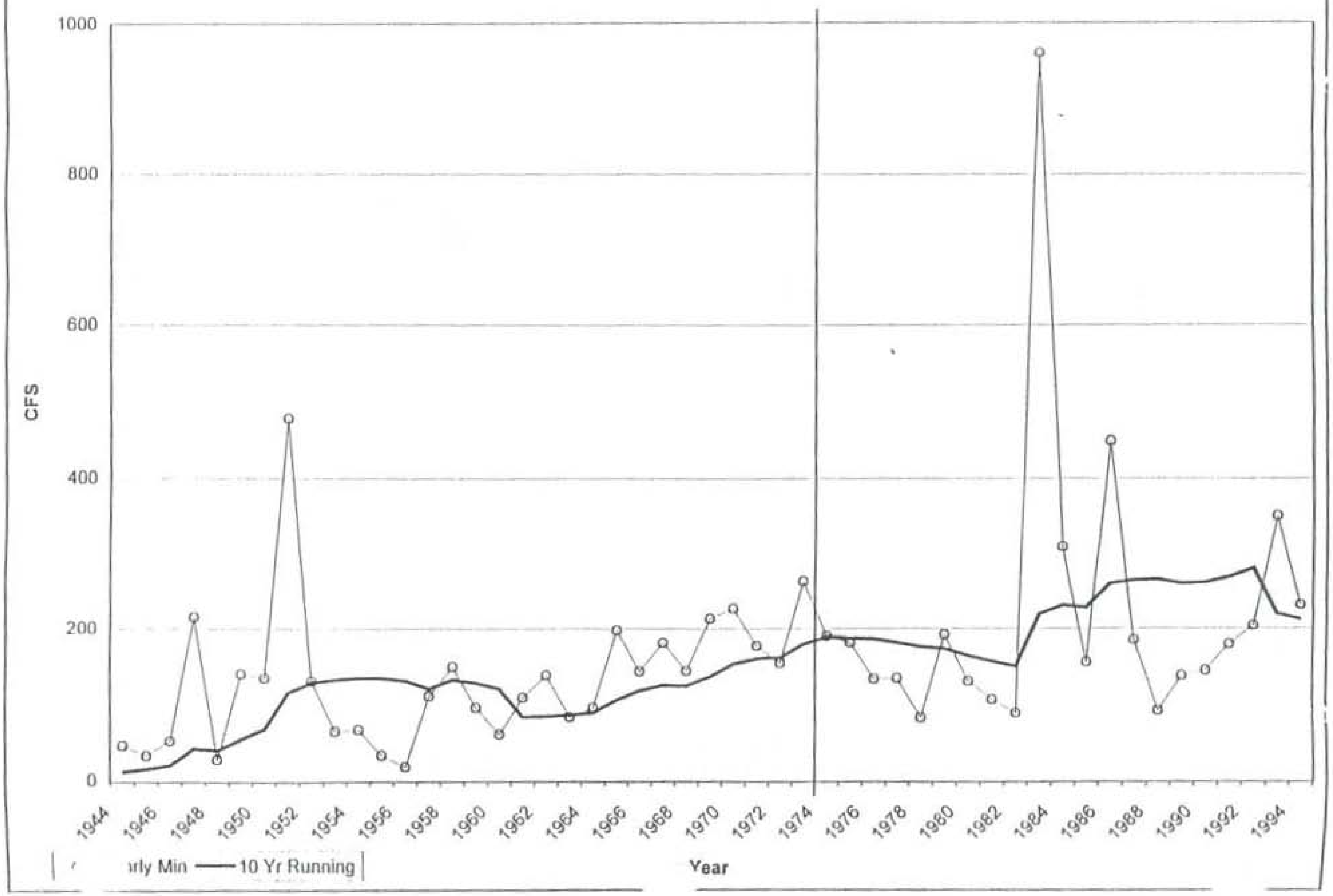
Figure 2

NORTH PLATTE TO OVERTON RIVER REACH

Historic Annual Net River Reach Gains



Annual Daily Minimum Flow
At Overton
Figure 3



File:databaseminflow.xls
Date:7/7/98
By:pns

Platte River System
Min. Annual Flow Values in CFS

Table - 1

	Yearly Min	10 YR Running Average	Yearly Min	10 YR Running Average	Yearly Min	10 YR Running Average	Yearly Min	10 YR Running Average	Yearly Min	10 YR Running Average
Year	NPR @ Lewellen		SPR @ Julesburg		SPR @ North Platte		PR @ Overton		PR @ Grand Island	
1925			18	0			0	0		
1926			27	0			500	0		
1927			22	0			0	0		
1928			17	0			0	0		
1929			14	0			1	0		
1930			23	0	0	0	0	0		
1931			14	0	0	0	0	0		
1932			18	0	0	0	0	0		
1933			20	0	0	0	0	0		
1934			18	20	0	0	0	50	0	0
1935			20	20	0	0	0	50	0	0
1936			17	18	0	0	0	0	0	0
1937			24	18	0	0	0	0	0	0
1938			21	20	13	0	48	5	0	0
1939			25	21	23	0	0	5	0	0
1940	200	0	15	20	20	6	0	5	0	0
1941	81	0	22	22	40	10	0	5	0	0
1942	290	0	32	23	68	16	2	5	0	0
1943	248	0	15	23	61	23	27	8	0	0
1944	237	275*	20	23	97	31	48	12	0	0
1945	548	244*	48	28	140	45	33	16	5	1
1946	170	261*	15	28	50	50	52	21	0	1
1947	430	289*	41	27	80	58	218	42	18	2
1948	212	283*	28	27	70	64	28	40	0	2
1949	299	333	53	30	28	65	140	54	39	6
1950	328	332	23	31	60	69	135	68	92	16
1951	582	358	27	32	71	72	478	116	224	38
1952	408	388	30	31	50	70	120	129	15	39
1953	213	371	24	32	79	72	64	132	0	39
1954	44	353	13	32	76	71	66	134	0	39
1955	80	328	15	29	60	63	33	134	0	39
1956	39	278	11	28	100	68	18	131	0	39
1957	116	273	30	27	55	66	110	120	0	37
1958	192	252	28	27	80	67	149	132	7	38
1959	76	230	12	23	87	72	95	128	0	34
1960	52	199	12	21	87	75	60	120	0	23
1961	80	176	33	21	81	78	108	83	0	2
1962	115	134	28	21	100	81	138	84	73	8
1963	118	108	18	20	79	81	82	86	0	8
1964	75	98	7.5	19	52	78	95	89	0	8
1965	189	108	19	20	120	84	198	105	28	11
1966	117	112	28	21	100	84	143	118	0	11
1967	348	134	28	21	120	91	181	125	18	13
1968	388	157	14	20	70	90	144	128	23	14
1969	201	158	22	21	80	89	214	136	62	20
1970	285	177	34	23	120	92	227	153	7	21
1971	530	220	17	21	90	93	177	160	128	35
1972	506	259	13	20	100	93	154	162	37	31
1973	616	305	42	22	90	94	284	180	215	52
1974	562	344	22	24	100	99	190	189	0	52
1975	384	370	34	25	100	97	181	188	6	50
1976	228	375	10	24	97	97	133	187	0	50
1977	211	383	23	23	90	94	134	182	31	52
1978	310	380	11	23	39	97	82	176	0	59
1979	290	373	34	24	54	97	192	173	90	52
1980	410	392	30	24	107	96	120	164	28	54
1981	132	378	16	24	90	96	106	157	54	56
1982	282	356	28	25	110	97	58	150	85	61
1983	929	394	400	61	130	101	960	220	1150	144
1984	1000	429	54	67	152	106	310	232	314	178
1985	270	402	20	65	131	109	155	229	277	203
1986	1000	461	25	68	122	112	449	281	0	203
1987	287	475	43	70	134	116	155	286	181	218
1988	226	488	37	72	108	117	81	287	4	218
1989	90	465	14	71	50	113	137	281	111	220
1990	107	448	19	69	58	110	144	283	28	221
1991	213	421	21	71	90	110	179	270	5	217
1992	50	428	23	71	115	110	204	281	112	219
1993	251	432	31	34	150	112	281	221	418	148
1994	120	359	12	27	84	106	222	213	229	138
1995	549	319	56	30	172	110	539	231	140	124
1996	370	345	40	31	160	114	411	247	780	202

*NPR @ Lewellen from 1944-1948 use a 5 yr running avg values.

Annual Precipitation For Selected Stations Above Grand Island
Table 2

Year	Dillon	Fort Collins	Laramie	Wheatland	Torrington	Bridgeport	Julesburg	North Platte	Gothenburg	Minden	Average
1931	12.41	9.88	8.93	13.50	8.60	10.70	8.72	10.01	17.02	20.11	11.99
1932	17.89	12.80	10.98	8.31	9.50	12.57	16.17	17.80	17.26	19.08	14.24
1933	20.32	15.65	5.57	11.22	13.17	12.15	19.27	17.12	19.02	22.33	15.58
1934	20.67	8.87	9.93	8.05	10.50	7.93	10.47	13.56	14.19	13.25	11.74
1935	21.60	15.95	11.66	16.40	15.69	12.18	13.26	19.19	26.15	21.25	17.33
1936	26.76	11.81	9.81	11.76	12.14	7.95	10.31	11.26	16.04	12.59	13.04
1937	16.15	12.93	16.36	13.54	11.94	9.33	11.17	12.37	20.88	17.11	14.18
1938	20.74	19.72	14.23	16.03	13.82	20.22	15.92	21.81	15.30	18.33	17.61
1939	13.55	7.85	7.70	7.44	7.11	13.18	15.08	11.93	14.05	18.79	11.67
1940	18.89	13.94	11.11	12.46	13.58	14.21	13.97	10.98	16.86	15.87	14.19
1941	18.87	17.81	13.70	12.52	19.46	17.68	21.72	19.99	23.84	27.14	19.27
1942	19.72	21.19	10.49	19.36	17.52	22.74	18.08	29.74	26.28	27.35	21.25
1943	17.34	12.27	7.75	8.79	9.89	16.47	10.43	14.34	13.18	14.39	12.49
1944	13.68	13.53	12.26	7.81	15.18	21.57	17.90	18.49	21.99	34.43	17.68
1945	26.36	15.73	14.49	15.05	19.15	19.86	21.33	20.71	21.19	22.91	19.68
1946	16.23	14.11	13.35	13.12	13.31	12.92	19.35	20.74	24.62	36.58	18.43
1947	23.96	17.95	17.34	15.74	17.94	19.69	16.86	18.47	27.06	23.15	19.82
1948	16.17	10.45	9.35	14.03	13.46	16.55	15.09	15.83	20.98	19.41	15.13
1949	18.85	18.79	11.51	13.77	13.58	16.15	18.67	23.30	25.65	26.62	18.69
1950	17.51	12.70	10.48	12.89	14.04	13.63	14.08	21.35	21.74	32.06	17.05
1951	21.80	22.52	9.07	15.92	14.16	17.99	25.66	33.44	29.52	35.26	22.53
1952	15.18	12.74	9.00	13.92	13.74	10.24	19.20	14.31	12.84	18.25	13.94
1953	18.80	11.42	9.86	9.18	13.21	14.71	19.22	13.65	14.42	20.27	14.47
1954	13.36	7.98	8.28	8.13	10.32	10.32	10.36	10.46	16.61	20.15	11.60
1955	19.17	12.97	9.67	12.84	21.06	18.18	17.62	18.10	13.00	18.09	16.07
1956	15.82	12.19	9.16	10.30	8.77	10.50	17.53	16.90	15.25	15.12	13.15
1957	21.16	19.56	10.48	17.30	18.97	19.65	19.78	29.72	26.70	31.54	21.49
1958	14.34	17.44	11.26	11.50	11.65	19.64	23.12	21.77	22.16	25.24	17.81
1959	20.11	14.67	10.98	14.04	15.06	14.27	13.90	20.37	24.70	29.90	17.80
1960	15.03	10.01	7.83	8.61	8.59	12.72	15.30	15.32	19.07	33.07	14.55
1961	19.91	28.42	13.58	12.68	15.96	17.91	18.93	18.71	20.24	26.20	19.25
1962	11.99	13.20	10.56	13.64	17.58	20.59	15.94	24.75	30.81	28.17	18.72
1963	15.50	12.00	8.72	10.31	14.45	14.93	14.81	19.34	21.86	15.88	14.78
1964	11.56	8.07	7.66	11.06	7.00	13.82	12.65	20.96	22.56	18.92	13.43
1965	15.61	16.17	13.18	16.98	13.86	23.68	25.25	29.61	30.04	39.35	22.37
1966	12.39	7.34	6.56	9.52	10.16	15.15	20.26	17.57	18.92	16.47	13.63
1967	12.50	21.54	13.00	14.08	15.74	15.83	15.55	17.45	20.67	29.45	17.58
1968	10.20	13.31	9.63	11.28	11.19	15.69	13.08	17.04	18.85	26.47	14.67
1969	16.52	17.71	11.23	8.26	10.58	13.81	17.64	15.19	21.12	26.57	15.86
1970	13.57	14.29	9.75	11.07	12.62	12.05	13.72	16.21	16.80	18.98	13.91
1971	10.62	13.98	10.18	17.74	12.73	15.18	18.78	24.25	25.41	22.08	17.10
1972	10.22	9.91	12.85	9.77	13.20	14.59	15.50	16.37	18.73	26.25	14.74
1973	12.95	14.07	15.81	13.00	10.57	22.56	19.36	21.73	25.17	31.76	18.70
1974	13.27	11.62	9.22	7.72	8.96	8.35	8.84	12.17	15.05	12.63	10.78
1975	13.21	17.07	10.67	9.89	9.52	11.68	21.64	16.19	20.32	23.50	15.37
1976	14.76	10.56	6.86	8.91	13.74	13.44	9.34	18.36	20.73	15.34	13.20
1977	13.17	12.15	11.14	12.37	13.20	12.97	20.66	24.87	28.40	29.38	17.83
1978	10.45	15.02	8.47	12.84	15.32	20.43	11.80	19.85	23.17	19.59	15.69
1979	11.27	22.14	8.90	10.32	13.06	17.45	20.26	25.00	21.18	31.33	18.09
1980	14.72	13.64	9.76	10.16	12.09	12.44	15.15	14.32	14.21	21.17	13.77
1981	15.28	14.06	11.16	13.08	10.74	13.87	20.78	23.79	31.48	32.74	18.70
1982	15.28	21.03	10.80	17.21	20.44	24.59	22.56	19.90	20.27	29.99	20.22
1983	20.93	19.45	15.80	15.67	11.71	18.15	20.32	19.20	20.00	27.41	18.86
1984	18.99	16.03	11.87	14.86	14.61	15.02	12.69	21.16	27.27	25.02	17.75
1985	12.99	16.37	11.58	11.99	12.71	12.21	15.01	19.29	23.02	30.10	16.53
1986	14.62	12.40	10.80	13.97	17.85	16.98	14.66	16.94	20.37	29.22	16.78
1987	12.82	14.80	12.00	9.50	14.53	19.33	22.60	20.41	26.40	28.85	18.12
1988	12.74	15.39	9.93	8.27	8.67	16.96	19.84	19.75	25.77	19.45	15.68
1989	13.40	12.85	8.49	10.92	9.14	9.27	12.68	14.01	18.56	23.84	13.32
1990	13.71	17.27	15.11	15.02	16.36	18.96	18.21	15.80	17.70	17.28	16.54
1991	13.31	14.13	16.60	18.21	15.16	13.79	13.34	20.55	22.63	17.09	16.48
1992	12.74	20.68	13.61	10.78	10.59	17.75	24.35	23.01	20.23	22.85	17.66
1993	14.53	17.34	14.87	14.85	17.76	19.86	15.50	26.20	27.07	41.89	20.99
1994	10.81	13.43	6.42	12.61	10.02	13.22	10.92	18.85	23.10	27.72	14.71

RELEVANT TIME PERIOD AVERAGES

31-94	15.92	14.73	10.96	12.38	13.23	15.44	16.60	18.93	21.18	24.10	16.35
44-94	15.18	14.95	11.04	12.41	13.41	15.90	17.21	19.64	21.87	25.39	16.70
75-94	13.99	15.79	11.24	12.57	13.36	15.92	17.12	19.87	22.59	25.69	16.81

APPENDIX E

Determination of Monthly Loss Factors for the Platte River Study

January 5, 1999

DETERMINATION OF MONTHLY LOSS FACTORS FOR THE PLATTE RIVER FOR THE HISTORICAL 1975-1994 WATER YEAR PERIOD

As required by Milestone W14-1 of the Cooperative Agreement, the Water Management Committee (WMC) has developed monthly loss factors for 19 river reaches in the Platte River Basin for the historical water year period of 1975 through 1994. These monthly % loss factors will be used by the Consultant in the performance of the Water Conservation and Supply Study. These historic loss factors may also form some of the basis for monthly loss or shrink factors used to route depletions and accretions to the critical habitat from future development in all three states as part of the effort to determine replacement obligations for offsetting future depletions.

It is important to remember that this analysis for historic monthly loss factors is developed for planning and screening purposes to compare the yield of one water conservation/supply alternative to another over the 1975-94 historical period. Because of the monthly increment for this loss factor analysis, the travel times for water to flow from one location to another are not considered. Daily lag times and daily river losses assessed by river administrators will be utilized when the WMC develops the water accounting procedures to track actual water contributions to the Recovery Program.

The spreadsheets for 19 river reaches will be combined by the Consultant in order to convey depletions and accretions in the basin down to the critical habitat in central Nebraska. Loss factors have not been developed for all the tributaries and certain sections of the mainstem in the upper basin. A loss factor analysis will be performed on these other tributaries and mainstem sections if the Consultant identifies a water conservation/supply alternative in these areas.

An important underlying assumption in these monthly % loss computations is that generally losses are shared by and prorated among all inflows. In other words, a contribution of water from a water conservation/supply alternative entering a reach at the upstream end will experience the same % loss or shrink as historic inflows to the reach. In general, the analysis of historic river loss factors is a three step procedure where each step computes a different part of the loss. Reach specific analysis procedures, such as data availability, computational techniques, operational considerations, etc. are described in the Addendums to this report.

Table 1 lists the 19 river reaches of the Platte River that were analyzed for loss factors and includes information about each of the reaches. A reach is defined as a section of river between two river flow gages. Figure 1 is a map of the Platte River Basin showing the location of the 19 river reaches and the corresponding upstream and downstream gages that define the reaches. The 19 reaches were separated into four sections or regions as shown in Table 1 where each region was analyzed by different individuals using this same three step procedure. The four regions analyzed for loss factors are:

(1) North Platte River in Wyoming
(2) South Platte River
(3) North Platte River above Lake McConaughy in Nebraska
(4) North Platte River and Platte River below Lake McConaughy.

Spreadsheets titled NPWYlos, SPloss, NPNEls, and PRNEloss to correspond to these four regions respectively are currently on the CNPPID's FTP site for access by the Consultant and others. Access to this FTP site is as follows:
Host Name: 164.119.100.4
Host Type: Automatic detect
User ID: anonymous
Password: guest
Directory: /pub/data/mad/w14-1

The three steps of this procedure to determine historic river loss factors are summarized below and described in more detail later.

Step 1 computes the monthly loss due to gross evaporation from the open water surface area of the river channel in a reach. This step computes that part of loss due to evaporation (ie, % evap).

Step 2 computes the monthly net gain, whether positive or negative, for a reach from a water balance analysis on the flowing river channel where the evaporation from Step 1 is a separate value in the water balance computation. A net negative gain indicates that the river channel reach is losing or seeping water. This step computes that part of loss due to seepage from the river channel into groundwater or bank storage (ie, % seep) for only those months of a net negative gain. This seepage is due to a groundwater gradient away from the water surface in the river where this gradient could be also caused by numerous factors such as phreatophyte transpiration, groundwater well pumping, etc.

Step 3 computes the historical amount of water that was diverted in a reach (ie, % divert). Water entering a reach can be considered lost from that reach due to diversions unless it is protected by current or future statutes and water administration and can be bypassed around existing diversions. There may be water conservation/supply alternatives that produce water which can not be protected under current state water law and therefore would have been subject to diversion during this historical period of analysis. These % divert factors may also form some of the basis for routing accretions and depletions from new development which will not be bypassed but instead subject to diversion under a state's appropriation doctrine. This step computes that part of loss due to diversions at existing river headgates for water that is not protected but subject to appropriation. As discussed later in this report, these % divert factors are gross values rather than net values because they do not account for return flows to the river.

All three loss factors (% evap, % seep, and % divert) are expressed as a percent loss per mile within a given reach. These % loss factors per mile can be applied to water contributions introduced at any point within the reach where the appropriate number of miles is multiplied by the % loss factor per mile to shrink the water contribution as it moves downstream to the bottom of the reach.

As stated previously, an underlying assumption in these % loss computations is that losses are shared by and prorated among all inflows which include measured inflow at the upstream end of the reach, other measured inflows within the reach such as tributaries and canal/reservoir returns, and net positive gains. The denominator in the % loss ratio is the sum of all inflows where:

Sum of All Inflows =
Measured gage inflow at upstream end of reach +
Other measured inflows +
Positive net gains computed from river water balance

The following is an example which clarifies the application of the three % loss factors (% evap, % seep, and % divert). If 100 acre-feet was the monthly amount to be routed through a 100 mile long reach and the % evap for the reach was 0.05% per mile, % seep was 0.10% per mile, and % divert was 0.50% per mile, then the loss due to evaporation for the 100 mile reach would be 5 acre-feet, the loss due to seepage would be 10 acre-feet, and the loss due to diversions would be 50 acre-feet for a total loss of 65 acre-feet. In other words only 35 acre-feet of the 100 acre-feet would be in the river at the downstream end of the reach. This example assumes that the 100 acre-feet was subject to appropriation and not passed by existing diversions. If the 100 acre-feet was protected so it would bypass existing diversions, then the loss would be only 15 acre-feet (% evap plus % seep only) and 85 acre-feet would be in the river at the downstream end of the reach. This same procedure would then be applied in the next reach downstream where the 35 or 85 acre-feet entering that reach would be shrunk by that reach's three loss factors.

On the North Platte River in Wyoming, about 90 miles are inundated by reservoirs (Seminoe, Kortes, Pathfinder, Alcova, Gray Reef, Glendo, and Guernsey). The loss factors developed for these reaches with reservoirs were the average of the monthly % evap loss factors for the reaches above and below the reaches with reservoirs. The loss factors for % seep and % divert were not developed for these reaches with reservoirs. The procedures for these reaches are described further in Addendum 1 of this report. The % evap loss factors in these reaches will not be applied for the river miles beneath the reservoirs. The Consultant should consider the operational characteristics of these reservoirs when routing water into and out of storage. There are two major diversions (Interstate Canal and Gering-Ft. Laramie Canal) just below Guernsey Reservoir that occur at the Whalen Diversion Dam. Monthly diversion records are available for these canals and the Consultant should consider the implications of these diversions in routing water developed from water conservation/supply alternatives.

In addition, loss factors will not be applied to the reach of the North Platte River under Lake McConaughy. The Lake McConaughy reach is excluded from this analysis because the reach upstream of Lake McConaughy ends at the Lewellen gage which is the inflow point to Lake McConaughy and the reach downstream of Lake McConaughy begins at the Keystone gage below Lake McConaughy. The Consultant should consider the operations of the Environmental Account in Lake McConaughy when routing the water from conservation/supply alternatives to and through Lake McConaughy. NPPD's Keystone Canal diverts just below Lake McConaughy and just above the Keystone gage and therefore the monthly diversions of this canal are not included in a % divert computation for the reach starting with the Keystone gage. Water diverted at the Keystone Canal is returned to the river near North Platte. The operations of the Keystone Canal should be considered by the Consultant when considering the operations of Lake McConaughy and its Environmental Account.

The following is a more detailed description of the three steps used to compute the three % loss factors.

STEP 1: Monthly reach loss due to gross evaporation from the river water surface area.

1. Monthly gross pan evaporation values in inches for the period of 1975-1994 were obtained from weather stations along the Platte River. A factor of 0.7 was multiplied times pan evaporation to obtain river water surface gross evaporation. The weather stations with pan evaporation values used for analysis on the North Platte River in Wyoming were located at Seminoe Reservoir, Pathfinder Reservoir, and Whalen Diversion Dam. The stations with pan evaporation values used for analysis in Nebraska were Bridgeport, Kingsley Dam, North Platte, and Grand Island. If pan evaporation was not available such as on the South Platte River in Colorado, then temperature data from weather stations was used to compute an open water surface gross evaporation by the Modified Blaney-Criddle equation. This procedure for the South Platte is described in more detail in Addendum 2 to this report.

2. River water surface areas at different stages of river flow were obtained by computing surface areas from field data taken during flow measurement ratings at the river gages which define the upstream and downstream ends of the different reaches. Field rating data at the various river gages was used to develop graphs and equations of channel width in feet versus flowrate in cfs. These graphs and equations at the river gages for all the reaches of this analysis are included in Addendum 5 to this report. At most river gages the equation that provided the best fitting equation for channel width versus flowrate was a natural log equation. However in a few cases as shown in Addendum 5, a polynomial equation provided the best fit over the range of available data, however caution was shown in using these polynomial equations beyond the range of data used in the development of the equation.

Using these equations with an average monthly flowrate, an average monthly width at the gaging station was computed. An approximate average monthly river water surface area was computed for a reach by averaging the monthly average widths at the reach's upstream and downstream gaging stations for the given month and multiplying by the reach length.

This computation for an approximate average monthly river water surface area was calibrated to river water surface area determined from other sources of information. This other information consisted of satellite imagery on the South Platte in Colorado and DOQQs (Digital Ortho Quarter Quads) and aerial photos for some of the river reaches in Nebraska. For example on the South Platte River in Colorado, a calibration factor of 0.755 was determined from the satellite imagery which was multiplied by the approximate monthly river area determined from rating curve data to obtain a more accurate estimate of average monthly river water surface area for a reach.

As described in more detail in Addendum 4 to this report, for the two lower reaches on the Platte River in Nebraska (Overton to Odessa and Odessa to Grand Island), data for river surface areas and flows from river cross-sectional study sites of the Prairie Bend Study were used to develop graphs and equations of river water surface area versus flow. In the wide braided channel system of the lower Platte River, this provided a better estimate of river water surface area than using rating curve data at flow gages near bridges because bridges significantly restrict these wide channels and do not give a representative width for the rest of the reach.

3. The calibrated monthly river water surface area in acres were multiplied by the feet of gross monthly evaporation determined from the weather stations to obtain monthly acre-feet of gross evaporation loss by reach. To obtain the % evap value, this monthly acre-feet of gross evaporation was divided by the "Sum of all Inflows" to the reach as discussed above. This was further divided by the miles in the reach and multiplied by 100 to get the % evap value per mile for the reach.

STEP 2: Monthly reach loss due to seepage as computed from a river water balance analysis.

A river water balance was computed for most of the 19 reaches on a monthly time step for the flowing river channel between the upstream and downstream gages that define the reaches. Net gains whether positive or negative are computed as the difference between the sum of measured outflows minus the sum of measured inflows. For a monthly water balance calculation, changes in storage volume in the river channel are assumed to be negligible. Outflows are the gaged flow at the downstream end of the reach, all measured diversions, and monthly gross evaporation computed from Step 1. Inflows are the gaged flow at the upstream end of the reach and other measured inflows such as tributaries, reservoir releases and canal/hydropower returns to the river. The reach water balance equation to compute net gains on a monthly basis for a reach is as follows:

Net Gains (+ or -) =
Measured gage outflow at downstream end of reach +
Sum of all measured diversions +
Gross evaporation from Step 1 -
Measured gage inflow at upstream end of reach -
Other measured inflows

For months where the above calculation shows a negative gain indicating a losing or seeping river, then that month has a % loss factor due to seep (ie, % seep). To obtain the % seep value for those months of a losing river, this monthly acre-feet of negative gain was divided by the "Sum of all Inflows" to the reach as discussed above. This was further divided by the miles in the reach and multiplied by 100 to get the % seep value per mile for the reach. Since this is a month of negative gains, the "Sum of all Inflows" will be the sum of only (1) measured gage inflow at upstream end of the reach and (2) other measured inflows.

STEP 3: Monthly reach loss due to historic diversions.

As discussed above, water entering a reach can be considered lost from that reach due to diversions if it is not protected for bypass around existing diversions. In screening and ranking water conservation/supply alternatives, the Consultant may compare protected and unprotected water supplies in terms of their yield when routed to central Nebraska for this historical period of analysis. Unprotected water supplies may need to be shrunk by the additional % diversion factor.

A monthly historic % loss factor due to diversions (ie, % divert) was computed as the ratio of total measured diversions divided by the "Sum of all Inflows". This was further divided by the miles in the reach and multiplied by 100 to get the % divert value per mile for the reach. Table 2 lists the measured diversions which were included in the water balance calculations and the historic % diversion factor computations for the different reaches. In the use of these % divert loss factors, the Consultant should exercise caution and review with the WMC situations during the historical analysis period where a canal may be considered at full capacity or canal demands are fully satisfied.

The discussion in Addendum 4 to this report for river reaches below Lake McConaughy in Nebraska addresses the applicability in using these % diversion factors in relation to diversion requirements and Lake McConaughy operational releases. Since diversion requirements were met for this historical analysis period from natural flow rights and Lake McConaughly releases, additional water from conservation and supply alternatives would not be diverted. However, adding unprotected natural flow water that could meet diversion requirements could result in a decrease in water being released from Lake McConaughy. The implications of such a scenario on Lake McConaughy operations and the potential of adding or "exchanging" this water resulting from reduced releases into the Environmental Account in Lake McConaughy should be addressed by the Consultant, Nebraska interests, and the WMC.

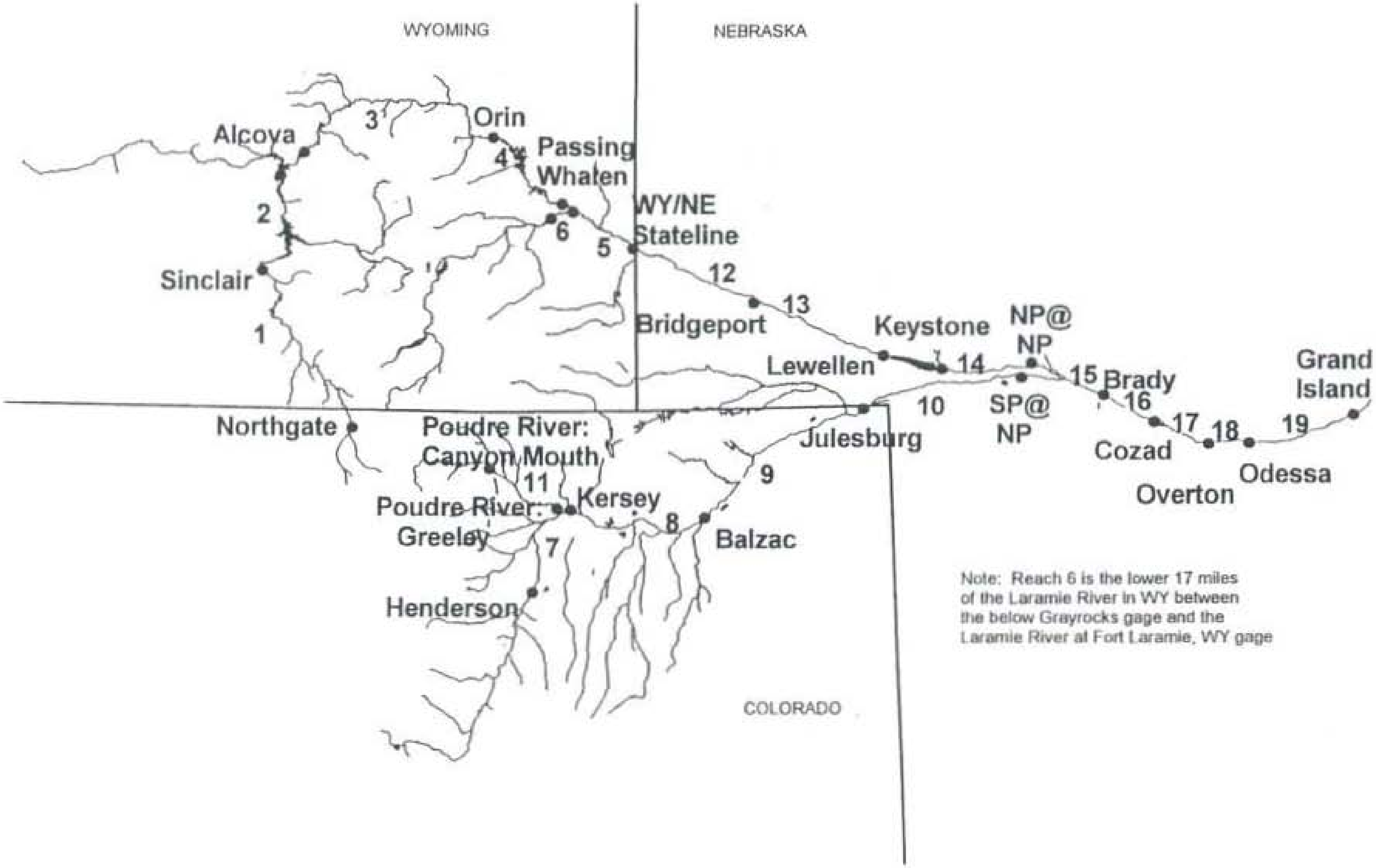
It is important to note that the % divert values are a gross value and do not account for returns to the river that may result from water being diverted. There may be immediate and direct returns to the river such as diversions for hydropower. An example of this is the diversions by NPPD's Korty Canal on the South Platte River in Reach 10, Julesburg to S. Platte at N. Platte. When routing water down the South Platte River, the water lost by the % divert value attributable to the Korty Canal in this reach should be reintroduced at the start of the next downstream reach with some adjustment for the seepage (for example 20%) in the Korty/Keystone/Sutherland Canal system that is not immediately returned to the river during the month. The water diverted by the Korty Canal is combined with water diverted by NPPD's Keystone Canal on the North Platte to be returned to the river at NPPD's North Platte Hydroplant Return. Table 3 lists by month the percent of diverted water returned to the river through the North Platte Hydroplant Return from NPPD's Korty and Keystone diversions.

A similiar situation also occurs for the CNPPID's Canal in Reach 15 which supplies both irrigation and hydropower. A portion of the diversions by this canal is returned to the river through the Jeffrey River Return in Reach 16 downstream and a portion is returned to the river through the Johnson River Return in Reach 17 downstream. Table 4 lists by month the percent of diverted water returned to the river from the CNPPID's diversion.

With the % divert values being gross values, lagged groundwater and surface water returns are not considered which can result from diversions of river water that are used for irrigation. Deep percolation from canal seepage and field irrigation and surface runoff from irrigation can return a portion of the diverted water to the river. If a water conservation/supply alternative is being considered where the water developed from the alternative can not be protected under current laws, then the Consultant may need to be directed by the WMC to develop and apply return flow factors which reintroduces a portion of the diverted water back into the river in the month of diversion and subsequent months for continued routing downstream to central Nebraska.

It is important to reemphasize that the utilization of the loss factors developed in all three steps of this procedure is for a monthly planning analysis to evaluate, screen, and compare water conservation and supply alternatives as to their potential for reducing flow shortages with respect to the USFWS annual species target flows in central Nebraska over the 1975-94 historical period. Actual implementation and tracking of alternatives in a Recovery Program may rely less on these monthly factors but instead upon decisions made daily by project operators and river administrators.

FIGURE 1: Platte River Basin Study Reaches



Note: Reach 6 is the lower 17 miles of the Laramie River in WY between the below Grayrocks gage and the Laramie River at Fort Laramie, WY gage

TABLE 1:

Platte River Basin Reaches Analyzed for Loss Factors for Water Years 1975 through 1994 by Water Management Committee (Analysis period of 240 months)

REGION LOCATION OF REACHES	CONTACT PERSON ON ANALYSIS
Reaches 1 through 6: North Platte River, Wyoming	Becky Mathisen
Reaches 7 through 11: South Platte River	Jon Altenhofen
Reaches 12 and 13: North Platte River above Lake McConaughy, Nebraska	Ann Bleed
Reaches 14 through 19: North Platte and Platte River below Lake McConaughy, Neb	Jeremie Kerkman

REACH NUMBER	SPREADSHEET WITH ANALYSIS	UPSTREAM GAGE	DOWNSTREAM GAGE	TOTAL REACH LENGTH (miles)	REACH LENGTH NOT INUNDATED BY RESERVOIRS (miles)	COMMENTS
1	NPWYlos1.xls	Northgate	Sinclair	100	100	
2	NPWYls24.xls	Sinclair	Alcova	104	40	Inundated by Seminoe, Kortes, Pathfinder, Alcova, and Gray Reef
3	NPWYlos3.xls	Alcova	Orin	132	132	
4	NPWYls24.xls	Orin	Below Whalen	66	40	Inundated by Glendo and Guernsey
5	NPWYlos5.xls	Below Whalen	WY/NE Stateline	47	47	
6	NPWYlos6.xls	Laramie River: Below Grayrocks	Laramie River: Fort Laramie	17	17	Only 1981 through 1994 data available
7	SPloss.xls	Henderson	Kersey	54.9	54.9	
8	SPloss.xls	Kersey	Balzac	69.7	69.7	
9	SPloss.xls	Balzac	Julesburg	97.6	97.6	
10	SPloss.xls	Julesburg	South Platte at North Platte	85.6	85.6	
11	SPloss.xls	Poudre River; Canyon Mouth	Poudre River; Greeley	51.8	51.8	
12	NPNEls12.xls	WY/NE Stateline	Bridgeport	57.5	57.5	
13	NPNEls13.xls	Bridgeport	Lewellen	60.0	60.0	
14	prneloss.xls	Keystone	North Platte at North Platte	51.5	51.5	
15	prneloss.xls	North Platte at North Platte	Brady	23.8	23.8	
16	prneloss.xls	Brady	Cozad	25.5	25.5	
17	prneloss.xls	Cozad	Overton	28.1	28.1	
18	prneloss.xls	Overton	Odessa	15.7	15.7	
19	prneloss.xls	Odessa	Grand Island	56.2	56.2	

TABLE 1 (Continued):

Platte River Basin Reaches Analyzed for Loss Factors for Water Years 1975 through 1994 by Water Management Committee (Analysis period of 240 months)

REGION LOCATION OF REACHES	CONTACT PERSON ON ANALYSIS
Reaches 1 through 6: North Platte River, Wyoming	Becky Mathisen
Reaches 7 through 11: South Platte River	Jon Altenhofen
Reaches 12 and 13: North Platte River above Lake McConaughy, Nebraska	Ann Bleed
Reaches 14 through 19: North Platte and Platte River below Lake McConaughy, Neb	Jeremie Kerkman

REACH NUMBER	STEP 1 % EVAP LOSS FACTOR	STEP 2 % SEEP LOSS FACTOR		STEP 3 % DIVERT LOSS FACTOR	
	Weather Stations Used for Evaporation	Monthly Water Balance Equation (Inflows=Outflows) Assume:No change in channel reach storage	# of Months of a losing river for 1975-1994	Yes or No if Factor Computed	# of Diversions Listed in Table 2
1	Seminoe Res. Evap. Pan	NorthgateGage + NetGainLoss= SinclairGage + Evap	0	No	Approx. 40 diversions. Few monthly records.
2	Used Average of % Evap Factors from Reach 1 and 3	Not Computed	na	No	No permanent diversions from live river.
3	Pathfinder Res. Evap. Pan	AlcovaGage + NetGainLoss= OrinGage + Evap	33	No	Approx. 150 diversions. Few monthly records.
4	Used Average of % Evap Factors from Reach 3 and 5	Not Computed	na	No	25 Diversions Few monthly records.
5	Whalen Dam Evap. Pan	BelowWhalenGage + FtLaramieGage + NetGainLoss=WY/NEStatelineGage + Evap + Diversions	9	Yes	10 Diversions
6	Whalen Dam Evap. Pan	BelGrayrocksGage + NetGainLoss = FtLaramieGage + Evap	69 (for 1981-1994)	No	10 Diversions Few monthly records.
7	Blaney-Criddle Average of Brighton, Longmont, Ft. Collins, Greeley	HendersonGage + OtherInflows + NetGainLoss=KerseyGage + Evap + Diversions	3	Yes	15 Diversions
8	Blaney-Criddle Average of Greeley, Ft. Morgan, Sterling, Julesburg	KerseyGage + OtherInflows + NetGainLoss=BalzacGage + Evap + Diversions	18	Yes	16 Diversions
9	Blaney-Criddle Average of Greeley, Ft. Morgan, Sterling, Julesburg	BalzacGage + OtherInflows + NetGainLoss=JulesburgGage + Evap + Diversions	16	Yes	23 Diversions
10	Average of North Platte Evap. Pan (Bridgeport for winter pan) and Julesburg Blaney-Criddle	JulesburgGage + NetGainLoss = SouthPlatteatNPGage + Evap + Diversions	22	Yes	2 Diversions
11	Blaney-Criddle Average of Ft. Collins and Greeley	CanyonMouthGage + Other Inflows + NetGainLoss=GreeleyGage + Evap + Diversions	3	Yes	25 Diversions
12	Bridgeport Evap. Pan	WY/NEStatelineGage + OtherInflows +NetGainLoss=BridgeportGage + Evap+ Diversions	0	Yes	10 Diversions
13	Average of Bridgeport and Kinsley (summer only) Evap. Pans	BridgeportGage + OtherInflows + NetGainLoss=LewellenGage + Evap + Diversions	14	Yes	4 Diversions
14	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	KeystoneGage + OtherInflows + NetGainLoss=NorthPlatteatNPGage + Evap + Diversions	1	Yes	5 Diversions
15	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	NorthPlatteatNPGage + OtherInflows + NetGainLoss=BradyGage + Evap + Diversions	5	Yes	1 Diversion
16	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	BradyGage + OtherInflows + NetGainLoss=CozadGage + Evap + Diversions	27	Yes	6 Diversions
17	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	CozadGage + OtherInflows + NetGainLoss=OvertonGage + Evap	7	No	No Diversions
18	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	OvertonGage + NetGainLoss= OdessaGage + Evap + Diversions	91	Yes	1 Diversion
19	Avg summer evap. from Kingsley, N. Platte, Grand Is.(winter from Bridgeport)	OdessaGage + OtherInflows + NetGainLoss=GrandIslandGage + Evap	127	No	No Diversions

TABLE 2: LIST OF DIVERSIONS USED IN WATER BALANCE CALCULATIONS

DIVERSIONS FOR NORTH PLATTE RIVER REACH #5 IN WYOMING:
Passing Whalen to WY/NE Stateline

1 Grattan
2 North Platte Ditch
3 Rock Ranch
4 Pratte-Ferris
5 Burbank
6 Torrington
7 Lucerne
8 Narrows
9 Mitchell
10 Gering

DIVERSIONS FOR THE TWO NORTH PLATTE RIVER REACHES ABOVE LAKE MCCONAUGHY IN NEBRASKA

Reach 12: WY/NE Stateline to Bridgeport
1 Castle Rock-Steamboat Canal
2 Central Canal
3 Enterprise Canal
4 Minatare Canal
5 Tri-State Canal
6 Winters Creek Canal
7 Belmont Canal
8 Chimney Rock Canal
9 Nine Mile Canal
10 Short Line Canal

Reach 13: Bridgeport to Lewellen
1 Beerline Canal
2 Browns Creek Canal
3 Lisco Canal
4 Midland-Overland Canal

DIVERSIONS FOR THE SIX PLATTE RIVER REACHES BELOW LAKE MCCONAUGHY IN NEBRASKA

Reach 14: Keystone to North Platte at North Platte
1 Keith-Lincoln Irrigation Canal
2 North Platte Irrigation Canal
3 Paxton-Hershey Irrigation Canal
4 Suburban Irrigation Canal
5 Cody-Dillon Irrigation Canal

NOTE: NPPD's (Nebraska Public Power District's) Keystone Canal diverts just above the Keystone Gage and therefore is not included in the Water Balance Calculation for Reach 14.

Reach 15: North Platte at North Platte to Brady
1 Central Nebraska Public Power and Irrigation District (CNPPID) Canal

Reach 16: Brady to Cozad
1 Thirty Mile Canal
2 Gothenburg Canal (NPPD)
3 Six Mile Canal
4 Cozad Canal
5 Orchard-Alfalfa Canal
6 Dawson County Canal (NPPD)

Reach 17: Cozad to Overton
No Diversions

Reach 18: Overton to Odessa
1 Kearney Canal (NPPD)

Reach 19: Odessa to Grand Island
No Diversions

TABLE 2: LIST OF DIVERSIONS (Continued)

DIVERSIONS FOR THE FIVE SOUTH PLATTE RIVER REACHES

Reach 7: Henderson to Kersey, Colorado

1 Brighton Canal
2 Lupton Bottom Canal
3 Platteville Irrigation
4 Side Hill / Meadow Island 1
5 Platte Valley System
6 Mutual / Beeman-Meadow Island 2
7 Ruckers Canal
8 Farmers Independent Canal
9 Western Canal
10 Jay Thomas Canal
11 Union Ditch
12 Godfrey Canal
13 Lower Latham Canal
14 Patterson Canal
15 Highline / Plumb Canal

Reach 8: Kersey to Balzac, Colorado

1 Empire Reservoir Inlet Canal
2 Riverside System
3 Illinois Canal
4 Bijou System (includes Corona Ranch / Putnam)
5 Jackson Lake Inlet Canal
6 Weldon Valley Canal
7 Fort Morgan Canal
8 Duel and Snyder Canal
9 Upper Platte and Beaver Canal
10 Tremont / Smith-Snyder Canal
11 Lower Platte and Beaver Canal
12 North Sterling Reservoir Inlet Canal
13 Union Canal
14 Tetsel Canal
15 Prewitt Reservoir Inlet Canal
16 Johnson-Edwards Canal

NOTE: Balzac Gage was moved upstream 6 miles in Oct. 1987 which resulted in the Tetsel, Prewitt Res. Inlet, and Johnson-Edwards being downstream of the Gage since Oct. 1987. This is accounted for in the Reach Water Balance Calculations.

Reach 9: Balzac to Julesburg, Colorado

1 South Platte Canal
2 Farmers-Pawnee canal
3 Davis Brothers Canal
4 Schneider Canal
5 Springdale Canal
6 Sterling No. 1 Irrigation Co. Canal
7 Sterling No. 2 Canal
8 Henderson Smith
9 Lowline Canal
10 Bravo Canal
11 Farmers Canal
12 Iliff and Platte Valley Canal
13 Lone Tree Canal
14 Powell Canal
15 Ramsey Canal
16 Chambers Ditch
17 Harmony No. 1 Canal / Julesburg Reservoir Inlet
18 Tamarack Ditch
19 Red Lion Canal
20 Peterson Canal
21 South Reservation Canal
22 Liddle Ditch
23 Carlson Canal

Reach 10: Julesburg, Colorado to South Platte at North Platte, Nebraska

1 Western Canal
2 Korty Canal (NPPD;
Nebraska Public Power District)

Reach 11: Cache la Poudre River Canyon Mouth to Greeley, Colorado

1 Greeley Pipeline
2 Pleasant Valley and Lake Canal
3 Larimer County Canal
4 Jackson Ditch
5 Little Cache Ditch
6 Taylor and Gill
7 New Mercer
8 Larimer No. 2
9 Ideal Cement
10 Arthur Ditch
11 Larimer and Weld Canal
12 Josh Ames
13 Lake Canal
14 Coy Ditch
15 Timnath Reservoir Inlet Canal
16 Chaffee Ditch
17 Boxelder Ditch
18 Fossil Creek Reservoir Inlet
19 Greeley No. 2 Canal
20 Whitney Ditch
21 B.H. Eaton Ditch
22 Jones Ditch
23 Greeley No.3 Canal
24 Boyd-Freeman Ditch
25 Ogilvy Ditch

Table 3. NPPD Percent of Water Returned

Percent of NPPD (Nebraska Public Power District) Diversions Returned through North Platte Hydro Return

NPPD Return/ (Korty Diversion + Keystone Diversion) *100

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Yearly Average Total*
1975	104	117	53	66	71	107	65	91	58	94	100	59	78.3
1976	95	106	50	60	82	88	92	92	46	86	377	----	81.8
1977	---	30	70	74	82	53	56	50	58	88	106	84	71.6
1978	60	74	73	71	60	83	106	63	60	91	101	89	77.9
1979	68	69	71	67	54	54	72	85	49	90	87	120	74.2
1980	52	34	83	102	80	67	101	93	69	92	104	109	84.3
1981	65	59	69	81	96	89	66	67	61	90	131	59	77.7
1982	109	51	88	87	95	89	66	45	45	86	93	65	76.1
1983	230	87	81	71	80	78	94	96	83	74	88	85	84.3
1984	---	84	73	68	82	86	92	74	67	89	94	85	81.2
1985	85	90	94	99	75	81	87	66	81	86	99	71	85.0
1986	88	90	82	80	91	77	83	87	72	88	93	90	84.6
1987	63	81	85	97	95	72	86	87	81	93	100	95	87.2
1988	79	74	94	68	67	83	85	80	77	81	103	81	81.2
1989	57	70	59	78	83	75	58	66	68	95	94	60	74.9
1990	70	54	55	63	70	71	83	75	72	85	99	81	76.8
1991	84	52	54	47	50	69	57	57	70	82	88	60	68.5
1992	208	35	41	53	64	80	72	69	68	80	82	77	71.6
1993	42	75	69	65	76	97	51	53	38	75	96	71	68.9
1994	86	85	82	82	83	78	53	84	63	85	94	66	80.0
MAX	230.1	117.3	93.6	102.4	95.7	107.1	105.9	95.6	82.6	95.3	376.7	120.2	
MIN	42.1	30.4	41.1	47.0	50.1	52.5	51.2	44.7	38.3	73.9	81.8	58.8	
AVE*	78.6	74.1	74.4	75.8	77.9	78.2	80.2	76.5	65.4	86.6	98.8	79.7	79.4

*Calculated using average acre-feet not the average of the monthly averages

Table 4. CNPPID Percent of Water Returned

CENTRAL NEBRASKA PUBLIC POWER AND IRRIGATION DISTRICT (CNPPID)

Percent of CNPPID Diversion Returned through Jeffrey and Johnson Return

(JEFFRTN + J2RTN)/ CNPPID DIV *100

WATER YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Yearly Average Total*
1975	78	67	78	74	74	76	73	46	49	6	22	66	54.2
1976	63	67	73	77	80	75	70	42	27	7	11	45	49.0
1977	64	58	71	65	65	65	70	38	22	2	26	68	46.5
1978	59	56	67	93	90	73	57	24	17	7	19	40	42.7
1979	52	53	70	73	64	71	52	27	45	39	19	43	47.6
1980	40	44	76	79	78	83	74	52	39	3	14	55	53.0
1981	49	57	74	78	78	70	42	21	17	22	32	40	46.0
1982	64	61	72	75	78	77	39	13	9	12	19	50	45.7
1983	35	64	78	75	81	82	72	63	42	1	5	48	57.8
1984	63	63	88	59	77	80	74	66	56	20	18	57	57.5
1985	65	69	52	75	79	81	71	57	46	21	32	66	57.8
1986	75	59	74	78	82	81	74	57	34	19	37	72	61.1
1987	75	72	82	81	87	85	71	58	46	33	27	70	64.6
1988	69	73	76	75	70	81	64	54	24	23	33	60	57.3
1989	56	51	64	78	73	78	38	24	31	29	23	47	47.9
1990	46	57	67	76	69	68	69	42	27	5	26	30	45.4
1991	65	88	78	79	76	66	25	30	23	5	16	37	39.4
1992	26	57	55	77	79	79	59	23	34	41	23	31	49.2
1993	83	68	77	76	78	76	59	23	37	60	44	84	64.6
1994	79	86	83	83	85	86	56	38	30	31	18	60	60.4
MAX	83.3	87.5	87.7	93.1	89.7	85.9	74.3	66.4	55.8	60.1	43.9	83.8	
MIN	26.2	44.1	51.6	59.0	63.5	65.2	25.4	12.9	8.9	0.9	5.1	30.0	
AVE*	63.0	64.4	73.3	76.2	77.4	77.5	63.6	43.5	33.8	18.9	22.9	54.7	53.1

* Calculated using average acre-feet not the average of the monthly averages

ADDENDUMS

Addendums 1, 2 , 3, and 4 provide information and specific procedures for the analysis in each of the four regions. The Addendums were written by the listed authors who performed the analysis.

		Author
Addendum 1.	North Platte River, WY	Becky Mathisen
Addendum 2.	South Platte River, CO and NE	Jon Altenhofen
Addendum 3.	North Platte River above Lake McConaughy, NE	Ann Bleed
Addendum 4.	North Platte and Platte River below Lake McConaughy, NE	Jeremie Kerkman

Addendum 5. Plots of river width or surface area versus flow rate at gages.

Addendum 6. Tables of percent loss factors per mile (% evap, % seep, % divert) for reaches.

Addendum 1. North Platte River, Wyoming

Addendum 1 to "Determination of Monthly Loss Factors for the Platte River for the Historical 1975-1994 Water Year Period" to document the
segment-specific methods for estimating losses from the North Platte in Wyoming for the purpose of ranking alternatives for water supply and conservation alternatives

Note: If a viable alternative is identified in a location away from the mainstem of the North Platte, additional conveyance loss analyses will be needed.

Segment 1: North Platte River near Northgate Gage to North Platte River above Seminoe Reservoir, near Sinclair Gage, about 100 miles.

The end point gages are USGS gages and have continuous records through the 20 year baseline period of water years 1975 through 1994. Both gages have a long history of width measurements taken during manual flow measurements, hence the average width and average surface areas were readily computed. No scaling factors were used. Seminoe Reservoir's evaporation pan is the closest pan, and was used to compute the monthly evaporation from the surface of the river. To compute the percent of the inflow that was lost per mile of river length (Step 1), the monthly evaporation was divided by the sum of the inflows and the length of the segment.

Since there are many ungaged inflows to the segment and no monthly diversion data, the mass balance had only four elements:

In = Out (assume 0 change in storage in segment)
NorthGateGage + NetGainLoss = SinclairGage + Evap
(The NetGainLoss factor can be either positive (gains) or negative (losses).)

The sum of the segment's inflows is NorthGateGage + positive gains.

The mass balance showed that during no month of the 20 year period did the inflows exceed the outflows. This segment was a gaining segment at all times during the study period.

Since diversion records for this segment are sporadic, Step 3 was not conducted. About forty diversions could be active during the summer months. Uses include irrigation, industrial, municipal, stock and domestic.

All data and computations for Segment 1 are found in the Excel workbook called NPWYlos1.xls. The tab called Evap%inflows (labelled NPS1.STEP1 at the top) is the only table of losses for Segment 1 of North Platte River (Northgate to Sinclair gages), and should be applied to up to 100 miles of segment length depending on the location of the alternative for the purpose of comparing water supply and conservation alternatives.

Segment 2: North Platte River above Seminoe Reservoir near Sinclair Gage to North Platte River at Alcova Gage, about 104 miles in length of which 30 to 40 miles are living river (the other miles are inundated by Seminoe, Kortes, Pathfinder, Alcova, and Gray Reef Reservoirs).

Since Segment 2 contains several short subsegments of live river, it was decided to average the evaporation rates for the two surrounding segments (Segment 1 and Segment 3) and apply the average rate to the number of live river miles of Segment 2. Since the number of live river miles changes as the reservoirs rise and fall, it is assumed that 40 miles of live river is a reasonable estimate for the purposes of ranking the alternative in the water conservation and supply study.

Step 3 was not computed due to the lack of permanent diversions in this segment.

The data and computations for Segment 2 are found in the Excel workbook called NPWYls24.xls. The tab called "Average1,3", also titled NPS2.STEP1 at the top, is the only table of losses for Segment 2 of North Platte River (Sinclair to Alcova gages), and should be applied to up to 40 miles of segment length depending on the location of the alternative for the purpose of comparing water supply and conservation alternatives.

Segment 3: North Platte River at Alcova Gage to North Platte River at Orin Gage, about 132 miles.

The end point gages are USGS gages and have continuous records through the 20 years baseline period of water year 1975 through 1994. Both gages have a long history of width measurements taken during manual flow measurements, hence the average width and average surface areas were readily computed. Pathfinder Reservoir's evaporation pan was used to compute the monthly evaporation from the surface of the river. To compute the percent of the inflow that was lost per mile of river length (Step 1), the monthly evaporation was divided by the sum of the inflows and the length of the segment. The results of these computations are in tab Evap%inflows, also titled NPS3.STEP1. It is interesting and comforting to see that the 20-year averages of these monthly evaporation losses, expressed in cfs, correlate closely to the evaporation component of Bishop-Brogden's 1990 report for the months studied by Bishop-Brogden.

About 150 diversions may be active during the summer months. Uses include irrigation, municipal, industrial, stock, domestic and others.

Since there are many ungaged inflows to the segment, and most diversion records are not monthly, the mass balance has only four elements:

In = Out (assume 0 change in storage in system)
AlcovaGage + NetGainLoss = OrinGage + Evap
(The NetGainLoss factor can be either positive (gains) and negative (losses).)

The sum of the segment's inflows is AlcovaGage + positive gains.

The mass balance showed several months of the 20 year baseline period when the inflows exceeded the outflows. Therefore, the result of Step 2 is the tab Loss%Inflows (also titled NPS3.STEP2) showing those few months of net loss, expressed as percent of inflow lost per mile of segment length.

Most diversion records for this segment are instantaneous or seasonal. Therefore, Step 3 was not conducted.

All data and computations for Segment 3 are found in the Excel workbook called NPWYlos3.xls.

Segment 4: North Platte River at Orin Gage to North Platte River Below Whalen Diversion Dam Gage, about 66 miles in length of which 30 to 40 miles are living river (the remainder are under Glendo and Guernsey Reservoirs).

Since Segment 4 contains three subsegments of live river, it was decided to average the evap rates for the two surrounding segments (Segment 3 and Segment 5) and apply the average rate to the number of live river miles of Segment 4. Since the number of live river miles changes as the reservoirs rise and fall, it is assumed that 40 miles of live river is a reasonable estimate for the purposes of ranking the alternatives in the water conservation and supply study.

Step 3 was not computed due to the lack of monthly diversion data in this segment. About 25 diversions could be active during any summer.

The data and computations for Segment 4 are found in the Excel workbook called NPWYls24.xls. The tab called "Average3,5", also titled NPS4.STEP1 at the top, is the only table of losses for Segment 4 of the North Platte River (Orin to Below Whalen gages), and should be applied for the months of April through September to about 40 miles of segment length depending on the location of the alternative for the purpose of comparing water supply and conservation alternatives. It should be noted that from October through February every year, the outflow from Glendo dam is about 25 cfs. From October through March, the gates at Guernsey dam are closed. If Program water is to be transferred through this segment during October through March, addition analyses will be required.

Segment 5: North Platte River Below Whalen Diversion Dam Gage to North Platte River at WY-NE Stateline Gage, about 47 miles.

The end point gages are USGS gages and have continuous records through the 20 year baseline period of water years 1975 through 1994. Both gages have a long history of width measurements that were taken during manual flow measurements, hence the average width and average surface areas were readily computed. Whalen Dam's evaporation pan was used to compute the monthly evaporation from the surface of the river. To compute the percent of the inflow that was lost per mile of river length (Step 1), the monthly evaporation was divided by the sum of the inflows and the length of the segment. The results of the Step 1 computations are in the tab called Evap%Inflow, also labelled NPS5.STEP1 at the top. It is interesting and comforting to see that the 20-year averages of these monthly evaporation losses, expressed in cfs, correlate closely to the evaporation component of Bishop-Brogden's 1990 report for the months studied by Bishop-Brogden.

Monthly diversion records are available for this segment of the North Platte for the10 ditches: Grattan, North Platte, Rock Ranch, Pratte-Ferris, Burbank, Torrington, Lucerne, Narrows, Mitchell and Gering. The Laramie River is a gaged inflow into this segment. Therefore, the mass balance has six elements:

In = Out (assume 0 change in storage in segment)
BelowWhalenGage + FtLaramieGage + NetGainLoss = OrinGage + Evap + Diversions
(The NetGainLoss factor can be either positive (gains) and negative (losses).)

The sum of the segment's inflows is BelowWhalenGage + FtLaramieGage + positive gains.

The mass balance showed several months of the 20 year baseline period when the inflows exceeded the outflows. The result of Step 2 is the tab called Loss%Inflows (also titled NPS5.STEP2).

In Step 3, the monthly diversions were divided by the sum of the inflows and the length of the segment, resulting in the tab called Divert% (also titled NPS5.STEP3).

All data and computations for Segment 5 are found in the Excel spreadsheet called NPWYlos5.xls.

Segment 6: Laramie River below Grayrocks Dam Gage to Laramie River near Fort Laramie Gage, about 17 miles.

The upstream end of this segment is a State gage installed after the construction of Grayrocks Dam and fully operational in water year 1981. The downstream gage is a USGS gage and has a long continuous record, although only data for water year 1981 through 1994 are used in this study. Both gages have width measurements taken during manual flow measurements, hence the average width and average surface areas were readily computed. The evaporation pan at Whalen was used to compute the monthly evaporation from the surface of the river. To compute the percent of the inflow that was lost per mile of river length (Step 1), the monthly evaporation was divided by the sum of the inflows and the length of the segment. The results of the Step 1 computations are in the tab called Evap%Inflow, also labelled LRS6.STEP1 at the top.

Since there are ungaged inflows to the segment, and most diversion records are not monthly, the mass balance had only four elements:

In = Out (assume 0 change in storage in system)
BelGrayrocksGage + NetGainLoss = FtLarGage + Evap

The sum of the segment's inflows is BelGrayrocksGage + positive gains

The mass balance showed many months of the 14 year period from 1981-1994 when the inflows exceeded the outflows. The result of Step 2 is the tab called Loss%Inflow (also titled Table LRS6.STEP2).

Up to ten diversions could be active during the summer months. Most diversion records for this segment are instantaneous or seasonal. Therefore, Step 3 was not conducted.

All data and computations for Segment 6 are found in the Excel spreadsheet called NPWYlos6.xls..

NPS1.STEP1

Evap as percent of total inflows per mile of reach
(includes netgainloss as part of sum of inflows)

STEP 1 results for Segment 1 Northgate to Sinclair gages
Segment 1 is 100 miles long

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0242	0.0105	0.0066	0.0047	0.0062	0.0120	0.0087	0.0039	0.0038	0.0072	0.0284	0.0416
1976	0.0321	0.0141	0.0115	0.0046	0.0069	0.0171	0.0107	0.0052	0.0062	0.0180	0.0316	0.0411
1977	0.0315	0.0162	0.0094	0.0095	0.0172	0.0149	0.0139	0.0096	0.0174	0.0716	0.0606	0.0718
1978	0.0493	0.0170	0.0109	0.0052	0.0062	0.0150	0.0109	0.0048	0.0035	0.0088	0.0280	0.0496
1979	0.0345	0.0123	0.0068	0.0053	0.0066	0.0097	0.0087	0.0028	0.0038	0.0112	0.0199	0.0441
1980	0.0316	0.0155	0.0081	0.0048	0.0068	0.0076	0.0066	0.0018	0.0052	0.0160	0.0472	0.0445
1981	0.0244	0.0150	0.0092	0.0104	0.0159	0.0206	0.0239	0.0077	0.0107	0.0306	0.0535	0.0566
1982	0.0207	0.0200	0.0150	0.0113	0.0108	0.0124	0.0116	0.0038	0.0030	0.0058	0.0164	0.0145
1983	0.0094	0.0061	0.0030	0.0046	0.0072	0.0086	0.0052	0.0032	0.0016	0.0040	0.0115	0.0239
1984	0.0149	0.0089	0.0035	0.0045	0.0037	0.0041	0.0047	0.0020	0.0025	0.0061	0.0116	0.0128
1985	0.0071	0.0080	0.0041	0.0035	0.0031	0.0064	0.0052	0.0039	0.0061	0.0168	0.0340	0.0328
1986	0.0144	0.0054	0.0075	0.0089	0.0044	0.0080	0.0049	0.0032	0.0027	0.0084	0.0223	0.0192
1987	0.0078	0.0051	0.0077	0.0120	0.0096	0.0068	0.0096	0.0062	0.0207	0.0390	0.0458	0.0561
1988	0.0337	0.0103	0.0045	0.0051	0.0066	0.0027	0.0059	0.0039	0.0055	0.0248	0.0615	0.0578
1989	0.0335	0.0135	0.0063	0.0117	0.0053	0.0062	0.0096	0.0104	0.0114	0.0431	0.0406	0.0441
1990	0.0339	0.0167	0.0053	0.0123	0.0105	0.0082	0.0075	0.0082	0.0062	0.0151	0.0368	0.0384
1991	0.0285	0.0111	0.0035	0.0144	0.0126	0.0117	0.0093	0.0058	0.0075	0.0272	0.0366	0.0393
1992	0.0359	0.0057	0.0098	0.0083	0.0111	0.0102	0.0157	0.0099	0.0105	0.0224	0.0453	0.0561
1993	0.0282	0.0143	0.0098	0.0044	0.0045	0.0080	0.0056	0.0035	0.0025	0.0105	0.0215	0.0254
1994	0.0118	0.0046	0.0027	0.0078	0.0029	0.0071	0.0083	0.0057	0.0134	0.0448	0.0657	0.0731
Average	0.0254	0.0115	0.0073	0.0077	0.0079	0.0099	0.0093	0.0053	0.0072	0.0216	0.0359	0.0422
Max	0.0493	0.0200	0.0150	0.0144	0.0172	0.0206	0.0239	0.0104	0.0207	0.0716	0.0657	0.0731
Min	0.0071	0.0046	0.0027	0.0035	0.0029	0.0027	0.0047	0.0018	0.0016	0.0040	0.0115	0.0128

Average of Segments 1 and 3 evap loss rates, in % of inflows per mile

NPS2.STEP1

Apply to Segment 2 (Sinclair to Alcova gages)
About 30-40 miles of open river (104 miles total)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0181	0.0081	0.0053	0.0035	0.0047	0.0093	0.0092	0.0067	0.0078	0.0122	0.0208	0.0261
1976	0.0229	0.0104	0.0083	0.0035	0.0053	0.0136	0.0120	0.0087	0.0118	0.0184	0.0229	0.0265
1977	0.0221	0.0120	0.0068	0.0067	0.0120	0.0116	0.0120	0.0118	0.0200	0.0460	0.0365	0.0460
1978	0.0348	0.0128	0.0087	0.0043	0.0047	0.0127	0.0144	0.0055	0.0173	0.0143	0.0212	0.0332
1979	0.0237	0.0100	0.0054	0.0040	0.0049	0.0082	0.0120	0.0082	0.0105	0.0160	0.0149	0.0302
1980	0.0214	0.0119	0.0064	0.0044	0.0047	0.0069	0.0074	0.0044	0.0097	0.0166	0.0306	0.0280
1981	0.0168	0.0114	0.0072	0.0081	0.0122	0.0194	0.0263	0.0096	0.0200	0.0250	0.0332	0.0360
1982	0.0151	0.0163	0.0133	0.0102	0.0086	0.0119	0.0135	0.0061	0.0161	0.0144	0.0178	0.0134
1983	0.0091	0.0060	0.0030	0.0039	0.0061	0.0077	0.0048	0.0031	0.0032	0.0043	0.0098	0.0180
1984	0.0131	0.0083	0.0031	0.0037	0.0029	0.0029	0.0036	0.0030	0.0031	0.0068	0.0119	0.0123
1985	0.0065	0.0074	0.0038	0.0031	0.0027	0.0056	0.0061	0.0065	0.0105	0.0147	0.0226	0.0207
1986	0.0118	0.0053	0.0068	0.0073	0.0040	0.0090	0.0059	0.0055	0.0057	0.0083	0.0174	0.0147
1987	0.0069	0.0040	0.0064	0.0094	0.0078	0.0060	0.0109	0.0136	0.0232	0.0283	0.0299	0.0390
1988	0.0236	0.0080	0.0040	0.0038	0.0054	0.0026	0.0087	0.0077	0.0172	0.0204	0.0377	0.0344
1989	0.0239	0.0104	0.0053	0.0093	0.0045	0.0088	0.0115	0.0140	0.0158	0.0322	0.0281	0.0296
1990	0.0280	0.0144	0.0046	0.0100	0.0092	0.0091	0.0118	0.0134	0.0205	0.0197	0.0243	0.0351
1991	0.0262	0.0113	0.0035	0.0117	0.0105	0.0122	0.0091	0.0066	0.0125	0.0262	0.0265	0.0260
1992	0.0290	0.0047	0.0084	0.0071	0.0103	0.0108	0.0200	0.0165	0.0120	0.0179	0.0346	0.0364
1993	0.0227	0.0136	0.0086	0.0039	0.0042	0.0081	0.0061	0.0058	0.0057	0.0119	0.0166	0.0244
1994	0.0113	0.0050	0.0027	0.0075	0.0032	0.0094	0.0111	0.0106	0.0142	0.0281	0.0374	0.0429
Average	0.0193	0.0095	0.0061	0.0062	0.0064	0.0093	0.0108	0.0083	0.0128	0.0191	0.0247	0.0286
Max	0.0348	0.0163	0.0133	0.0117	0.0122	0.0194	0.0263	0.0165	0.0232	0.0460	0.0377	0.0460
Min	0.0065	0.0040	0.0027	0.0031	0.0027	0.0026	0.0036	0.0030	0.0031	0.0043	0.0098	0.0123

Evap as percent of total inflows per mile of reach

NPS3.STEP1

STEP 1 results for Segment 3 Alcova to Orin gages
Segment 3 is about 132 miles long.

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0119	0.0056	0.0039	0.0023	0.0031	0.0065	0.0097	0.0095	0.0118	0.0171	0.0126	0.0106
1976	0.0136	0.0067	0.0050	0.0024	0.0037	0.0101	0.0132	0.0121	0.0174	0.0176	0.0141	0.0118
1977	0.0127	0.0078	0.0042	0.0038	0.0067	0.0083	0.0100	0.0139	0.0212	0.0194	0.0123	0.0200
1978	0.0202	0.0086	0.0065	0.0034	0.0032	0.0103	0.0179	0.0062	0.0311	0.0198	0.0140	0.0167
1979	0.0129	0.0076	0.0040	0.0026	0.0032	0.0066	0.0152	0.0136	0.0171	0.0208	0.0098	0.0162
1980	0.0111	0.0083	0.0047	0.0039	0.0026	0.0062	0.0082	0.0070	0.0142	0.0170	0.0138	0.0114
1981	0.0091	0.0078	0.0052	0.0058	0.0085	0.0182	0.0282	0.0114	0.0286	0.0193	0.0123	0.0154
1982	0.0094	0.0126	0.0116	0.0091	0.0064	0.0114	0.0154	0.0083	0.0292	0.0229	0.0191	0.0122
1983	0.0088	0.0059	0.0030	0.0032	0.0049	0.0067	0.0043	0.0029	0.0048	0.0045	0.0081	0.0121
1984	0.0113	0.0077	0.0027	0.0029	0.0021	0.0016	0.0024	0.0039	0.0036	0.0074	0.0121	0.0118
1985	0.0058	0.0067	0.0035	0.0026	0.0022	0.0047	0.0070	0.0090	0.0145	0.0126	0.0110	0.0086
1986	0.0091	0.0051	0.0060	0.0056	0.0036	0.0099	0.0069	0.0077	0.0086	0.0081	0.0121	0.0102
1987	0.0060	0.0029	0.0051	0.0067	0.0060	0.0051	0.0122	0.0210	0.0257	0.0160	0.0136	0.0218
1988	0.0135	0.0057	0.0031	0.0025	0.0041	0.0024	0.0114	0.0114	0.0265	0.0149	0.0133	0.0110
1989	0.0143	0.0073	0.0039	0.0068	0.0037	0.0114	0.0133	0.0176	0.0201	0.0201	0.0143	0.0150
1990	0.0220	0.0121	0.0038	0.0076	0.0079	0.0099	0.0161	0.0186	0.0347	0.0218	0.0118	0.0318
1991	0.0239	0.0114	0.0033	0.0089	0.0084	0.0126	0.0088	0.0073	0.0175	0.0252	0.0158	0.0126
1992	0.0221	0.0037	0.0069	0.0059	0.0095	0.0114	0.0243	0.0217	0.0134	0.0133	0.0239	0.0166
1993	0.0171	0.0128	0.0073	0.0033	0.0038	0.0082	0.0066	0.0080	0.0088	0.0132	0.0116	0.0233
1994	0.0107	0.0053	0.0027	0.0072	0.0034	0.0117	0.0138	0.0155	0.0143	0.0110	0.0087	0.0126
Average	0.0133	0.0076	0.0048	0.0048	0.0049	0.0087	0.0122	0.0113	0.0181	0.0161	0.0132	0.0151
Max	0.0239	0.0128	0.0116	0.0091	0.0095	0.0182	0.0282	0.0217	0.0347	0.0252	0.0239	0.0318
Min	0.0058	0.0029	0.0027	0.0023	0.0021	0.0016	0.0024	0.0029	0.0036	0.0045	0.0081	0.0086

Months of loss when segment loses water

NPS3.STEP2

STEP 1 results for Segment 3 Alcova to Orin gages
Segment 3 is about 132 miles long.

As percent of sum of inflows per mile of segment

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975											0.0344	
1976										0.0500		
1977									0.0466	0.0370		0.0088
1978											0.0138	
1979												
1980										0.0041	0.0139	
1981							0.0126		0.0163	0.0000	0.0317	
1982												
1983												
1984												
1985									0.0241		0.0136	
1986											0.0183	
1987										0.0693	0.0194	
1988			0.0636						0.0609	0.0548	0.0343	
1989			0.0633						0.0001	0.0410	0.0634	
1990										0.0769		
1991			0.0084							0.0012	0.0232	
1992								0.0419				
1993												
1994									0.0375	0.0189	0.0233	

Average of Segments 3 and 5 evap loss rates, in % of inflows per mile

NPS4.STEP1

Apply to Segement 4 Orin to Passing Whalen gage.
About 30-40 miles of open river (66 miles total)

Year	*Oct	*Nov	*Dec	*Jan	*Feb	*Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0137	0.0060	0.0043	0.0045	0.0048	0.0084	0.0152	0.0149	0.0145	0.0151	0.0142	0.0123
1976	0.0146	0.0075	0.0056	0.0028	0.0056	0.0118	0.0182	0.0145	0.0189	0.0168	0.0142	0.0119
1977	0.0130	0.0075	0.0046	0.0047	0.0073	0.0106	0.0196	0.0181	0.0232	0.0177	0.0133	0.0186
1978	0.0186	0.0099	0.0082	0.0053	0.0044	0.0131	0.0236	0.0093	0.0257	0.0168	0.0130	0.0158
1979	0.0140	0.0070	0.0050	0.0032	0.0055	0.0080	0.0211	0.0184	0.0172	0.0171	0.0108	0.0153
1980	0.0146	0.0069	0.0058	0.0040	0.0037	0.0065	0.0085	0.0067	0.0139	0.0161	0.0132	0.0125
1981	0.0127	0.0088	0.0055	0.0056	0.0076	0.0164	0.0389	0.0177	0.0262	0.0160	0.0126	0.0143
1982	0.0111	0.0109	0.0095	0.0073	0.0089	0.0155	0.0311	0.0145	0.0326	0.0177	0.0156	0.0111
1983	0.0094	0.0057	0.0033	0.0057	0.0081	0.0100	0.0059	0.0033	0.0041	0.0044	0.0063	0.0081
1984	0.0091	0.0061	0.0029	0.0039	0.0029	0.0018	0.0026	0.0040	0.0037	0.0074	0.0095	0.0089
1985	0.0056	0.0058	0.0035	0.0023	0.0027	0.0047	0.0112	0.0134	0.0147	0.0125	0.0116	0.0097
1986	0.0099	0.0047	0.0061	0.0037	0.0047	0.0117	0.0058	0.0077	0.0077	0.0072	0.0111	0.0081
1987	0.0047	0.0030	0.0078	0.0077	0.0069	0.0079	0.0147	0.0189	0.0230	0.0155	0.0134	0.0169
1988	0.0142	0.0062	0.0051	0.0031	0.0051	0.0080	0.0172	0.0136	0.0261	0.0145	0.0136	0.0120
1989	0.0145	0.0086	0.0038	0.0112	0.0037	0.0104	0.0253	0.0216	0.0205	0.0190	0.0146	0.0141
1990	0.0203	0.0105	0.0031	0.0078	0.0084	0.0133	0.0283	0.0298	0.0462	0.0204	0.0127	0.0236
1991	0.0206	0.0120	0.0051	0.0066	0.0091	0.0131	0.0179	0.0167	0.0171	0.0191	0.0139	0.0123
1992	0.0196	0.0041	0.0054	0.0051	0.0089	0.0138	0.0275	0.0262	0.0216	0.0118	0.0161	0.0134
1993	0.0136	0.0098	0.0064	0.0032	0.0044	0.0083	0.0152	0.0109	0.0120	0.0116	0.0102	0.0160
1994	0.0101	0.0049	0.0032	0.0066	0.0056	0.0151	0.0204	0.0199	0.0172	0.0115	0.0096	0.0118
verage	0.0132	0.0073	0.0052	0.0052	0.0059	0.0104	0.0184	0.0150	0.0193	0.0144	0.0125	0.0133
ax	0.0206	0.0120	0.0095	0.0112	0.0091	0.0164	0.0389	0.0298	0.0462	0.0204	0.0161	0.0236
in	0.0047	0.0030	0.0029	0.0023	0.0027	0.0018	0.0026	0.0033	0.0037	0.0044	0.0063	0.0081

* Months when Guernsey dam gates are closed and when Glendo release is limited to about 25 cfs.

Evap as percent of total inflows per mile of reach

NPS5.STEP1

STEP 1 results for segment 5 Whalen to Stateline gages

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0154	0.0064	0.0048	0.0070	0.0069	0.0109	0.0206	0.0202	0.0172	0.0130	0.0151	0.0140
1976	0.0155	0.0083	0.0065	0.0033	0.0078	0.0143	0.0231	0.0168	0.0203	0.0147	0.0142	0.0119
1977	0.0132	0.0071	0.0050	0.0059	0.0084	0.0137	0.0292	0.0223	0.0237	0.0150	0.0142	0.0170
1978	0.0170	0.0112	0.0098	0.0071	0.0056	0.0159	0.0293	0.0119	0.0202	0.0137	0.0116	0.0149
1979	0.0151	0.0063	0.0059	0.0039	0.0078	0.0094	0.0270	0.0231	0.0172	0.0134	0.0118	0.0144
1980	0.0180	0.0055	0.0069	0.0041	0.0047	0.0068	0.0080	0.0064	0.0136	0.0150	0.0124	0.0135
1981	0.0163	0.0098	0.0058	0.0057	0.0072	0.0157	0.0491	0.0240	0.0220	0.0127	0.0124	0.0131
1982	0.0127	0.0092	0.0073	0.0054	0.0114	0.0210	0.0467	0.0206	0.0359	0.0125	0.0121	0.0100
1983	0.0100	0.0055	0.0036	0.0081	0.0113	0.0132	0.0062	0.0036	0.0034	0.0043	0.0044	0.0041
1984	0.0069	0.0045	0.0030	0.0049	0.0037	0.0019	0.0027	0.0041	0.0038	0.0073	0.0068	0.0060
1985	0.0054	0.0048	0.0034	0.0019	0.0031	0.0047	0.0153	0.0178	0.0145	0.0124	0.0120	0.0107
1986	0.0107	0.0042	0.0062	0.0018	0.0060	0.0135	0.0046	0.0077	0.0067	0.0062	0.0097	0.0060
1987	0.0033	0.0031	0.0105	0.0087	0.0078	0.0106	0.0162	0.0167	0.0203	0.0133	0.0127	0.0119
1988	0.0149	0.0066	0.0067	0.0036	0.0061	0.0136	0.0229	0.0157	0.0233	0.0130	0.0132	0.0129
1989	0.0147	0.0099	0.0034	0.0167	0.0038	0.0093	0.0372	0.0255	0.0209	0.0166	0.0136	0.0131
1990	0.0186	0.0089	0.0025	0.0085	0.0094	0.0178	0.0405	0.0409	0.0475	0.0165	0.0135	0.0153
1991	0.0172	0.0125	0.0072	0.0045	0.0104	0.0147	0.0270	0.0260	0.0167	0.0130	0.0115	0.0120
1992	0.0171	0.0044	0.0041	0.0047	0.0089	0.0173	0.0306	0.0293	0.0297	0.0102	0.0083	0.0102
1993	0.0100	0.0068	0.0055	0.0031	0.0050	0.0083	0.0238	0.0138	0.0152	0.0099	0.0088	0.0087
1994	0.0094	0.0044	0.0037	0.0059	0.0078	0.0184	0.0269	0.0242	0.0194	0.0117	0.0102	0.0109
Average	0.0131	0.0070	0.0056	0.0057	0.0072	0.0126	0.0243	0.0185	0.0196	0.0122	0.0114	0.0115
Max	0.0186	0.0125	0.0105	0.0167	0.0114	0.0210	0.0491	0.0409	0.0475	0.0166	0.0151	0.0170
Min	0.0033	0.0031	0.0025	0.0018	0.0031	0.0019	0.0027	0.0036	0.0034	0.0043	0.0044	0.0041

NPS5.STEP2

Step 2 results for Segment 5 (Passing Whalen to Stateline)

Months of loss when sum inflows exceeds sum outflows

Loss months only

As percent of sum of inflows per mile of segment (47 miles long)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978								0.0850				
1979												
1980							0.1951					
1981									0.1145			
1982												
1983							0.3265					
1984							0.0220					
1985												
1986							0.0653					
1987							0.1028					
1988												
1989												
1990									0.3732			
1991												
1992												
1993								0.0024				
1994												

Step 3 - Percent of inflows per mile diverted in Segment 5 (Passing Whalen to Stateline)

NPS5.STEP3

Step 3 results for Segment 5 (Passing Whalen to Stateline)

As percent of sum of inflows

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.64	0.50	0.62	0.65
1976	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.64	0.56	0.62	0.67
1977	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.68	0.54	0.62	0.68
1978	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.63	0.58	0.67	0.69
1979	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.59	0.57	0.63	0.83
1980	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.37	0.56	0.55	0.67
1981	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.64	0.49	0.54	0.68
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77	0.35	0.51	0.55	0.61
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.16	0.18	0.15
1984	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.10	0.27	0.30	0.30
1985	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.49	0.58	0.58	0.48
1986	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.15	0.27	0.54	0.36
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.45	0.56	0.63	0.57
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.42	0.62	0.57	0.60	0.53
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.70	0.59	0.64	0.62
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.46	0.85	0.56	0.64	0.66
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.22	0.60	0.63	0.52
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	1.58	0.58	0.62	0.63
1993	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.34	0.56	0.54	0.58
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.61	0.54	0.61	0.61
Average	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.54	0.51	0.57	0.57
Max	0.16	0.00	0.00	0.00	0.00	0.00	0.00	1.46	1.58	0.60	0.67	0.83
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.09	0.16	0.18	0.15

Evap as percent of total inflows per mile of reach

LRS6.STEP1

STEP 1 results for segment 7 Gray Rocks to Fr. Laramie gages

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
1975	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1976	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1977	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1978	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1979	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1980	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1981	0.0746	0.0610	0.0276	0.0344	0.0265	0.0558	0.0795	0.0626	0.1096	0.1115	0.0961	0.0760
1982	0.0560	0.0433	0.0325	0.0168	0.0347	0.0589	0.0406	0.0836	0.0772	0.1067	0.0984	0.0592
1983	0.0373	0.0219	0.0139	0.0282	0.0378	0.0359	0.0093	0.0026	0.0026	0.0050	0.0192	0.0215
1984	0.0150	0.0055	0.0036	0.0042	0.0036	0.0044	0.0033	0.0032	0.0072	0.0369	0.0182	0.0180
1985	0.0060	0.0046	0.0028	0.0018	0.0046	0.0151	0.0439	0.0463	0.0868	0.1064	0.0868	0.0545
1986	0.0364	0.0139	0.0166	0.0034	0.0101	0.0173	0.0123	0.0194	0.0067	0.0233	0.0566	0.0191
1987	0.0080	0.0132	0.0192	0.0145	0.0205	0.0170	0.0402	0.0606	0.0561	0.0990	0.0727	0.0577
1988	0.0442	0.0192	0.0190	0.0085	0.0132	0.0256	0.0272	0.0351	0.0941	0.0770	0.1035	0.0667
1989	0.0440	0.0301	0.0099	0.0446	0.0094	0.0229	0.0513	0.0795	0.0841	0.1372	0.1032	0.0731
1990	0.0504	0.0286	0.0069	0.0239	0.0240	0.0471	0.0665	0.0935	0.1423	0.1312	0.0763	0.0753
1991	0.0489	0.0374	#NUM!	0.0112	0.0216	0.0329	0.0424	0.0295	0.0297	#NUM!	0.0864	0.0614
1992	0.0496	0.0124	0.0123	0.0132	0.0229	0.0443	0.0449	0.0623	0.0615	0.0485	0.0594	0.0496
1993	0.0304	0.0204	0.0161	0.0075	0.0113	0.0201	0.0420	0.0211	0.0223	0.0702	0.0372	0.0359
1994	0.0258	0.0131	0.0098	0.0139	0.0172	0.0400	0.0432	0.0642	0.1039	0.0817	0.0772	0.0519
Average	0.0376	0.0232	#NUM!	0.0161	0.0184	0.0312	0.0390	0.0474	0.0632	#NUM!	0.0708	0.0514
Max	0.0746	0.0610	#NUM!	0.0446	0.0378	0.0589	0.0795	0.0935	0.1423	#NUM!	0.1035	0.0760
Min	0.0060	0.0046	#NUM!	0.0018	0.0036	0.0044	0.0033	0.0026	0.0026	#NUM!	0.0182	0.0180

Months of loss when sum inflows exceeds sum outflows

Loss months only

LRS6.STEP2

Results of Step 2 for Gray Rocks outflow gage to Ft. Laramie Gage

As percent of sum of inflows per mile of segment (17 miles long)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1976	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1977	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1978	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1979	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1980	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
1981			2.3325	0.8097	1.1898		0.1559	0.5609	1.1736			
1982		0.6380	0.3755	0.8455	1.3936		1.5248	0.3942	0.7566		0.8667	
1983							0.4175	0.0488				0.0064
1984		0.3222			0.0628			0.4196	0.1019			
1985			0.1314		0.0791	0.2730					0.1612	
1986			0.1277	0.4892	0.3925							0.6109
1987	0.0174	0.9663	0.0447	0.0888	0.4697			0.5093			1.2530	
1988	0.6495	0.6688	0.9149	1.3833	0.8815	0.0622	0.0010	0.2558		0.1268		
1989					0.7267	0.0173	0.4916		1.5984	0.3402	0.0816	
1990			0.8235	0.1524	0.3010		0.1416	0.5679	0.4511		0.7259	
1991			#NUM!	0.4362	0.5863	0.0807				#NUM!		
1992							0.3314	1.2528	0.7322			
1993				0.6828				0.0709				
1994			0.3709		0.3856						0.3967	

Addendum 2. South Platte River, Colorado and Nebraska

Addendum 2 to "Determination of Monthly Loss Factors for the Platte River for the Historical 1975-1994 Water Year Period" to document the segment-specific methods for estimating losses from the South Platte River in Colorado and Nebraska.

The three step procedure to compute % evap, % seep, and % divert loss factors discussed in the general description of the monthly loss factor analysis was used in all five reaches (Reach 7 through 11) of the South Platte River. The following describes specific notable points and analysis methods for the South Platte calculations.

I. Change in River Gage Location: As noted in Table 2 for Reach 8 which lists diversions used in the river water balance computation, the Balzac Gage location was moved upstream about 6 miles with gage measurements starting at this new location on October 1, 1987. This relocation put the new gage above three diversions (Tetsel Canal, Prewitt Reservoir Inlet, and Johnson-Edwards Canal). Therefore in the water balance computations to compute monthly net gains, the period from October 1975 through September 1987 included these three diversions in the sum of diversions for Reach 8 while for the period of October 1987 through September 1994, these three diversions are included in the sum of diversions for Reach 9.

II. Evaporation Computations: Due to the lack of weather stations with pan evaporation data along the South Platte River in Colorado, temperature data from NOAA-NWS weather stations was used to compute an open water surface gross evaporation by the Modified Blaney-Criddle equation (TR-21, Irrigation Water Requirements, SCS-USDA). For shallow open water, a coefficient of 1.0 was multiplied by the monthly Blaney-Criddle consumptive use factor to obtain an estimate of monthly river water surface gross evaporation in feet (acre-feet per acre). This coefficient of 1.0 was obtained from TR-21 and FAO-24 (United Nations Food and Agriculture Organization Paper 24, Crop Water Requirements). This estimate of evaporation computed from the Modified Blaney-Criddle was compared to pan evaporation data (multiplied by 0.7) for the summer months available at two weather stations (Fort Collins, CO and North Platte, NE) in the South Platte basin in order to obtain monthly calibration coefficients. These coefficients were multiplied times the open water gross evaporation estimated by the Blaney-Criddle equation for the weather stations used in the South Platte analysis. These monthly calibration coefficients were as follows:

Oct	1.4	Apr	1.7
Nov	1.4	May	1.2
Dec	1.4	Jun	1.0
Jan	1.4	Jul	1.0
Feb	1.4	Aug	0.9
Mar	1.4	Sep	1.1

For Reach 7 on the South Platte (Henderson to Kersey), an average Blaney-Criddle open water evaporation was computed for each month from four weather stations at Brighton, Longmont, Fort Collins, and Greeley with the monthly value then multiplied by the calibration coefficients.

For Reach 8 (Kersey to Balzac) and Reach 9 (Balzac to Julesburg), an average Blaney-Criddle open water evaporation from the weather stations at Greeley, Fort Morgan, Sterling, and Julesburg was computed for each month and then multiplied by the calibration coefficients. For Reach 10 (Julesburg to South Platte at North Platte, NE), an average of the calibrated open water Blaney-Criddle at Julesburg and the pan evaporation data multiplied by 0.7 for the North Platte weather station was used. Bridgeport, NE pan evaporation data was used for the winter months because North Platte does not record winter pan data. For the Cache la Poudre River Reach 11 in Colorado, an average of the calibrated open water Blaney-Criddle computation was used for each month based on the Fort Collins and Greeley weather stations.

For the five reaches of the South Platte, the standard procedure previously described was used to obtain an average monthly river water surface area based on the average river width in the reach using the width (feet) versus flow (cfs) curves developed at the upstream and downstream gage locations for each reach. Flow measurement sheets for 1975 through 1994 tabulating field measurements of width versus flow were used at all the gages on the South Platte. For the Cache la Poudre River, the upstream gage was not used to determine a channel width at the upstream end of the reach because this gage at the Canyon Mouth is in a confined bedrock channel that is not representative of the alluvial channel that prevails for the entire length of the Poudre River reach that was analyzed for loss factors. Instead the width versus flow rate relationship determined from the Greeley gage at the reach's downstream end was used to represent the width versus flow rate for the entire reach length.

The computation for an average monthly river water surface area (ie, average of the monthly widths at the upstream and downstream gages multiplied by reach length) was calibrated to river water surface area determined from 1997 Landsat TM satellite imagery for the alluvial channel in the two middle reaches of the South Platte from Kersey to Balzac and Balzac to Julesburg. Two satellite images on different dates were needed to cover both reaches entirely. The lengths of these two river reaches were also determined from the satellite imagery. The flow rates in the South Platte River on these two different image dates varied by three times which therefore allowed the comparison of calibration factors between low and high flows. For the high flow date, the factor was 0.79 and for the low flow date the factor was 0.72. An average of these factors of 0.755 was used to multiply by the approximate monthly river area determined from width versus flow rating curve data to obtain the monthly river water surface area for each reach used in the computation of monthly acre-feet of gross evaporation loss. This calibration factor was considered a reasonable factor to be used on the other reaches of the South Platte because of their similar alluvial nature.

Addendum 3. North Platte River above Lake McConaughy in Nebraska

Addendum 3 to "Determination of Monthly Loss Factors for the Platte River for the Historical 1975-1994 Water Year Period" to document the segment-specific methods for estimating losses from the North Platte River above Lake McConaughy in Nebraska for the purpose of ranking alternatives for water supply and conservation.

Reach 12 for the North Platte River from the Wyoming-Nebraska state line gage to the Bridgeport Gage is about 57.5 miles in length and Reach 13 for the North Platte River from the Bridgeport Gage to the Lewellen gage is about 60 miles in length.

The data used to calculate conveyance losses were average monthly stream flows, measured tributary inflows and diversions in each reach and pan evaporation rates from nearby weather stations. The river gages used were the gage at the Wyoming-Nebraska state line, which has been operated continuously by the U. S. Geological Survey (USGS) for the time period covered by this study; the gage at Bridgeport, which was operated by the USGS from 1975-1991 and by the Nebraska Department of Water Resources from 1992 to 1994, and the Lewellen gage, which was operated by the USGS from 1975-1991 and by the Nebraska Department of Water Resources from 1992-1994. Stream flow records for these gages were obtained from an Earthinfo Inc. CD-ROM of USGS Daily values and from the Nebraska Natural Resources Commission data bank. The tributary inflow and diversion data used in the calculations are listed in Table 1. Evaporation data were the pan evaporation rates collected at the Bridgeport weather station, which was the closest year-round weather station for the state line to Bridgeport reach, and the weather station at Kingsley Dam.

Table 1.

Gagging Station	Source of Data
NORTH PLATTE RIVER AT WYO-NEBR STATE LINE	Earthinfo Inc. and the Nebraska Natural Resources Commission
CASTLE ROCK-STEAMBOAT CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
CENTRAL CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
ENTERPRISE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
MINATARE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
TRI-STATE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
WINTERS CREEK CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
HORSE CREEK NEAR LYMAN, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
SHEEP CREEK NEAR MORRILL, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission

DRY SPOTTEDTAIL CREEK AT MITCHELL, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
TUB SPRINGS NEAR SCOTTSBLUFF	Earthinfo Inc. and the Nebraska Natural Resources Commission
WINTERS CREEK NEAR SCOTTSBLUFF, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
GERING CREEK NEAR GERING, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
BELMONT CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
CHIMNEY ROCK CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
NINE MILE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
SHORT LINE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
NINEMILE CREEK NEAR MCGREW, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
BAYARD SUGAR FACTORY CREEK NEAR BAYARD, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
RED WILLOW CREEK NEAR BAYARD, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
NORTH PLATTE RIVER AT BRIDGEPORT, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
BEERLINE CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
BROWNS CREEK CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
LISCO CANAL FROM NORTH PLATTE RIVER	Nebraska Dept. of Water Resources Gage Data
PUMPKIN CREEK NEAR BRIDGEPORT, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
MIDLAND-OVERLAND CANAL FROM NORTH PLATTE RIVER 4 FOOT	Nebraska Dept. of Water Resources Gage Data
BLUE CREEK NEAR LEWELLEN, NE	Earthinfo Inc. and the Nebraska Natural Resources Commission
NORTH PLATTE RIVER AT LEWELLEN NE	Earthinfo Inc. and the Nebraska Natural Resources Commission

Calculation of Evaporation Losses

The evaporation rate for the state line to Bridgeport reach was calculated as .7 times the monthly pan evaporation for the Bridgeport weather station. For the Bridgeport to Lewellen section the evaporation was the average of the pan evaporation rate at the Bridgeport weather station and the Lewellen station. The monthly pan evaporation data from the weather stations was multiplied by 0.7 to adjust pan evaporation rates to stream evaporation rates. This figure was then multiplied by the average surface water area expected at each average monthly flow.

The function relating reach width to average monthly flow was based on fitting a regression line to data on stream flow and reach width as noted on manual stream flow measurement notes at the upstream and downstream ends of each reach. The gaging stations used for these calculations were the North Platte River at Mitchell, the North Platte River at Bridgeport and the North Platte River at Lewellen. The data from the state line gage were not used to calculate the upstream river width because the Tri-State diversion dam, which is within a half a mile of the stream gage, restricts flow and, during the irrigation season, diverts a large portion of the flow. Instead, data from the Mitchell gage, located approximately 15 miles below the state line gage, were used. The graphs and resulting regression equations are shown in Figures 1, 2, and 3.

The average monthly flow at each gage was then plugged into the regression equations to determine the width of the river at each gaging station during each month. The average reach width was calculated by averaging the upstream reach width and the downstream reach width. Measurements of reach widths from aerial photos indicated that the average reach width at gaging stations was slightly narrower than the river between gaging stations. Based on these measurements, the average reach width was adjusted by multiplying it by 1.42 for Reach 12, the upper segment, and 1.18 for Reach 13, the lower segment. To obtain the adjusted monthly evaporation for each segment, the monthly river width was multiplied by the segment length times the monthly average evaporation.

To determine the percentage evaporation loss, the monthly reach evaporation was divided by the total reach inflow, which was calculated according to the formula:

> Inflow = Inflow at the upstream gage + measured tributary inflows + any positive reach gains.

Reach gains or losses were calculated as the sum of all the inflows and outflows of the section. The previously calculated evaporation losses were included as part of the outflow in the reach. The percentage loss to evaporation per mile was calculated by dividing the percentage loss by the total number of miles in each reach.

Calculation of Reach Seepage Loss to Groundwater

As stated above, section gains and losses were calculated by summing all the inflows and outflows, including evaporation losses. As for the evaporation losses above, the total seepage loss was divided by the total inflow and the number of miles in the reach to calculate the percentage seepage loss per mile. In the state line to Bridgeport reach, there were no monthly seepage losses for the months analyzed. From Bridgeport to Lewellen, there were a few months with seepage losses.

Calculation of Losses to Diversions

The percentage loss of unprotected water to surface water diversions was calculated by summing the total diversions in each reach and dividing this sum by the total reach inflow, as calculated above, and by the number of miles in the reach. The diversions used in this calculation are shown in Table 1.

FIGURE 1.

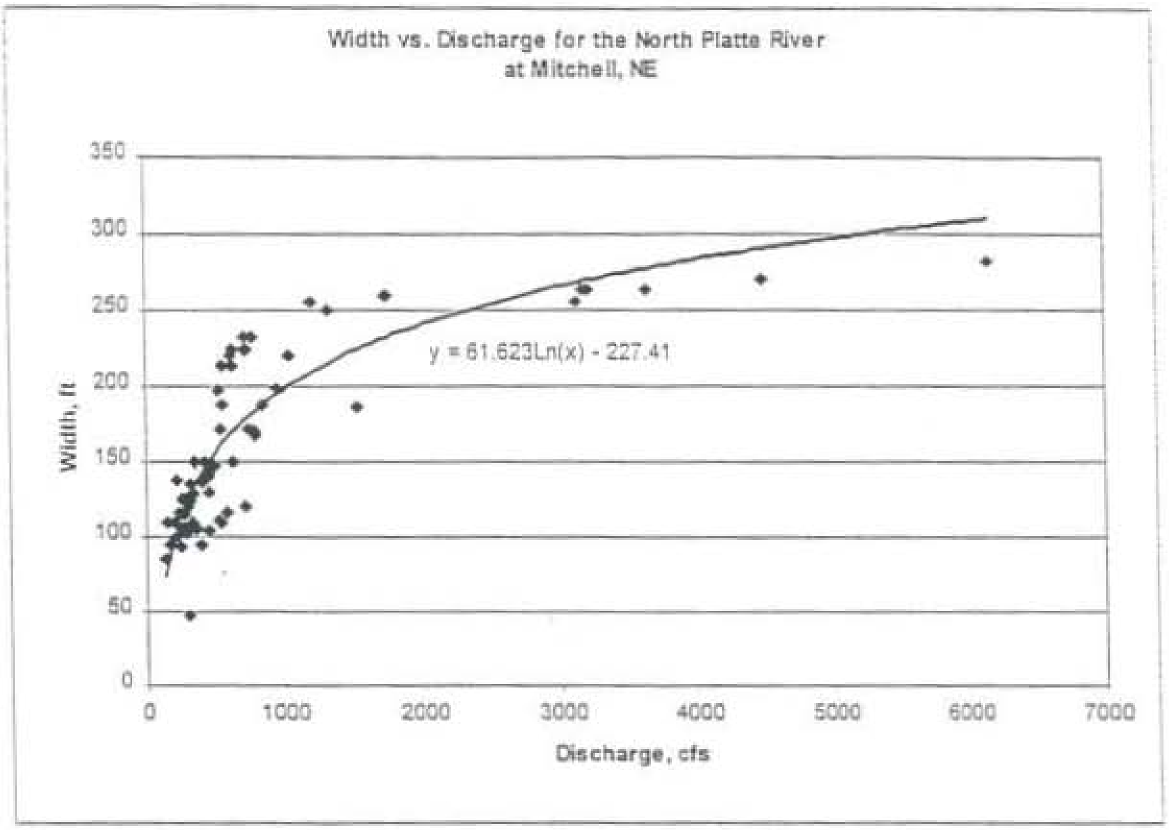
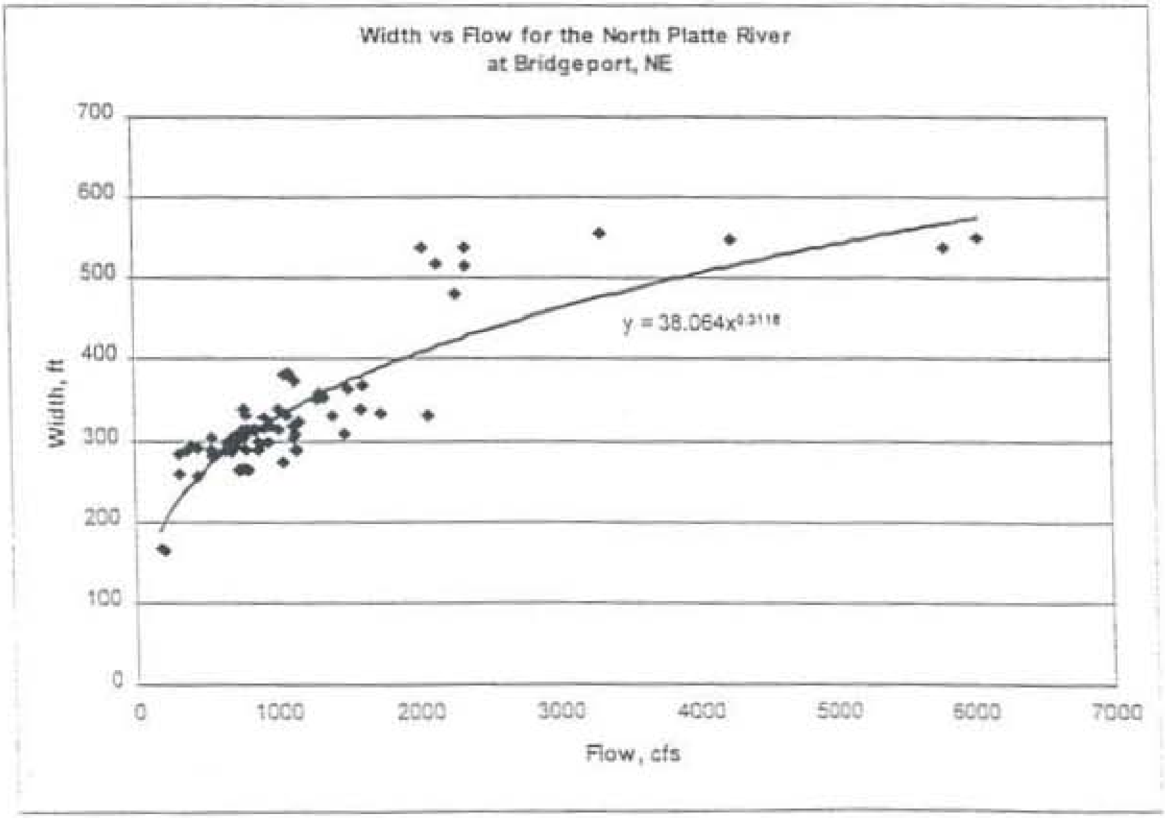


FIGURE 2.



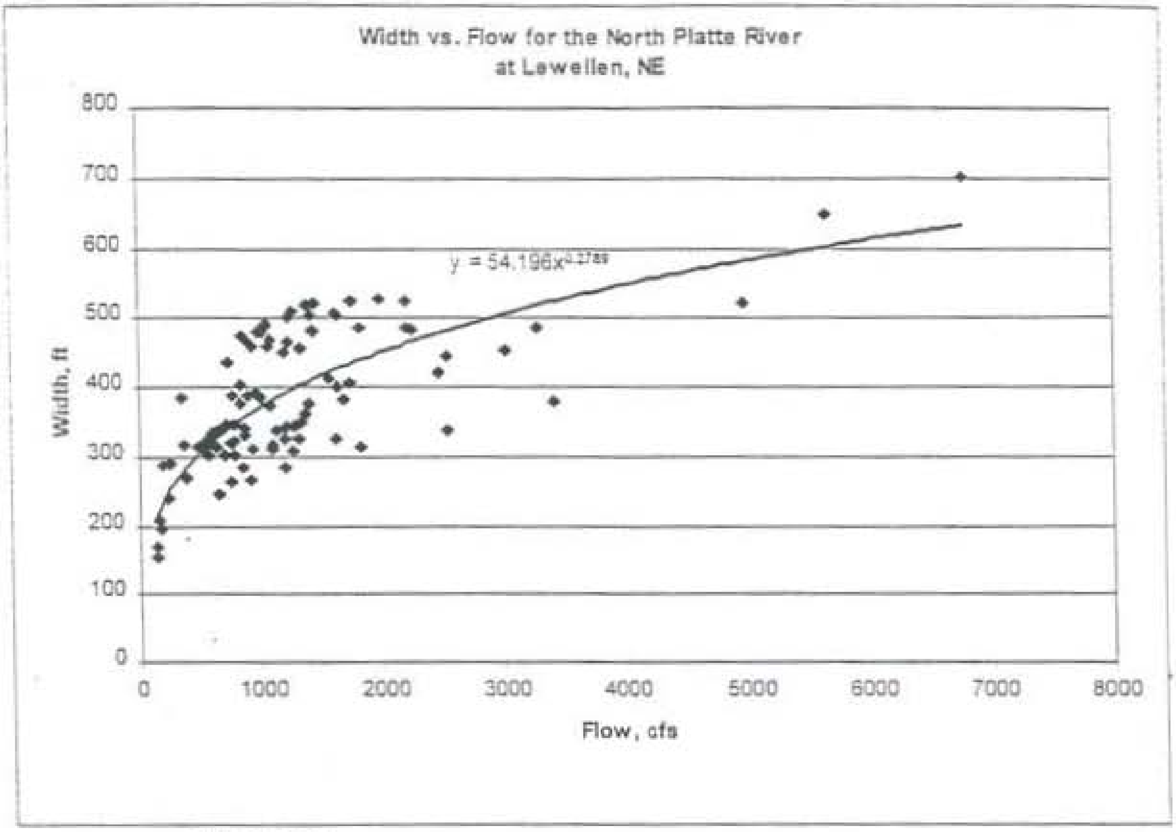
Width vs. Flow for the North Platte River
at Lewellen, NE
$y = 54.196x^{0.2788}$
Width, ft
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Flow, cfs

FIGURE 3.

Addendum 4. North Platte and Platte River below Lake McConaughy, Nebraska

Addendum 4 to "Determination of Monthly Loss Factors for the Platte River for the Historical 1975-1994 Water Year Period" to document segment-specific methods for estimating losses from the North Platte River at Keystone to the Platte River at Grand Island

OVERVIEW

For all of the segments, unless otherwise noted, the river water surface evaporation is determined using the following steps:

1. Develop logarithmic width v. discharge equations at the upstream and downstream end of the reach using measured values taken by Nebraska Department of Water Resources in 1975, 1978, 1982, 1987, 1990-1997 and recorded on US DOI Form 9-207.
2. Find the reach length using DOQQ's (Digital Orthographic Quarter-Quad) to trace the length of the center of the stream.
3. For given monthly gage flows at the upstream and downstream end, find the upstream and downstream widths using the logarithmic equations. If the logarithmic equation yields a width value of less than 10, set the width equal to 10 feet. These widths are averaged and multiplied by the reach length to determine an approximate monthly river area.
4. Using DOQQ's, find the actual surface area of the reach and the corresponding flow. When using the DOQQ's it was discovered that the entire reach was not photographed in a single day. To determine a single flow that would represent the surface area, the flow on each photograph date was multiplied by the percent of reach length photographed on that date and summed.
5. Determine a factor to calibrate the approximate monthly river reach area to the actual measured river reach area using the DOQQ's
6. The calibrated river water surface area is multiplied by the gross monthly evaporation determined from the weather stations. The gross monthly evaporation used is the average of the Kingsley, North Platte and Grand Island weather stations. Evaporation from shallow open water is obtained by multiplying pan evaporation at these stations by 0.7. Missing data is filled in by using the long-term average for the month at that station. Winter evaporation numbers are determined by using the winter evaporation numbers from the Bridgeport weather station.

Fraction of total water lost to evaporation for the reach is determined by dividing River Water Surface Evaporation (found above) by Total Inflows. This value is divided by the number of miles and multiplied by one hundred to get % EVAP PER MILE.

Total Inflows are all inflows into the reach. These inflows include the flow at the upstream end of the reach, other measured inflows, and any positive gains that occur in the reach.

Positive gains are found from a water balance.

Gains = Outflow at Downstream end + Diversions + Evaporation – Inflow at Upstream end – Other Measured Inflows

Diversions and Other Measured Inflows in each reach are listed below.

Fraction of total water lost to seepage for the reach is determined by dividing any negative Net Gains by Total Inflows. This value is divided by the number of miles and multiplied by one hundred to get % SEEP PER MILE.

Fraction of total water diverted for the reach is determined by dividing the sum of Diversions in the reach by Total Inflows. This value is divided by the number of miles and multiplied by one hundred to get %DIV PER MILE.

Applying the % DIV implies there is a demand for additional water in that reach. Canals along the North Platte River below McConaughy and canals on the Platte River use a combination of their natural flow rights and storage water from McConaughy to fill their diversion requirements. Adding water to these reaches will not result in a larger quantity of water being diverted. Therefore the % DIV should not be applied unless the operation of McConaughy is changed as a result of the increased flows. Adding unprotected natural flow to the Platte River could result in a decrease in water being released from McConaughy.

REACHES

Reach 14. Keystone Gage to North Platte Gage at North Platte

River water surface evaporation was found using the standard method as described above with one modification. At the North Platte Gage, prior to 1990, DWR measured the width of the stream 50 to 100 feet below the Highway 83 bridge. In the 1990's, DWR has been measuring the stream 200 to 500 feet below the bridge. The measuring location affects the width v. discharge equation so all readings taken before 1990 were removed from the data set that generated the width v. discharge equation.

Diversions: are Keith-Lincoln Irrigation Canal, North Platte Irrigation Canal, Paxton-Hershey Irrigation Canal, Suburban Irrigation Canal, and Cody-Dillon Irrigation Canal.

NPPD North Platte River Diversion at Keystone was not considered to be a diversion from this reach. The diversion is below McConaughy but is above the North Platte River gage at Keystone. This water, along with South Platte River water diverted at Korty, is returned to the River near North Platte.

Other Measured Inflows: Birdwood Creek As of January 1994, the gage on Birdwood Creek is only being recorded from May through September. Data for January through April 1994 was created for use in OPSTUDY. Data to fill in the four missing months was taken from OPSTUDY Input File BS3_4394.INH.

There are several non-gaged tributary inflows in this reach including Sarben Slough, East Cedar (Clear) Creek, Lincoln County Drain #2, and Lincoln County Drain #1. These tributary inflows were not included in this analysis, and as a result they become part of the gains in the reach.

Reach 15. North Platte Gage at North Platte to Brady Gage

River water surface evaporation was found using the standard method with the following exceptions: Only data taken after 1990 was used to develop the width v. discharge at North Platte as explained for Segment 14. At Brady, only the North Channel flows and measured widths were used to develop the width v. discharge equation.

Diversions: Central Nebraska Public Power and Irrigation District (CNPPID) supply canal diversion

Water from this diversion is used for power and irrigation and a portion is returned to the River at the Jeffrey River Return and Johnson River Return.

Other Measured Inflows: Nebraska Public Power District (NPPD) North Platte Hydro Return and South Platte River.

Non-gaged inflows are Fremont Slough, White Horse Creek, and Pawnee Creek. These were not included in this analysis.

The South Platte River and NPPD Hydro Return enter the reach very near the upstream end of this reach. CNPPID Supply Canal Diversion occurs only a short distance downstream of the confluence of the North and South Platte Rivers. Because the South Platte and NPPD Hydro Return can introduce a large amount of water in this reach and CNPPID Diversion removes a large portion of water from this reach, it is questionable whether or not the flow in the North Platte River at North Platte should be used to represent the flow at the upstream end of the reach. This question arises when determining the surface area for the reach.

During the period of 1975 to 1994, the inflows from the South Platte and NPPD Hydro Return were 21,139,030 acre-feet. CNPPID diverted 22,654,660 acre-feet during the same period. The difference over this 20-year period was 7%. Differences on a day by day or month by month basis are more than 7%. Looking at the period as a whole, using the North Platte Gage at North Platte may be the best estimate of flow at the upstream end of the reach.

Another approach considered was using (North Platte Gage + South Platte Gage at North Platte + NPPD Hydro Return – CNPPID Diversion) as the flow at the upstream end. This method would yield negative flow values for 107 of the 240 months because it does not account for the gains and tributary inflows such as Fremont Slough that occur between the three gages and the diversion. Estimates for these gains may be made and a more accurate estimate of flow during extreme conditions acquired. When the South Platte + NPPD Hydro Return is much higher or lower than CNPPID's Diversion the North Platte Gage is not a good estimate of what is passing the diversion dam. With this approach it would also be difficult to develop an equation to relate width to discharge.

The last approach considered was to use a gage, Passing Central Diversion Dam, located approximately two miles downstream of the North Platte Diversion Dam as the inflow into this reach. This method would ignore the gains between North Platte and this gage as well as the tributary inflows from the Fremont Slough and White Horse Creek. This gage was only used to record May through September prior to 1991. Data would need to be created to find flow values for the non-irrigation season.

Because the distinction of the upstream flow is only required for the % Evaporation calculation, the North Platte Gage at North Platte was chosen as the upstream flow for this reach. This is an underestimate of flow when the South Platte + NPPD Hydro Return is greater than CNPPID's diversion and an overestimate when South Platte + NPPD Hydro Return in less than CNPPID's diversion. One extreme case is when the South Platte is high such as 1983. Because the width v. discharge equation is a logarithmic equation and the curve flattens at high flows, an underestimate of flow at high flows in the reach will cause a smaller underestimate of width and consequently % Evaporation. The % Evaporation calculation resulted in a maximum % Evaporation of 0.65 % for the entire reach. Because of the small amount of evaporation in this reach, it was not a concern if this is an overestimate.

Reach 16. Brady Gage to Cozad Gage

River water surface evaporation was found using the standard method with the following exceptions: At Brady, only the North Channel flows and measured width was used to develop the width v. discharge equation. The North Channel and South Channel at Cozad were added together to develop the equation for width v. discharge. A Logarithmic equation did not fit the data at Cozad so a third-order polynomial equation was used to relate width to discharges. This equation is only intended to be used for discharges less than 18000 cfs.

The third-order polynomial equation used at Cozad shows a decreasing width as average monthly flows increase from 11000 to 15000 cfs. While this is not an accurate trend for width v. discharge in this range, this equation is more representative of measured data below 11000 than a logarithmic equation. For the historic period, only one month, June 1983, had an average flow above 11000 cfs. The average flow for this month was 17,456 cfs. The next highest average flow month was July 1983 with a flow of 10,450. Using the third-order polynomial equation, the width for June 1983 would be 828 feet, and July's width would be 833 feet. Because of a lack of data about flows above 11000 cfs, the error associated with using this equation is unknown. Also, the width is only needed to determine the % EVAP which is an order of magnitude less than the % SEEP for June 1983.

Diversions: Thirty Mile Canal, Gothenburg Canal, Six Mile Canal, Cozad Canal, Orchard-Alfalfa Canal, and Dawson County Canal

Other Measured Inflows: Jeffrey River Return

Reach 17. Cozad Gage to Overton Gage

River water surface evaporation was found using the standard method with the following exceptions: The North Channel and South Channel at Cozad were added together to develop the width v. discharge equation. A third order polynomial equation was used to represent the data.

Diversions: None

Other Measured Inflows: Johnson River Return

Plum Creek and Dawson County Drain #2 also flow into this reach but were not included in this analysis, and therefore become part of the gains.

Reach 18. Overton Gage to Odessa Gage

River water surface area was found using data contained in the Prairie Bend Study (Prairie Bend Unit, P – S MBP, Nebraska). The Prairie Bend Study divided the Platte River from below Lexington to Chapman into segments. A Study Site that was representative of the Segment was chosen. At each study site, a total area v. discharge curve was developed and applied to the entire Segment. The curves for Segments from Overton to Odessa were summed to find the total area v. discharge curve that applied to the entire reach. Prairie Bend Study Sites chosen are Study Sites 2, 4A, 4B, and 5. This total area curve was divided by the number of represented miles and multiplied by the total reach length to obtain a surface area v. discharge curve for the entire reach. A logarithmic equation was developed from this curve. The surface area was obtained by using the average of the upstream and downstream flows and the equation developed from the curve. This surface area was multiplied by a factor that relates this surface area to a surface area found using DOQQ's. The surface area was multiplied by the monthly open water evaporation to obtain river water surface evaporation.

Diversions: Kearney Canal

Other Measured Inflows: None

Streever Creek, Buffalo Creek, and Elm Creek are non-gauged inflows into this reach.

Reach 19. Odessa Gage to Grand Island Gage

River water surface area was found using the same technique as for Segment 18. Prairie Bend Study Sites chosen to represent this reach are 5, 6, 7, 8A N&S, 8B, 8C, 9BW, 10, and 11.

Diversions: None

Other Measured Inflows: Kearney Power Return

ADDENDUM 5:
PLOTS OF RIVER WIDTH OR SURFACE AREA VERSUS FLOW RATE

Plots are in the following order:

Gages on North Platte River, Wyoming

1 Northgate, CO
2 Sinclair
3 Alcova
4 Orin
5 Below Whalen
6 WY/NE Stateline

Gages on Laramie River, Wyoming

7 Grayrocks Reservoir Outflow
8 Fort Laramie

Gages on North Platte River above Lake McConaughy, Nebraska

9 Mitchell
10 Bridgeport
11 Lewellen

Gages on South Platte River, Colorado

12 Henderson
13 Kersey
14 Balzac
15 Julesburg
16 South Platte at North Platte, NE

Gage on Cache la Poudre River, Colorado

17 Greeley

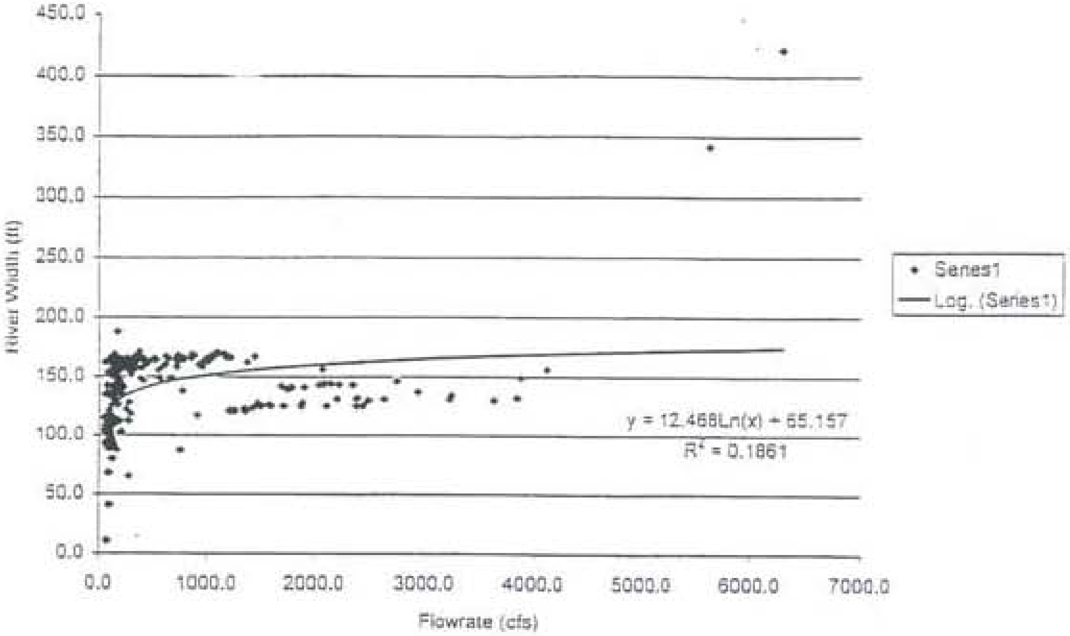
Gages on North Platte River below Lake McConaughy, Nebraska

18 Keystone
19 North Platte at North Platte

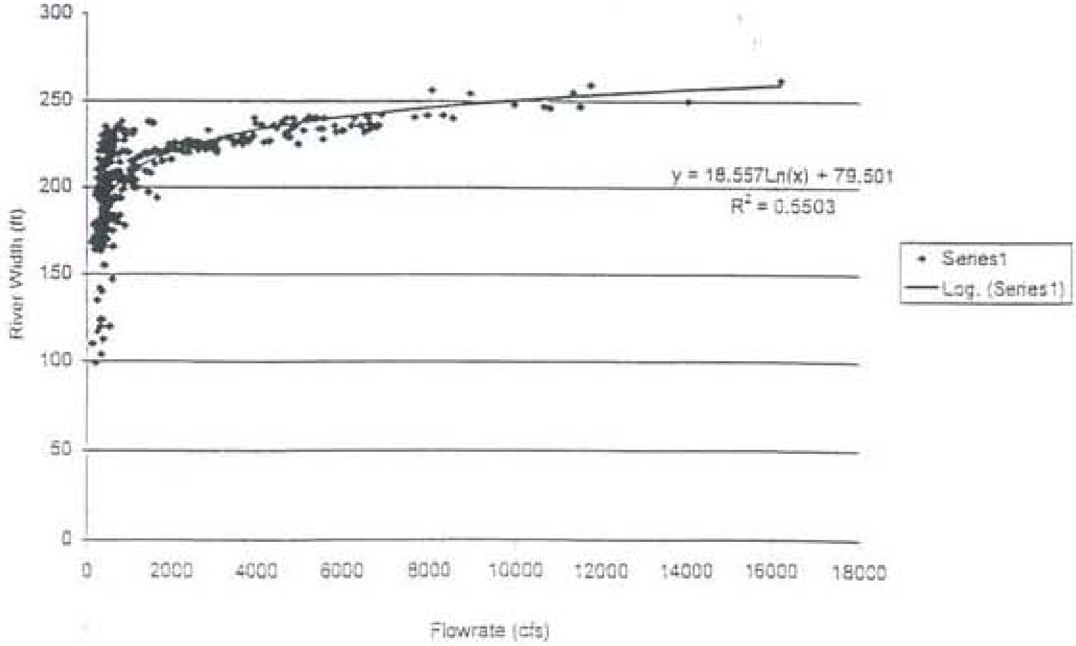
Gages on Platte River, Nebraska

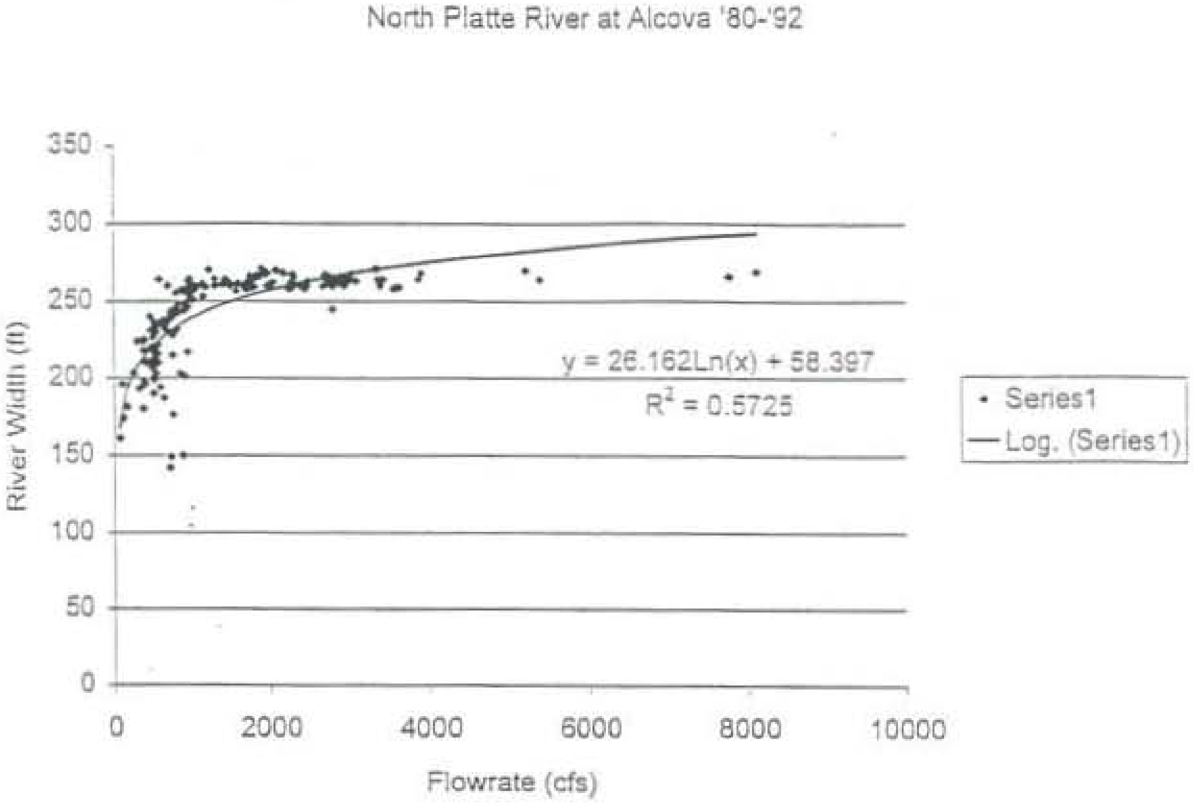
20 Brady
21 Cozad
22 Overton
23 Overton to Odessa (Reach 18); Surface Area versus Flow
24 Odessa to Grand Island (Reach 19); Surface Area versus Flow

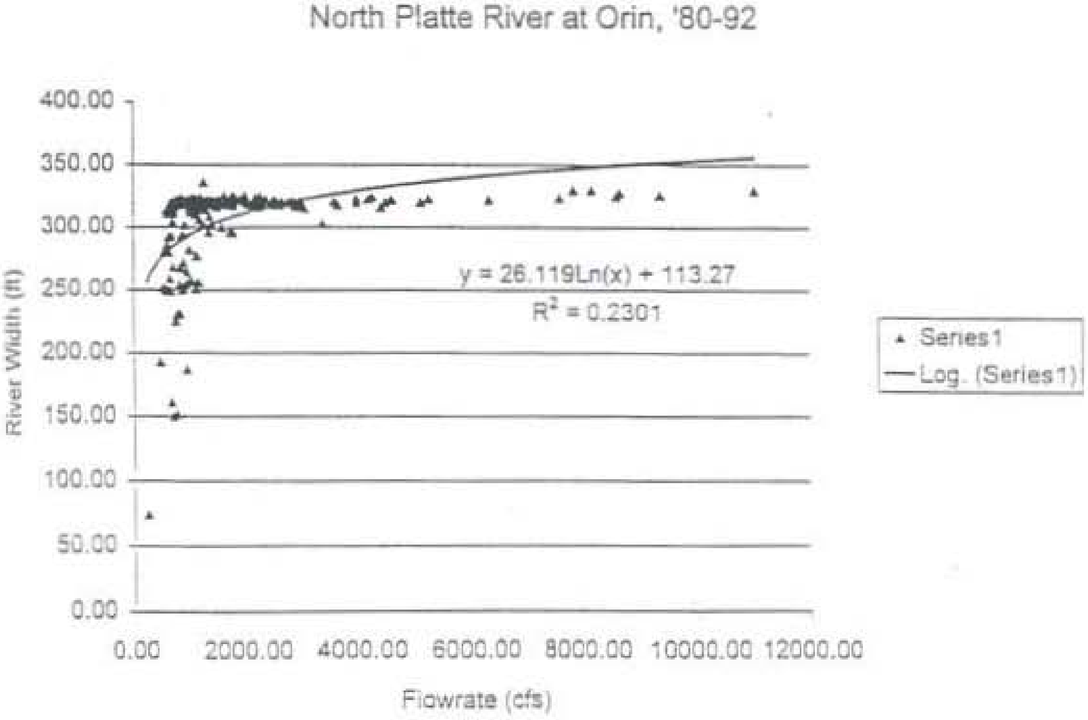
North Platte River near Northgate, Colo.

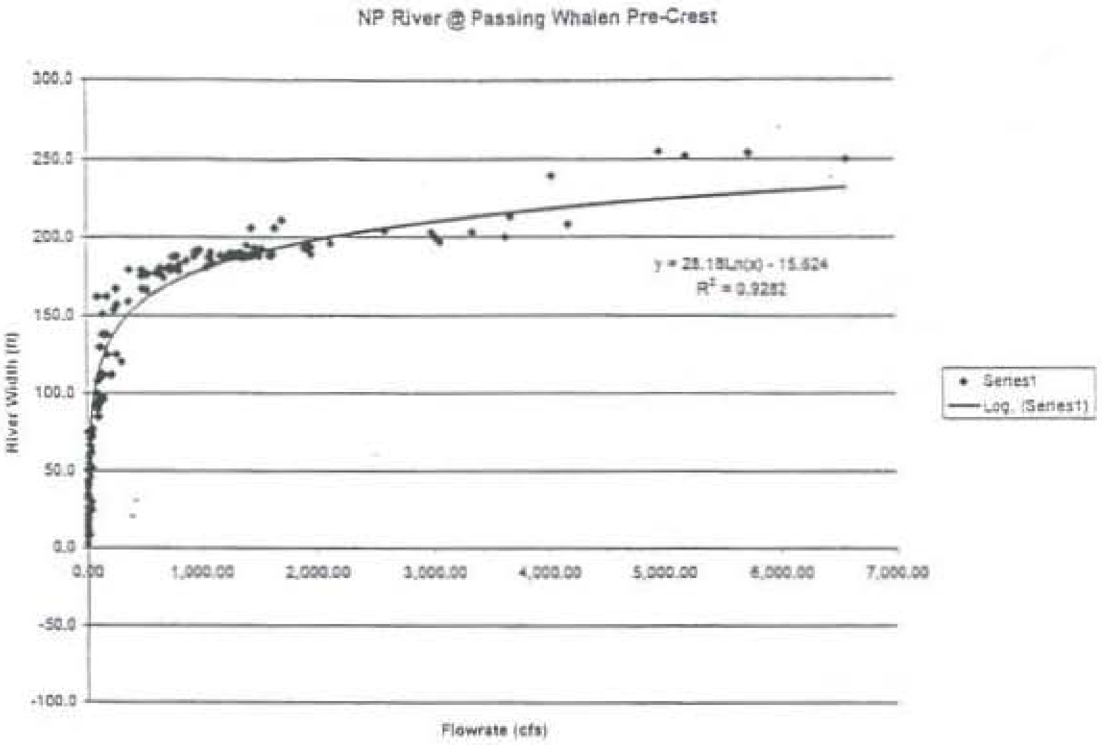


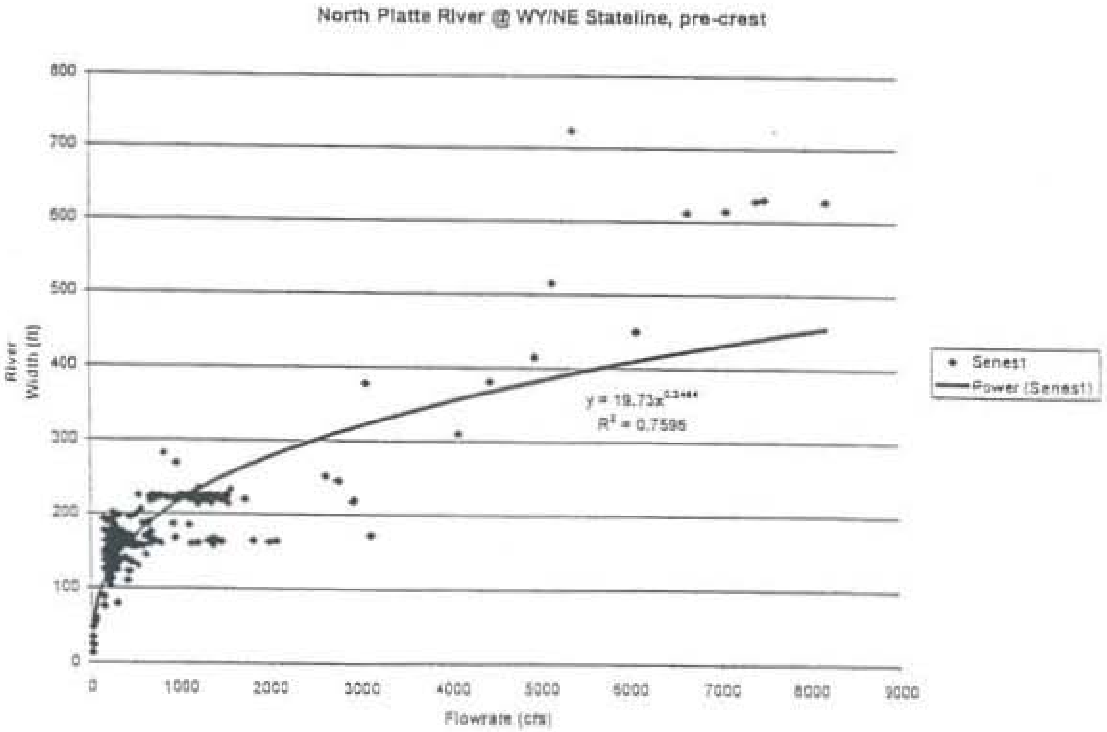
North Platte River above Seminoe near Sinclair

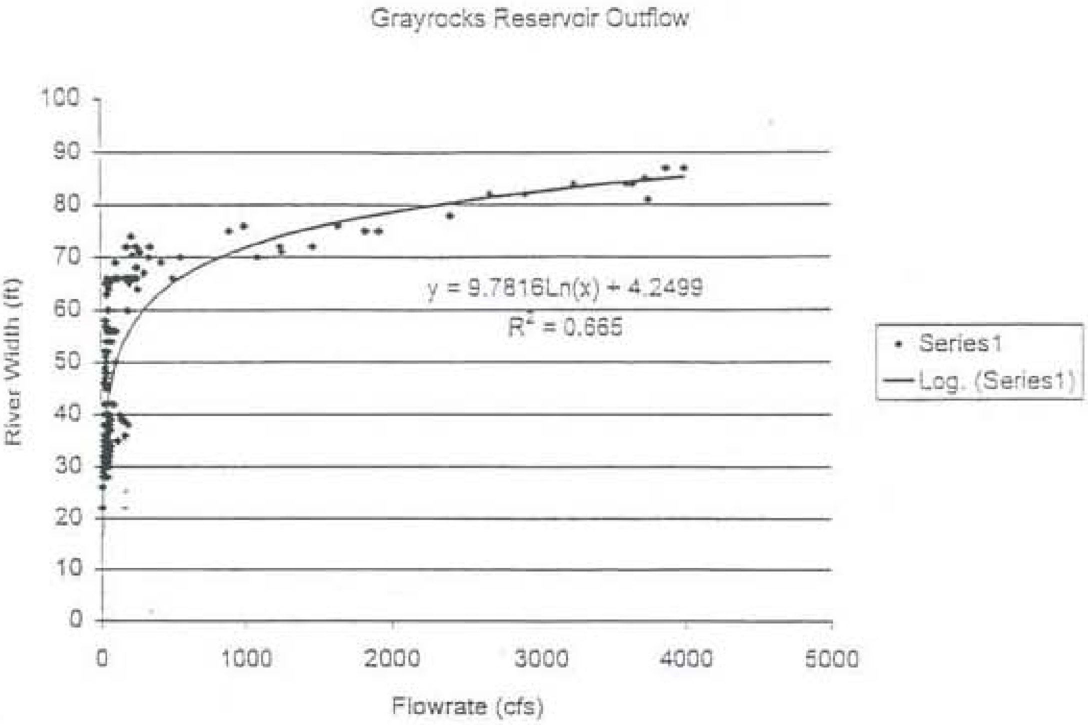


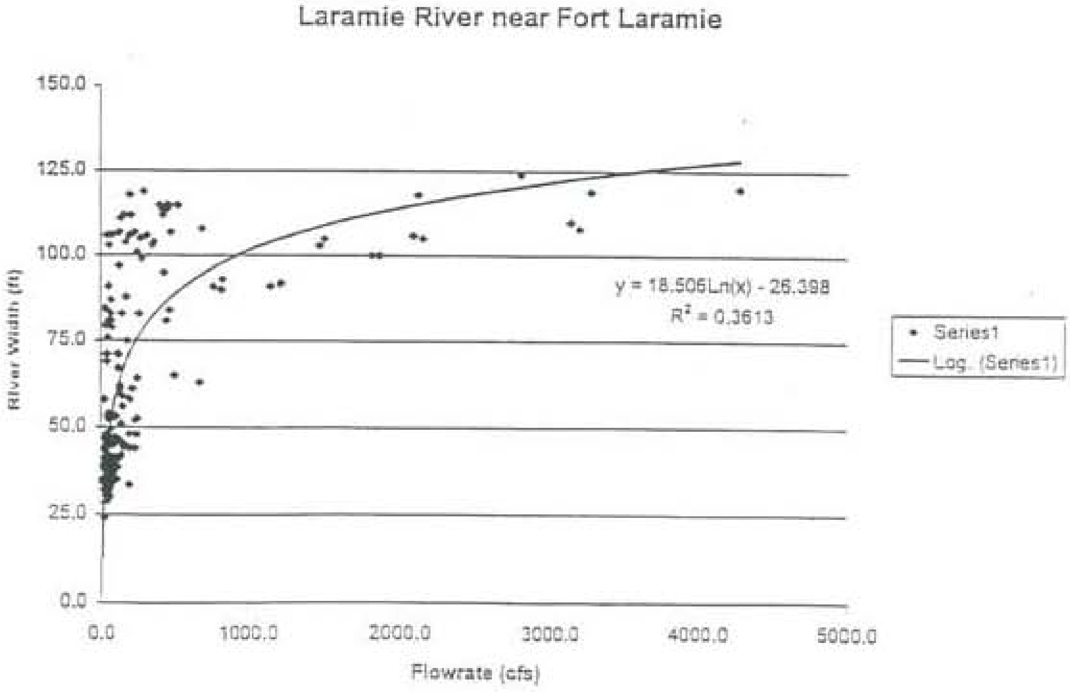

North Platte River at Alcova '80-'92
River Width (ft)
350
300
250
200
150
100
50
0
0
2000
4000
6000
8000
10000
Flowrate (cfs)
y = 26.162Ln(x) + 58.397
R² = 0.5725
Series1
Log. (Series1)

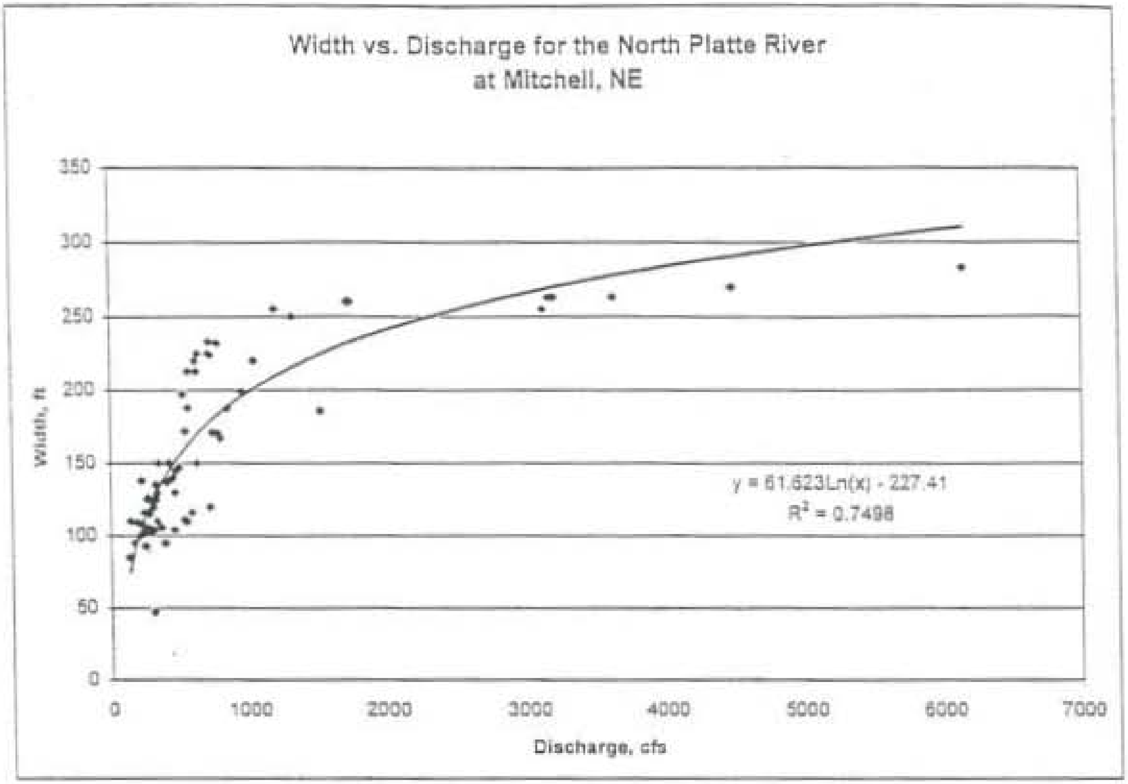

North Platte River at Orin, '80-92
River Width (ft)
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0.00
2000.00
4000.00
6000.00
8000.00
10000.00
12000.00
Flowrate (cfs)
y = 26.119Ln(x) + 113.27
R² = 0.2301
Series1
Log. (Series1)

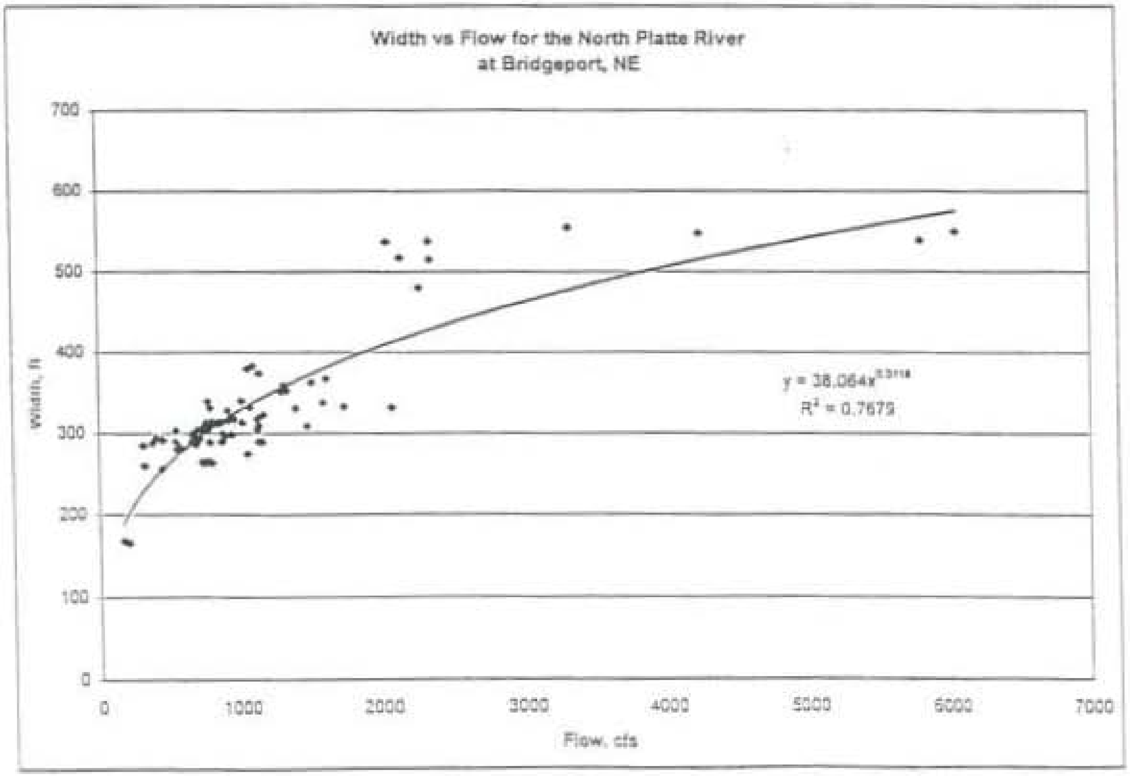

NP River @ Passing Whalen Pre-Crest
River Width (ft)
300.0
250.0
200.0
150.0
100.0
50.0
0.0
-50.0
-100.0
0.00
1,000.00
2,000.00
3,000.00
4,000.00
5,000.00
6,000.00
7,000.00
Flowrate (cfs)
y = 28.18Ln(x) - 15.624
R² = 0.9282
Series1
Log. (Series1)

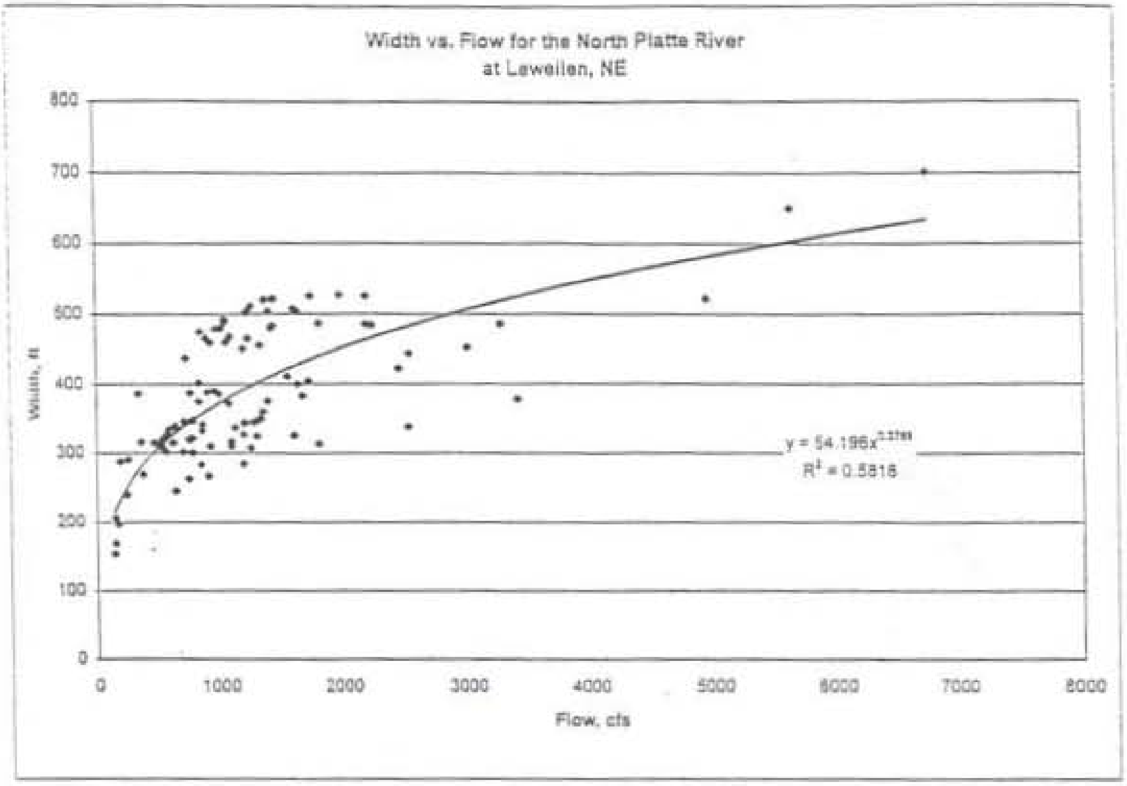

North Platte River @ WY/NE Stateline, pre-crest
River Width (ft)
800
700
600
500
400
300
200
100
0
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Flowrate (cfs)
y = 19.73x^0.3484
R² = 0.7595
Series1
Power (Series1)


Grayrocks Reservoir Outflow
River Width (ft)
100
90
80
70
60
50
40
30
20
10
0
0
1000
2000
3000
4000
5000
Flowrate (cfs)
y = 9.7816Ln(x) + 4.2499
R² = 0.665
Series1
Log. (Series1)

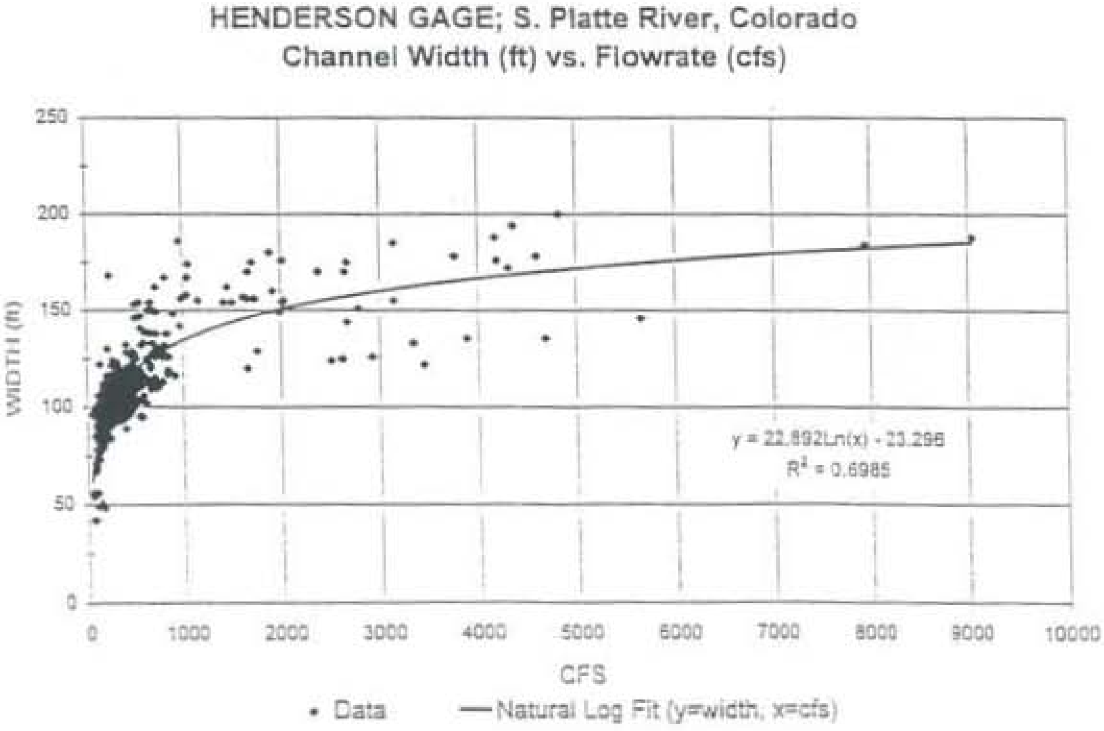

Laramie River near Fort Laramie
River Width (ft)
150.0
125.0
100.0
75.0
50.0
25.0
0.0
0.0
1000.0
2000.0
3000.0
4000.0
5000.0
Flowrate (cfs)
y = 18.506Ln(x) - 26.398
R² = 0.3613
Series1
Log. (Series1)


Width vs. Discharge for the North Platte River
at Mitchell, NE
350
300
250
200
150
100
50
0
Width, ft
0
1000
2000
3000
4000
5000
6000
7000
Discharge, cfs
y = 61.623Ln(x) - 227.41
R² = 0.7498

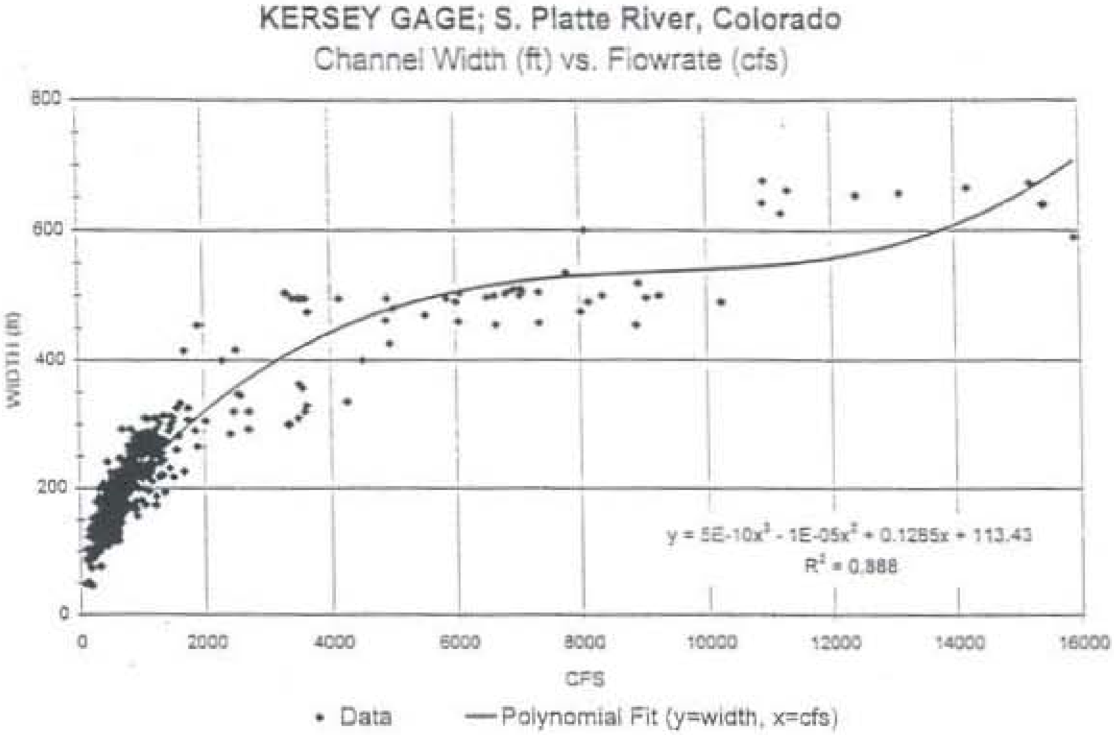

Width vs Flow for the North Platte River
at Bridgeport, NE
700
600
500
400
300
200
100
0
Width, ft
0
1000
2000
3000
4000
5000
6000
7000
Flow, cfs
y = 38.064x[illegible]
R² = 0.7679

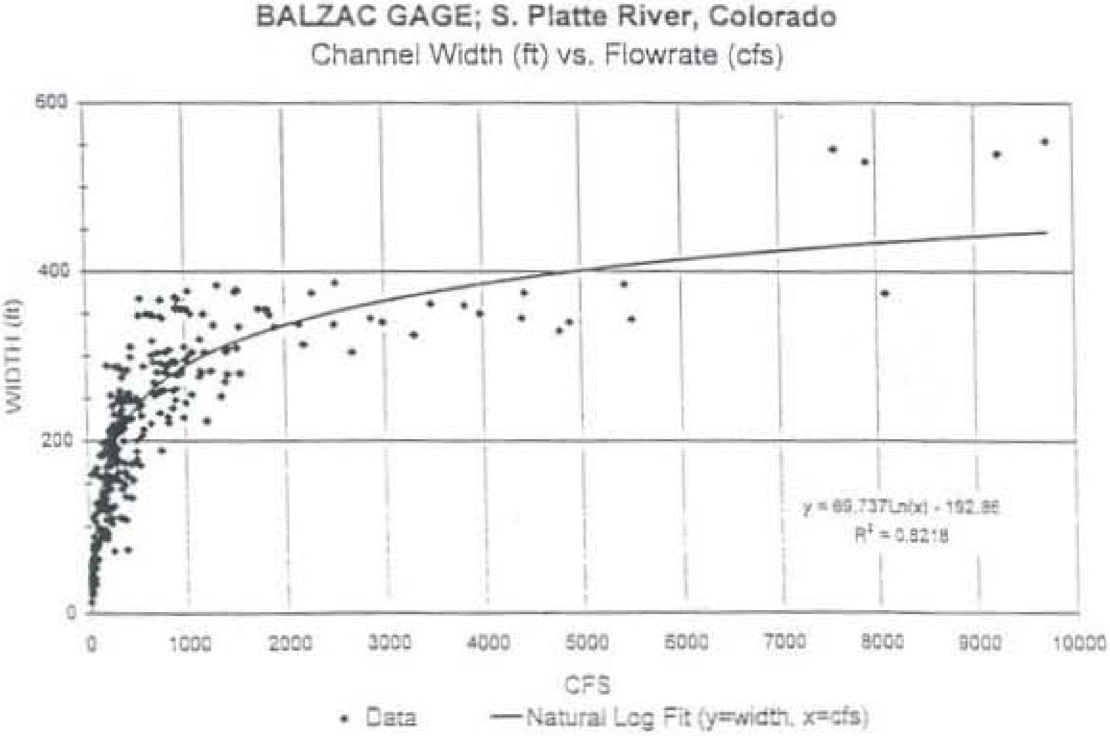


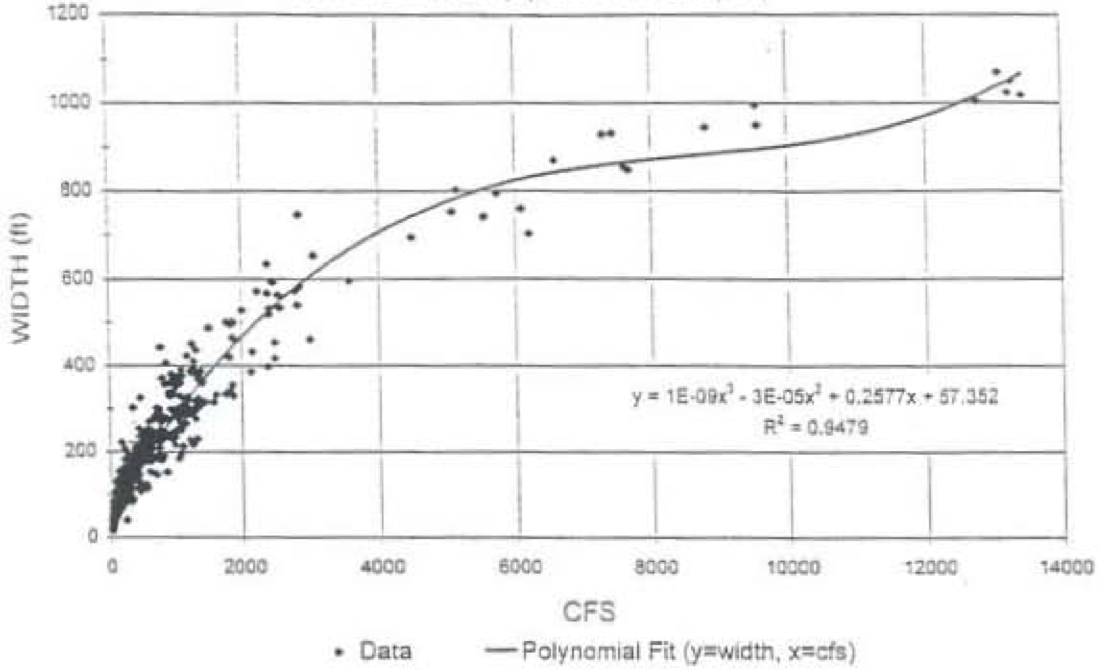
Width vs. Flow for the North Platte River
at Lewellen, NE



HENDERSON GAGE; S. Platte River, Colorado
Channel Width (ft) vs. Flowrate (cfs)

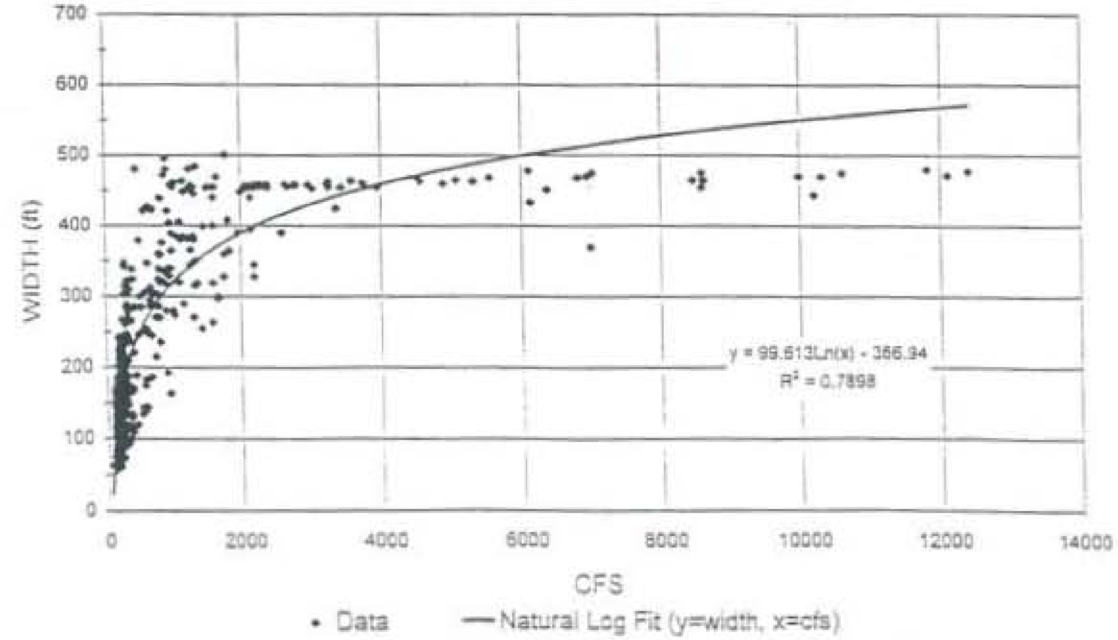

KERSEY GAGE; S. Platte River, Colorado
Channel Width (ft) vs. Flowrate (cfs)
800
600
400
200
0
WIDTH (ft)
0
2000
4000
6000
8000
10000
12000
14000
16000
CFS
y = 5E-10x³ - 1E-05x² + 0.1285x + 113.43
R² = 0.888
• Data
—Polynomial Fit (y=width, x=cfs)


BALZAC GAGE; S. Platte River, Colorado
Channel Width (ft) vs. Flowrate (cfs)
600
400
200
0
WIDTH (ft)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
CFS
y = 69.737Ln(x) - 192.86
R² = 0.8218
• Data
—Natural Log Fit (y=width, x=cfs)



JULESBURG GAGE; S. Platte River, Colorado

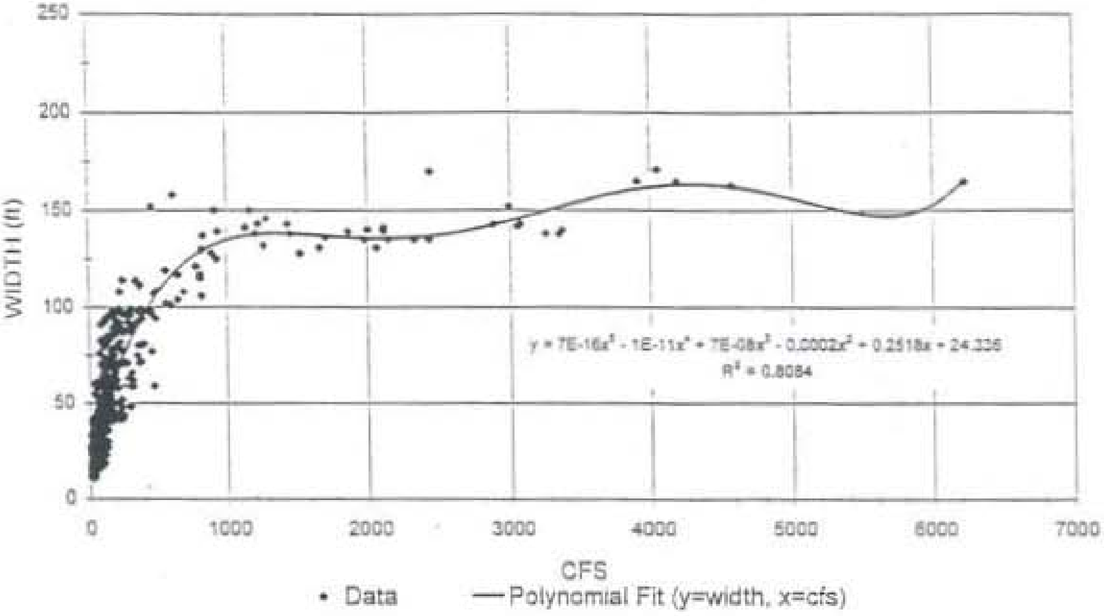
Channel Width (ft) vs. Flowrate (cfs)

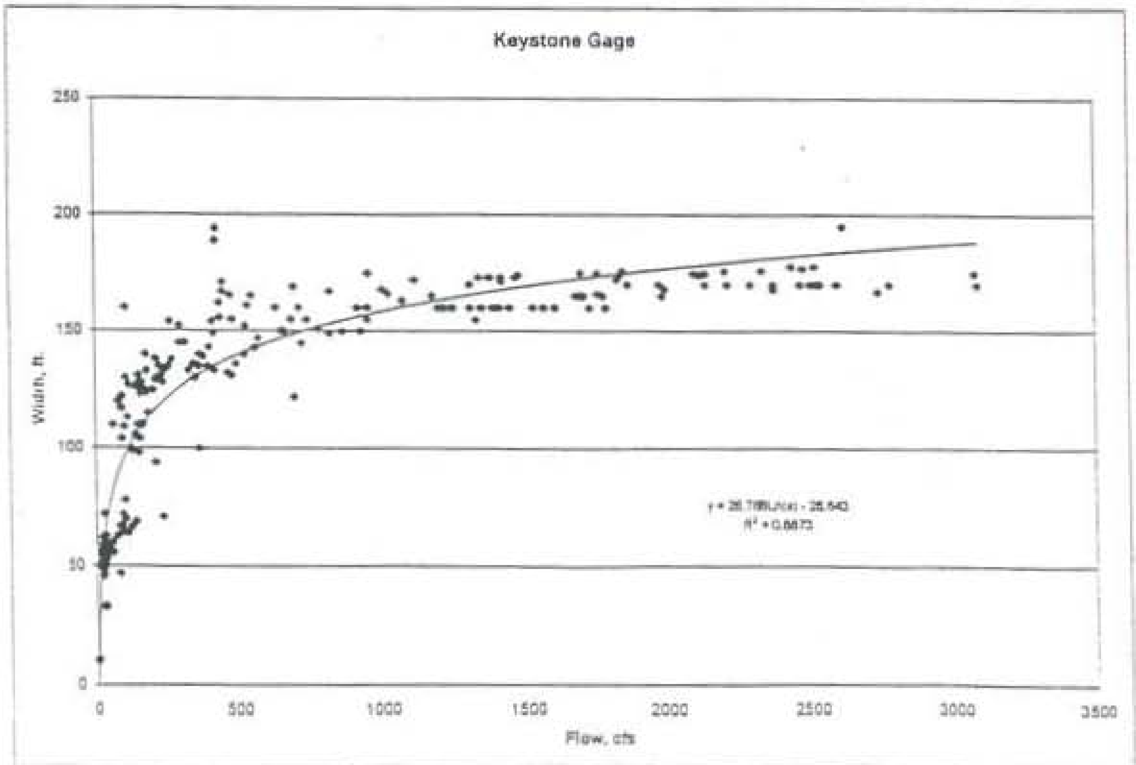


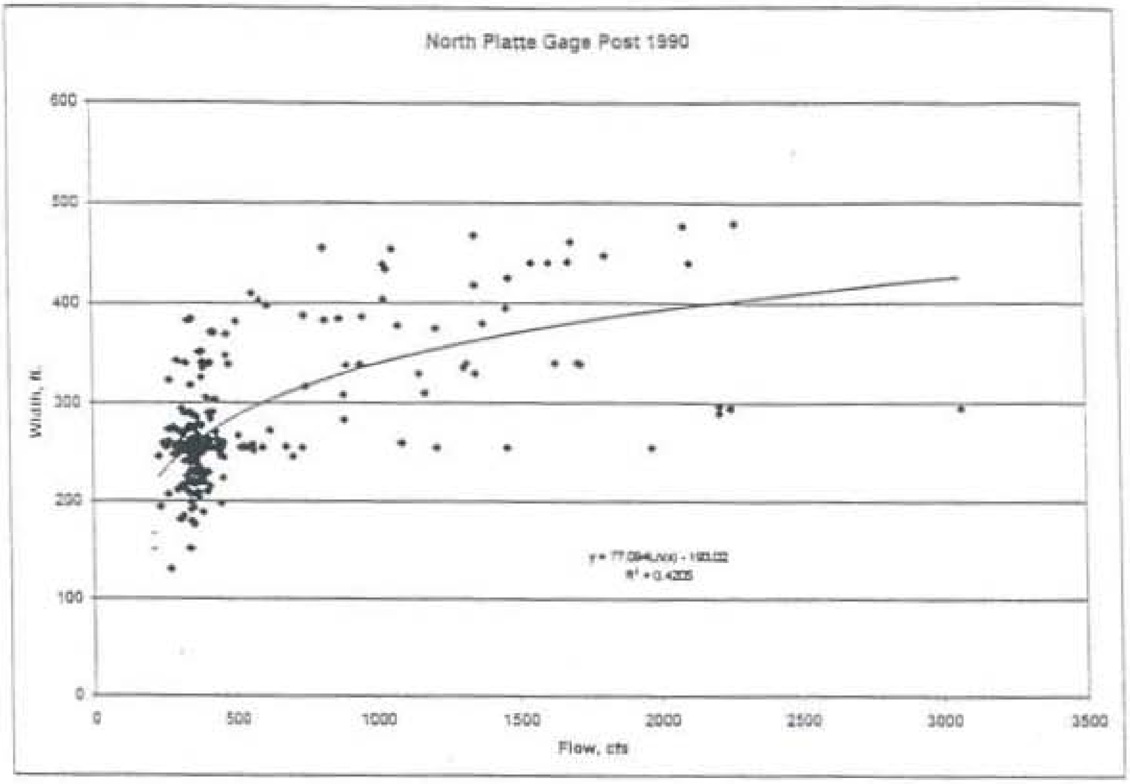
SOUTH PLATTE GAGE at North Platte, Nebraska

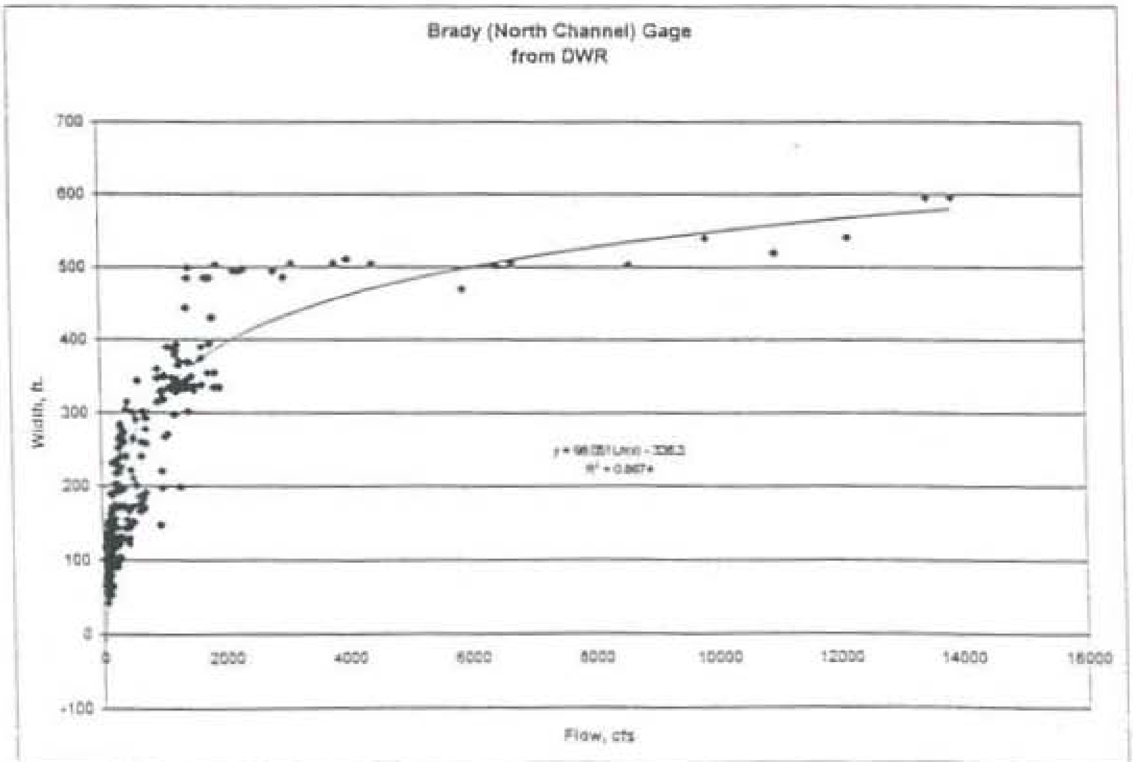
Channel Width (ft) vs. Flowrate (cfs)

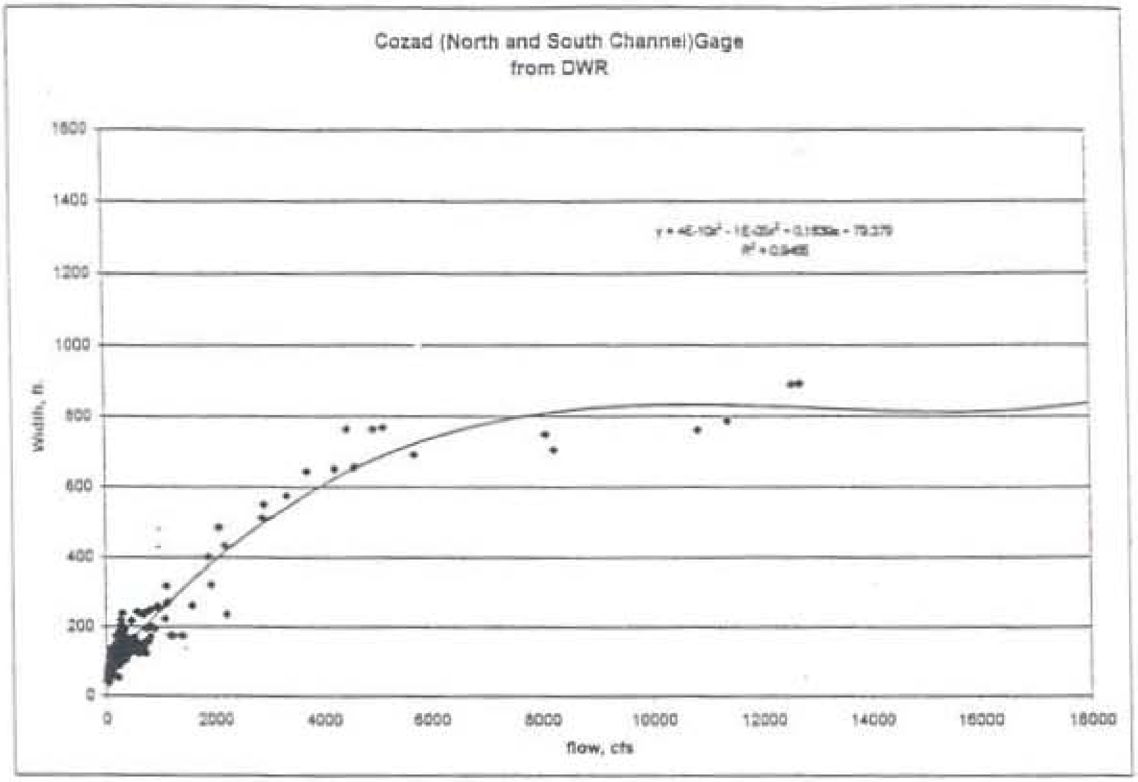
CACHE LA POUDRE RIVER GAGE
Near Greeley, Colorado
Channel Width (ft) vs. Flowrate (cfs)

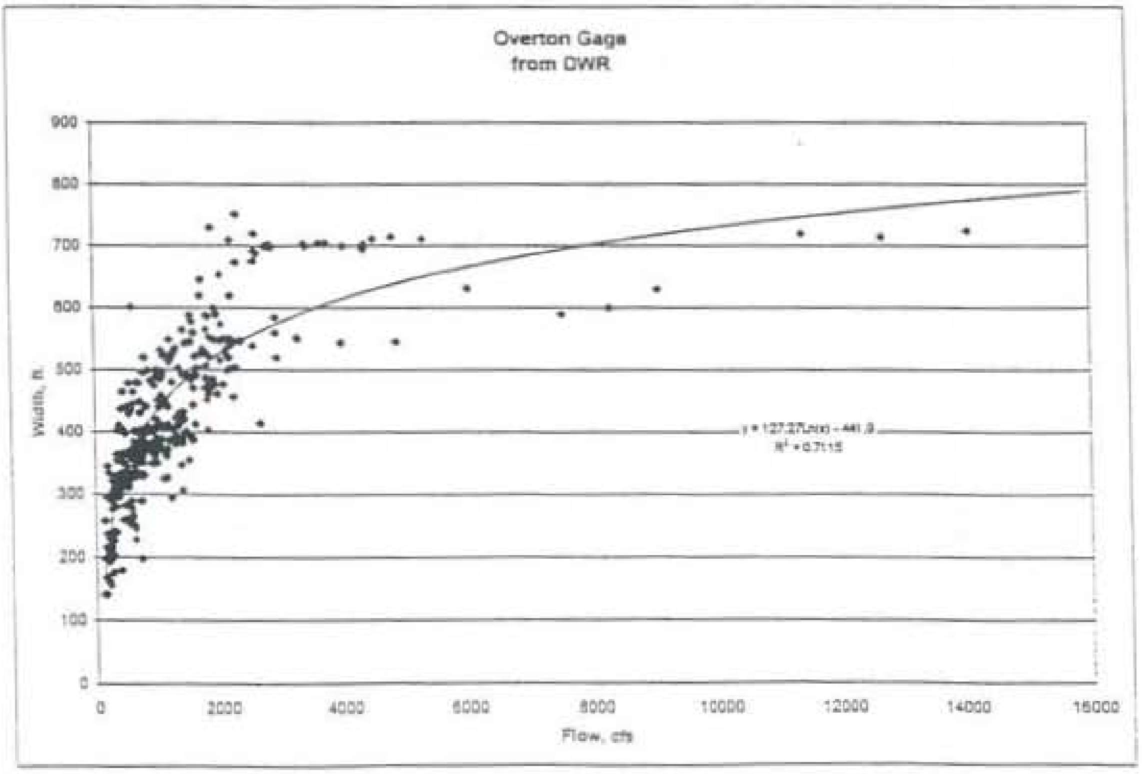


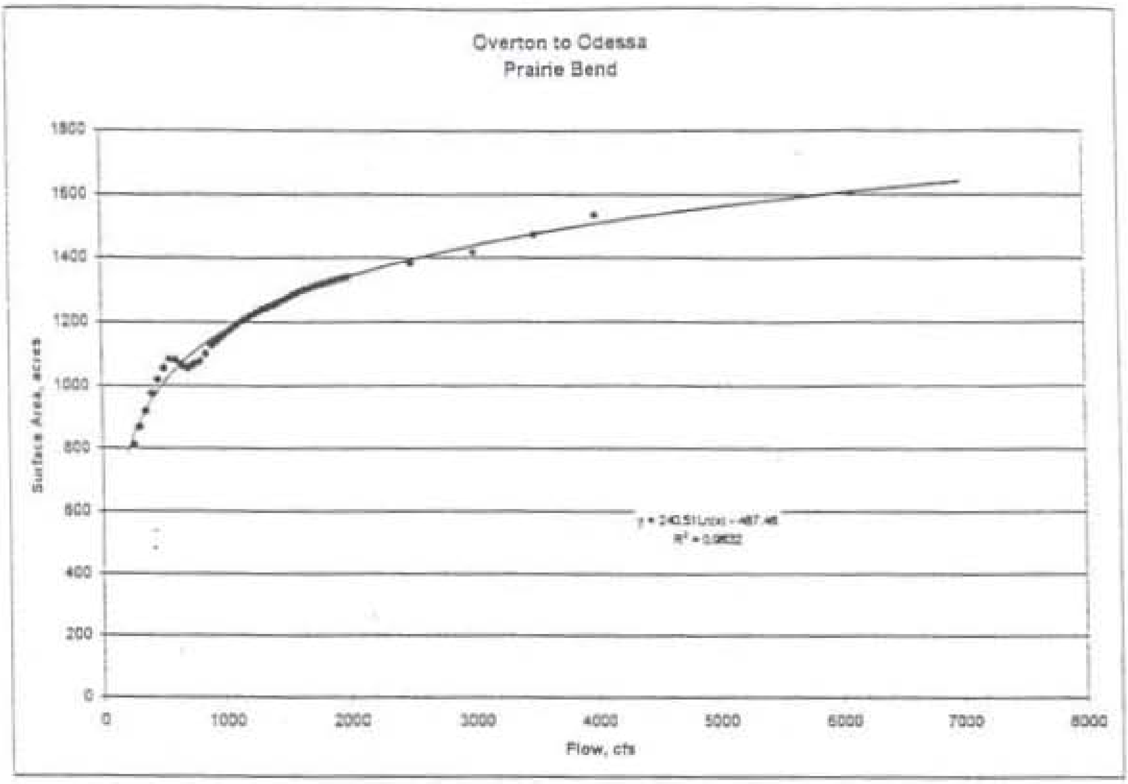

Keystone Gage

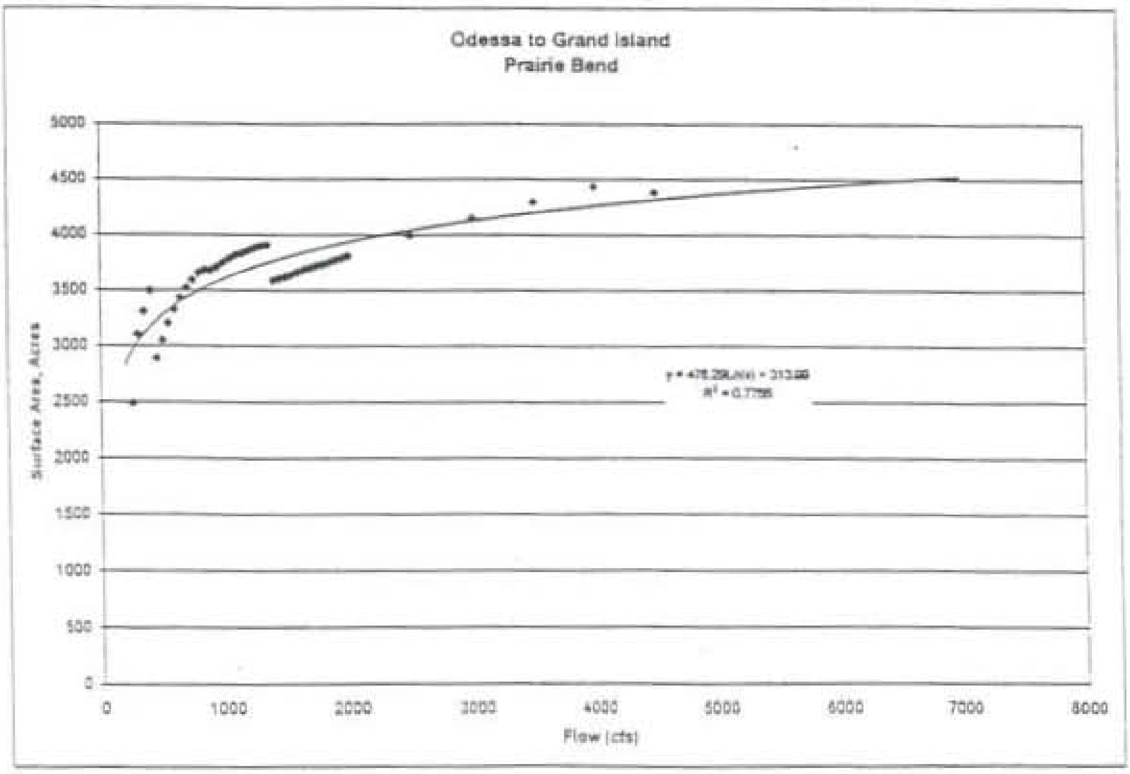

North Platte Gage Post 1990
600
500
400
300
200
100
0
Width, ft.
0
500
1000
1500
2000
2500
3000
3500
Flow, cfs
y = 77.094Ln(x) - 193.02
R² = 0.4205


Brady (North Channel) Gage
from DWR
700
600
500
400
300
200
100
0
-100
Width, ft.
0
2000
4000
6000
8000
10000
12000
14000
16000
Flow, cfs
y = 98.051Ln(x) - 336.3
R² = 0.8674


Cozad (North and South Channel)Gage
from DWR
1600
1400
1200
1000
800
600
400
200
0
Width, ft.
y = 4E-10x³ - 1E-05x² + 0.1536x + 79.379
R² = 0.9465
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
flow, cfs


Overton Gage
from DWR
900
800
700
600
500
400
300
200
100
0
Width, ft.
y = 127.27Ln(x) - 441.9
R² = 0.7115
0
2000
4000
6000
8000
10000
12000
14000
16000
Flow, cfs


Overton to Odessa
Prairie Bend
Surface Area, acres
1800
1600
1400
1200
1000
800
600
400
200
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Flow, cfs
y = 240.51Ln(x) - 487.46
R² = 0.9832


Odessa to Grand Island
Prairie Bend
Surface Area, Acres
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Flow (cfs)
y = 476.29Ln(x) + 313.99
R² = 0.7756

ADDENDUM 6:

TABLES OF PERCENT LOSS FACTORS PER MILE
(%EVAP, %SEEP, AND %DIV)
FOR THE 19 REACHES

%EVAP PER MILE

NPS1.STEP1

Reach 1: NORTHGATE TO SINCLAIR REACH

100 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0242	0.0105	0.0066	0.0047	0.0062	0.0120	0.0087	0.0039	0.0038	0.0072	0.0284	0.0416
1976	0.0321	0.0141	0.0115	0.0046	0.0089	0.0171	0.0107	0.0052	0.0062	0.0180	0.0316	0.0411
1977	0.0315	0.0162	0.0094	0.0095	0.0172	0.0149	0.0139	0.0096	0.0174	0.0716	0.0606	0.0718
1978	0.0493	0.0170	0.0109	0.0052	0.0062	0.0150	0.0109	0.0046	0.0035	0.0088	0.0280	0.0496
1979	0.0345	0.0123	0.0068	0.0053	0.0066	0.0097	0.0087	0.0028	0.0038	0.0112	0.0199	0.0441
1980	0.0316	0.0155	0.0081	0.0048	0.0068	0.0076	0.0066	0.0018	0.0052	0.0160	0.0472	0.0445
1981	0.0244	0.0150	0.0092	0.0104	0.0159	0.0206	0.0239	0.0077	0.0107	0.0306	0.0535	0.0566
1982	0.0207	0.0200	0.0150	0.0113	0.0108	0.0124	0.0116	0.0038	0.0030	0.0058	0.0164	0.0145
1983	0.0094	0.0061	0.0030	0.0046	0.0072	0.0086	0.0052	0.0032	0.0016	0.0040	0.0115	0.0239
1984	0.0149	0.0089	0.0035	0.0045	0.0037	0.0041	0.0047	0.0020	0.0025	0.0061	0.0116	0.0128
1985	0.0071	0.0080	0.0041	0.0035	0.0031	0.0064	0.0052	0.0039	0.0061	0.0168	0.0340	0.0328
1986	0.0144	0.0054	0.0075	0.0089	0.0044	0.0080	0.0049	0.0032	0.0027	0.0084	0.0223	0.0192
1987	0.0078	0.0051	0.0077	0.0120	0.0096	0.0068	0.0096	0.0062	0.0207	0.0390	0.0458	0.0561
1988	0.0337	0.0103	0.0045	0.0051	0.0066	0.0027	0.0059	0.0039	0.0055	0.0248	0.0615	0.0578
1989	0.0335	0.0135	0.0063	0.0117	0.0053	0.0062	0.0096	0.0104	0.0114	0.0431	0.0406	0.0441
1990	0.0339	0.0167	0.0053	0.0123	0.0105	0.0082	0.0075	0.0082	0.0062	0.0151	0.0368	0.0384
1991	0.0285	0.0111	0.0035	0.0144	0.0126	0.0117	0.0093	0.0058	0.0075	0.0272	0.0366	0.0393
1992	0.0359	0.0057	0.0098	0.0083	0.0111	0.0102	0.0157	0.0099	0.0105	0.0224	0.0453	0.0561
1993	0.0282	0.0143	0.0098	0.0044	0.0045	0.0080	0.0056	0.0035	0.0025	0.0105	0.0215	0.0254
1994	0.0118	0.0046	0.0027	0.0078	0.0029	0.0071	0.0083	0.0057	0.0134	0.0448	0.0657	0.0731
Avg	0.0254	0.0115	0.0073	0.0077	0.0079	0.0099	0.0093	0.0053	0.0072	0.0216	0.0359	0.0422
Max	0.0493	0.0200	0.0150	0.0144	0.0172	0.0206	0.0239	0.0104	0.0207	0.0716	0.0657	0.0731
Min	0.0071	0.0046	0.0027	0.0035	0.0029	0.0027	0.0047	0.0018	0.0016	0.0040	0.0115	0.0128
Std	0.0111	0.0045	0.0032	0.0033	0.0039	0.0043	0.0045	0.0026	0.0051	0.0167	0.0161	0.0168

%SEEP PER MILE

Reach 1: NORTHGATE TO SINCLAIR REACH

100 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												
1992												
1993												
1994												

Diversions NOT included in water balance computations.

%DIV PER MILE

Reach 1: NORTHGATE TO SINCLAIR REACH

100 miles

NOT COMPUTED: FEW MONTHLY DIVERSION RECORDS

%EVAP PER MILE

NPS2.STEP1

Reach 2: SINCLAIR TO ALCOVA REACH 30 to 40 miles of open river not under reservoirs (104 miles total)

AVERAGE of Reaches 1 and 3 Factors for %EVAP PER MILE

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0181	0.0081	0.0053	0.0035	0.0047	0.0093	0.0092	0.0067	0.0078	0.0122	0.0208	0.0281
1976	0.0229	0.0104	0.0083	0.0035	0.0053	0.0136	0.0120	0.0087	0.0118	0.0184	0.0229	0.0265
1977	0.0221	0.0120	0.0068	0.0067	0.0120	0.0116	0.0120	0.0118	0.0200	0.0460	0.0365	0.0460
1978	0.0348	0.0128	0.0087	0.0043	0.0047	0.0127	0.0144	0.0055	0.0173	0.0143	0.0212	0.0332
1979	0.0237	0.0100	0.0054	0.0040	0.0049	0.0082	0.0120	0.0082	0.0105	0.0160	0.0149	0.0302
1980	0.0214	0.0119	0.0064	0.0044	0.0047	0.0069	0.0074	0.0044	0.0097	0.0166	0.0306	0.0280
1981	0.0168	0.0114	0.0072	0.0081	0.0122	0.0194	0.0263	0.0095	0.0200	0.0250	0.0332	0.0360
1982	0.0151	0.0163	0.0133	0.0102	0.0066	0.0119	0.0135	0.0061	0.0161	0.0144	0.0178	0.0134
1983	0.0091	0.0060	0.0030	0.0039	0.0061	0.0077	0.0048	0.0031	0.0032	0.0043	0.0098	0.0180
1984	0.0131	0.0083	0.0031	0.0037	0.0029	0.0029	0.0036	0.0030	0.0031	0.0068	0.0119	0.0123
1985	0.0065	0.0074	0.0038	0.0031	0.0027	0.0056	0.0061	0.0065	0.0105	0.0147	0.0226	0.0207
1986	0.0118	0.0053	0.0068	0.0073	0.0040	0.0090	0.0059	0.0055	0.0057	0.0083	0.0174	0.0147
1987	0.0069	0.0040	0.0064	0.0094	0.0078	0.0060	0.0109	0.0136	0.0232	0.0283	0.0299	0.0390
1988	0.0236	0.0080	0.0040	0.0038	0.0054	0.0026	0.0087	0.0077	0.0172	0.0204	0.0377	0.0344
1989	0.0239	0.0104	0.0053	0.0093	0.0045	0.0088	0.0115	0.0140	0.0158	0.0322	0.0281	0.0296
1990	0.0280	0.0144	0.0046	0.0100	0.0092	0.0091	0.0118	0.0134	0.0205	0.0197	0.0243	0.0351
1991	0.0252	0.0113	0.0035	0.0117	0.0105	0.0122	0.0091	0.0066	0.0125	0.0262	0.0265	0.0260
1992	0.0290	0.0047	0.0084	0.0071	0.0103	0.0108	0.0200	0.0165	0.0120	0.0179	0.0346	0.0364
1993	0.0227	0.0136	0.0086	0.0039	0.0042	0.0081	0.0061	0.0058	0.0057	0.0119	0.0166	0.0244
1994	0.0113	0.0050	0.0027	0.0075	0.0032	0.0094	0.0111	0.0106	0.0142	0.0281	0.0374	0.0429
Avg	0.0193	0.0095	0.0061	0.0062	0.0064	0.0093	0.0108	0.0083	0.0128	0.0191	0.0247	0.0286
Max	0.0348	0.0163	0.0133	0.0117	0.0122	0.0194	0.0263	0.0165	0.0232	0.0460	0.0377	0.0460
Min	0.0065	0.0040	0.0027	0.0031	0.0027	0.0026	0.0036	0.0030	0.0031	0.0043	0.0098	0.0123
Std	0.0076	0.0034	0.0025	0.0027	0.0030	0.0037	0.0051	0.0037	0.0058	0.0095	0.0084	0.0093

%SEEP PER MILE and %DIV PER MILE

Reach 2: SINCLAIR TO ALCOVA REACH 30 to 40 miles of open river not under reservoirs (104 miles total)

NOT COMPUTED: NO PERMANENT DIVERSIONS FROM LIVE RIVER

%EVAP PER MILE

NPS3.STEP1

Reach 3: ALCOVA TO ORIN REACH

132 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0119	0.0056	0.0039	0.0023	0.0031	0.0065	0.0097	0.0095	0.0118	0.0171	0.0125	0.0106
1976	0.0136	0.0067	0.0050	0.0024	0.0037	0.0101	0.0132	0.0121	0.0174	0.0176	0.0141	0.0118
1977	0.0127	0.0078	0.0042	0.0038	0.0067	0.0083	0.0100	0.0139	0.0212	0.0194	0.0123	0.0200
1978	0.0202	0.0086	0.0065	0.0034	0.0032	0.0103	0.0179	0.0062	0.0311	0.0198	0.0140	0.0167
1979	0.0129	0.0076	0.0040	0.0026	0.0032	0.0066	0.0152	0.0136	0.0171	0.0208	0.0098	0.0162
1980	0.0111	0.0083	0.0047	0.0039	0.0026	0.0062	0.0082	0.0070	0.0142	0.0170	0.0138	0.0114
1981	0.0091	0.0078	0.0052	0.0058	0.0085	0.0182	0.0282	0.0114	0.0286	0.0193	0.0123	0.0154
1982	0.0094	0.0126	0.0116	0.0091	0.0064	0.0114	0.0154	0.0083	0.0292	0.0229	0.0191	0.0122
1983	0.0088	0.0059	0.0030	0.0032	0.0049	0.0067	0.0043	0.0029	0.0048	0.0045	0.0081	0.0121
1984	0.0113	0.0077	0.0027	0.0029	0.0021	0.0016	0.0024	0.0039	0.0036	0.0074	0.0121	0.0118
1985	0.0058	0.0067	0.0035	0.0026	0.0022	0.0047	0.0070	0.0090	0.0145	0.0126	0.0110	0.0086
1986	0.0091	0.0051	0.0060	0.0056	0.0036	0.0099	0.0069	0.0077	0.0086	0.0081	0.0121	0.0102
1987	0.0060	0.0029	0.0051	0.0067	0.0060	0.0051	0.0122	0.0210	0.0257	0.0160	0.0136	0.0218
1988	0.0135	0.0057	0.0031	0.0025	0.0041	0.0024	0.0114	0.0114	0.0265	0.0149	0.0133	0.0110
1989	0.0143	0.0073	0.0039	0.0068	0.0037	0.0114	0.0133	0.0176	0.0201	0.0201	0.0143	0.0150
1990	0.0220	0.0121	0.0038	0.0076	0.0079	0.0099	0.0161	0.0186	0.0347	0.0218	0.0118	0.0318
1991	0.0239	0.0114	0.0033	0.0089	0.0084	0.0126	0.0088	0.0073	0.0175	0.0252	0.0158	0.0125
1992	0.0221	0.0037	0.0069	0.0059	0.0095	0.0114	0.0243	0.0217	0.0134	0.0133	0.0239	0.0166
1993	0.0171	0.0128	0.0073	0.0033	0.0038	0.0082	0.0066	0.0080	0.0088	0.0132	0.0116	0.0233
1994	0.0107	0.0053	0.0027	0.0072	0.0034	0.0117	0.0138	0.0155	0.0143	0.0110	0.0087	0.0126
Avg	0.0133	0.0076	0.0048	0.0048	0.0049	0.0087	0.0122	0.0113	0.0181	0.0161	0.0132	0.0151
Max	0.0239	0.0128	0.0116	0.0091	0.0095	0.0182	0.0282	0.0217	0.0347	0.0252	0.0239	0.0318
Min	0.0058	0.0029	0.0027	0.0023	0.0021	0.0016	0.0024	0.0029	0.0036	0.0045	0.0081	0.0086
Std	0.0051	0.0027	0.0020	0.0022	0.0022	0.0038	0.0062	0.0053	0.0086	0.0053	0.0034	0.0054

%SEEP PER MILE

NPS3.STEP2

Reach 3: ALCOVA TO ORIN REACH

132 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975											0.0344	
1976										0.0500		
1977									0.0466	0.0370		0.0088
1978											0.0138	
1979												
1980										0.0041	0.0139	
1981							0.0126		0.0163	0.0000	0.0317	
1982												
1983												
1984												
1985									0.0241		0.0136	
1986											0.0183	
1987										0.0693	0.0194	
1988			0.0636						0.0609	0.0548	0.0343	
1989			0.0633						0.0001	0.0410	0.0634	
1990										0.0769		
1991			0.0084							0.0012	0.0232	
1992								0.0419				
1993												
1994									0.0375	0.0189	0.0233	

Diversions NOT included in water balance computations.

%DIV PER MILE

Reach 3: ALCOVA TO ORIN REACH

132 miles

NOT COMPUTED: FEW MONTHLY DIVERSION RECORDS

%EVAP PER MILE

NPS4.STEP1

Reach 4: ORIN TO PASSING WHALEN REACH 30 to 40 miles of open river not under reservoirs (66 miles total)

AVERAGE of Reaches 3 and 5 Factors for %EVAP PER MILE

Wtr Yr	*Oct	*Nov	*Dec	*Jan	*Feb	*Mar	Apr	May	Jun	Jul	Aug	Sept
1975	0.0137	0.0060	0.0043	0.0045	0.0048	0.0084	0.0152	0.0149	0.0145	0.0151	0.0142	0.0123
1976	0.0146	0.0075	0.0056	0.0028	0.0056	0.0118	0.0182	0.0145	0.0189	0.0168	0.0142	0.0119
1977	0.0130	0.0075	0.0046	0.0047	0.0073	0.0106	0.0196	0.0181	0.0232	0.0177	0.0133	0.0186
1978	0.0186	0.0099	0.0082	0.0053	0.0044	0.0131	0.0236	0.0093	0.0257	0.0168	0.0130	0.0158
1979	0.0140	0.0070	0.0050	0.0032	0.0055	0.0080	0.0211	0.0184	0.0172	0.0171	0.0108	0.0153
1980	0.0146	0.0069	0.0058	0.0040	0.0037	0.0085	0.0085	0.0067	0.0139	0.0161	0.0132	0.0125
1981	0.0127	0.0088	0.0055	0.0056	0.0076	0.0164	0.0389	0.0177	0.0262	0.0160	0.0126	0.0143
1982	0.0111	0.0109	0.0095	0.0073	0.0089	0.0155	0.0311	0.0145	0.0326	0.0177	0.0156	0.0111
1983	0.0094	0.0057	0.0033	0.0057	0.0081	0.0100	0.0059	0.0033	0.0041	0.0044	0.0063	0.0081
1984	0.0091	0.0061	0.0029	0.0039	0.0029	0.0018	0.0026	0.0040	0.0037	0.0074	0.0095	0.0089
1985	0.0056	0.0058	0.0035	0.0023	0.0027	0.0047	0.0112	0.0134	0.0147	0.0125	0.0116	0.0097
1986	0.0099	0.0047	0.0061	0.0037	0.0047	0.0117	0.0058	0.0077	0.0077	0.0072	0.0111	0.0081
1987	0.0047	0.0030	0.0078	0.0077	0.0069	0.0079	0.0147	0.0189	0.0230	0.0155	0.0134	0.0169
1988	0.0142	0.0062	0.0051	0.0031	0.0051	0.0080	0.0172	0.0136	0.0261	0.0145	0.0136	0.0120
1989	0.0145	0.0086	0.0038	0.0112	0.0037	0.0104	0.0253	0.0216	0.0205	0.0190	0.0146	0.0141
1990	0.0203	0.0105	0.0031	0.0078	0.0084	0.0133	0.0283	0.0298	0.0462	0.0204	0.0127	0.0236
1991	0.0206	0.0120	0.0051	0.0066	0.0091	0.0131	0.0179	0.0167	0.0171	0.0191	0.0139	0.0123
1992	0.0196	0.0041	0.0054	0.0051	0.0089	0.0138	0.0275	0.0262	0.0216	0.0118	0.0161	0.0134
1993	0.0136	0.0096	0.0064	0.0032	0.0044	0.0083	0.0152	0.0109	0.0120	0.0116	0.0102	0.0160
1994	0.0101	0.0049	0.0032	0.0066	0.0056	0.0151	0.0204	0.0199	0.0172	0.0115	0.0096	0.0118
Avg	0.0132	0.0073	0.0052	0.0052	0.0059	0.0104	0.0184	0.0150	0.0193	0.0144	0.0125	0.0133
Max	0.0206	0.0120	0.0095	0.0112	0.0091	0.0164	0.0389	0.0298	0.0462	0.0204	0.0161	0.0236
Min	0.0047	0.0030	0.0029	0.0023	0.0027	0.0018	0.0026	0.0033	0.0037	0.0044	0.0063	0.0081
Std	0.0043	0.0024	0.0017	0.0021	0.0020	0.0037	0.0089	0.0067	0.0095	0.0042	0.0023	0.0036

* Months when Guernsey dam gates are closed and when Glendo release is limited to about 25 cfs.

%SEEP PER MILE and %DIV PER MILE

Reach 4: ORIN TO PASSING WHALEN REACH 30 to 40 miles of open river not under reservoirs (66 miles total)

NOT COMPUTED: FEW MONTHLY DIVERSION RECORDS

%EVAP PER MILE

NPS5.STEP1

Reach 5: PASSING WHALEN TO WY/NE STATELINE REACH

47 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0154	0.0064	0.0048	0.0070	0.0069	0.0105	0.0206	0.0202	0.0172	0.0130	0.0151	0.0140
1976	0.0155	0.0083	0.0065	0.0033	0.0078	0.0143	0.0231	0.0168	0.0203	0.0147	0.0142	0.0119
1977	0.0132	0.0071	0.0050	0.0059	0.0084	0.0137	0.0292	0.0223	0.0237	0.0150	0.0142	0.0170
1978	0.0170	0.0112	0.0098	0.0071	0.0056	0.0159	0.0293	0.0119	0.0202	0.0137	0.0116	0.0149
1979	0.0151	0.0063	0.0059	0.0039	0.0078	0.0094	0.0270	0.0231	0.0172	0.0134	0.0118	0.0144
1980	0.0180	0.0055	0.0069	0.0041	0.0047	0.0068	0.0080	0.0064	0.0136	0.0150	0.0124	0.0135
1981	0.0163	0.0098	0.0058	0.0057	0.0072	0.0157	0.0491	0.0240	0.0220	0.0127	0.0124	0.0131
1982	0.0127	0.0092	0.0073	0.0054	0.0114	0.0210	0.0467	0.0206	0.0359	0.0125	0.0121	0.0100
1983	0.0100	0.0055	0.0036	0.0081	0.0113	0.0132	0.0062	0.0036	0.0034	0.0043	0.0044	0.0041
1984	0.0069	0.0045	0.0030	0.0049	0.0037	0.0019	0.0027	0.0041	0.0038	0.0073	0.0068	0.0060
1985	0.0054	0.0048	0.0034	0.0019	0.0031	0.0047	0.0153	0.0178	0.0145	0.0124	0.0120	0.0107
1986	0.0107	0.0042	0.0062	0.0018	0.0060	0.0135	0.0046	0.0077	0.0067	0.0062	0.0097	0.0080
1987	0.0033	0.0031	0.0105	0.0087	0.0078	0.0106	0.0162	0.0167	0.0203	0.0133	0.0127	0.0119
1988	0.0149	0.0066	0.0067	0.0038	0.0061	0.0136	0.0229	0.0157	0.0233	0.0130	0.0132	0.0129
1989	0.0147	0.0099	0.0034	0.0167	0.0038	0.0093	0.0372	0.0255	0.0209	0.0166	0.0136	0.0131
1990	0.0186	0.0089	0.0025	0.0085	0.0094	0.0178	0.0405	0.0409	0.0475	0.0165	0.0135	0.0153
1991	0.0172	0.0125	0.0072	0.0045	0.0104	0.0147	0.0270	0.0260	0.0167	0.0130	0.0115	0.0120
1992	0.0171	0.0044	0.0041	0.0047	0.0089	0.0173	0.0306	0.0293	0.0297	0.0102	0.0083	0.0102
1993	0.0100	0.0068	0.0055	0.0031	0.0050	0.0083	0.0238	0.0138	0.0152	0.0099	0.0088	0.0087
1994	0.0094	0.0044	0.0037	0.0059	0.0078	0.0184	0.0269	0.0242	0.0194	0.0117	0.0102	0.0109
Avg	0.0131	0.0070	0.0056	0.0057	0.0072	0.0126	0.0243	0.0185	0.0196	0.0122	0.0114	0.0115
Max	0.0186	0.0125	0.0105	0.0167	0.0114	0.0210	0.0491	0.0409	0.0475	0.0166	0.0151	0.0170
Min	0.0033	0.0031	0.0025	0.0018	0.0031	0.0019	0.0027	0.0036	0.0034	0.0043	0.0044	0.0041
Std	0.0043	0.0025	0.0021	0.0032	0.0024	0.0047	0.0128	0.0089	0.0099	0.0032	0.0026	0.0032

%SEEP PER MILE

NPS5.STEP2

Reach 5: PASSING WHALEN TO WY/NE STATELINE REACH

47 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978								0.0850				
1979												
1980							0.1951					
1981									0.1145			
1982												
1983							0.3265					
1984							0.0220					
1985												
1986							0.0653					
1987							0.1028					
1988												
1989												
1990									0.3732			
1991												
1992												
1993								0.0024				
1994												

%DIV PER MILE

NPS5.STEP3

Reach 5: PASSING WHALEN TO WY/NE STATELINE REACH

47 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6862	0.6392	0.5049	0.6153	0.6499
1976	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6876	0.6406	0.5618	0.6176	0.6714
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7208	0.6825	0.5355	0.6213	0.6778
1978	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2431	0.6278	0.5846	0.6746	0.6908
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7600	0.5892	0.5714	0.6324	0.8304
1980	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1509	0.3706	0.5621	0.5541	0.6740
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.1654	0.6381	0.4908	0.5449	0.6775
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7732	0.3535	0.5082	0.5530	0.6133
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0344	0.0852	0.1564	0.1848	0.1503
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0477	0.0998	0.2707	0.3007	0.3035
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6137	0.4936	0.5798	0.5805	0.4754
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1991	0.1489	0.2668	0.5391	0.3611
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4571	0.4480	0.5647	0.6333	0.5672
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4243	0.6230	0.5708	0.6049	0.5257
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8367	0.6963	0.5905	0.5396	0.6215
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.4553	0.6450	0.5609	0.6381	0.6610
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6121	0.2195	0.6046	0.6297	0.5205
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0342	1.5813	0.5813	0.6208	0.6287
1993	0.1589	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5803	0.3443	0.5575	0.5439	0.5785
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5893	0.6118	0.5397	0.6123	0.6132
Avg	0.0079	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6036	0.5369	0.5081	0.5671	0.5746
Max	0.1589	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.4553	1.5813	0.6046	0.6746	0.8304
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0344	0.0852	0.1564	0.1848	0.1503
Std	0.0346	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3569	0.3196	0.1214	0.1158	0.1508

%EVAP PER MILE

LRS6.STEP1

Reach 6: LARAMIE RIVER; Below Grayrocks Reservoir to Fort Laramie Gage Reach 17 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1976	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1977	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1979	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1980	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1981	0.0746	0.0610	0.0276	0.0344	0.0285	0.0558	0.0795	0.0626	0.1096	0.1115	0.0961	0.0760
1982	0.0560	0.0433	0.0325	0.0168	0.0347	0.0589	0.0406	0.0836	0.0772	0.1067	0.0984	0.0592
1983	0.0373	0.0219	0.0139	0.0282	0.0378	0.0359	0.0093	0.0026	0.0026	0.0050	0.0192	0.0215
1984	0.0150	0.0055	0.0036	0.0042	0.0036	0.0044	0.0033	0.0032	0.0072	0.0369	0.0182	0.0180
1985	0.0060	0.0046	0.0028	0.0018	0.0046	0.0151	0.0439	0.0463	0.0868	0.1064	0.0868	0.0545
1986	0.0364	0.0139	0.0166	0.0034	0.0101	0.0173	0.0123	0.0194	0.0067	0.0233	0.0566	0.0191
1987	0.0080	0.0132	0.0192	0.0145	0.0205	0.0170	0.0402	0.0606	0.0561	0.0990	0.0727	0.0577
1988	0.0442	0.0192	0.0190	0.0085	0.0132	0.0256	0.0272	0.0351	0.0941	0.0770	0.1035	0.0667
1989	0.0440	0.0301	0.0099	0.0446	0.0094	0.0229	0.0513	0.0795	0.0841	0.1372	0.1032	0.0731
1990	0.0504	0.0286	0.0069	0.0239	0.0240	0.0471	0.0665	0.0935	0.1423	0.1312	0.0763	0.0753
1991	0.0489	0.0374		0.0112	0.0216	0.0329	0.0424	0.0295	0.0297		0.0864	0.0614
1992	0.0496	0.0124	0.0123	0.0132	0.0229	0.0443	0.0449	0.0623	0.0615	0.0485	0.0594	0.0496
1993	0.0304	0.0204	0.0161	0.0075	0.0113	0.0201	0.0420	0.0211	0.0223	0.0702	0.0372	0.0359
1994	0.0258	0.0131	0.0098	0.0139	0.0172	0.0400	0.0432	0.0642	0.1039	0.0817	0.0772	0.0519
Avg	0.0376	0.0232	0.0146	0.0161	0.0184	0.0312	0.0390	0.0474	0.0632	0.0796	0.0708	0.0514
Max	0.0746	0.0610	0.0325	0.0446	0.0378	0.0589	0.0795	0.0935	0.1423	0.1372	0.1035	0.0760
Min	0.0060	0.0046	0.0028	0.0018	0.0036	0.0044	0.0033	0.0026	0.0026	0.0050	0.0182	0.0180
Std	0.0185	0.0151	0.0084	0.0121	0.0100	0.0158	0.0201	0.0284	0.0423	0.0397	0.0280	0.0196

%SEEP PER MILE

LRS6.STEP2

Reach 6: LARAMIE RIVER; Below Grayrocks Reservoir to Fort Laramie Gage Reach 17 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1976	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1977	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1978	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1979	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1980	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1981			2.3325	0.8097	1.1898		0.1559	0.5609	1.1736			
1982		0.6380	0.3755	0.8455	1.3936		1.5248	0.3942	0.7566		0.8667	
1983							0.4175	0.0468				0.0064
1984		0.3222			0.0628			0.4196	0.1019			
1985			0.1314		0.0791	0.2730					0.1612	
1986			0.1277	0.4892	0.3925							0.6109
1987	0.0174	0.9663	0.0447	0.0888	0.4697			0.5093			1.2530	
1988	0.6495	0.6688	0.9149	1.3833	0.8815	0.0622	0.0010	0.2558		0.1268		
1989					0.7267	0.0173	0.4916		1.5984	0.3402	0.0816	
1990			0.6235	0.1524	0.3010		0.1416	0.5679	0.4511		0.7259	
1991			N/A	0.4362	0.5663	0.0807				N/A		
1992							0.3314	1.2528	0.7322			
1993				0.6828				0.0709				
1994			0.3709		0.3856						0.3967	

Laramie River Diversions NOT included in water balance computations.

%DIV PER MILE

Reach 6: LARAMIE RIVER; Below Grayrocks Reservoir to Fort Laramie Gage Reach 17 miles

NOT COMPUTED: FEW MONTHLY DIVERSION RECORDS

%EVAP PER MILE

Reach 7: HENDERSON TO KERSEY REACH

54.9 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0065	0.0029	0.0014	0.0017	0.0020	0.0045	0.0074	0.0073	0.0059	0.0079	0.0069	0.0067
1976	0.0065	0.0024	0.0020	0.0012	0.0036	0.0038	0.0109	0.0089	0.0092	0.0102	0.0066	0.0068
1977	0.0055	0.0025	0.0022	0.0010	0.0035	0.0047	0.0104	0.0112	0.0124	0.0120	0.0085	0.0104
1978	0.0075	0.0034	0.0022	0.0005	0.0014	0.0063	0.0121	0.0063	0.0063	0.0091	0.0074	0.0082
1979	0.0061	0.0031	0.0004	0.0000	0.0020	0.0044	0.0094	0.0045	0.0038	0.0081	0.0063	0.0084
1980	0.0064	0.0014	0.0013	0.0004	0.0011	0.0020	0.0042	0.0028	0.0047	0.0061	0.0069	0.0075
1981	0.0058	0.0032	0.0031	0.0022	0.0028	0.0044	0.0134	0.0081	0.0097	0.0106	0.0079	0.0090
1982	0.0054	0.0041	0.0018	0.0014	0.0022	0.0061	0.0121	0.0086	0.0065	0.0071	0.0071	0.0059
1983	0.0055	0.0018	0.0010	0.0017	0.0029	0.0023	0.0028	0.0025	0.0033	0.0050	0.0060	0.0067
1984	0.0061	0.0018	0.0000	0.0003	0.0014	0.0025	0.0031	0.0039	0.0047	0.0070	0.0053	0.0047
1985	0.0024	0.0015	0.0008	0.0005	0.0007	0.0041	0.0082	0.0056	0.0059	0.0077	0.0067	0.0058
1986	0.0057	0.0005	0.0004	0.0021	0.0024	0.0055	0.0058	0.0063	0.0053	0.0072	0.0066	0.0062
1987	0.0051	0.0017	0.0008	0.0013	0.0025	0.0027	0.0072	0.0044	0.0065	0.0085	0.0070	0.0074
1988	0.0069	0.0024	0.0008	0.0003	0.0015	0.0035	0.0081	0.0073	0.0065	0.0084	0.0071	0.0070
1989	0.0068	0.0028	0.0007	0.0015	0.0002	0.0045	0.0099	0.0088	0.0077	0.0097	0.0071	0.0074
1990	0.0064	0.0033	0.0006	0.0021	0.0019	0.0026	0.0071	0.0071	0.0083	0.0081	0.0068	0.0076
1991	0.0060	0.0033	0.0004	0.0008	0.0035	0.0054	0.0100	0.0093	0.0061	0.0083	0.0067	0.0070
1992	0.0065	0.0017	0.0014	0.0013	0.0034	0.0035	0.0096	0.0081	0.0069	0.0076	0.0060	0.0076
1993	0.0068	0.0016	0.0003	0.0004	0.0010	0.0044	0.0081	0.0086	0.0065	0.0078	0.0065	0.0060
1994	0.0049	0.0014	0.0012	0.0018	0.0012	0.0049	0.0085	0.0084	0.0084	0.0099	0.0085	0.0085
Avg	0.0059	0.0023	0.0011	0.0011	0.0020	0.0041	0.0084	0.0069	0.0068	0.0084	0.0069	0.0072
Max	0.0075	0.0041	0.0031	0.0022	0.0036	0.0063	0.0134	0.0112	0.0124	0.0120	0.0085	0.0104
Min	0.0024	0.0005	0.0000	0.0000	0.0002	0.0020	0.0028	0.0025	0.0033	0.0050	0.0053	0.0047
Std	0.0010	0.0009	0.0008	0.0007	0.0010	0.0012	0.0028	0.0023	0.0021	0.0015	0.0007	0.0013

%SEEP PER MILE

Reach 7: HENDERSON TO KERSEY REACH

54.9 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982		0.1970	0.0342									
1983												
1984												
1985												
1986		0.1513										
1987												
1988												
1989												
1990												
1991												
1992												
1993												
1994												

%DIV PER MILE

Reach 7: HENDERSON TO KERSEY REACH

54.9 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.3859	0.0588	0.0000	0.0000	0.0000	0.0000	0.3122	0.8493	0.2650	0.9463	1.0491	0.7169
1976	0.4867	0.2603	0.0000	0.0000	0.0000	0.0214	0.6597	0.9403	1.2985	1.4564	1.1125	0.5542
1977	0.3612	0.2612	0.0043	0.0113	0.1620	0.2064	0.7903	1.2086	1.5658	1.0213	1.2355	1.1582
1978	0.7508	0.4519	0.1298	0.2875	0.2189	0.0000	0.6605	0.3691	0.5073	1.3587	1.2775	1.0464
1979	0.5710	0.0225	0.2463	0.3071	0.2862	0.0377	0.2179	0.0958	0.1024	1.1975	0.8093	0.8337
1980	0.4497	0.0061	0.0095	0.0120	0.0101	0.0078	0.0043	0.0170	0.2722	1.0066	1.1412	0.6993
1981	0.5685	0.1524	0.0115	0.0130	0.0252	0.0216	0.5624	0.6763	0.7201	1.4205	1.3084	1.0919
1982	0.7832	0.4424	0.4502	0.1277	0.0212	0.1314	1.2176	0.9257	0.8501	0.7942	1.1252	0.6057
1983	0.1441	0.2897	0.2849	0.0000	0.0000	0.0000	0.0000	0.0284	0.0453	0.2475	0.5670	0.5376
1984	0.2902	0.4978	0.4748	0.0000	0.0000	0.0000	0.0000	0.0832	0.2637	0.8539	0.4216	0.3585
1985	0.0673	0.2394	0.5338	0.0000	0.0000	0.0000	0.4161	0.1668	0.5578	0.8969	1.1467	0.6281
1986	0.2061	0.8749	0.5720	0.0004	0.0023	0.1513	0.1183	0.6412	0.2397	0.9651	1.1024	0.6807
1987	0.2752	0.5762	0.6102	0.0000	0.0000	0.0000	0.1872	0.1402	0.5080	1.2612	1.0860	0.8184
1988	0.4322	0.8334	0.5015	0.0000	0.0000	0.0000	0.2977	0.5189	0.8079	1.2261	1.1130	0.7894
1989	0.7904	0.5850	0.5362	0.0000	0.0000	0.0574	0.9053	1.0642	0.7696	1.3392	1.1561	0.5544
1990	0.4036	0.3798	0.5507	0.0000	0.0966	0.0259	0.1007	0.9190	0.7960	1.0883	1.1493	0.7070
1991	0.4270	0.3696	0.4225	0.0000	0.0000	0.2362	0.9423	0.9160	0.3988	1.0801	1.0588	0.8227
1992	0.3820	0.3547	0.3704	0.0000	0.0000	0.0000	0.2099	1.0465	0.7214	1.1563	0.8017	0.9412
1993	0.4529	0.4728	0.4741	0.0000	0.0000	0.0067	0.2484	0.9281	0.5874	1.2333	1.2103	0.6855
1994	0.4665	0.3993	0.4555	0.0000	0.0000	0.1973	0.6197	0.9075	1.0698	1.4793	1.1628	0.9780
Avg	0.4357	0.3614	0.3319	0.0380	0.0411	0.0551	0.4235	0.6222	0.6073	1.1014	1.0417	0.7609
Max	0.7904	0.8749	0.6102	0.3071	0.2862	0.2362	1.2176	1.2086	1.5658	1.4793	1.3084	1.1582
Min	0.0673	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000	0.0170	0.0453	0.2475	0.4216	0.3585
Std	0.1892	0.2066	0.2189	0.0908	0.0815	0.0785	0.3443	0.3949	0.3781	0.2783	0.2377	0.1997

%EVAP PER MILE

Reach 8: KERSEY TO BALZAC REACH

69.7 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0082	0.0022	0.0012	0.0013	0.0014	0.0034	0.0097	0.0106	0.0102	0.0141	0.0133	0.0100
1976	0.0071	0.0016	0.0014	0.0009	0.0027	0.0035	0.0132	0.0113	0.0156	0.0193	0.0151	0.0118
1977	0.0043	0.0014	0.0013	0.0003	0.0021	0.0041	0.0119	0.0173	0.0182	0.0204	0.0149	0.0138
1978	0.0094	0.0019	0.0008	0.0002	0.0005	0.0030	0.0149	0.0097	0.0113	0.0186	0.0135	0.0144
1979	0.0073	0.0013	0.0000	0.0000	0.0015	0.0034	0.0117	0.0064	0.0056	0.0159	0.0108	0.0123
1980	0.0103	0.0015	0.0014	0.0005	0.0012	0.0026	0.0060	0.0036	0.0075	0.0155	0.0123	0.0101
1981	0.0044	0.0029	0.0024	0.0019	0.0017	0.0040	0.0135	0.0097	0.0148	0.0180	0.0130	0.0129
1982	0.0051	0.0023	0.0012	0.0007	0.0013	0.0029	0.0104	0.0109	0.0101	0.0144	0.0121	0.0080
1983	0.0035	0.0016	0.0013	0.0016	0.0034	0.0033	0.0037	0.0033	0.0041	0.0078	0.0102	0.0095
1984	0.0070	0.0027	0.0000	0.0002	0.0014	0.0027	0.0038	0.0053	0.0074	0.0124	0.0092	0.0054
1985	0.0033	0.0021	0.0008	0.0004	0.0007	0.0037	0.0087	0.0082	0.0092	0.0139	0.0113	0.0078
1986	0.0052	0.0007	0.0002	0.0012	0.0017	0.0038	0.0085	0.0074	0.0084	0.0135	0.0118	0.0086
1987	0.0053	0.0021	0.0010	0.0013	0.0027	0.0024	0.0095	0.0067	0.0106	0.0147	0.0121	0.0093
1988	0.0040	0.0019	0.0011	0.0001	0.0014	0.0037	0.0082	0.0112	0.0152	0.0164	0.0135	0.0097
1989	0.0054	0.0022	0.0012	0.0016	0.0003	0.0040	0.0106	0.0134	0.0108	0.0192	0.0126	0.0086
1990	0.0061	0.0023	0.0006	0.0015	0.0018	0.0038	0.0085	0.0111	0.0142	0.0162	0.0126	0.0114
1991	0.0044	0.0021	0.0003	0.0008	0.0034	0.0054	0.0101	0.0142	0.0106	0.0163	0.0125	0.0105
1992	0.0056	0.0015	0.0014	0.0010	0.0035	0.0045	0.0095	0.0133	0.0103	0.0132	0.0110	0.0104
1993	0.0056	0.0014	0.0001	0.0002	0.0005	0.0044	0.0094	0.0122	0.0103	0.0154	0.0124	0.0082
1994	0.0064	0.0016	0.0013	0.0014	0.0011	0.0054	0.0093	0.0124	0.0138	0.0159	0.0160	0.0126
Avg	0.0059	0.0019	0.0010	0.0009	0.0017	0.0037	0.0096	0.0099	0.0109	0.0156	0.0125	0.0103
Max	0.0103	0.0029	0.0024	0.0019	0.0035	0.0054	0.0149	0.0173	0.0182	0.0204	0.0160	0.0144
Min	0.0033	0.0007	0.0000	0.0000	0.0003	0.0024	0.0037	0.0033	0.0041	0.0078	0.0092	0.0064
Std	0.0018	0.0005	0.0006	0.0006	0.0010	0.0008	0.0028	0.0035	0.0034	0.0028	0.0016	0.0021

%SEEP PER MILE

Reach 8: KERSEY TO BALZAC REACH

69.7 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975									0.0012			0.0784
1976												
1977												
1978								0.0513	0.0282			
1979								0.4831	0.4285			
1980							0.0305	0.1496	0.1139			
1981												
1982												
1983							0.1212	0.2447	0.1919			
1984							0.0939	0.0515			0.0585	
1985												
1986							0.0535					
1987								0.1633				
1988												
1989												
1990												
1991									0.0138			
1992												
1993												
1994												

%DIV PER MILE

Reach 8: KERSEY TO BALZAC REACH

69.7 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	1.2329	1.3495	1.1986	0.9814	0.9390	1.1976	0.8966	0.9312	0.6577	0.9233	0.9153	0.8578
1976	1.2894	1.3728	1.1225	0.9145	1.2181	0.9082	1.0357	1.1067	1.0997	1.1338	1.0314	1.0893
1977	1.4030	1.4063	1.3374	1.2642	1.3623	1.0753	1.2376	1.0797	1.2633	1.0880	1.0584	1.2783
1978	1.3017	1.4076	1.4072	1.3399	1.3806	1.3991	0.9537	1.1605	1.1182	1.0830	1.0526	1.0491
1979	1.2429	1.4012	1.3488	1.1358	0.8950	1.3485	1.1466	0.4061	0.1373	0.9656	0.4886	0.9774
1980	1.1530	1.0308	0.5016	0.3902	0.3639	0.4410	0.2404	0.1306	0.3618	1.0319	1.1121	0.9745
1981	1.3745	1.1446	1.0175	0.6745	1.2530	1.1965	0.9381	1.1091	0.6835	1.1713	1.0855	1.0959
1982	1.3674	1.4146	1.3697	1.1954	1.1888	1.3902	1.1948	1.1764	1.2437	1.0016	1.0476	1.1568
1983	1.3883	1.3372	0.4632	0.2043	0.2587	0.3633	0.1129	0.0985	0.0773	0.3477	0.4967	0.4766
1984	0.8189	0.7209	0.3217	0.2374	0.3233	0.7546	0.2660	0.2320	0.4577	1.0895	0.5064	0.4177
1985	0.3357	0.4275	0.6096	0.3363	0.3335	1.2725	1.1602	0.4011	0.5899	0.9291	0.9094	0.7352
1986	0.9206	0.9921	0.3656	0.4191	0.9027	1.3872	0.3412	1.1749	0.3311	0.9087	1.0478	0.5984
1987	1.1117	1.0282	0.6987	0.6331	0.8320	0.3588	0.7293	0.2851	0.4756	1.0587	0.9324	0.9029
1988	1.3835	1.2978	0.7898	0.1860	0.1838	0.7679	1.0665	0.8242	0.8258	1.0485	1.0556	1.0088
1989	1.3652	1.3921	0.8401	0.6347	0.5789	1.1153	1.2424	0.9443	1.0960	1.1421	1.0195	1.1305
1990	1.3419	1.3911	1.0269	0.8383	0.7096	0.6287	0.6656	1.0918	1.0156	0.9737	0.9506	1.0298
1991	1.2706	1.3997	1.1191	0.6352	0.8345	1.0133	1.1695	1.0088	0.7973	0.9871	1.0114	0.9628
1992	1.2947	1.3319	1.3109	0.5371	0.5662	0.4639	0.9826	0.9478	1.1010	1.1730	0.8580	0.9353
1993	1.2878	1.3249	0.6042	0.4624	0.6042	0.5913	0.8794	1.0162	1.1429	0.9849	1.0522	0.5768
1994	1.2024	1.1368	1.1186	0.3681	0.5161	0.8399	1.1316	1.0005	1.1730	1.0941	0.9553	0.9342
Avg	1.2093	1.2154	0.9286	0.6944	0.7622	0.9257	0.8695	0.8063	0.7824	1.0068	0.9293	0.9094
Max	1.4030	1.4146	1.4072	1.3399	1.3806	1.3991	1.2424	1.1764	1.2633	1.1730	1.1121	1.2783
Min	0.3357	0.4275	0.3217	0.1860	0.1838	0.3588	0.1129	0.0985	0.0773	0.3477	0.4886	0.4177
Std	0.2512	0.2578	0.3525	0.3509	0.3698	0.3545	0.3511	0.3740	0.3710	0.1706	0.1925	0.2280

%EVAP PER MILE

Reach 9: BALZAC TO JULESBURG REACH

97.5 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0232	0.0107	0.0030	0.0026	0.0025	0.0084	0.0122	0.0134	0.0144	0.0144	0.0135	0.0134
1976	0.0248	0.0050	0.0032	0.0018	0.0059	0.0064	0.0158	0.0141	0.0168	0.0200	0.0176	0.0198
1977	0.0086	0.0079	0.0072	0.0013	0.0062	0.0079	0.0187	0.0167	0.0178	0.0260	0.0147	0.0145
1978	0.0181	0.0076	0.0029	0.0008	0.0015	0.0068	0.0170	0.0187	0.0209	0.0188	0.0164	0.0196
1979	0.0140	0.0036	0.0002	0.0000	0.0027	0.0065	0.0143	0.0120	0.0086	0.0154	0.0125	0.0132
1980	0.0145	0.0032	0.0020	0.0006	0.0014	0.0032	0.0082	0.0030	0.0095	0.0179	0.0132	0.0140
1981	0.0063	0.0059	0.0045	0.0028	0.0032	0.0069	0.0178	0.0124	0.0174	0.0170	0.0128	0.0140
1982	0.0086	0.0034	0.0026	0.0018	0.0028	0.0047	0.0132	0.0134	0.0177	0.0182	0.0135	0.0129
1983	0.0075	0.0048	0.0019	0.0020	0.0039	0.0045	0.0048	0.0040	0.0027	0.0089	0.0134	0.0122
1984	0.0106	0.0047	0.0000	0.0003	0.0020	0.0049	0.0057	0.0063	0.0104	0.0151	0.0120	0.0090
1985	0.0046	0.0028	0.0012	0.0005	0.0008	0.0067	0.0204	0.0115	0.0132	0.0178	0.0127	0.0107
1986	0.0090	0.0019	0.0002	0.0016	0.0027	0.0077	0.0109	0.0127	0.0114	0.0139	0.0122	0.0126
1987	0.0108	0.0048	0.0018	0.0022	0.0047	0.0032	0.0155	0.0100	0.0129	0.0154	0.0134	0.0120
1988	0.0090	0.0048	0.0019	0.0001	0.0019	0.0058	0.0130	0.0152	0.0182	0.0158	0.0129	0.0130
1989	0.0089	0.0038	0.0022	0.0023	0.0005	0.0070	0.0168	0.0143	0.0147	0.0163	0.0136	0.0130
1990	0.0083	0.0041	0.0014	0.0023	0.0024	0.0055	0.0129	0.0106	0.0177	0.0152	0.0127	0.0136
1991	0.0091	0.0043	0.0005	0.0009	0.0046	0.0080	0.0126	0.0127	0.0174	0.0162	0.0137	0.0140
1992	0.0091	0.0027	0.0030	0.0016	0.0049	0.0082	0.0151	0.0159	0.0142	0.0153	0.0135	0.0144
1993	0.0123	0.0048	0.0002	0.0002	0.0007	0.0054	0.0131	0.0138	0.0148	0.0152	0.0132	0.0116
1994	0.0094	0.0034	0.0025	0.0023	0.0012	0.0075	0.0139	0.0147	0.0182	0.0168	0.0177	0.0181
Avg	0.0113	0.0047	0.0021	0.0014	0.0028	0.0062	0.0136	0.0123	0.0144	0.0165	0.0138	0.0138
Max	0.0248	0.0107	0.0072	0.0028	0.0062	0.0084	0.0204	0.0187	0.0209	0.0260	0.0177	0.0198
Min	0.0046	0.0019	0.0000	0.0000	0.0005	0.0032	0.0048	0.0030	0.0027	0.0089	0.0120	0.0090
Std	0.0051	0.0020	0.0017	0.0009	0.0017	0.0015	0.0039	0.0039	0.0042	0.0031	0.0016	0.0026

%SEEP PER MILE

Reach 9: BALZAC TO JULESBURG REACH

97.5 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980							0.0413	0.0282				
1981												
1982												
1983			0.1801				0.1442	0.0312				
1984			0.1913								0.0577	
1985	0.0987							0.0256	0.0761			
1986		0.0347	0.1620						0.0376			
1987												
1988			0.3152	0.2252								
1989												
1990												
1991												
1992				0.0294								
1993												
1994												

%DIV PER MILE

Reach 9: BALZAC TO JULESBURG REACH

97.5 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.3857	0.0666	0.0000	0.0090	0.0194	0.0000	0.2411	0.6703	0.1727	0.9262	0.9153	0.7956
1976	0.2407	0.0719	0.0143	0.0000	0.0262	0.0055	0.6642	0.8350	0.9116	0.9595	0.9706	0.8773
1977	0.5560	0.0488	0.0000	0.0000	0.0000	0.0072	0.1902	0.6968	0.7075	0.9091	0.9151	0.8739
1978	0.4734	0.0400	0.0762	0.1632	0.0639	0.0234	0.8315	0.8370	0.6279	0.9541	0.9731	0.9665
1979	0.6914	0.5499	0.4351	0.2102	0.0407	0.3143	0.4400	0.3769	0.0759	0.7106	0.5127	0.6403
1980	0.3973	0.0127	0.0000	0.0000	0.0000	0.0670	0.0083	0.0280	0.1167	0.8527	0.9596	0.7673
1981	0.7621	0.3524	0.1337	0.1132	0.1179	0.2763	0.4260	0.5037	0.3870	0.9276	0.9439	0.9686
1982	0.6609	0.6569	0.2059	0.1006	0.0438	0.4059	0.7408	0.8195	0.4965	0.6138	0.9304	0.7137
1983	0.6638	0.1139	0.0203	0.0215	0.0077	0.0723	0.0076	0.0211	0.0120	0.1342	0.3764	0.3213
1984	0.1636	0.0384	0.0000	0.0000	0.0000	0.0050	0.0105	0.0524	0.1631	0.8024	0.4877	0.1553
1985	0.0799	0.0791	0.0282	0.0061	0.0007	0.1802	0.6326	0.1560	0.3744	0.8455	0.8722	0.5080
1986	0.1469	0.0000	0.0000	0.0000	0.0028	0.1539	0.0071	0.5561	0.1559	0.9104	0.9377	0.3013
1987	0.2873	0.0134	0.0001	0.0000	0.0078	0.0043	0.0397	0.0589	0.1551	0.8189	0.8821	0.5274
1988	0.4669	0.2679	0.1271	0.0000	0.0000	0.1147	0.3179	0.2339	0.4486	0.9301	0.9492	0.8647
1989	0.6511	0.6595	0.1307	0.0343	0.1571	0.1733	0.5550	0.9373	0.8120	0.9620	0.9373	0.5706
1990	0.7064	0.7667	0.5885	0.0000	0.0660	0.1171	0.1376	0.8211	0.8794	0.9712	0.9155	0.8232
1991	0.5529	0.4768	0.1090	0.1348	0.1489	0.2523	0.5246	0.8703	0.3080	0.9481	0.9347	0.5906
1992	0.6760	0.7608	0.3383	0.0347	0.0011	0.1187	0.2522	0.9194	0.5196	0.8570	0.5620	0.3143
1993	0.2016	0.2181	0.0104	0.0114	0.1223	0.0989	0.2015	0.7880	0.7850	0.9492	0.9418	0.3703
1994	0.1733	0.4556	0.0639	0.0000	0.1738	0.2711	0.5402	0.8855	0.9101	0.9659	0.9706	0.9613
Avg	0.4469	0.2825	0.1130	0.0419	0.0500	0.1331	0.3384	0.5534	0.4510	0.8374	0.8444	0.6456
Max	0.7621	0.7667	0.5885	0.2102	0.1738	0.4059	0.8315	0.9373	0.9116	0.9712	0.9731	0.9686
Min	0.0799	0.0000	0.0000	0.0000	0.0000	0.0000	0.0071	0.0211	0.0120	0.1342	0.3764	0.1553
Std	0.2182	0.2595	0.1559	0.0632	0.0568	0.1162	0.2609	0.3341	0.2969	0.1915	0.1842	0.2475

%EVAP PER MILE

Reach 10: JULESBURG TO S. PLATTE at N. PLATTE REACH

85.5 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0187	0.0066	0.0031	0.0023	0.0027	0.0057	0.0111	0.0179	0.0160	0.0331	0.0316	0.0266
1976	0.0218	0.0074	0.0026	0.0020	0.0040	0.0052	0.0156	0.0211	0.0363	0.0575	0.0523	0.0356
1977	0.0198	0.0100	0.0054	0.0028	0.0049	0.0059	0.0138	0.0222	0.0218	0.0433	0.0295	0.0318
1978	0.0192	0.0071	0.0040	0.0032	0.0048	0.0066	0.0204	0.0224	0.0268	0.0583	0.0480	0.0465
1979	0.0307	0.0097	0.0049	0.0046	0.0042	0.0059	0.0176	0.0144	0.0100	0.0186	0.0194	0.0190
1980	0.0177	0.0038	0.0022	0.0019	0.0028	0.0041	0.0105	0.0037	0.0115	0.0359	0.0493	0.0346
1981	0.0178	0.0060	0.0033	0.0021	0.0034	0.0067	0.0173	0.0116	0.0192	0.0416	0.0293	0.0341
1982	0.0147	0.0071	0.0034	0.0022	0.0039	0.0073	0.0242	0.0225	0.0220	0.0242	0.0311	0.0204
1983	0.0138	0.0050	0.0022	0.0016	0.0027	0.0044	0.0059	0.0050	0.0031	0.0112	0.0198	0.0193
1984	0.0107	0.0040	0.0022	0.0014	0.0026	0.0050	0.0071	0.0073	0.0120	0.0259	0.0244	0.0103
1985	0.0056	0.0032	0.0019	0.0014	0.0021	0.0058	0.0214	0.0124	0.0155	0.0335	0.0249	0.0135
1986	0.0060	0.0031	0.0015	0.0018	0.0025	0.0081	0.0121	0.0157	0.0133	0.0292	0.0362	0.0157
1987	0.0103	0.0044	0.0028	0.0023	0.0038	0.0041	0.0151	0.0110	0.0136	0.0305	0.0385	0.0198
1988	0.0213	0.0034	0.0031	0.0018	0.0026	0.0059	0.0127	0.0170	0.0230	0.0386	0.0373	0.0269
1989	0.0147	0.0075	0.0034	0.0023	0.0025	0.0054	0.0220	0.0253	0.0240	0.0487	0.0304	0.0193
1990	0.0177	0.0099	0.0035	0.0021	0.0032	0.0049	0.0113	0.0147	0.0319	0.0467	0.0355	0.0404
1991	0.0171	0.0074	0.0022	0.0016	0.0041	0.0068	0.0159	0.0194	0.0183	0.0405	0.0430	0.0245
1992	0.0200	0.0065	0.0047	0.0020	0.0040	0.0053	0.0136	0.0315	0.0165	0.0189	0.0250	0.0195
1993	0.0132	0.0049	0.0016	0.0013	0.0023	0.0046	0.0115	0.0188	0.0253	0.0339	0.0255	0.0170
1994	0.0099	0.0057	0.0032	0.0022	0.0033	0.0064	0.0144	0.0277	0.0410	0.0461	0.0437	0.0410
Avg	0.0161	0.0062	0.0031	0.0021	0.0033	0.0057	0.0147	0.0171	0.0201	0.0357	0.0337	0.0258
Max	0.0307	0.0100	0.0054	0.0046	0.0049	0.0081	0.0242	0.0315	0.0410	0.0583	0.0523	0.0465
Min	0.0056	0.0031	0.0015	0.0013	0.0021	0.0041	0.0059	0.0037	0.0031	0.0112	0.0194	0.0103
Std	0.0056	0.0021	0.0010	0.0007	0.0008	0.0010	0.0047	0.0071	0.0090	0.0122	0.0095	0.0099

%SEEP PER MILE

Reach 10: JULESBURG TO S. PLATTE at N. PLATTE REACH

85.5 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979					0.0983							
1980				0.0839			0.0125	0.0995				
1981												
1982												
1983							0.0553	0.0192	0.0777			
1984							0.0453	0.0300			0.1233	
1985			0.1003									
1986												
1987			0.1103					0.0657				
1988												
1989			0.0861									
1990				0.1756								
1991			0.3290	0.2874								
1992				0.1527								
1993			0.2467									0.0063
1994			0.0150	0.0061								

%DIV PER MILE

Reach 10: JULESBURG TO S. PLATTE at N. PLATTE REACH

85.5 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.6171	0.6136	0.7098	0.8536	0.9068	0.7356	0.8608	0.7039	0.5772	0.4861	0.4888	0.3993
1976	0.4467	0.2973	0.8055	0.8063	0.8133	0.8618	0.6731	0.5409	0.4397	0.1827	0.0812	0.1945
1977	0.2177	0.1585	0.4181	0.5169	0.7925	0.7425	0.7946	0.6151	0.5477	0.3894	0.3429	0.2427
1978	0.4951	0.4780	0.4682	0.5296	0.6944	0.7061	0.5364	0.5403	0.7011	0.2413	0.1159	0.0764
1979	0.3543	0.2447	0.3428	0.3325	0.7071	0.7140	0.7619	0.9017	0.3370	0.6435	0.7235	0.8085
1980	0.7636	0.8917	0.9198	0.6379	0.4538	0.5001	0.1062	0.1164	0.1671	0.4425	0.2234	0.3412
1981	0.5202	0.7452	0.8951	0.9646	0.8798	0.8222	0.8528	0.8502	0.8633	0.2688	0.1881	0.1903
1982	0.5226	0.4736	0.6552	0.6827	0.7778	0.6907	0.5491	0.5115	0.6602	0.7428	0.3140	0.6006
1983	0.6106	0.7440	0.9142	0.5460	0.6592	0.8187	0.4573	0.1633	0.0203	0.1403	0.4196	0.1466
1984	0.0654	0.8295	0.2788	0.1656	0.1385	0.1626	0.2875	0.0356	0.0515	0.3521	0.4181	0.2536
1985	0.1852	0.1991	0.2312	0.2463	0.1982	0.3812	0.5571	0.6541	0.6895	0.4729	0.6111	0.8267
1986	0.9189	0.7689	0.4042	0.3871	0.3642	0.5719	0.2849	0.4752	0.1433	0.4922	0.2764	0.4761
1987	0.4211	0.5333	0.4284	0.4903	0.7113	0.5399	0.5639	0.2997	0.3828	0.4843	0.3057	0.4838
1988	0.6469	0.7049	0.6325	0.5303	0.3342	0.7694	0.6395	0.4875	0.8125	0.3606	0.2823	0.3211
1989	0.4739	0.4959	0.6004	0.7436	0.6756	0.6447	0.5899	0.4615	0.6008	0.2573	0.4596	0.7245
1990	0.6232	0.4070	0.4810	0.7316	0.8741	0.9533	0.9633	0.6379	0.5602	0.3257	0.4338	0.4066
1991	0.5224	0.5208	0.4156	0.6309	0.7106	0.7400	0.6942	0.5452	0.6016	0.3356	0.3952	0.7066
1992	0.2664	0.3744	0.4480	0.6375	0.7699	0.7216	0.7882	0.3852	0.7729	0.7369	0.5860	0.5923
1993	0.5264	0.6394	0.6329	0.5794	0.6705	0.6617	0.7249	0.4732	0.4619	0.2594	0.1853	0.6112
1994	0.7036	0.3417	0.6135	0.6626	0.6233	0.7280	0.6130	0.3786	0.2110	0.1638	0.1400	0.1241
Avg	0.4952	0.5231	0.5648	0.5888	0.6378	0.6758	0.6249	0.4889	0.4801	0.3889	0.3496	0.4253
Max	0.9189	0.8917	0.9198	0.9646	0.9068	0.9533	0.9633	0.9017	0.8633	0.7428	0.7235	0.8267
Min	0.0654	0.1585	0.2312	0.1656	0.1385	0.1626	0.1062	0.0356	0.0203	0.1403	0.0812	0.0764
Std	0.2006	0.2102	0.2022	0.1947	0.2172	0.1706	0.2132	0.2158	0.2479	0.1710	0.1684	0.2298

%EVAP PER MILE

Reach 11: CACHE LA POUDRE RIVER; Canyon Mouth to Greeley Gage Reach 51.8 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0041	0.0037	0.0019	0.0021	0.0026	0.0051	0.0078	0.0043	0.0049	0.0043	0.0030	0.0035
1976	0.0052	0.0030	0.0023	0.0012	0.0038	0.0044	0.0129	0.0058	0.0037	0.0041	0.0033	0.0037
1977	0.0041	0.0032	0.0024	0.0012	0.0045	0.0065	0.0101	0.0053	0.0050	0.0046	0.0032	0.0041
1978	0.0073	0.0040	0.0028	0.0007	0.0017	0.0073	0.0109	0.0053	0.0044	0.0044	0.0032	0.0046
1979	0.0040	0.0029	0.0004	0.0000	0.0023	0.0051	0.0096	0.0060	0.0042	0.0045	0.0039	0.0054
1980	0.0056	0.0018	0.0017	0.0005	0.0014	0.0029	0.0066	0.0035	0.0043	0.0047	0.0034	0.0042
1981	0.0042	0.0032	0.0037	0.0028	0.0032	0.0058	0.0159	0.0046	0.0058	0.0040	0.0029	0.0045
1982	0.0036	0.0044	0.0023	0.0016	0.0025	0.0071	0.0105	0.0052	0.0044	0.0053	0.0041	0.0047
1983	0.0040	0.0024	0.0016	0.0026	0.0037	0.0041	0.0047	0.0032	0.0096	0.0038	0.0047	0.0048
1984	0.0053	0.0029	0.0000	0.0007	0.0023	0.0043	0.0062	0.0046	0.0042	0.0047	0.0043	0.0045
1985	0.0038	0.0036	0.0018	0.0007	0.0011	0.0058	0.0054	0.0048	0.0042	0.0048	0.0032	0.0042
1986	0.0057	0.0011	0.0006	0.0025	0.0030	0.0071	0.0099	0.0036	0.0042	0.0045	0.0035	0.0038
1987	0.0054	0.0028	0.0014	0.0019	0.0039	0.0038	0.0121	0.0052	0.0059	0.0044	0.0040	0.0052
1988	0.0068	0.0035	0.0013	0.0006	0.0024	0.0039	0.0105	0.0056	0.0043	0.0051	0.0040	0.0041
1989	0.0086	0.0038	0.0012	0.0023	0.0003	0.0060	0.0092	0.0042	0.0051	0.0043	0.0035	0.0053
1990	0.0049	0.0046	0.0010	0.0031	0.0022	0.0030	0.0105	0.0043	0.0050	0.0050	0.0041	0.0060
1991	0.0063	0.0041	0.0006	0.0008	0.0038	0.0073	0.0088	0.0053	0.0049	0.0048	0.0041	0.0048
1992	0.0062	0.0025	0.0020	0.0019	0.0040	0.0046	0.0104	0.0037	0.0046	0.0048	0.0041	0.0059
1993	0.0060	0.0020	0.0006	0.0006	0.0013	0.0049	0.0083	0.0045	0.0047	0.0042	0.0040	0.0050
1994	0.0045	0.0020	0.0017	0.0023	0.0015	0.0068	0.0094	0.0043	0.0052	0.0039	0.0042	0.0061
Avg	0.0053	0.0031	0.0016	0.0015	0.0026	0.0053	0.0095	0.0047	0.0049	0.0045	0.0037	0.0047
Max	0.0086	0.0046	0.0037	0.0031	0.0045	0.0073	0.0159	0.0060	0.0096	0.0053	0.0047	0.0061
Min	0.0036	0.0011	0.0000	0.0000	0.0003	0.0029	0.0047	0.0032	0.0037	0.0038	0.0029	0.0035
Std	0.0013	0.0009	0.0009	0.0009	0.0011	0.0014	0.0025	0.0008	0.0012	0.0004	0.0005	0.0007

%SEEP PER MILE

Reach 11: CACHE LA POUDRE RIVER; Canyon Mouth to Greeley Gage Reach 51.8 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976	0.1133											
1977												
1978												
1979												
1980												
1981												
1982												
1983	0.0876											
1984												
1985												
1986												
1987												
1988												
1989												
1990	0.1966											
1991												
1992												
1993												
1994												

%DIV PER MILE

Reach 11: CACHE LA POUDRE RIVER; Canyon Mouth to Greeley Gage Reach 51.8 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	1.3400	0.5483	0.2021	0.2075	0.3488	0.5515	0.9941	1.7195	1.3414	1.7898	1.8650	1.7415
1976	1.1750	0.6932	0.7119	0.8537	0.7723	0.7105	0.9075	1.7613	1.8623	1.6883	1.7707	1.7039
1977	1.3926	0.7736	0.3592	0.5484	0.6403	0.6673	1.4826	1.8412	1.9116	1.7448	1.8755	1.8497
1978	1.2936	0.9212	0.7695	0.7017	0.6633	0.6605	1.1970	1.6194	1.3556	1.8850	1.8751	1.7367
1979	1.4169	0.8457	0.9081	0.8967	0.8373	0.7495	1.0584	0.6172	0.7809	1.8212	1.6487	1.5923
1980	1.0783	0.3921	0.4849	0.5803	0.1781	0.1760	0.1607	0.0574	1.2592	1.8503	1.8603	1.6878
1981	1.3709	1.0351	0.8835	0.9313	0.6505	0.6555	1.2222	1.7580	1.5018	1.8894	1.8762	1.7532
1982	1.5292	0.9724	0.7506	0.8628	0.9303	0.7329	1.3907	1.8664	1.3537	1.3870	1.8378	1.4350
1983	1.2123	0.9508	0.1402	0.4025	0.7105	0.5097	0.1034	0.2288	0.2298	1.1012	1.5606	1.4888
1984	1.3143	0.5618	0.5138	0.1361	0.1022	0.1310	0.1051	0.5958	1.1468	1.5049	1.6695	1.4594
1985	0.9505	0.3231	0.1229	0.1447	0.2275	0.6123	1.5954	1.7744	1.4980	1.8025	1.8549	1.6447
1986	1.0528	0.7270	0.5894	0.4431	0.2907	0.4320	0.3439	1.6989	0.9559	1.7041	1.8474	1.6460
1987	1.0763	0.9064	0.3967	0.5757	0.3587	0.3553	1.2786	1.4300	1.5374	1.8701	1.8568	1.7572
1988	1.1943	0.9616	0.7345	0.7696	0.7761	0.8430	1.1981	1.7571	1.7492	1.8357	1.8377	1.6946
1989	1.0397	0.9435	0.7459	0.6928	0.4410	0.7106	1.4602	1.8924	1.7435	1.8664	1.8082	1.5638
1990	1.1802	0.8890	1.0257	0.6251	0.6288	0.8306	0.4921	1.8127	1.6172	1.8457	1.8455	1.5761
1991	1.1711	0.8649	0.7144	0.6218	0.5848	0.6650	1.4818	1.8627	1.3894	1.8430	1.8416	1.7291
1992	1.2668	0.9780	0.9413	0.8038	0.7642	0.7470	1.3523	1.8816	1.7357	1.8076	1.7552	1.6211
1993	1.1785	0.9264	0.8137	0.8063	0.6557	0.4858	0.8466	1.8017	1.3613	1.8182	1.8459	1.8117
1994	1.2079	0.6990	0.5126	0.4458	0.5512	0.4222	1.2787	1.8990	1.7769	1.8820	1.7917	1.8602
Avg	1.2221	0.7957	0.6160	0.5925	0.5556	0.5824	0.9975	1.4938	1.4054	1.7589	1.8062	1.6527
Max	1.5292	1.0351	1.0257	0.9313	0.9303	0.8430	1.5954	1.8990	1.9116	1.8894	1.8762	1.8497
Min	0.9505	0.3231	0.1229	0.1361	0.1022	0.1310	0.1034	0.0574	0.2298	1.1012	1.5606	1.4350
Std	0.1414	0.1979	0.2603	0.2308	0.2288	0.1938	0.4808	0.5790	0.3936	0.1960	0.0842	0.1031

%EVAP PER MILE

Reach 12: WY/NE STATELINE TO BRIDGEPORT REACH

57.5 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0100	0.0070	0.0048	0.0043	0.0079	0.0122	0.0164	0.0167	0.0174	0.0163	0.0127	0.0133
1976	0.0126	0.0072	0.0049	0.0042	0.0074	0.0124	0.0250	0.0178	0.0204	0.0153	0.0126	0.0118
1977	0.0101	0.0071	0.0047	0.0046	0.0081	0.0124	0.0217	0.0218	0.0219	0.0147	0.0133	0.0162
1978	0.0147	0.0078	0.0051	0.0048	0.0080	0.0120	0.0272	0.0169	0.0188	0.0139	0.0127	0.0154
1979	0.0168	0.0078	0.0053	0.0027	0.0069	0.0144	0.0232	0.0227	0.0179	0.0188	0.0125	0.0137
1980	0.0146	0.0052	0.0075	0.0029	0.0047	0.0102	0.0133	0.0089	0.0169	0.0152	0.0118	0.0131
1981	0.0134	0.0084	0.0091	0.0056	0.0148	0.0188	0.0374	0.0206	0.0202	0.0153	0.0120	0.0131
1982	0.0130	0.0088	0.0067	0.0049	0.0094	0.0163	0.0298	0.0150	0.0216	0.0221	0.0113	0.0104
1983	0.0114	0.0047	0.0049	0.0056	0.0085	0.0105	0.0129	0.0093	0.0068	0.0094	0.0105	0.0078
1984	0.0084	0.0073	0.0047	0.0070	0.0049	0.0043	0.0052	0.0081	0.0080	0.0120	0.0131	0.0093
1985	0.0068	0.0057	0.0020	0.0023	0.0074	0.0079	0.0218	0.0201	0.0195	0.0180	0.0132	0.0111
1986	0.0116	0.0052	0.0027	0.0012	0.0078	0.0128	0.0099	0.0124	0.0149	0.0111	0.0141	0.0091
1987	0.0058	0.0039	0.0043	0.0075	0.0079	0.0051	0.0222	0.0219	0.0201	0.0160	0.0228	0.0109
1988	0.0149	0.0058	0.0046	0.0030	0.0072	0.0106	0.0262	0.0211	0.0220	0.0166	0.0137	0.0112
1989	0.0116	0.0117	0.0058	0.0044	0.0094	0.0116	0.0260	0.0238	0.0170	0.0170	0.0146	0.0131
1990	0.0160	0.0155	0.0038	0.0078	0.0096	0.0155	0.0219	0.0218	0.0207	0.0143	0.0135	0.0257
1991	0.0132	0.0085	0.0056	0.0051	0.0097	0.0154	0.0278	0.0258	0.0182	0.0146	0.0134	0.0122
1992	0.0128	0.0080	0.0059	0.0053	0.0090	0.0141	0.0285	0.0222	0.0270	0.0133	0.0115	0.0128
1993	0.0139	0.0087	0.0054	0.0050	0.0096	0.0121	0.0258	0.0194	0.0253	0.0131	0.0118	0.0141
1994	0.0114	0.0076	0.0049	0.0045	0.0086	0.0126	0.0351	0.0190	0.0142	0.0108	0.0148	0.0109
Avg	0.0121	0.0076	0.0051	0.0046	0.0083	0.0121	0.0229	0.0183	0.0185	0.0149	0.0133	0.0128
Max	0.0168	0.0155	0.0091	0.0078	0.0148	0.0188	0.0374	0.0258	0.0270	0.0221	0.0228	0.0257
Min	0.0058	0.0039	0.0020	0.0012	0.0047	0.0043	0.0052	0.0081	0.0068	0.0094	0.0105	0.0078
Std	0.0028	0.0025	0.0015	0.0016	0.0020	0.0034	0.0079	0.0050	0.0048	0.0029	0.0024	0.0036

%SEEP PER MILE

Reach 12: WY/NE STATELINE TO BRIDGEPORT REACH

57.5 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991												
1992												
1993												
1994												

%DIV PER MILE

Reach 12: WY/NE STATELINE TO BRIDGEPORT REACH

57.5 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0666	0.0000	0.0000	0.0000	0.0000	0.0000	0.0250	0.6794	0.8034	1.1136	1.2219	0.8401
1976	0.0834	0.0000	0.0000	0.0000	0.0000	0.0000	0.2031	0.8368	0.9400	1.3619	1.0963	0.8450
1977	0.0849	0.0000	0.0000	0.0000	0.0000	0.0000	0.0579	0.8457	0.9060	1.2884	1.1215	0.8855
1978	0.1052	0.0026	0.0000	0.0000	0.0000	0.0000	0.0487	0.4456	0.6942	1.1545	1.1049	0.8030
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0033	0.6616	0.9874	1.1779	1.0339	0.7196
1980	0.0877	0.0000	0.0000	0.0000	0.0000	0.0000	0.0175	0.2577	0.6202	1.2217	1.1839	0.8295
1981	0.1595	0.0000	0.0000	0.0000	0.0000	0.0000	0.1648	0.7703	1.2391	1.2153	1.1535	0.8826
1982	0.1323	0.0000	0.0000	0.0000	0.0000	0.0000	0.1697	0.9015	0.8416	1.1150	1.0006	0.6760
1983	0.0975	0.0000	0.0000	0.0000	0.0000	0.0000	0.1256	0.2268	0.2330	0.3839	0.4311	0.3216
1984	0.0454	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1889	0.2360	0.6171	0.6751	0.4502
1985	0.0479	0.0000	0.0000	0.0000	0.0000	0.0000	0.1210	0.9007	0.9236	1.3093	1.1920	0.6955
1986	0.0162	0.0000	0.0000	0.0000	0.0000	0.0000	0.0050	0.3598	0.3262	0.5170	0.9172	0.4461
1987	0.0429	0.0000	0.0000	0.0000	0.0000	0.0000	0.0158	0.4873	0.7436	1.2067	0.7525	0.6021
1988	0.0631	0.0000	0.0000	0.0000	0.0000	0.0000	0.1541	0.4800	0.8800	1.2562	1.2154	0.7738
1989	0.0509	0.0000	0.0000	0.0000	0.0000	0.0000	0.1942	0.9187	1.2842	1.5135	1.2885	0.7920
1990	0.0520	0.0000	0.0000	0.0000	0.0000	0.0000	0.0258	0.4186	0.9858	1.4318	1.1664	0.9648
1991	0.0827	0.0000	0.0000	0.0000	0.0000	0.0000	0.1008	0.5301	0.4411	1.3361	1.4182	0.8242
1992	0.0738	0.0000	0.0000	0.0000	0.0000	0.0000	0.1311	1.1971	0.8251	1.1820	1.3793	1.0006
1993	0.1164	0.0004	0.0000	0.0000	0.0000	0.0000	0.0352	0.9821	0.7358	1.2208	0.9099	0.6368
1994	0.0381	0.0000	0.0000	0.0000	0.0000	0.0000	0.0319	0.9017	1.0308	1.0169	1.1693	0.7650
Avg	0.0713	0.0001	0.0000	0.0000	0.0000	0.0000	0.0815	0.6495	0.7839	1.1320	1.0728	0.7377
Max	0.1595	0.0026	0.0000	0.0000	0.0000	0.0000	0.2031	1.1971	1.2842	1.5135	1.4182	1.0006
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1889	0.2330	0.3839	0.4311	0.3216
Std	0.0375	0.0006	0.0000	0.0000	0.0000	0.0000	0.0683	0.2788	0.2867	0.2874	0.2336	0.1712

%EVAP PER MILE

Reach 13: BRIDGEPORT TO LEWELLEN REACH

60 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0099	0.0068	0.0044	0.0038	0.0067	0.0113	0.0172	0.0276	0.0308	0.0397	0.0431	0.0246
1976	0.0125	0.0067	0.0043	0.0037	0.0065	0.0117	0.0247	0.0323	0.0409	0.0622	0.0368	0.0219
1977	0.0106	0.0073	0.0048	0.0046	0.0071	0.0113	0.0231	0.0349	0.0381	0.0550	0.0335	0.0268
1978	0.0139	0.0081	0.0056	0.0046	0.0077	0.0100	0.0266	0.0241	0.0267	0.0352	0.0306	0.0253
1979	0.0125	0.0075	0.0042	0.0037	0.0053	0.0104	0.0225	0.0313	0.0338	0.0458	0.0261	0.0178
1980	0.0123	0.0064	0.0054	0.0035	0.0046	0.0099	0.0152	0.0126	0.0211	0.0476	0.0354	0.0239
1981	0.0119	0.0076	0.0068	0.0049	0.0110	0.0142	0.0355	0.0272	0.0512	0.0493	0.0297	0.0250
1982	0.0111	0.0085	0.0060	0.0045	0.0078	0.0143	0.0365	0.0324	0.0357	0.0496	0.0238	0.0153
1983	0.0098	0.0058	0.0047	0.0046	0.0088	0.0106	0.0156	0.0118	0.0076	0.0112	0.0125	0.0087
1984	0.0069	0.0070	0.0041	0.0050	0.0049	0.0048	0.0065	0.0095	0.0095	0.0158	0.0203	0.0126
1985	0.0070	0.0056	0.0031	0.0031	0.0071	0.0077	0.0237	0.0371	0.0390	0.0540	0.0389	0.0179
1986	0.0105	0.0070	0.0038	0.0026	0.0066	0.0115	0.0133	0.0163	0.0191	0.0140	0.0262	0.0120
1987	0.0065	0.0038	0.0038	0.0057	0.0077	0.0075	0.0244	0.0260	0.0358	0.0535	0.0399	0.0217
1988	0.0194	0.0080	0.0056	0.0040	0.0070	0.0102	0.0282	0.0264	0.0517	0.0671	0.0563	0.0254
1989	0.0137	0.0094	0.0054	0.0037	0.0083	0.0121	0.0330	0.0480	0.0611	0.1074	0.0602	0.0291
1990	0.0226	0.0120	0.0055	0.0057	0.0094	0.0142	0.0264	0.0306	0.0644	0.0959	0.0523	0.0608
1991	0.0187	0.0087	0.0062	0.0057	0.0096	0.0144	0.0307	0.0348	0.0264	0.0874	0.0789	0.0362
1992	0.0185	0.0086	0.0057	0.0050	0.0090	0.0126	0.0308	0.0780	0.0502	0.0417	0.0544	0.0401
1993	0.0175	0.0092	0.0060	0.0051	0.0096	0.0113	0.0234	0.0372	0.0432	0.0502	0.0303	0.0243
1994	0.0152	0.0077	0.0050	0.0046	0.0085	0.0122	0.0342	0.0443	0.0482	0.0362	0.0503	0.0283
Avg	0.0130	0.0076	0.0050	0.0044	0.0077	0.0111	0.0246	0.0311	0.0367	0.0499	0.0390	0.0249
Max	0.0226	0.0120	0.0068	0.0057	0.0110	0.0144	0.0365	0.0780	0.0644	0.1074	0.0789	0.0608
Min	0.0065	0.0038	0.0031	0.0026	0.0046	0.0048	0.0065	0.0095	0.0076	0.0112	0.0125	0.0087
Std	0.0043	0.0016	0.0009	0.0009	0.0016	0.0024	0.0078	0.0146	0.0151	0.0232	0.0155	0.0111

%SEEP PER MILE

Reach 13: BRIDGEPORT TO LEWELLEN REACH

60 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												0.0001
1976												
1977												
1978												
1979												
1980							0.0651	0.0068				
1981												
1982												
1983								0.0243	0.0225			
1984						0.0240		0.0525				
1985						0.0398						
1986									0.0135			0.0564
1987												
1988												
1989												
1990			0.0342									
1991				0.0028								
1992												
1993			0.2191									
1994										0.0390		

%DIV PER MILE

Reach 13: BRIDGEPORT TO LEWELLEN REACH

60 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0203	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0720	0.2278	0.3121	0.1013
1976	0.0212	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0280	0.1437	0.4039	0.2206	0.0966
1977	0.0186	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0233	0.1260	0.3958	0.2003	0.1086
1978	0.0225	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0708	0.1827	0.1699	0.0780
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0221	0.1192	0.2081	0.1679	0.0697
1980	0.0187	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0071	0.0401	0.2902	0.2381	0.0608
1981	0.0112	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0716	0.2736	0.1166	0.0911	0.0576
1982	0.0229	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0369	0.1520	0.2024	0.1262	0.0604
1983	0.0129	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0089	0.0410	0.0432	0.0250
1984	0.0239	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0016	0.0198	0.0755	0.0926	0.0515
1985	0.0137	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0471	0.1343	0.3126	0.2296	0.0707
1986	0.0035	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0193	0.0357	0.0689	0.1536	0.0420
1987	0.0050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0308	0.1034	0.2684	0.1139	0.0465
1988	0.0169	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0130	0.1254	0.3783	0.2922	0.0713
1989	0.0235	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1116	0.3838	0.7368	0.4613	0.0735
1990	0.0228	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0253	0.2525	0.5096	0.3001	0.1690
1991	0.0341	0.0000	0.0000	0.0000	0.0000	0.0000	0.0544	0.0900	0.0261	0.3566	0.4720	0.1010
1992	0.0235	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2302	0.1454	0.2096	0.3514	0.1192
1993	0.0281	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400	0.1058	0.2783	0.1650	0.0495
1994	0.0045	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1083	0.2656	0.1902	0.2801	0.1325
Avg	0.0174	0.0000	0.0000	0.0000	0.0000	0.0000	0.0028	0.0453	0.1302	0.2727	0.2241	0.0792
Max	0.0341	0.0006	0.0000	0.0000	0.0000	0.0000	0.0544	0.2302	0.3838	0.7368	0.4720	0.1690
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0089	0.0410	0.0432	0.0250
Std	0.0087	0.0001	0.0000	0.0000	0.0000	0.0000	0.0119	0.0541	0.0955	0.1601	0.1140	0.0340

%EVAP PER MILE

Reach 14: KEYSTONE TO NORTH PLATTE REACH

51.5 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0355	0.0103	0.0065	0.0055	0.0098	0.0139	0.0254	0.0348	0.0313	0.0185	0.0167	0.0202
1976	0.0200	0.0097	0.0055	0.0054	0.0083	0.0139	0.0250	0.0348	0.0273	0.0156	0.0156	0.0129
1977	0.0137	0.0071	0.0063	0.0058	0.0092	0.0118	0.0221	0.0373	0.0330	0.0163	0.0175	0.0250
1978	0.0260	0.0108	0.0068	0.0058	0.0100	0.0119	0.0309	0.0360	0.0319	0.0171	0.0203	0.0310
1979	0.0204	0.0099	0.0064	0.0060	0.0102	0.0108	0.0308	0.0391	0.0361	0.0206	0.0181	0.0277
1980	0.0250	0.0109	0.0061	0.0055	0.0090	0.0151	0.0201	0.0184	0.0291	0.0170	0.0185	0.0283
1981	0.0182	0.0101	0.0068	0.0060	0.0116	0.0148	0.0373	0.0252	0.0361	0.0172	0.0236	0.0253
1982	0.0159	0.0109	0.0064	0.0058	0.0100	0.0140	0.0378	0.0271	0.0366	0.0167	0.0143	0.0158
1983	0.0164	0.0094	0.0064	0.0066	0.0102	0.0138	0.0206	0.0313	0.0052	0.0084	0.0067	0.0053
1984	0.0123	0.0100	0.0026	0.0024	0.0032	0.0035	0.0045	0.0069	0.0086	0.0144	0.0151	0.0141
1985	0.0172	0.0048	0.0027	0.0031	0.0072	0.0064	0.0342	0.0309	0.0324	0.0166	0.0207	0.0211
1986	0.0176	0.0103	0.0063	0.0053	0.0088	0.0133	0.0177	0.0216	0.0258	0.0131	0.0093	0.0072
1987	0.0085	0.0059	0.0064	0.0063	0.0097	0.0118	0.0399	0.0333	0.0376	0.0276	0.0174	0.0351
1988	0.0208	0.0090	0.0060	0.0054	0.0084	0.0124	0.0374	0.0351	0.0296	0.0205	0.0236	0.0301
1989	0.0298	0.0109	0.0066	0.0053	0.0104	0.0142	0.0497	0.0362	0.0330	0.0224	0.0172	0.0351
1990	0.0348	0.0111	0.0070	0.0054	0.0102	0.0139	0.0357	0.0269	0.0395	0.0177	0.0226	0.0353
1991	0.0375	0.0120	0.0077	0.0060	0.0111	0.0164	0.0369	0.0340	0.0363	0.0164	0.0223	0.0420
1992	0.0234	0.0097	0.0063	0.0053	0.0089	0.0108	0.0342	0.0509	0.0349	0.0218	0.0253	0.0389
1993	0.0304	0.0118	0.0070	0.0056	0.0105	0.0119	0.0241	0.0362	0.0434	0.0310	0.0264	0.0327
1994	0.0283	0.0103	0.0065	0.0057	0.0108	0.0145	0.0306	0.0450	0.0433	0.0205	0.0196	0.0372
Avg	0.0226	0.0097	0.0061	0.0054	0.0094	0.0125	0.0298	0.0320	0.0316	0.0185	0.0185	0.0260
Max	0.0375	0.0120	0.0077	0.0066	0.0116	0.0164	0.0497	0.0509	0.0434	0.0310	0.0254	0.0420
Min	0.0085	0.0048	0.0026	0.0024	0.0032	0.0035	0.0045	0.0069	0.0052	0.0084	0.0067	0.0053
Std	0.0079	0.0018	0.0012	0.0010	0.0018	0.0029	0.0097	0.0092	0.0094	0.0048	0.0048	0.0104

%SEEP PER MILE

Reach 14: KEYSTONE TO NORTH PLATTE REACH

51.5 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980												
1981												
1982												
1983												
1984												
1985												
1986												
1987												
1988												
1989												
1990												
1991										0.0463		
1992												
1993												
1994												

%DIV PER MILE

Reach 14: KEYSTONE TO NORTH PLATTE REACH

51.5 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0832	0.0000	0.0000	0.0000	0.0000	0.0000	0.1258	0.8420	0.7425	0.5025	0.5119	0.5932
1976	0.3640	0.0000	0.0000	0.0000	0.0000	0.0137	0.4201	0.6389	0.5103	0.4273	0.3636	0.3157
1977	0.1288	0.0050	0.0000	0.0000	0.0000	0.0000	0.0040	0.4167	0.7009	0.3878	0.6285	0.8284
1978	0.0248	0.0000	0.0000	0.0000	0.0000	0.0000	0.0524	0.7571	0.7671	0.4510	0.7422	0.9823
1979	0.0601	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6024	0.8796	0.6594	0.6556	0.8732
1980	0.1622	0.0000	0.0000	0.0000	0.0000	0.0000	0.0106	0.2663	0.6162	0.5065	0.4701	0.7418
1981	0.0384	0.0000	0.0000	0.0000	0.0000	0.0000	0.4483	0.5865	0.5496	0.4595	0.7777	0.8870
1982	0.0582	0.0000	0.0000	0.0000	0.0000	0.0000	0.2941	0.6313	0.6115	0.4963	0.5984	0.5934
1983	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0580	0.2909	0.0785	0.1665	0.1472	0.1084
1984	0.0110	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0341	0.1083	0.5156	0.4917	0.3645
1985	0.1782	0.0000	0.0000	0.0000	0.0000	0.0000	0.4455	0.7407	0.8818	0.5404	0.7518	0.5533
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0478	0.3306	0.5119	0.4015	0.3120	0.1339
1987	0.0042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0955	0.7392	0.9634	0.6315	0.4951	0.4427
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0469	0.3810	0.5678	0.5504	0.6392	0.5543
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2593	0.9994	0.6167	0.6310	0.4619	0.2239
1990	0.0098	0.0000	0.0000	0.0000	0.0000	0.0000	0.0818	0.4869	0.8857	0.4234	0.6519	0.5668
1991	0.0108	0.0000	0.0000	0.0000	0.0000	0.0000	0.0786	0.3778	0.5692	0.4582	0.5504	0.5473
1992	0.0083	0.0000	0.0000	0.0000	0.0000	0.0000	0.0204	0.5913	0.5378	0.7734	0.5521	0.6404
1993	0.0862	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.4378	0.4614	0.8306	0.7818	0.6791
1994	0.0157	0.0000	0.0000	0.0000	0.0000	0.0000	0.2183	0.7134	0.7795	0.5244	0.6208	0.7465
Avg	0.0823	0.0003	0.0000	0.0000	0.0000	0.0007	0.1354	0.5432	0.6170	0.5163	0.5602	0.5688
Max	0.3640	0.0050	0.0000	0.0000	0.0000	0.0137	0.4483	0.9994	0.9634	0.8306	0.7818	0.9823
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0341	0.0785	0.1665	0.1472	0.1084
Std	0.0877	0.0011	0.0000	0.0000	0.0000	0.0030	0.1516	0.2239	0.2252	0.1403	0.1581	0.2403

%EVAP PER MILE

Reach 15: NORTH PLATTE TO BRADY REACH

23.8 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0163	0.0055	0.0032	0.0026	0.0044	0.0064	0.0122	0.0170	0.0167	0.0194	0.0173	0.0148
1976	0.0092	0.0050	0.0032	0.0023	0.0041	0.0064	0.0136	0.0193	0.0253	0.0192	0.0203	0.0181
1977	0.0130	0.0061	0.0034	0.0026	0.0049	0.0072	0.0158	0.0211	0.0186	0.0183	0.0141	0.0155
1978	0.0173	0.0053	0.0036	0.0035	0.0062	0.0074	0.0171	0.0164	0.0224	0.0185	0.0155	0.0184
1979	0.0148	0.0051	0.0032	0.0029	0.0048	0.0074	0.0178	0.0163	0.0111	0.0148	0.0144	0.0170
1980	0.0148	0.0064	0.0023	0.0020	0.0033	0.0048	0.0084	0.0050	0.0090	0.0185	0.0172	0.0162
1981	0.0098	0.0054	0.0030	0.0022	0.0040	0.0071	0.0204	0.0156	0.0210	0.0166	0.0128	0.0181
1982	0.0131	0.0060	0.0029	0.0024	0.0042	0.0068	0.0222	0.0207	0.0210	0.0187	0.0140	0.0140
1983	0.0120	0.0049	0.0028	0.0018	0.0034	0.0048	0.0062	0.0056	0.0031	0.0072	0.0092	0.0076
1984	0.0082	0.0057	0.0023	0.0017	0.0021	0.0033	0.0051	0.0052	0.0075	0.0140	0.0146	0.0085
1985	0.0050	0.0024	0.0019	0.0019	0.0029	0.0046	0.0166	0.0148	0.0185	0.0177	0.0159	0.0135
1986	0.0069	0.0044	0.0027	0.0019	0.0034	0.0051	0.0089	0.0138	0.0128	0.0145	0.0108	0.0077
1987	0.0112	0.0037	0.0023	0.0019	0.0036	0.0052	0.0131	0.0099	0.0153	0.0221	0.0178	0.0146
1988	0.0075	0.0039	0.0025	0.0026	0.0032	0.0050	0.0125	0.0179	0.0251	0.0199	0.0192	0.0168
1989	0.0149	0.0057	0.0032	0.0022	0.0042	0.0062	0.0219	0.0195	0.0206	0.0230	0.0160	0.0206
1990	0.0158	0.0069	0.0043	0.0026	0.0045	0.0057	0.0127	0.0157	0.0236	0.0193	0.0185	0.0256
1991	0.0215	0.0085	0.0052	0.0037	0.0047	0.0084	0.0179	0.0211	0.0217	0.0190	0.0203	0.0246
1992	0.0146	0.0065	0.0040	0.0030	0.0040	0.0052	0.0159	0.0263	0.0192	0.0162	0.0172	0.0232
1993	0.0172	0.0064	0.0033	0.0027	0.0044	0.0049	0.0142	0.0212	0.0273	0.0222	0.0175	0.0154
1994	0.0093	0.0044	0.0025	0.0023	0.0039	0.0061	0.0186	0.0194	0.0237	0.0193	0.0181	0.0269
Avg	0.0128	0.0054	0.0031	0.0024	0.0040	0.0059	0.0146	0.0161	0.0182	0.0179	0.0160	0.0169
Max	0.0215	0.0085	0.0052	0.0037	0.0062	0.0084	0.0222	0.0263	0.0273	0.0230	0.0203	0.0269
Min	0.0050	0.0024	0.0019	0.0017	0.0021	0.0033	0.0051	0.0050	0.0031	0.0072	0.0092	0.0076
Std	0.0041	0.0013	0.0007	0.0005	0.0009	0.0012	0.0047	0.0056	0.0064	0.0034	0.0029	0.0053

%SEEP PER MILE

Reach 15: NORTH PLATTE TO BRADY REACH

23.8 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976											0.0390	
1977												
1978				0.1109								
1979												
1980												
1981												
1982												
1983												
1984			0.6091									
1985												
1986												
1987												
1988												
1989												
1990												
1991	0.3839		0.1120									
1992												
1993												
1994												

%DIV PER MILE

Reach 15: NORTH PLATTE TO BRADY REACH

23.8 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	3.7563	3.7164	3.7362	3.7711	3.7927	3.7746	3.7231	3.7919	3.2406	2.5880	2.8234	3.7742
1976	3.8817	3.8631	3.7905	3.8164	3.7251	3.7338	3.7168	3.7256	3.4743	2.4969	2.7358	3.5134
1977	3.7277	3.8025	3.7636	3.8544	3.7411	3.5746	3.3227	3.4263	3.5880	2.2890	3.1085	3.7621
1978	3.6781	3.7316	3.6977	3.5521	3.6579	3.5652	3.5849	3.6737	3.5335	2.3185	3.2505	3.7779
1979	3.7884	3.7911	3.8082	3.8085	3.7695	3.4563	3.5875	3.7358	1.8793	3.0207	3.0512	3.8521
1980	3.7013	3.5963	3.8262	3.6581	3.0309	3.2394	1.7561	0.7617	1.4097	2.2366	2.5814	3.7364
1981	3.6614	3.8222	3.8469	3.8741	3.8101	3.7279	3.6700	3.5807	3.7120	2.7425	3.7369	3.7867
1982	3.6822	3.5896	3.7840	3.8631	3.7745	3.7129	3.6677	3.4689	3.4656	2.6712	2.8907	3.4455
1983	3.2467	3.5731	3.3933	2.7806	3.2839	3.4290	2.1498	0.9573	0.3050	0.2784	0.8801	0.8877
1984	2.7644	3.2743	0.9371	1.4786	1.3465	1.3200	0.9002	0.6241	0.8340	2.2049	2.5495	1.7703
1985	1.9748	1.3816	1.2791	1.3585	1.5159	1.8963	3.4539	3.2993	3.4411	2.7778	3.2528	3.4294
1986	3.7021	3.5718	3.2122	3.0924	2.8297	3.3962	1.8115	2.6116	1.5875	1.9608	1.8429	1.8770
1987	2.3120	2.8696	3.0035	2.8386	3.3781	2.9457	3.0617	2.1115	2.2961	3.0520	2.9195	3.7154
1988	3.8754	3.7975	3.6630	2.7162	2.4339	3.5895	3.7047	3.0699	3.1064	2.7327	3.0377	3.8205
1989	3.7781	3.7300	3.7699	3.8316	3.4615	3.5764	3.7023	3.7825	3.6170	2.9290	2.8612	3.6081
1990	3.6738	3.5741	3.6351	3.8056	3.7222	3.7522	3.4890	3.3326	3.7204	2.3928	3.1231	3.5193
1991	3.2871	3.4879	3.3975	3.5954	3.7435	3.5345	3.6027	3.3960	3.6029	2.4647	2.8457	3.7900
1992	3.7220	3.6683	3.6531	3.6966	3.8057	3.6268	3.7613	3.8000	3.7539	3.3721	2.9835	3.7324
1993	3.5835	3.6437	3.7438	3.3272	3.3710	3.1816	3.5193	3.5606	3.5197	3.3990	3.7180	3.7918
1994	3.9005	3.7962	3.7711	3.5708	3.6062	3.7471	3.5576	3.7627	3.5976	2.9899	2.9955	3.7064
Avg	3.4860	3.5141	3.3856	3.3145	3.2901	3.3490	3.1871	3.0236	2.8842	2.5469	2.8594	3.3648
Max	3.9005	3.8631	3.8469	3.8741	3.8101	3.7746	3.7613	3.8000	3.7539	3.3990	3.7369	3.8521
Min	1.9748	1.3816	0.9371	1.3585	1.3465	1.3200	0.9002	0.6241	0.3050	0.2784	0.8801	0.8877
Std	0.5165	0.5365	0.7911	0.7314	0.7158	0.6245	0.8086	1.0285	1.0551	0.6412	0.5998	0.8063

%EVAP PER MILE

Reach 16: BRADY TO COZAD REACH

25.5 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0809	0.0246	0.0149	0.0123	0.0227	0.0319	0.0535	0.0686	0.0448	0.0380	0.0311	0.0407
1976	0.0566	0.0255	0.0157	0.0121	0.0190	0.0307	0.0560	0.0645	0.0583	0.0345	0.0366	0.0460
1977	0.0450	0.0240	0.0159	0.0129	0.0222	0.0288	0.0447	0.0518	0.0561	0.0319	0.0268	0.0602
1978	0.0709	0.0241	0.0159	0.0151	0.0242	0.0206	0.0578	0.0651	0.0595	0.0320	0.0306	0.0542
1979	0.0672	0.0247	0.0166	0.0160	0.0239	0.0231	0.0649	0.0628	0.0297	0.0282	0.0259	0.0373
1980	0.0677	0.0253	0.0134	0.0098	0.0106	0.0172	0.0222	0.0149	0.0235	0.0298	0.0322	0.0549
1981	0.0471	0.0294	0.0170	0.0140	0.0254	0.0351	0.0710	0.0366	0.0524	0.0316	0.0236	0.0498
1982	0.0513	0.0228	0.0135	0.0136	0.0239	0.0308	0.0904	0.0590	0.0479	0.0328	0.0225	0.0389
1983	0.0331	0.0201	0.0115	0.0060	0.0131	0.0204	0.0191	0.0163	0.0112	0.0179	0.0205	0.0177
1984	0.0182	0.0187	0.0049	0.0038	0.0053	0.0080	0.0122	0.0138	0.0184	0.0281	0.0278	0.0207
1985	0.0120	0.0054	0.0038	0.0040	0.0066	0.0111	0.0579	0.0523	0.0555	0.0300	0.0256	0.0352
1986	0.0341	0.0191	0.0108	0.0072	0.0095	0.0201	0.0235	0.0347	0.0309	0.0263	0.0202	0.0181
1987	0.0252	0.0107	0.0083	0.0066	0.0142	0.0158	0.0401	0.0290	0.0387	0.0389	0.0334	0.0658
1988	0.0490	0.0185	0.0131	0.0082	0.0096	0.0235	0.0636	0.0541	0.0580	0.0366	0.0345	0.0495
1989	0.0234	0.0224	0.0149	0.0120	0.0194	0.0249	0.0801	0.0618	0.0446	0.0357	0.0264	0.0603
1990	0.0585	0.0237	0.0162	0.0113	0.0221	0.0270	0.0571	0.0446	0.0508	0.0331	0.0351	0.0673
1991	0.0772	0.0230	0.0162	0.0148	0.0227	0.0345	0.0664	0.0461	0.0597	0.0337	0.0356	0.0675
1992	0.0562	0.0227	0.0151	0.0109	0.0209	0.0230	0.0641	0.0781	0.0443	0.0286	0.0316	0.0477
1993	0.0653	0.0249	0.0152	0.0112	0.0212	0.0184	0.0461	0.0592	0.0559	0.0370	0.0285	0.0596
1994	0.0590	0.0223	0.0145	0.0127	0.0199	0.0267	0.0586	0.0702	0.0556	0.0349	0.0306	0.0817
Avg	0.0499	0.0217	0.0134	0.0107	0.0178	0.0236	0.0525	0.0492	0.0448	0.0320	0.0290	0.0488
Max	0.0809	0.0294	0.0170	0.0160	0.0254	0.0351	0.0904	0.0781	0.0597	0.0389	0.0366	0.0817
Min	0.0120	0.0054	0.0038	0.0038	0.0053	0.0080	0.0122	0.0138	0.0112	0.0179	0.0202	0.0177
Std	0.0195	0.0053	0.0037	0.0035	0.0063	0.0072	0.0200	0.0188	0.0143	0.0047	0.0048	0.0169

%SEEP PER MILE

Reach 16: BRADY TO COZAD REACH

25.5 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976										0.0686		
1977										0.3566		
1978										0.4303		
1979												
1980								0.1300		0.6240	0.2221	
1981												
1982										0.0314		
1983							0.0340	0.3006	0.2304	0.1365		
1984					0.0074			0.2906	0.3975			0.3979
1985		0.1463		0.3037	0.4728							
1986				0.2566			0.0251		0.2980	0.4294	0.6461	0.2831
1987												
1988									0.0035			
1989												
1990										0.2401		
1991												
1992												
1993					0.1060							
1994												

%DIV PER MILE

Reach 16: BRADY TO COZAD REACH

25.5 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.2746	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.5478	1.7922	3.3377	3.2796	3.1939
1976	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1097	2.4918	3.1350	3.4725	3.6093	2.8533
1977	0.2033	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.9466	2.6064	3.1138	3.5624	2.2014
1978	0.0083	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036	1.8620	3.4479	3.0289	3.4208	3.3659
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0614	2.3031	0.7179	2.6913	3.6474	3.1406
1980	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0106	0.0931	0.4021	3.0769	3.1501	2.6322
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.4215	2.7717	3.6137	2.8565	3.5631	1.6089
1982	0.0096	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2.4281	3.2266	3.6500	3.6672	2.4297
1983	0.0240	0.0000	0.0000	0.0000	0.0000	0.0000	0.0547	0.0919	0.0753	0.3208	0.5975	0.2421
1984	0.0096	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0331	0.0851	1.9140	3.0339	0.4223
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5417	1.3733	2.7510	3.4720	3.5076	2.0552
1986	0.2529	0.0000	0.0000	0.0000	0.0000	0.0000	0.1149	0.5129	0.5387	2.1935	1.6279	0.3066
1987	0.0336	0.0000	0.0000	0.0000	0.0000	0.0000	0.1355	0.3841	0.6575	3.5364	3.4132	1.4246
1988	0.2394	0.0352	0.0000	0.0000	0.0000	0.0000	0.4583	0.6298	3.2542	2.7707	3.5893	2.9572
1989	2.5065	0.0520	0.0000	0.0000	0.0000	0.0000	1.1043	3.4508	3.0251	3.6380	3.4086	1.2258
1990	0.0496	0.0000	0.0000	0.0000	0.0000	0.0000	0.3605	1.4676	3.4634	3.3652	3.2801	3.0874
1991	0.2552	0.0000	0.0000	0.0000	0.0000	0.0000	0.6599	0.7978	2.4038	3.6074	3.6363	2.5727
1992	0.1662	0.0000	0.0000	0.0000	0.0000	0.0000	0.7005	2.8887	3.2827	3.5027	2.8448	3.0699
1993	0.0555	0.0000	0.0000	0.0000	0.0000	0.0000	0.4998	2.0558	3.0369	3.2515	3.3254	1.7479
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.1045	1.0282	2.3648	3.3821	3.1040	3.4663	1.5718
Avg	0.2049	0.0044	0.0000	0.0000	0.0000	0.0052	0.4133	1.5797	2.2449	2.9952	3.1815	2.1055
Max	2.5065	0.0520	0.0000	0.0000	0.0000	0.1045	2.4215	3.4508	3.6137	3.6500	3.6672	3.3659
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0331	0.0753	0.3208	0.5975	0.2421
Std	0.5379	0.0133	0.0000	0.0000	0.0000	0.0228	0.5738	1.0421	1.2715	0.7649	0.7388	0.9766

%EVAP PER MILE

Reach 17: COZAD TO OVERTON REACH

28.1 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0146	0.0047	0.0027	0.0021	0.0037	0.0053	0.0102	0.0233	0.0155	0.0470	0.0368	0.0154
1976	0.0091	0.0039	0.0023	0.0018	0.0031	0.0049	0.0107	0.0222	0.0550	0.0620	0.0789	0.0204
1977	0.0103	0.0049	0.0026	0.0024	0.0041	0.0055	0.0093	0.0159	0.0292	0.0630	0.0333	0.0164
1978	0.0144	0.0048	0.0028	0.0026	0.0047	0.0053	0.0126	0.0226	0.0498	0.0578	0.0402	0.0301
1979	0.0135	0.0048	0.0029	0.0028	0.0046	0.0049	0.0162	0.0234	0.0135	0.0164	0.0336	0.0265
1980	0.0167	0.0065	0.0019	0.0015	0.0026	0.0035	0.0073	0.0067	0.0103	0.0735	0.0512	0.0191
1981	0.0098	0.0053	0.0028	0.0021	0.0038	0.0059	0.0241	0.0212	0.0500	0.0253	0.0236	0.0197
1982	0.0102	0.0055	0.0027	0.0024	0.0036	0.0051	0.0212	0.0271	0.0350	0.0604	0.0377	0.0142
1983	0.0103	0.0035	0.0021	0.0016	0.0023	0.0034	0.0055	0.0071	0.0052	0.0086	0.0108	0.0075
1984	0.0047	0.0040	0.0019	0.0014	0.0018	0.0026	0.0045	0.0056	0.0078	0.0184	0.0296	0.0080
1985	0.0048	0.0023	0.0015	0.0015	0.0027	0.0033	0.0124	0.0129	0.0221	0.0356	0.0328	0.0117
1986	0.0056	0.0036	0.0021	0.0013	0.0024	0.0039	0.0080	0.0113	0.0150	0.0224	0.0115	0.0065
1987	0.0080	0.0027	0.0016	0.0014	0.0025	0.0036	0.0103	0.0102	0.0146	0.0335	0.0281	0.0124
1988	0.0067	0.0030	0.0018	0.0017	0.0024	0.0036	0.0113	0.0160	0.0528	0.0279	0.0304	0.0178
1989	0.0139	0.0060	0.0028	0.0020	0.0034	0.0042	0.0273	0.0385	0.0300	0.0419	0.0317	0.0180
1990	0.0174	0.0064	0.0036	0.0023	0.0039	0.0052	0.0113	0.0155	0.0503	0.0734	0.0300	0.0366
1991	0.0200	0.0058	0.0040	0.0027	0.0038	0.0064	0.0197	0.0170	0.0277	0.0577	0.0509	0.0360
1992	0.0178	0.0055	0.0032	0.0024	0.0036	0.0040	0.0152	0.0453	0.0324	0.0239	0.0342	0.0424
1993	0.0123	0.0053	0.0027	0.0018	0.0035	0.0038	0.0110	0.0251	0.0294	0.0199	0.0249	0.0144
1994	0.0084	0.0035	0.0021	0.0019	0.0032	0.0046	0.0142	0.0254	0.0446	0.0270	0.0410	0.0256
Avg	0.0114	0.0046	0.0025	0.0020	0.0033	0.0045	0.0131	0.0196	0.0295	0.0398	0.0346	0.0199
Max	0.0200	0.0065	0.0040	0.0028	0.0047	0.0064	0.0273	0.0453	0.0550	0.0735	0.0789	0.0424
Min	0.0047	0.0023	0.0015	0.0013	0.0018	0.0026	0.0045	0.0056	0.0052	0.0088	0.0108	0.0065
Std	0.0044	0.0012	0.0006	0.0005	0.0008	0.0010	0.0059	0.0099	0.0160	0.0199	0.0142	0.0098

%SEEP PER MILE

Reach 17: COZAD TO OVERTON REACH

28.1 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975												
1976												
1977												
1978												
1979												
1980								0.1567				
1981												
1982		0.0327		0.4881								
1983												
1984												
1985					0.0264							
1986							0.3404					
1987												
1988												
1989												
1990												
1991												
1992												
1993												0.1053
1994				0.0403								

%DIV PER MILE

Reach 17: COZAD TO OVERTON REACH

28.1 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1976	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1980	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Avg	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Max	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

%EVAP PER MILE

Reach 18: OVERTON TO ODESSA REACH

15.7 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0316	0.0102	0.0058	0.0047	0.0081	0.0115	0.0216	0.0522	0.0309	0.0893	0.0711	0.0348
1976	0.0197	0.0085	0.0051	0.0038	0.0065	0.0105	0.0222	0.0484	0.1061	0.0953	0.1407	0.0454
1977	0.0225	0.0107	0.0053	0.0054	0.0088	0.0114	0.0180	0.0295	0.0583	0.1211	0.0643	0.0363
1978	0.0306	0.0106	0.0061	0.0058	0.0105	0.0095	0.0254	0.0449	0.1127	0.1242	0.0798	0.0683
1979	0.0287	0.0104	0.0065	0.0059	0.0096	0.0092	0.0308	0.0454	0.0201	0.0306	0.0578	0.0570
1980	0.0356	0.0125	0.0041	0.0031	0.0043	0.0062	0.0098	0.0063	0.0120	0.1222	0.0872	0.0420
1981	0.0209	0.0116	0.0061	0.0046	0.0083	0.0130	0.0481	0.0417	0.0936	0.0470	0.0415	0.0421
1982	0.0218	0.0114	0.0059	0.0058	0.0077	0.0109	0.0448	0.0536	0.0611	0.1032	0.0571	0.0300
1983	0.0186	0.0073	0.0042	0.0028	0.0042	0.0062	0.0083	0.0075	0.0032	0.0076	0.0115	0.0079
1984	0.0084	0.0083	0.0027	0.0019	0.0022	0.0031	0.0045	0.0051	0.0080	0.0250	0.0532	0.0117
1985	0.0064	0.0027	0.0019	0.0022	0.0038	0.0049	0.0254	0.0265	0.0428	0.0582	0.0466	0.0213
1986	0.0113	0.0074	0.0040	0.0025	0.0041	0.0072	0.0110	0.0164	0.0210	0.0356	0.0189	0.0092
1987	0.0112	0.0047	0.0031	0.0026	0.0048	0.0063	0.0158	0.0152	0.0217	0.0486	0.0492	0.0237
1988	0.0126	0.0060	0.0037	0.0032	0.0040	0.0072	0.0208	0.0279	0.1127	0.0451	0.0557	0.0389
1989	0.0302	0.0132	0.0063	0.0040	0.0069	0.0084	0.0552	0.0809	0.0499	0.0791	0.0565	0.0345
1990	0.0374	0.0142	0.0079	0.0050	0.0084	0.0103	0.0231	0.0249	0.0886	0.1265	0.0658	0.0807
1991	0.0439	0.0111	0.0068	0.0059	0.0082	0.0141	0.0402	0.0307	0.0504	0.1059	0.1060	0.0819
1992	0.0408	0.0121	0.0070	0.0050	0.0078	0.0080	0.0329	0.0985	0.0691	0.0423	0.0596	0.0774
1993	0.0272	0.0117	0.0058	0.0038	0.0061	0.0059	0.0214	0.0488	0.0516	0.0262	0.0395	0.0276
1994	0.0183	0.0076	0.0045	0.0039	0.0062	0.0095	0.0306	0.0567	0.0858	0.0434	0.0728	0.0513
Avg	0.0239	0.0096	0.0052	0.0041	0.0065	0.0087	0.0255	0.0381	0.0550	0.0688	0.0617	0.0411
Max	0.0439	0.0142	0.0079	0.0059	0.0105	0.0141	0.0552	0.0985	0.1127	0.1265	0.1407	0.0819
Min	0.0064	0.0027	0.0019	0.0019	0.0022	0.0031	0.0045	0.0051	0.0032	0.0076	0.0115	0.0079
Std	0.0106	0.0029	0.0015	0.0013	0.0022	0.0028	0.0132	0.0236	0.0347	0.0379	0.0276	0.0221

%SEEP PER MILE

Reach 18: OVERTON TO ODESSA REACH

15.7 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975		0.6520	0.2095		0.1043	0.2063	0.0101		0.0727			0.7529
1976	0.9291	1.2195	1.0255	1.0021	0.4467	0.2985	0.3650					0.1641
1977	0.0442	1.0920	0.2384	0.2338	0.4978		0.7329					0.4988
1978		0.0852	0.7870		0.2519				0.0484			0.1233
1979	0.8301	0.7010	0.0945						0.3565			
1980	0.2184		0.0302	0.3549								0.3941
1981	0.4626	0.6857			0.1404	0.4152						0.7824
1982			0.0851			0.4052						
1983		0.8729	0.6962	0.0280					0.2305		0.0520	0.4428
1984	0.0512	0.2084	0.0723	0.0373		0.0964		0.1652	0.0261			0.0664
1985	0.3171	0.4734	0.1676		0.2002	0.1289		0.0126				
1986		0.7581		0.1517					0.4130			
1987		0.3657	0.2644	0.1085								
1988			0.0758		0.2064							
1989	0.9034		0.0976									
1990		0.5384		0.1001	0.1468						0.0933	0.5019
1991	0.6422			0.7588	0.1905	0.1990						
1992	0.3265	0.0040			0.0498	0.2267						
1993	0.3415	0.6201	0.7018	0.4682								
1994	0.1684		0.0179									

%DIV PER MILE

Reach 18: OVERTON TO ODESSA REACH

15.7 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	1.2879	0.9841	0.0731	0.0000	0.0000	0.0892	0.6847	1.4363	1.1315	3.3057	2.9791	0.9157
1976	1.5850	0.7045	0.0000	0.0000	0.0000	0.1737	0.9803	0.8139	2.3995	3.1581	4.6621	1.9518
1977	1.5700	0.7032	0.0000	0.0000	0.0000	0.4412	0.7411	0.9214	2.0173	4.0440	3.7386	1.8480
1978	1.2263	0.3029	0.0000	0.0000	0.0000	0.0000	0.3983	1.4688	3.6300	2.7383	3.7623	2.8313
1979	1.7728	0.9125	0.0000	0.0000	0.0000	0.0000	0.3935	2.0228	0.6398	1.1489	3.0285	3.1106
1980	3.3932	0.3212	0.0000	0.0000	0.0000	0.0000	0.1443	0.1904	0.3314	4.2113	3.1367	2.3311
1981	2.3957	1.7283	0.0000	0.0000	0.0000	0.2061	2.2264	2.2169	3.7646	1.4798	2.2476	2.3065
1982	0.7610	0.0000	0.0000	0.0000	0.0000	0.0000	0.4729	1.2881	3.1210	4.3265	3.5641	1.9482
1983	0.1269	0.0000	0.0000	0.0000	0.0000	0.0000	0.4101	0.2078	0.0984	0.1672	0.3332	0.2459
1984	0.3525	0.0065	0.0000	0.0000	0.0000	0.0000	0.0001	0.0419	0.1456	0.7625	2.4029	0.5357
1985	0.4204	0.2120	0.0000	0.0000	0.0000	0.0000	0.3800	0.4999	0.7681	2.4334	1.9960	1.1152
1986	1.0120	0.5720	0.0000	0.0000	0.0000	0.0000	0.1070	0.5461	0.6161	1.2896	0.7876	0.4329
1987	0.3850	0.1699	0.0000	0.0000	0.0000	0.0000	0.0806	0.4160	0.4930	1.2766	1.8644	0.7656
1988	0.7830	0.8017	0.3094	0.0000	0.0000	0.0621	0.4532	0.7486	2.6666	1.0234	1.4333	1.3861
1989	0.3496	0.0000	0.0000	0.0000	0.0000	0.0000	0.6340	3.2831	1.2606	2.1587	2.2663	1.3528
1990	1.2915	0.0000	0.0000	0.0000	0.0000	0.0000	0.1376	0.9573	3.3306	4.8607	2.1522	3.2321
1991	1.5186	0.0337	0.0000	0.0000	0.0000	0.0000	0.3252	0.4888	0.6113	2.3160	2.2423	1.2378
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1242	2.4755	2.3696	0.9175	1.0579	1.4882
1993	0.1704	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1395	0.6947	0.2060	0.6142	0.4282
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0336	1.3138	0.9814	2.2138	0.7558
Avg	1.0241	0.3776	0.0191	0.0000	0.0000	0.0486	0.4347	1.0098	1.5702	2.1403	2.3242	1.5110
Max	3.3932	1.7283	0.3094	0.0000	0.0000	0.4412	2.2264	3.2831	3.7646	4.8607	4.6621	3.2321
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0336	0.0984	0.1672	0.3332	0.2459
Std	0.8553	0.4632	0.0685	0.0000	0.0000	0.1077	0.4895	0.8789	1.1967	1.4048	1.1110	0.8862

%EVAP PER MILE

Reach 19: ODESSA TO GRAND ISLAND REACH

56.2 miles

%Evap = Evap divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0280	0.0100	0.0050	0.0039	0.0069	0.0087	0.0177	0.0407	0.0252	0.0727	0.0747	0.0313
1976	0.0205	0.0090	0.0041	0.0037	0.0051	0.0084	0.0192	0.0375	0.1104	0.1076	0.1817	0.0391
1977	0.0204	0.0111	0.0050	0.0047	0.0075	0.0095	0.0140	0.0228	0.0416	0.1527	0.0688	0.0358
1978	0.0270	0.0091	0.0059	0.0049	0.0093	0.0043	0.0179	0.0372	0.1140	0.1469	0.0927	0.0657
1979	0.0295	0.0102	0.0055	0.0050	0.0060	0.0057	0.0196	0.0290	0.0172	0.0247	0.0596	0.0526
1980	0.0340	0.0109	0.0033	0.0026	0.0035	0.0043	0.0077	0.0048	0.0090	0.1113	0.1016	0.0400
1981	0.0202	0.0112	0.0051	0.0038	0.0070	0.0105	0.0415	0.0375	0.1026	0.0422	0.0309	0.0434
1982	0.0190	0.0094	0.0048	0.0047	0.0054	0.0077	0.0359	0.0338	0.0465	0.0994	0.0662	0.0271
1983	0.0161	0.0069	0.0034	0.0022	0.0034	0.0050	0.0066	0.0058	0.0025	0.0058	0.0091	0.0065
1984	0.0066	0.0066	0.0021	0.0013	0.0016	0.0024	0.0034	0.0040	0.0061	0.0172	0.0519	0.0093
1985	0.0052	0.0022	0.0015	0.0018	0.0029	0.0036	0.0170	0.0180	0.0357	0.0584	0.0433	0.0179
1986	0.0082	0.0068	0.0032	0.0021	0.0032	0.0055	0.0087	0.0134	0.0184	0.0317	0.0157	0.0073
1987	0.0090	0.0039	0.0026	0.0021	0.0038	0.0044	0.0116	0.0123	0.0157	0.0447	0.0462	0.0196
1988	0.0105	0.0050	0.0032	0.0026	0.0031	0.0059	0.0183	0.0230	0.0996	0.0412	0.0520	0.0340
1989	0.0269	0.0105	0.0051	0.0034	0.0057	0.0068	0.0492	0.0820	0.0451	0.0437	0.0552	0.0221
1990	0.0275	0.0103	0.0067	0.0028	0.0060	0.0073	0.0192	0.0199	0.0676	0.1602	0.0664	0.0920
1991	0.0448	0.0096	0.0058	0.0057	0.0064	0.0114	0.0365	0.0262	0.0354	0.1173	0.1131	0.0757
1992	0.0379	0.0104	0.0059	0.0041	0.0062	0.0066	0.0258	0.0986	0.0592	0.0385	0.0563	0.0762
1993	0.0246	0.0111	0.0053	0.0034	0.0050	0.0036	0.0158	0.0297	0.0398	0.0172	0.0306	0.0216
1994	0.0142	0.0057	0.0036	0.0032	0.0050	0.0056	0.0216	0.0484	0.0621	0.0353	0.0724	0.0463
Avg	0.0215	0.0085	0.0044	0.0034	0.0053	0.0064	0.0204	0.0312	0.0477	0.0684	0.0644	0.0382
Max	0.0448	0.0112	0.0067	0.0057	0.0093	0.0114	0.0492	0.0986	0.1140	0.1602	0.1817	0.0920
Min	0.0052	0.0022	0.0015	0.0013	0.0016	0.0024	0.0034	0.0040	0.0025	0.0058	0.0091	0.0065
Std	0.0105	0.0026	0.0014	0.0012	0.0019	0.0024	0.0117	0.0233	0.0345	0.0477	0.0371	0.0235

%SEEP PER MILE

Reach 19: ODESSA TO GRAND ISLAND REACH

56.2 miles

%Seep = Seep divided by Total Inflow to the Reach MULTIPLIED BY 100

Seep Computed from River Water Balance with river evaporation as a separate variable.

The months in this table with values are months of a net losing or seeping river. All other months have a net gaining river.

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.2666	0.2434	0.4072	0.2251	0.1382						0.4637	
1976	0.3405	0.1561		0.2015					0.2759	0.9518	1.3583	0.9573
1977	0.2292	0.1427	0.3839	0.3205						0.4382	0.5168	
1978	0.1870	0.2600	0.1442	0.4968						0.9512	0.7961	0.9156
1979	0.4337	0.2415	0.2297	0.3410	0.4217				0.4159		0.3587	0.7015
1980	0.4552	0.2993		0.3853	0.0936		0.0395	0.2426			0.1920	0.6221
1981	0.3152	0.3176	0.2023	0.3026	0.2667				0.2928	0.6775		0.5441
1982	0.2859										0.0336	0.4714
1983		0.0709		0.2305	0.0916	0.0447	0.1619		0.1185	0.1095	0.1612	0.1976
1984						0.0082	0.0324		0.0649		0.5319	0.2977
1985	0.1862	0.0245	0.0975	0.2854								
1986				0.0411			0.3029	0.0051	0.0337	0.1491	0.3720	0.2638
1987	0.1225		0.0998	0.1676	0.0975			0.0638			0.3941	0.4372
1988	0.3702	0.1445	0.3227	0.2900		0.0814	0.1259	0.1497		0.2006	0.1922	0.2818
1989				0.0945	0.0826	0.1559		0.0912			0.2422	
1990			0.3194				0.0024			0.5663	0.1041	0.4685
1991	0.2442	0.3462	0.5582	0.2007			0.1698	0.1611		1.0087	0.8704	0.8192
1992	0.5798	0.1019	0.1310					0.1482		0.3107	0.5846	0.4392
1993	0.1312			0.4136	0.6159							
1994				0.2924	0.3213							0.4433

%DIV PER MILE

Reach 19: ODESSA TO GRAND ISLAND REACH

56.2 miles

%Div = Diversions divided by Total Inflow to the Reach MULTIPLIED BY 100

Wtr Yr	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1975	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1976	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1980	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Avg	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Max	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Min	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

APPENDIX F

Additional Tables of Net Hydrologic Effects and Reductions to Target Flows Shortages

For the sake of brevity, all of the modeling results associated with alternatives were not included in the Draft Report.

Appendix F includes tables of

1) Net Hydrologic Effects,
2) Reductions to Target Flow Shortages with Diversions, and
3) Reductions to Target Flows without Diversions

for alternatives whose 20-year time series of modeling results are not presented in Chapter 8.

Tables are included, in the order that they are referenced in Chapter 8, for the following alternatives categories:

B. Reservoirs,

C. Agricultural Conservation,

F. Incentive Based Reductions to Agricultural Water Use, and

G. Groundwater

Table B.1
Horse Creek Re-Regulating Reservoir with Storage throughout the Irrigation Season
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	-3802	-4708	-120	-2	-856	-9488
1976	9033	0	0	0	0	0	0	-3250	-3574	-708	-382	-1890	-771
1977	9400	0	0	0	0	0	0	-2516	-5068	-978	-894	-400	-456
1978	9440	0	0	0	0	0	0	-1042	-2480	-722	0	-128	5068
1979	4102	0	0	0	0	0	0	-1336	-4024	-1834	0	-1542	-4634
1980	8392	0	0	0	0	0	0	-3738	-1856	0	-226	-882	1690
1981	6318	0	0	0	0	0	0	0	-1332	-2090	-2122	-1206	-432
1982	6596	0	0	0	0	0	0	-3796	0	-1322	-410	-2208	-1138
1983	7378	0	0	0	0	0	0	0	-740	-660	-950	-3540	1488
1984	5799	0	0	0	0	0	0	-1156	-5228	-3370	-1530	-48	-5543
1985	11000	0	0	0	0	0	0	-1908	-2140	-991	-154	-1384	4523
1986	6161	0	0	0	0	0	0	-4532	-4844	-1975	-34	0	-5225
1987	11000	0	0	0	0	0	0	-4948	-6199	0	0	0	-147
1988	11000	0	0	0	0	0	0	-4310	-5500	-628	-32	-1056	-526
1989	11000	0	0	0	0	0	0	-2384	-758	-494	-950	-46	6168
1990	4529	0	0	0	0	0	0	0	-124	-1496	-1176	-1420	313
1991	4146	0	0	0	0	0	0	0	-624	-1384	-474	-2452	-788
1992	4838	0	0	0	0	0	0	0	-310	-3168	-1076	-632	-348
1993	5064	0	0	0	0	0	0	0	-310	-3168	-1076	-632	-122
1994	5064	0	0	0	0	0	0	0	-310	-3168	-1076	-632	-122
Average	7013	0	0	0	0	0	0	-1941	-2507	-1414	-628	-1048	-324

Table B.2
Horse Creek Re-Regulating Reservoir with Storage throughout the Irrigation Season
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	-459	-592	-2	0	-119	-1172
1976	5857	0	0	0	0	0	0	-370	-128	-2	-1	-118	5238
1977	7702	0	0	0	0	0	0	-379	-223	-4	-13	-52	7031
1978	7806	0	0	0	0	0	0	-108	-59	-3	0	-4	7631
1979	2489	0	0	0	0	0	0	-128	-354	0	0	-78	1929
1980	5529	0	0	0	0	0	0	0	0	0	-3	-71	5454
1981	4542	0	0	0	0	0	0	0	-10	-48	0	-66	4417
1982	5223	0	0	0	0	0	0	-164	0	-9	-5	-271	4774
1983	7033	0	0	0	0	0	0	0	0	0	0	0	7033
1984	0	0	0	0	0	0	0	0	0	0	-38	0	-38
1985	0	0	0	0	0	0	0	-258	-163	-12	-3	0	-436
1986	5916	0	0	0	0	0	0	0	0	0	0	0	5916
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	8241	0	0	0	0	0	0	-1261	-205	-13	-1	-156	6604
1989	8842	0	0	0	0	0	0	-69	-17	0	-10	0	8746
1990	4155	0	0	0	0	0	0	0	-2	-2	-22	-48	4080
1991	2625	0	0	0	0	0	0	0	0	-3	-1	-121	2500
1992	2818	0	0	0	0	0	0	0	-17	-82	-12	-20	2687
1993	4103	0	0	0	0	0	0	0	-30	0	-62	0	4011
1994	0	0	0	0	0	0	0	0	-8	0	-11	-75	-95
Average	4144	0	0	0	0	0	0	-160	-91	-9	-10	-60	3814

Table B.3
Horse Creek Re-Regulating Reservoir with Storage throughout the Irrigation Season
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	-459	-592	-2	0	-119	-1172
1976	2832	0	0	0	0	0	0	-370	-128	-2	-1	-118	2213
1977	4420	0	0	0	0	0	0	-379	-223	-4	-13	-52	3749
1978	4526	0	0	0	0	0	0	-108	-59	-3	0	-4	4352
1979	1356	0	0	0	0	0	0	-128	-354	0	0	-78	797
1980	2297	0	0	0	0	0	0	0	0	0	-3	-71	2223
1981	2223	0	0	0	0	0	0	0	-10	-48	0	-66	2098
1982	3162	0	0	0	0	0	0	-164	0	-9	-5	-271	2713
1983	3290	0	0	0	0	0	0	0	0	0	0	0	3290
1984	0	0	0	0	0	0	0	0	0	0	-38	0	-38
1985	0	0	0	0	0	0	0	-258	-163	-12	-3	0	-436
1986	4512	0	0	0	0	0	0	0	0	0	0	0	4512
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	5650	0	0	0	0	0	0	-1261	-205	-13	-1	-156	4013
1989	4534	0	0	0	0	0	0	-69	-17	0	-10	0	4438
1990	2052	0	0	0	0	0	0	0	-2	-2	-22	-48	1977
1991	1675	0	0	0	0	0	0	0	0	-3	-1	-121	1550
1992	909	0	0	0	0	0	0	0	-17	-82	-12	-20	778
1993	3078	0	0	0	0	0	0	0	-30	0	-62	0	2986
1994	0	0	0	0	0	0	0	0	-8	0	-11	-75	-95
Average	2327	0	0	0	0	0	0	-160	-91	-9	-10	-60	1997

Table B.4
10,000 ac-ft Reservoir in middle of Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9253	183	99	62	42	31	25	20	-285
1976	17	14	-9988	58	8679	271	156	103	75	58	47	39	-474
1977	33	29	25	22	20	18	16	15	14	13	12	11	226
1978	10	10	9	9	8	-9992	9207	190	105	67	48	37	-292
1979	30	25	22	19	17	15	14	13	12	-9989	9191	185	-448
1980	105	68	-9951	86	-343	-404	-366	-361	-345	8815	437	282	-2179
1981	205	160	-9871	156	8762	343	219	160	126	104	89	78	531
1982	89	62	-9944	98	8724	306	189	125	104	85	73	83	-36
1983	57	51	-9954	90	-343	-400	-358	-338	-325	-319	-330	-304	-12674
1984	-273	9901	-9514	382	-324	-234	-226	-228	-249	565	8190	-9495	-2405
1985	409	-330	-214	-192	-173	-166	5475	3794	439	323	260	-9783	-157
1986	8622	1065	-9742	250	-417	-288	-278	-270	-257	556	561	-1833	-2032
1987	-109	-218	-171	-156	-151	-151	-153	-190	-192	615	8233	-9452	-2091
1988	9604	-9509	416	-291	-183	9065	334	381	297	247	214	189	10962
1989	170	155	-9858	179	8805	377	256	199	165	144	129	-9883	-9163
1990	9319	280	191	-9850	9378	295	199	154	129	112	101	93	10399
1991	86	80	-6632	-3190	8928	301	194	145	-9883	9263	273	180	-255
1992	136	112	-9903	134	6871	-7780	9294	359	237	177	144	121	-97
1993	107	95	-9914	127	8759	-9668	9422	342	226	168	137	-9884	-10083
1994	157	-317	-345	-306	8981	450	299	225	180	151	132	116	9523
Average	1438	32	-5267	-1119	4242	-873	1710	244	-455	559	1398	-2461	-351

Table B.5
10,000 ac-ft Reservoir in middle of Reach 8
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8239	172	93	56	39	28	16	16	8638
1976	11	10	0	0	7903	251	137	94	53	20	5	15	8499
1977	27	21	18	17	18	17	14	14	12	7	7	9	181
1978	8	8	7	6	8	0	8533	170	87	20	22	15	8883
1979	18	19	18	15	11	15	13	10	7	0	6612	100	6837
1980	69	55	0	0	0	0	0	0	0	6238	311	154	6827
1981	148	113	0	0	7132	310	199	149	90	57	0	42	8240
1982	54	60	0	0	8562	278	171	123	94	73	64	43	9522
1983	54	41	0	0	0	0	0	0	0	0	0	0	95
1984	0	8522	0	0	0	0	0	0	0	0	4256	0	12778
1985	0	0	0	0	0	0	4889	3476	374	288	237	0	9263
1986	8319	891	0	0	0	0	0	0	0	0	0	0	9210
1987	0	0	0	0	0	0	0	0	0	0	5723	0	5723
1988	7204	0	0	0	0	8438	463	324	254	196	170	145	17196
1989	138	150	0	0	8278	335	230	165	150	0	100	0	9545
1990	8683	248	134	0	8996	287	187	145	112	56	83	53	19005
1991	55	63	0	0	8471	281	161	0	0	3068	110	82	12292
1992	80	103	0	0	6364	0	8629	279	214	134	88	80	16169
1993	87	84	0	0	5486	0	8903	314	204	0	126	0	15204
1994	0	0	0	0	7245	437	279	202	157	0	115	76	8510
Average	1248	519	10	2	3846	341	1645	276	92	509	902	41	9632

Table B.6
10,000 ac-ft Reservoir in middle of Reach 8
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	3231	82	27	4	9	0	0	1	3353
1976	3	3	0	0	3221	120	19	3	0	0	0	0	3371
1977	3	6	7	6	6	3	3	1	0	0	0	0	37
1978	1	2	2	2	3	0	637	3	1	0	0	0	652
1979	1	2	4	5	4	3	2	1	3	0	118	7	150
1980	8	9	0	0	0	0	0	0	0	12	1	8	38
1981	8	20	0	0	2753	90	22	6	2	0	0	0	2901
1982	5	6	0	0	3745	65	10	2	1	0	0	2	3836
1983	7	13	0	0	0	0	0	0	0	0	0	0	20
1984	0	3881	0	0	0	0	0	0	0	0	185	0	4066
1985	0	0	0	0	0	0	747	1065	55	2	2	0	1872
1986	3150	358	0	0	0	0	0	0	0	0	0	0	3508
1987	0	0	0	0	0	0	0	0	0	0	64	0	64
1988	1175	0	0	0	0	4039	113	100	11	1	1	5	5446
1989	10	12	0	0	3926	120	19	1	3	0	0	0	4091
1990	572	17	26	0	3587	109	77	6	1	0	0	1	4396
1991	7	11	0	0	2817	78	11	0	0	4	0	5	2934
1992	5	7	0	0	3325	0	2114	3	9	4	3	5	5476
1993	23	22	0	0	2765	0	2193	9	5	0	1	0	5018
1994	0	0	0	0	3941	172	14	5	1	0	0	1	4154
Average	249	218	2	1	1666	244	301	60	5	1	19	2	2769

Table B.7
10,000 ac-ft Lined Reservoir in middle of Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9991	0	0	0	0	0	0	0	-9
1976	0	0	-10000	0	9975	0	0	0	0	0	0	0	-25
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-10000	9939	0	0	0	0	0	-61
1979	0	0	0	0	0	0	0	0	0	-10000	9927	0	-73
1980	0	0	-10000	0	-3	-8	-18	-50	-64	9799	0	0	-343
1981	0	0	-10000	0	9975	0	0	0	0	0	0	0	-25
1982	0	0	-10000	0	9983	0	0	0	0	0	0	0	-17
1983	0	0	-10000	0	-11	-16	-22	-39	-55	-72	-101	-90	-10406
1984	-68	8552	-8617	0	-2	-12	-22	-40	-74	0	9737	-10000	-545
1985	0	-33	-19	-9	-3	-5	4889	4977	0	0	0	-10000	-202
1986	8380	1577	-10000	0	-15	-15	-40	-60	-67	0	0	-271	-511
1987	-57	-41	-17	-8	-8	-15	-22	-65	-74	0	9734	-10000	-573
1988	9955	-10000	0	-6	-2	9967	0	0	0	0	0	0	9914
1989	0	0	-10000	0	9989	0	0	0	0	0	0	-10000	-10011
1990	9956	0	0	-10000	9990	0	0	0	0	0	0	0	9946
1991	0	0	-6707	-3293	9978	0	0	0	-10000	9900	0	0	-121
1992	0	0	-10000	0	6564	-6591	9917	0	0	0	0	0	-111
1993	0	0	-10000	0	9992	-10000	9947	0	0	0	0	-10000	-10061
1994	0	-38	-11	-10	9983	0	0	0	0	0	0	0	9925
Average	1408	1	-3269	-1166	4819	-835	1729	236	-317	481	1465	-2518	-166

Table B.8
10,000 ac-ft Lined Reservoir in middle of Reach 8
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8896	0	0	0	0	0	0	0	8896
1976	0	0	0	0	9084	0	0	0	0	0	0	0	9084
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	9210	0	0	0	0	0	9210
1979	0	0	0	0	0	0	0	0	0	0	7141	0	7141
1980	0	0	0	0	0	0	0	0	0	6935	0	0	6935
1981	0	0	0	0	8119	0	0	0	0	0	0	0	8119
1982	0	0	0	0	9797	0	0	0	0	0	0	0	9797
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8097	0	0	0	0	0	0	0	0	5060	0	13158
1985	0	0	0	0	0	0	4524	4561	0	0	0	0	9086
1986	8085	1319	0	0	0	0	0	0	0	0	0	0	9404
1987	0	0	0	0	0	0	0	0	0	0	6767	0	6767
1988	7467	0	0	0	0	9277	0	0	0	0	0	0	16744
1989	0	0	0	0	9391	0	0	0	0	0	0	0	9391
1990	9277	0	0	0	9584	0	0	0	0	0	0	0	18861
1991	0	0	0	0	9468	0	0	0	0	3279	0	0	12748
1992	0	0	0	0	6374	0	9207	0	0	0	0	0	15581
1993	0	0	0	0	6258	0	9399	0	0	0	0	0	15657
1994	0	0	0	0	8053	0	0	0	0	0	0	0	8053
Average	1241	471	0	0	4251	464	1617	228	0	511	948	0	9732

Table B.9
10,000 ac-ft Lined Reservoir in middle of Reach 8
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	3489	0	0	0	0	0	0	0	3489
1976	0	0	0	0	3703	0	0	0	0	0	0	0	3703
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	688	0	0	0	0	0	688
1979	0	0	0	0	0	0	0	0	0	0	128	0	128
1980	0	0	0	0	0	0	0	0	0	13	0	0	13
1981	0	0	0	0	3134	0	0	0	0	0	0	0	3134
1982	0	0	0	0	4236	0	0	0	0	0	0	0	4236
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	3688	0	0	0	0	0	0	0	0	220	0	3907
1985	0	0	0	0	0	0	667	1398	0	0	0	0	2065
1986	3062	530	0	0	0	0	0	0	0	0	0	0	3592
1987	0	0	0	0	0	0	0	0	0	0	76	0	76
1988	1218	0	0	0	0	4441	0	0	0	0	0	0	5659
1989	0	0	0	0	4434	0	0	0	0	0	0	0	4434
1990	612	0	0	0	3821	0	0	0	0	0	0	0	4432
1991	0	0	0	0	3148	0	0	0	0	5	0	0	3153
1992	0	0	0	0	3177	0	2256	0	0	0	0	0	5433
1993	0	0	0	0	3154	0	2315	0	0	0	0	0	5469
1994	0	0	0	0	4381	0	0	0	0	0	0	0	4381
Average	245	211	0	0	1837	222	296	70	0	1	21	0	2903

Table B.10
50,000 ac-ft Reservoir in middle of Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-12920	11954	237	127	80	55	41	32	26	-369
1976	21	18	-23524	-18092	33857	4100	398	381	267	201	159	130	-1883
1977	109	94	81	72	64	57	52	47	43	39	36	34	727
1978	31	29	28	26	24	-10955	10121	222	128	85	64	52	-144
1979	43	37	33	30	27	25	23	21	20	-11131	10254	213	-404
1980	123	82	-23740	-23640	-3578	-2343	-2070	-1982	-1869	43955	2083	1322	-11658
1981	947	728	-22219	-22202	31785	11820	1097	761	578	467	394	340	2495
1982	299	267	-9912	-7654	16339	597	400	306	252	217	192	173	1475
1983	159	146	-23665	-23562	-3520	-2302	-2013	-1855	-1759	-1709	-1749	-1607	-63437
1984	-1446	11130	-13646	-236	-1168	-1031	-1048	-1089	-1213	2846	40961	-21268	12792
1985	-22689	-1541	-1363	-1115	-981	-916	7749	27051	11487	1931	1469	-22614	-1531
1986	9516	13709	-22562	-22715	-2837	-1701	-1571	-1478	-1384	2697	2738	-9226	-34817
1987	-395	-1127	-895	-819	-627	-952	-784	-979	-986	3050	32284	-16117	11454
1988	25963	-13160	-20777	-11746	-751	16521	28542	2232	1513	1280	1081	939	32739
1989	837	757	-13328	-23096	34805	1358	962	772	660	586	134	-10158	-3310
1990	10269	623	310	-23349	22433	822	397	491	429	388	159	336	13908
1991	318	302	-6419	-11248	10764	6179	566	433	-23439	22126	729	506	818
1992	402	345	-13003	-23456	7277	-22304	27162	18048	1348	916	700	569	-1997
1993	486	426	-11567	-14519	24509	-22917	22518	905	627	488	411	-23442	-22076
1994	-2448	-20548	-4683	-1888	44572	1964	1263	926	729	604	321	457	21420
Average	1167	-183	-10583	-12156	11245	-1088	4714	2265	-621	3454	4663	-4967	-2290

Table B.11
50,000 ac-ft Reservoir in middle of Reach 8
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	7160	129	82	49	39	24	14	14	7511
1976	7	7	0	0	17731	2593	335	213	115	42	11	32	21088
1977	45	35	32	31	30	35	24	27	22	13	14	16	324
1978	14	12	11	10	12	0	6246	116	64	16	18	13	6532
1979	15	14	15	14	13	13	13	14	11	0	6113	76	6312
1980	48	43	0	0	0	0	0	0	0	19859	905	475	21330
1981	355	310	0	0	14567	6218	667	433	314	150	0	114	23129
1982	124	131	0	0	9388	279	211	164	128	120	107	70	10722
1983	78	63	0	0	0	0	0	0	0	0	0	0	141
1984	0	7903	0	0	0	0	0	0	0	0	17439	0	25342
1985	0	0	0	0	0	0	4263	21313	7773	1160	915	0	35424
1986	6230	7504	0	0	0	0	0	0	0	0	0	0	13734
1987	0	0	0	0	0	0	0	0	0	0	15119	0	15119
1988	10460	0	0	0	0	11257	15614	1350	981	645	543	467	41318
1989	355	379	0	0	26120	736	487	428	349	0	266	0	29141
1990	5084	285	264	0	16195	625	431	285	241	126	197	123	23856
1991	107	121	0	0	7240	3728	278	0	0	4793	191	133	16609
1992	129	170	0	0	5670	0	16554	9376	749	408	292	252	33600
1993	219	201	0	0	12117	0	14736	535	340	0	239	0	28389
1994	0	0	0	0	29453	1348	712	539	373	0	302	202	32929
Average	1163	859	16	3	7285	1348	3033	1742	576	1368	2134	100	19627

Table B.12
50,000 ac-ft Reservoir in middle of Reach 8
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4175	106	34	5	11	0	0	1	4332
1976	4	4	0	0	12568	1813	75	12	1	0	0	1	14480
1977	11	19	21	19	18	17	10	3	1	0	0	1	120
1978	4	6	6	7	8	0	700	4	1	0	0	0	736
1979	2	3	6	8	6	5	3	2	5	0	132	8	180
1980	9	11	0	0	0	0	0	0	0	58	3	40	121
1981	37	69	0	0	9987	3090	111	26	9	2	0	2	13352
1982	20	23	0	0	7014	126	21	3	3	1	0	7	7220
1983	20	36	0	0	0	0	0	0	0	0	0	0	56
1984	0	4808	0	0	0	0	0	0	0	0	924	0	5732
1985	0	0	0	0	0	0	1057	7597	1443	14	12	0	10123
1986	3477	4611	0	0	0	0	0	0	0	0	0	0	8088
1987	0	0	0	0	0	0	0	0	0	0	252	0	252
1988	3299	0	0	0	0	7362	6062	557	61	6	4	27	17407
1989	49	38	0	0	15519	433	71	4	30	0	1	0	16145
1990	631	38	69	0	8580	303	227	18	3	0	2	3	9879
1991	26	42	0	0	3396	1609	33	0	0	10	1	13	5129
1992	14	22	0	0	3322	0	6179	130	52	23	15	23	9982
1993	105	97	0	0	7736	0	5341	24	15	0	4	0	13322
1994	0	0	0	0	19538	748	143	19	5	0	1	5	20459
Average	385	493	5	2	4603	781	999	422	81	5	68	7	7851

Table B.13
10,000 ac-ft Reservoir in middle of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9234	183	99	62	42	31	25	20	-284
1976	17	14	-9988	58	8680	271	156	103	73	38	47	39	-472
1977	33	29	25	22	20	18	16	15	14	13	12	11	228
1978	10	10	9	9	8	-9992	9205	190	105	67	48	37	-294
1979	30	25	22	19	17	15	14	13	12	-9989	9184	185	-455
1980	105	68	-9951	86	-543	-404	-366	-362	-348	8801	437	252	-2197
1981	205	160	-9871	156	8766	343	219	160	126	104	89	78	534
1982	69	62	-9944	98	8729	306	189	135	104	85	73	64	-31
1983	37	51	-9954	90	-543	-401	-359	-338	-327	-321	-337	-312	-12695
1984	-277	8998	-9514	382	-323	-233	-226	-228	-251	565	8170	-9495	-2430
1985	409	-334	-213	-189	-173	-165	5475	3790	419	323	280	-9783	-161
1986	8622	1068	-9742	250	-410	-285	-276	-272	-256	356	561	-1846	-2029
1987	-110	-218	-169	-156	-151	-153	-149	-190	-198	615	8215	-9452	-2116
1988	9602	-9509	416	-292	-182	9062	534	381	297	247	214	189	10957
1989	170	155	-9858	179	8805	277	256	199	165	144	129	-9883	-9163
1990	9316	280	191	-9850	9379	295	199	154	129	112	101	92	10398
1991	86	80	-6632	-3190	8928	301	194	145	-9883	9231	273	180	-267
1992	136	112	-9903	134	6871	-7778	9296	359	237	177	144	121	-94
1993	107	95	-9914	127	8763	-9668	9420	342	226	168	137	-9884	-10080
1994	157	-321	-346	-306	9984	450	299	225	180	151	132	116	9522
Average	1437	31	-5267	-1119	4244	-873	1710	244	-456	558	1396	-2462	-557

Table B.14
10,000 ac-ft Reservoir in middle of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8254	173	94	57	39	28	16	16	8677
1976	11	10	0	0	7935	252	139	95	53	21	5	15	8536
1977	27	21	18	17	18	17	14	14	13	7	7	9	183
1978	8	8	7	6	8	0	8647	175	90	20	22	15	9006
1979	18	19	18	15	11	15	13	12	8	0	6672	101	6903
1980	70	55	0	0	0	0	0	0	0	6317	314	155	6912
1981	148	114	0	0	7150	311	202	151	91	38	0	43	8267
1982	55	60	0	0	8581	279	173	124	95	74	65	44	9549
1983	54	41	0	0	0	0	0	0	0	0	0	0	96
1984	0	8548	0	0	0	0	0	0	0	0	4507	0	13055
1985	0	0	0	0	0	0	4889	3549	393	292	240	0	9362
1986	8371	910	0	0	0	0	0	0	0	0	0	0	9281
1987	0	0	0	0	0	0	0	0	0	0	5773	0	5773
1988	7245	0	0	0	0	8470	470	327	258	199	172	146	17287
1989	138	151	0	0	8281	336	232	167	152	0	101	0	9558
1990	8735	249	154	0	9014	288	189	146	114	56	84	53	19083
1991	53	63	0	0	8500	283	163	0	0	3106	112	83	12363
1992	80	103	0	0	6564	0	8724	283	216	135	87	81	16273
1993	88	84	0	0	5491	0	8989	317	206	0	128	0	15303
1994	0	0	0	0	7254	440	282	204	159	0	116	77	8532
Average	1255	522	10	2	3853	543	1661	281	94	316	921	42	9700

Table B.15
10,000 ac-ft Reservoir in middle of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	4860	142	45	11	13	1	1	4	5076
1976	6	7	0	0	5699	177	61	18	4	1	0	3	5974
1977	10	12	12	10	11	8	6	5	1	0	0	3	77
1978	3	4	4	4	5	0	3278	19	3	1	1	2	3323
1979	5	7	10	9	5	7	5	2	4	0	218	20	292
1980	17	14	0	0	0	0	0	0	0	70	12	34	147
1981	38	41	0	0	5222	154	46	14	3	5	0	8	5561
1982	17	22	0	0	6555	167	40	8	3	1	1	9	6825
1983	27	25	0	0	0	0	0	0	0	0	0	0	52
1984	0	5302	0	0	0	0	0	0	0	0	368	0	5670
1985	0	0	0	0	0	0	2367	1386	99	13	13	0	3877
1986	5068	559	0	0	0	0	0	0	0	0	0	0	5627
1987	0	0	0	0	0	0	0	0	0	0	426	0	426
1988	3261	0	0	0	0	5891	224	164	22	14	10	33	9621
1989	36	44	0	0	3366	218	54	11	13	0	4	0	3748
1990	2224	84	65	0	4941	149	110	29	5	1	4	5	7716
1991	22	31	0	0	4329	142	29	0	0	61	2	12	4629
1992	18	32	0	0	4162	0	3802	24	23	15	7	10	8094
1993	48	46	0	0	3744	0	3597	40	24	0	13	0	7513
1994	0	0	0	0	5305	289	59	33	12	0	4	22	5752
Average	545	312	5	1	2310	369	685	88	12	9	34	8	4600

Table B.16
10,000 ac-ft Lined Reservoir in middle of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9992	0	0	0	0	0	0	0	-8
1976	0	0	-10000	0	9976	0	0	0	0	0	0	0	-24
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-10000	9936	0	0	0	0	0	-64
1979	0	0	0	0	0	0	0	0	0	-10000	9920	0	-80
1980	0	0	-10000	0	-3	-7	-18	-52	-67	9784	0	0	-363
1981	0	0	-10000	0	9979	0	0	0	0	0	0	0	-21
1982	0	0	-10000	0	9988	0	0	0	0	0	0	0	-12
1983	0	0	-10000	0	-11	-17	-23	-39	-58	-75	-110	-99	-10430
1984	-72	8552	-8619	0	-1	-10	-22	-39	-76	0	9714	-10000	-574
1985	0	-37	-19	-6	-2	-4	4889	4973	0	0	0	-10000	-206
1986	8380	1580	-10000	0	-8	-10	-37	-62	-67	0	0	-285	-510
1987	-60	-43	-15	-7	-8	-17	-17	-65	-81	0	9712	-10000	-601
1988	9953	-10000	0	-7	0	9964	0	0	0	0	0	0	9910
1989	0	0	-10000	0	9989	0	0	0	0	0	0	-10000	-10011
1990	9954	0	0	-10000	9992	0	0	0	0	0	0	0	9946
1991	0	0	-6707	-3293	9979	0	0	0	-10000	9888	0	0	-133
1992	0	0	-10000	0	6564	-6590	9918	0	0	0	0	0	-108
1993	0	0	-10000	0	9996	-10000	9945	0	0	0	0	-10000	-10058
1994	0	-41	-12	-9	9986	0	0	0	0	0	0	0	9924
Average	1408	1	-5269	-1166	4820	-835	1729	236	-317	480	1462	-2319	-171

Table B.17
10,000 ac-ft Lined Reservoir in middle of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8913	0	0	0	0	0	0	0	8913
1976	0	0	0	0	9120	0	0	0	0	0	0	0	9120
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	9334	0	0	0	0	0	9334
1979	0	0	0	0	0	0	0	0	0	0	7207	0	7207
1980	0	0	0	0	0	0	0	0	0	7023	0	0	7023
1981	0	0	0	0	8140	0	0	0	0	0	0	0	8140
1982	0	0	0	0	9819	0	0	0	0	0	0	0	9819
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8124	0	0	0	0	0	0	0	0	5359	0	13483
1985	0	0	0	0	0	0	4584	4656	0	0	0	0	9240
1986	8135	1347	0	0	0	0	0	0	0	0	0	0	9483
1987	0	0	0	0	0	0	0	0	0	0	6825	0	6825
1988	7509	0	0	0	0	9313	0	0	0	0	0	0	16822
1989	0	0	0	0	9395	0	0	0	0	0	0	0	9395
1990	9333	0	0	0	9602	0	0	0	0	0	0	0	18935
1991	0	0	0	0	9501	0	0	0	0	3320	0	0	12821
1992	0	0	0	0	6398	0	9308	0	0	0	0	0	15705
1993	0	0	0	0	6264	0	9490	0	0	0	0	0	15754
1994	0	0	0	0	8063	0	0	0	0	0	0	0	8063
Average	1249	474	0	0	4261	466	1636	233	0	517	970	0	9804

Table B.18
10,000 ac-ft Lined Reservoir in middle of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	5247	0	0	0	0	0	0	0	5247
1976	0	0	0	0	6550	0	0	0	0	0	0	0	6550
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	3538	0	0	0	0	0	3538
1979	0	0	0	0	0	0	0	0	0	0	235	0	235
1980	0	0	0	0	0	0	0	0	0	78	0	0	78
1981	0	0	0	0	5945	0	0	0	0	0	0	0	5945
1982	0	0	0	0	7501	0	0	0	0	0	0	0	7501
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	5039	0	0	0	0	0	0	0	0	437	0	5477
1985	0	0	0	0	0	0	2114	1818	0	0	0	0	3932
1986	4925	828	0	0	0	0	0	0	0	0	0	0	5753
1987	0	0	0	0	0	0	0	0	0	0	304	0	304
1988	3381	0	0	0	0	6478	0	0	0	0	0	0	9859
1989	0	0	0	0	6088	0	0	0	0	0	0	0	6088
1990	2483	0	0	0	5263	0	0	0	0	0	0	0	7746
1991	0	0	0	0	4839	0	0	0	0	65	0	0	4904
1992	0	0	0	0	3976	0	4057	0	0	0	0	0	8032
1993	0	0	0	0	4271	0	3797	0	0	0	0	0	8068
1994	0	0	0	0	5896	0	0	0	0	0	0	0	5896
Average	539	293	0	0	2779	324	675	91	0	7	49	0	4768

Table B.19
50,000 ac-ft Reservoir in middle of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-12920	11956	237	127	80	55	41	32	26	-367
1976	21	18	-23524	-18092	33857	4105	398	381	267	201	159	130	-1878
1977	109	94	81	72	64	57	52	47	43	39	36	34	727
1978	31	29	28	26	24	-10955	10118	222	128	85	64	52	-147
1979	-43	37	33	30	27	25	23	21	20	-11131	10246	213	-412
1980	123	82	-23740	-23640	-3578	-2342	-2069	-1989	-1885	43885	2082	1321	-11750
1981	946	728	-23219	-23202	31785	11834	1097	761	578	467	394	340	2509
1982	299	267	-9913	-7654	16345	597	400	306	252	217	192	173	1481
1983	159	146	-23665	-23562	-3518	-2307	-2017	-1855	-1772	-1722	-1786	-1648	-63548
1984	-1463	11149	-13658	-235	-1164	-1045	-1048	-1088	-1223	2846	40863	-21269	12665
1985	-22689	-1553	-1362	-1104	-977	-913	7749	27051	11463	1951	1468	-22614	-1548
1986	9516	13718	-22582	-22716	-2820	-1682	-1560	-1488	-1382	2697	2737	-9288	-34830
1987	-604	-1135	-887	-817	-628	-960	-763	-979	-1018	3049	32282	-18119	11422
1988	26879	-13163	-20779	-11748	-745	16520	28533	2231	1612	1280	1081	939	32639
1989	837	757	-13328	-23096	34804	1358	961	772	660	586	534	-10158	-5314
1990	10267	623	510	-23349	22437	822	597	491	429	388	359	336	13908
1991	318	302	-6419	-11248	10763	6179	566	433	-23439	22097	729	506	789
1992	402	345	-13003	-23456	7277	-22303	27162	18043	1548	916	700	569	-2000
1993	486	426	-11568	-14520	24518	-22917	22515	905	627	488	411	-23442	-22071
1994	-2448	-20548	-4693	-1885	44537	1964	1261	926	729	604	531	457	21427
Average	1162	-384	-10583	-12156	11248	-1086	4715	2264	-628	3448	4655	-4972	-2315

Table B.20
50,000 ac-ft Reservoir in middle of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	10665	223	121	73	51	36	21	21	11211
1976	14	13	0	0	30952	3817	333	351	190	72	18	52	36012
1977	89	69	60	56	57	36	43	44	39	22	23	29	587
1978	26	24	22	18	23	0	9505	204	109	26	30	21	10008
1979	26	28	28	24	18	24	21	20	14	0	7444	116	7764
1980	82	67	0	0	0	0	0	0	0	31302	1498	728	33876
1981	685	519	0	0	25928	10740	1008	715	418	259	0	187	40457
1982	238	259	0	0	16069	345	365	282	230	188	171	119	18465
1983	152	119	0	0	0	0	0	0	0	0	0	0	271
1984	0	8552	0	0	0	0	0	0	0	0	22543	0	31095
1985	0	0	0	0	0	0	4889	24202	10271	1743	1356	0	42460
1986	8380	11695	0	0	0	0	0	0	0	0	0	0	20075
1987	0	0	0	0	0	0	0	0	0	0	22686	0	22686
1988	20279	0	0	0	0	13999	23116	1918	1400	1033	870	729	63344
1989	682	738	0	0	32733	1211	872	647	605	0	418	0	37908
1990	9626	554	412	0	21562	803	566	465	379	194	299	194	35056
1991	205	237	0	0	10248	5803	475	0	0	7420	298	234	24920
1992	237	317	0	0	6564	0	23491	14206	1231	701	422	378	49548
1993	400	373	0	0	15363	0	21484	840	573	0	383	0	39419
1994	0	0	0	0	35960	1700	1189	840	643	0	460	304	41096
Average	2056	1178	26	3	10307	1946	4584	2240	808	2160	2947	136	28413

Table B.21
50,000 ac-ft Reservoir in middle of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	6279	183	59	15	16	1	1	5	6558
1976	8	9	0	0	22229	2678	234	65	13	2	1	10	25248
1977	34	38	40	34	35	27	20	9	4	1	1	8	251
1978	9	13	13	14	16	0	3603	22	4	1	1	3	3699
1979	7	31	15	15	9	11	8	4	7	0	243	22	331
1980	20	17	0	0	0	0	0	0	0	351	57	157	602
1981	176	189	0	0	18956	6335	229	65	16	24	0	33	26002
1982	73	95	0	0	12274	326	85	19	8	3	4	25	12913
1983	76	72	0	0	0	0	0	0	0	0	0	0	148
1984	0	6570	0	0	0	0	0	0	0	0	1840	0	8410
1985	0	0	0	0	0	0	3350	9890	2572	75	75	0	15962
1986	5591	7188	0	0	0	0	0	0	0	0	0	0	12779
1987	0	0	0	0	0	0	0	0	0	0	1676	0	1676
1988	9129	0	0	0	0	10740	12000	960	122	71	51	166	33240
1989	179	216	0	0	21210	785	204	44	52	0	17	0	22708
1990	2561	158	174	0	11818	415	329	93	19	2	14	17	15630
1991	80	119	0	0	5219	2919	86	0	0	145	7	33	8608
1992	33	99	0	0	4407	0	11111	1217	132	76	36	47	17177
1993	237	205	0	0	10474	0	8597	106	68	0	44	0	19731
1994	0	0	0	0	26298	1259	377	133	47	0	14	85	28214
Average	911	751	12	1	6960	1254	2015	632	154	38	204	31	12994

Table B.22
10,000 ac-ft Lined Reservoir at bottom of Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-10000	9992	0	0	0	0	0	0	0	-8
1976	0	0	-10000	0	9976	0	0	0	0	0	0	0	-24
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-10000	9936	0	0	0	0	0	-64
1979	0	0	0	0	0	0	0	0	0	-10000	9920	0	-80
1980	0	0	-10000	0	-3	-7	-18	-52	-67	9784	0	0	-363
1981	0	0	-10000	0	9979	0	0	0	0	0	0	0	-21
1982	0	0	-10000	0	9988	0	0	0	0	0	0	0	-12
1983	0	0	-10000	0	-11	-17	-23	-39	-58	-75	-110	-99	-10430
1984	-72	8552	-8619	0	-1	-10	-22	-39	-76	0	9714	-10000	-574
1985	0	-37	-19	-6	-2	-4	4889	4973	0	0	0	-10000	-206
1986	8380	1580	-10000	0	-8	-10	-37	-62	-67	0	0	-285	-510
1987	-60	-43	-15	-7	-8	-17	-17	-65	-81	0	9712	-10000	-601
1988	9953	-10000	0	-7	0	9964	0	0	0	0	0	0	9910
1989	0	0	-10000	0	9989	0	0	0	0	0	0	-10000	-10011
1990	9954	0	0	-10000	9992	0	0	0	0	0	0	0	9946
1991	0	0	-6707	-3293	9979	0	0	0	-10000	9888	0	0	-133
1992	0	0	-10000	0	6564	-6390	9918	0	0	0	0	0	-108
1993	0	0	-10000	0	9986	-10000	9845	0	0	0	0	-10000	-10058
1994	0	-41	-12	-9	9986	0	0	0	0	0	0	0	9924
Average	1408	1	-5269	-1166	4820	-433	1729	236	-317	480	1462	-2519	-171

Table B.23
10,000 ac-ft Lined Reservoir at bottom of Reach 9
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	8924	0	0	0	0	0	0	0	8924
1976	0	0	0	0	9147	0	0	0	0	0	0	0	9147
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	9412	0	0	0	0	0	9412
1979	0	0	0	0	0	0	0	0	0	0	7251	0	7251
1980	0	0	0	0	0	0	0	0	0	7085	0	0	7085
1981	0	0	0	0	8153	0	0	0	0	0	0	0	8153
1982	0	0	0	0	9832	0	0	0	0	0	0	0	9832
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	8143	0	0	0	0	0	0	0	0	3548	0	11691
1985	0	0	0	0	0	0	4630	4742	0	0	0	0	9372
1986	8171	1372	0	0	0	0	0	0	0	0	0	0	9543
1987	0	0	0	0	0	0	0	0	0	0	6870	0	6870
1988	7542	0	0	0	0	9339	0	0	0	0	0	0	16882
1989	0	0	0	0	9397	0	0	0	0	0	0	0	9397
1990	9371	0	0	0	9613	0	0	0	0	0	0	0	18984
1991	0	0	0	0	9522	0	0	0	0	3347	0	0	12869
1992	0	0	0	0	6413	0	9377	0	0	0	0	0	15790
1993	0	0	0	0	6266	0	9551	0	0	0	0	0	15817
1994	0	0	0	0	8068	0	0	0	0	0	0	0	8068
Average	1254	476	0	0	4267	467	1649	237	0	522	883	0	9854

Table B.24
10,000 ac-ft Lined Reservoir at bottom of Reach 9
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	5304	0	0	0	0	0	0	0	5304
1976	0	0	0	0	6654	0	0	0	0	0	0	0	6654
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	6039	0	0	0	0	0	6039
1979	0	0	0	0	0	0	0	0	0	0	317	0	317
1980	0	0	0	0	0	0	0	0	0	136	0	0	136
1981	0	0	0	0	6318	0	0	0	0	0	0	0	6318
1982	0	0	0	0	7675	0	0	0	0	0	0	0	7675
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	5148	0	0	0	0	0	0	0	0	601	0	5749
1985	0	0	0	0	0	0	3102	2007	0	0	0	0	5109
1986	5531	643	0	0	0	0	0	0	0	0	0	0	6174
1987	0	0	0	0	0	0	0	0	0	0	896	0	896
1988	4403	0	0	0	0	6833	0	0	0	0	0	0	11236
1989	0	0	0	0	6595	0	0	0	0	0	0	0	6595
1990	3812	0	0	0	5445	0	0	0	0	0	0	0	9257
1991	0	0	0	0	5230	0	0	0	0	123	0	0	5353
1992	0	0	0	0	3987	0	4665	0	0	0	0	0	8652
1993	0	0	0	0	4543	0	4242	0	0	0	0	0	8785
1994	0	0	0	0	6447	0	0	0	0	0	0	0	6447
Average	687	290	0	0	2910	344	902	100	0	13	91	0	5337

Table C.1
Conservation Cropping Patterns - Reach 5
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1976	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1977	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1978	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1979	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1980	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1981	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1982	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1983	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1984	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1985	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1986	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1987	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1988	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1989	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1990	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1991	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1992	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1993	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
1994	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269
Average	79	-317	-327	-333	-335	-334	-285	2	687	1854	1873	706	3269

Table C.2
Conservation Cropping Patterns - Reach 7
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1976	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1977	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1978	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1979	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1980	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1981	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1982	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1983	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1984	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1985	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1986	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1987	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1988	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1989	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1990	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1991	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1992	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1993	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
1994	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873
Average	-191	-200	-205	-208	-209	-209	-123	32	699	1339	1087	60	1873

Table C.3
Conservation Cropping Patterns - Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1976	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1977	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1978	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1979	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1980	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1981	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1982	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1983	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1984	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1985	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1986	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1987	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1988	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1989	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1990	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1991	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1992	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1993	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
1994	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613
Average	-1409	-1459	-1467	-1478	-1490	-1488	-829	269	5403	10082	8097	382	14613

Table C.4
Conservation Cropping Patterns - Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1976	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1977	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1978	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1979	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1980	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1981	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1982	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1983	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1984	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1985	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1986	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1987	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1988	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1989	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1990	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1991	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1992	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1993	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
1994	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515
Average	-1524	-1514	-1402	-1292	-1187	-1100	-481	141	3699	7958	6190	25	9515

Table C.5
Conservation Cropping Patterns - Reach 11
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	33	83	423	704	583	0	1826
1976	0	0	0	0	0	0	33	83	423	704	583	0	1826
1977	0	0	0	0	0	0	33	83	423	704	583	0	1826
1978	0	0	0	0	0	0	33	83	423	704	583	0	1826
1979	0	0	0	0	0	0	33	83	423	704	583	0	1826
1980	0	0	0	0	0	0	33	83	423	704	583	0	1826
1981	0	0	0	0	0	0	33	83	423	704	583	0	1826
1982	0	0	0	0	0	0	33	83	423	704	583	0	1826
1983	0	0	0	0	0	0	33	83	423	704	583	0	1826
1984	0	0	0	0	0	0	33	83	423	704	583	0	1826
1985	0	0	0	0	0	0	33	83	423	704	583	0	1826
1986	0	0	0	0	0	0	33	83	423	704	583	0	1826
1987	0	0	0	0	0	0	33	83	423	704	583	0	1826
1988	0	0	0	0	0	0	33	83	423	704	583	0	1826
1989	0	0	0	0	0	0	33	83	423	704	583	0	1826
1990	0	0	0	0	0	0	33	83	423	704	583	0	1826
1991	0	0	0	0	0	0	33	83	423	704	583	0	1826
1992	0	0	0	0	0	0	33	83	423	704	583	0	1826
1993	0	0	0	0	0	0	33	83	423	704	583	0	1826
1994	0	0	0	0	0	0	33	83	423	704	583	0	1826
Average	0	0	0	0	0	0	33	83	423	704	583	0	1826

Table C.6
Conservation Cropping Patterns - Reach 12
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1976	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1977	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1978	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1979	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1980	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1981	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1982	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1983	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1984	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1985	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1986	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1987	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1988	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1989	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1990	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1991	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1992	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1993	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
1994	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667
Average	172	-1018	-1016	-1016	-1017	-1020	-914	-421	1515	5436	6047	1920	8667

Table C.7
Conservation Cropping Patterns - Reach 13
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1976	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1977	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1978	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1979	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1980	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1981	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1982	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1983	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1984	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1985	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1986	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1987	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1988	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1989	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1990	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1991	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1992	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1993	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
1994	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250
Average	13	-438	-454	-456	-448	-435	-381	-188	490	1830	2058	658	2250

Table C.8
Conservation Cropping Patterns - Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1976	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1977	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1978	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1979	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1980	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1981	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1982	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1983	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1984	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1985	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1986	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1987	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1988	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1989	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1990	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1991	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1992	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1993	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
1994	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541
Average	-202	-202	-202	-202	-202	-202	-167	-127	608	1808	1668	-38	2541

Table C.9
Conservation Cropping Patterns - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1976	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1977	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1978	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1979	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1980	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1981	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1982	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1983	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1984	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1985	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1986	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1987	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1988	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1989	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1990	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1991	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1992	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1993	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
1994	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116
Average	-516	-516	-515	-515	-515	-515	-449	-359	1191	4462	3553	-191	5116

Table C.10
Conservation Cropping Patterns - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1976	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1977	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1978	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1979	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1980	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1981	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1982	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1983	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1984	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1985	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1986	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1987	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1988	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1989	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1990	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1991	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1992	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1993	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
1994	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287
Average	-460	-460	-460	-460	-460	-461	-414	-350	1430	5261	4256	-136	7287

Table C.11
Conservation Cropping Patterns - Reach 19
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1976	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1977	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1978	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1979	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1980	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1981	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1982	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1983	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1984	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1985	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1986	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1987	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1988	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1989	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1990	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1991	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1992	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1993	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
1994	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732
Average	-517	-517	-518	-518	-518	-518	-494	-463	1617	5628	4824	-274	7732

Table C.12
Conservation Cropping Patterns - Reach 5
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	44	-163	-190	0	-226	-243	-183	0	75	21	21	85	-759
1976	25	-156	0	0	-252	-234	-122	0	21	4	3	38	-673
1977	37	-144	-180	-177	-209	-222	-169	0	26	7	23	79	-930
1978	38	-158	-183	-216	-286	0	-154	0	14	8	9	19	-909
1979	26	-133	-201	-200	-168	-247	-130	0	53	0	16	29	-974
1980	22	-135	0	0	0	0	0	0	0	5	21	49	-38
1981	28	-138	0	0	-215	-219	-68	0	5	38	0	33	-537
1982	38	-206	0	0	-263	-239	-83	0	13	11	20	76	-633
1983	35	-179	0	0	0	0	0	0	0	0	0	0	-144
1984	0	-213	0	0	0	0	0	0	0	0	67	0	-146
1985	0	0	0	0	0	0	-134	0	47	19	30	0	-37
1986	58	-179	0	0	0	0	0	0	0	0	0	0	-121
1987	0	0	0	0	0	0	0	0	0	0	76	0	76
1988	41	0	0	0	0	-256	-137	1	22	35	30	93	-172
1989	33	-173	0	0	-242	-240	-78	0	13	0	18	0	-670
1990	36	-178	-183	0	-231	-230	-179	0	10	2	31	21	-904
1991	32	-221	0	0	-249	-219	-65	0	0	3	4	31	-685
1992	15	-182	0	0	-263	0	-145	0	25	42	18	19	-470
1993	47	-200	0	0	-174	0	-165	0	61	0	96	0	-336
1994	0	0	0	0	-234	-281	-134	0	16	0	17	73	-543
Average	25	-139	-47	-30	-151	-132	-98	0	20	10	25	32	-490

Table C.13
Conservation Cropping Patterns - Reach 7
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-7	-5	-14	0	-37	-28	-16	1	92	1	1	1	-9
1976	-5	-4	0	0	-20	-49	-5	0	1	0	0	0	-81
1977	-1	-1	-7	-12	-5	-23	-4	0	2	0	1	0	-49
1978	-3	-1	-2	-6	-5	0	-3	0	2	0	0	0	-17
1979	-2	-1	-4	-17	-22	-4	-3	2	139	0	9	1	95
1980	-4	-12	0	0	0	0	0	0	0	1	0	1	-14
1981	0	-8	0	0	-13	-15	-5	0	6	1	0	0	-36
1982	-1	0	0	0	-26	-2	-1	0	2	3	1	1	-23
1983	-1	-6	0	0	0	0	0	0	0	0	0	0	-7
1984	0	-49	0	0	0	0	0	0	0	0	16	0	-33
1985	0	0	0	0	0	0	-5	7	55	4	3	0	64
1986	-34	-23	0	0	0	0	0	0	0	0	0	0	-57
1987	0	0	0	0	0	0	0	0	0	0	3	0	3
1988	-1	0	0	0	0	-59	-10	4	12	2	1	1	-50
1989	-1	-1	0	0	-70	-24	-2	0	3	0	1	0	-92
1990	-1	-1	-10	0	-52	-55	-32	0	2	0	2	0	-147
1991	-1	-1	0	0	-39	-23	-2	0	0	0	0	1	-64
1992	-1	-1	0	0	-76	0	-12	0	8	7	10	1	-65
1993	-6	-6	0	0	-48	0	-15	0	4	0	3	0	-68
1994	0	0	0	0	-72	-44	-4	0	1	0	0	0	-117
Average	-3	-6	-2	-2	-24	-16	-6	1	16	1	3	0	-39

Table C.14
Conservation Cropping Patterns - Reach 8
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-239	-328	-355	0	-520	-663	-224	17	1102	28	30	17	-1139
1976	-232	-354	0	0	-553	-659	-104	8	27	5	1	4	-1856
1977	-140	-291	-383	-390	-430	-432	-165	15	117	13	23	12	-2052
1978	-157	-319	-346	-377	-477	0	-57	4	52	5	5	1	-1665
1979	-62	-136	-233	-387	-316	-292	-121	25	1469	0	104	14	45
1980	-102	-196	0	0	0	0	0	0	0	13	13	11	-260
1981	-54	-179	0	0	-468	-389	-84	9	84	43	0	2	-1035
1982	-93	-138	0	0	-640	-314	-43	3	66	56	14	15	-1073
1983	-178	-359	0	0	0	0	0	0	0	0	0	0	-537
1984	0	-629	0	0	0	0	0	0	0	0	183	0	-447
1985	0	0	0	0	0	0	-113	75	679	72	67	0	780
1986	-515	-491	0	0	0	0	0	0	0	0	0	0	-1006
1987	0	0	0	0	0	0	0	0	0	0	63	0	63
1988	-172	0	0	0	0	-663	-176	71	205	50	28	11	-648
1989	-83	-112	0	0	-664	-474	-61	1	85	0	22	0	-1286
1990	-47	-89	-198	0	-570	-549	-522	10	54	5	57	-4	-1727
1991	-115	-205	0	0	-470	-388	-45	0	0	5	7	10	-1202
1992	-51	-91	0	0	-721	0	-188	2	210	251	178	17	-398
1993	-305	-352	0	0	-470	0	-193	7	126	0	70	0	-1098
1994	0	0	0	0	-654	-567	-94	5	35	0	10	4	-1260
Average	-129	-212	-77	-58	-348	-270	-100	13	215	27	43	6	-890

Table C.15
Conservation Cropping Patterns - Reach 9
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-608	-670	-584	0	-623	-849	-221	26	1094	217	195	5	-2017
1976	-537	-734	0	0	-779	-717	-189	24	177	73	24	2	-2656
1977	-491	-611	-689	-609	-654	-516	-191	27	321	101	167	6	-3128
1978	-457	-667	-676	-676	-757	0	-171	14	112	72	83	2	-3122
1979	-252	-437	-625	-632	-374	-500	-165	25	1312	0	147	3	-1498
1980	-247	-320	0	0	0	0	0	0	0	64	168	3	-333
1981	-283	-392	0	0	-707	-589	-100	12	101	403	0	2	-1552
1982	-373	-537	0	0	-891	-602	-103	9	121	123	114	4	-2135
1983	-730	-744	0	0	0	0	0	0	0	0	0	0	-1474
1984	0	-892	0	0	0	0	0	0	0	0	279	0	-613
1985	0	0	0	0	0	0	-208	32	830	310	316	0	1299
1986	-896	-793	0	0	0	0	0	0	0	0	0	0	-1688
1987	0	0	0	0	0	0	0	0	0	0	321	0	321
1988	-517	0	0	0	0	-715	-202	61	279	444	295	4	-351
1989	-326	-433	0	0	-723	-636	-102	8	293	0	194	0	-1725
1990	-380	-452	-479	0	-625	-556	-265	27	166	50	250	1	-2263
1991	-383	-594	0	0	-575	-519	-73	0	0	52	57	2	-2034
1992	-201	-435	0	0	-719	0	-197	10	362	659	316	2	-203
1993	-681	-729	0	0	-507	0	-184	18	400	0	427	0	-1257
1994	0	0	0	0	-703	-705	-144	21	239	0	168	5	-1116
Average	-368	-472	-153	-96	-432	-345	-126	17	290	128	176	2	-1377

Table C.16
Conservation Cropping Patterns - Reach 11
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	4	1	39	1	1	0	45
1976	0	0	0	0	0	0	1	0	0	0	0	0	2
1977	0	0	0	0	0	0	1	1	1	0	0	0	3
1978	0	0	0	0	0	0	1	0	1	0	0	0	2
1979	0	0	0	0	0	0	1	3	69	0	3	0	77
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	1	1	3	0	0	0	5
1982	0	0	0	0	0	0	0	0	1	1	0	0	3
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	6	0	6
1985	0	0	0	0	0	0	1	10	24	1	1	0	38
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	0	0	0	0	0	0	2	7	5	1	0	0	15
1989	0	0	0	0	0	0	0	0	1	0	0	0	2
1990	0	0	0	0	0	0	8	1	1	0	1	0	10
1991	0	0	0	0	0	0	0	0	0	0	0	0	1
1992	0	0	0	0	0	0	2	0	3	3	4	0	12
1993	0	0	0	0	0	0	3	1	2	0	1	0	7
1994	0	0	0	0	0	0	1	0	0	0	0	0	2
Average	0	0	0	0	0	0	1	1	8	0	1	0	12

Table C.17
Conservation Cropping Patterns - Reach 12
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	98	-525	-591	0	-689	-747	-395	-70	286	136	178	411	-2108
1976	56	-502	0	0	-768	-721	-421	-74	91	39	23	185	-2092
1977	83	-465	-561	-540	-636	-684	-360	-99	109	59	170	397	-2727
1978	86	-511	-569	-661	-870	0	-507	-53	50	54	66	89	-2827
1979	57	-429	-627	-610	-511	-761	-486	-56	232	0	109	138	-2944
1980	49	-434	0	0	0	0	0	0	0	36	167	236	54
1981	64	-446	0	0	-657	-676	-235	-39	29	283	0	167	-1510
1982	86	-662	0	0	-802	-736	-288	-50	47	70	129	324	-1862
1983	79	-577	0	0	0	0	0	0	0	0	0	0	-498
1984	0	-686	0	0	0	0	0	0	0	0	311	0	-375
1985	0	0	0	0	0	0	-449	-97	189	175	240	0	58
1986	127	-575	0	0	0	0	0	0	0	0	0	0	-448
1987	0	0	0	0	0	0	0	0	0	0	410	0	410
1988	91	0	0	0	0	-787	-463	-132	90	280	252	415	-279
1989	73	-558	0	0	-736	-739	-270	-19	87	0	171	0	-1992
1990	80	-575	-575	0	-705	-711	-587	-114	53	28	251	112	-2743
1991	71	-714	0	0	-758	-673	-219	0	0	33	46	143	-2074
1992	33	-585	0	0	-802	0	-490	-24	138	306	206	106	-1113
1993	110	-644	0	0	-551	0	-542	-53	205	0	427	0	-1028
1994	0	0	0	0	-714	-866	-440	-59	74	0	134	332	-1538
Average	62	-443	-146	-91	-459	-403	-325	-47	64	75	165	153	-1382

Table C.18
Conservation Cropping Patterns - Reach 13
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	8	-227	-265	0	-305	-323	-252	-40	123	74	107	195	-900
1976	4	-217	0	0	-339	-310	-189	-45	43	26	13	87	-926
1977	7	-201	-251	-243	-281	-294	-240	-60	51	38	93	192	-1191
1978	7	-221	-255	-297	-385	0	-218	-27	21	29	35	41	-1270
1979	4	-185	-281	-274	-228	-327	-205	-32	111	0	56	62	-1297
1980	4	-187	0	0	0	0	0	0	0	23	95	110	45
1981	5	-193	0	0	-291	-291	-105	-23	16	155	0	79	-647
1982	7	-287	0	0	-355	-317	-129	-18	22	38	65	142	-832
1983	6	-249	0	0	0	0	0	0	0	0	0	0	-243
1984	0	-297	0	0	0	0	0	0	0	0	137	0	-160
1985	0	0	0	0	0	0	-197	-61	89	109	137	0	77
1986	10	-249	0	0	0	0	0	0	0	0	0	0	-239
1987	0	0	0	0	0	0	0	0	0	0	189	0	189
1988	7	0	0	0	0	-338	-206	-60	42	176	150	189	-61
1989	6	-242	0	0	-326	-317	-121	-12	53	0	114	0	-845
1990	6	-249	-260	0	-312	-306	-230	-59	27	21	148	58	-1177
1991	6	-309	0	0	-336	-290	-97	0	0	21	33	67	-905
1992	3	-253	0	0	-355	0	-216	-18	63	171	136	54	-417
1993	9	-279	0	0	-235	0	-232	-34	89	0	278	0	-404
1994	0	0	0	0	-316	-372	-188	-37	38	0	78	155	-643
Average	5	-192	-66	-41	-203	-174	-142	-27	39	44	93	71	-592

Table C.19
Conservation Cropping Patterns - Reach 16
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-153	-148	-148	0	-181	-191	-158	-78	434	811	583	-18	754
1976	-130	-144	0	0	-186	-189	-146	-80	254	365	151	-10	-114
1977	-159	-150	-151	-158	-184	-196	-141	-105	359	515	550	-23	157
1978	-170	-168	-161	-144	-192	0	-159	-89	265	306	394	-9	-128
1979	-124	-149	-172	-162	-152	-200	-155	-83	384	0	625	-13	-202
1980	-140	-167	0	0	0	0	0	0	0	649	642	-15	970
1981	-148	-147	0	0	-166	-185	-104	-77	228	651	0	-17	33
1982	-163	-198	0	0	-200	-187	-148	-77	320	735	715	-18	779
1983	-197	-166	0	0	0	0	0	0	0	0	0	0	-363
1984	0	-193	0	0	0	0	0	0	0	0	625	0	432
1985	0	0	0	0	0	0	-146	-98	355	838	819	0	1767
1986	-190	-178	0	0	0	0	0	0	0	0	0	0	-368
1987	0	0	0	0	0	0	0	0	0	0	660	0	660
1988	-152	0	0	0	0	-189	-133	-104	291	935	729	-19	1359
1989	-113	-198	0	0	-191	-182	-132	-59	339	0	725	0	190
1990	-189	-182	-164	0	-196	-200	-153	-99	294	477	751	-13	326
1991	-140	-160	0	0	-194	-193	-128	0	0	309	346	-12	-171
1992	-120	-188	0	0	-199	0	-145	-63	300	768	626	-15	965
1993	-169	-180	0	0	-129	0	-153	-89	344	0	427	0	51
1994	0	0	0	0	-164	-197	-141	-84	302	0	745	-21	440
Average	-123	-136	-40	-23	-117	-105	-107	-59	223	368	506	-10	377

Table C.20
Conservation Cropping Patterns - Reach 17
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-412	-380	-378	0	-464	-489	-427	-330	1112	3536	2165	-157	3775
1976	-334	-369	0	0	-476	-483	-400	-334	845	1669	607	-81	644
1977	-422	-384	-387	-405	-471	-501	-381	-341	1070	2318	2172	-162	2106
1978	-441	-430	-413	-369	-491	0	-432	-334	943	1370	1509	-85	829
1979	-320	-384	-440	-414	-390	-512	-425	-334	832	0	2516	-112	18
1980	-362	-428	0	0	0	0	0	0	0	3087	2432	-111	4619
1981	-382	-377	0	0	-425	-475	-412	-338	842	2551	0	-110	874
1982	-422	-509	0	0	-512	-479	-403	-321	1082	3477	2891	-133	4671
1983	-509	-425	0	0	0	0	0	0	0	0	0	0	-933
1984	0	-496	0	0	0	0	0	0	0	0	2195	0	1697
1985	0	0	0	0	0	0	-425	-338	1085	3757	3189	0	7268
1986	-506	-456	0	0	0	0	0	0	0	0	0	0	-962
1987	0	0	0	0	0	0	0	0	0	0	2519	0	2519
1988	-405	0	0	0	0	-484	-384	-321	995	3608	2898	-154	5756
1989	-429	-511	0	0	-488	-467	-418	-302	1096	0	2762	0	1243
1990	-492	-468	-420	0	-500	-511	-436	-345	1047	2220	2782	-106	2771
1991	-374	-411	0	0	-497	-494	-380	0	0	1433	1387	-91	584
1992	-317	-482	0	0	-508	0	-433	-287	1026	1230	2116	-127	2219
1993	-441	-461	0	0	-335	0	-445	-343	1118	0	427	0	-478
1994	0	0	0	0	-420	-512	-440	-343	1059	0	2878	-133	2089
Average	-328	-349	-102	-59	-299	-270	-312	-231	708	1513	1873	-78	2066

Table C.21
Conservation Cropping Patterns - Reach 18
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-376	-367	-346	0	-419	-448	-402	-332	1374	4622	2788	-123	5971
1976	-333	-373	0	0	-443	-446	-389	-334	1071	2057	642	-59	1394
1977	-386	-381	-353	-369	-440	-453	-381	-339	1344	3136	2735	-124	3987
1978	-399	-387	-395	-330	-449	0	-404	-335	1240	1822	1974	-61	2276
1979	-313	-369	-396	-371	-349	-459	-401	-335	1042	0	3142	-79	1112
1980	-328	-381	0	0	0	0	0	0	0	4305	3244	-82	6758
1981	-357	-356	0	0	-385	-442	-393	-336	1066	3076	0	-85	1789
1982	-379	-457	0	0	-459	-444	-389	-328	1349	4550	3749	-96	7096
1983	-455	-410	0	0	0	0	0	0	0	0	0	0	-865
1984	0	-450	0	0	0	0	0	0	0	0	2749	0	2298
1985	0	0	0	0	0	0	-401	-338	1354	4770	3995	0	9380
1986	-455	-433	0	0	0	0	0	0	0	0	0	0	-887
1987	0	0	0	0	0	0	0	0	0	0	3116	0	3116
1988	-361	0	0	0	0	-436	-367	-315	1277	4409	3579	-111	7676
1989	-418	-457	0	0	-437	-418	-395	-306	1358	0	3434	0	2361
1990	-446	-438	-376	0	-453	-458	-406	-342	1322	2879	3597	-84	4796
1991	-360	-367	0	0	-452	-450	-358	0	0	1818	1795	-66	1559
1992	-292	-430	0	0	-457	0	-404	-291	1310	1230	2635	-94	3208
1993	-407	-435	0	0	-300	0	-409	-340	1373	0	427	0	-90
1994	0	0	0	0	-376	-459	-408	-338	1330	0	3775	-96	3429
Average	-303	-325	-93	-53	-271	-246	-295	-231	891	1934	2369	-58	3318

Table C.22
Conservation Cropping Patterns - Reach 19
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-475	-481	-458	0	-497	-517	-492	-457	1605	5513	4094	-272	7566
1976	-465	-493	0	0	-517	-517	-492	-458	1441	3952	2723	-197	4978
1977	-481	-495	-461	-470	-517	-516	-493	-460	1598	4693	4030	-271	6158
1978	-486	-478	-496	-445	-516	0	-492	-458	1565	3891	3619	-198	5506
1979	-450	-481	-483	-467	-455	-517	-492	-459	1420	0	4257	-216	1657
1980	-446	-472	0	0	0	0	0	0	0	5452	4426	-223	8737
1981	-469	-470	0	0	-478	-516	-489	-458	1437	4490	0	-229	2819
1982	-473	-516	0	0	-517	-517	-490	-458	1596	5469	4689	-236	8548
1983	-515	-506	0	0	0	0	0	0	0	0	0	0	-1021
1984	0	-516	0	0	0	0	0	0	0	0	4033	0	3516
1985	0	0	0	0	0	0	-492	-460	1601	5535	4765	0	10949
1986	-516	-516	0	0	0	0	0	0	0	0	0	0	-1033
1987	0	0	0	0	0	0	0	0	0	0	4227	0	4227
1988	-462	0	0	0	0	-505	-474	-440	1572	5245	4493	-250	9179
1989	-513	-516	0	0	-505	-494	-488	-440	1596	0	4421	0	3061
1990	-513	-516	-470	0	-517	-517	-491	-460	1586	4479	4593	-231	6943
1991	-475	-466	0	0	-517	-516	-466	0	0	3847	3491	-205	4693
1992	-428	-501	0	0	-517	0	-491	-430	1590	1230	3955	-234	4174
1993	-495	-516	0	0	-427	0	-492	-459	1599	0	427	0	-363
1994	0	0	0	0	-470	-517	-491	-456	1589	0	4726	-236	4143
Average	-383	-397	-118	-69	-323	-282	-366	-318	1090	2690	3349	-150	4722

Table C.23
Conservation Cropping Patterns - Reach 5
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	62	-165	-190	0	-226	-243	-183	2	622	1628	1206	576	3092
1976	51	-156	0	0	-252	-234	-122	2	483	864	216	285	937
1977	65	-144	-180	-177	-209	-222	-169	2	611	1014	1171	393	2354
1978	65	-158	-183	-216	-286	0	-154	2	577	577	870	286	1380
1979	48	-133	-201	-200	-168	-247	-150	2	457	0	1344	381	1133
1980	52	-135	0	0	0	0	0	0	0	1317	1359	388	2981
1981	57	-138	0	0	-215	-219	-68	2	464	1022	0	387	1291
1982	63	-206	0	0	-263	-239	-83	2	607	1569	1665	485	3599
1983	75	-179	0	0	0	0	0	0	0	0	0	0	-104
1984	0	-215	0	0	0	0	0	0	0	0	1189	0	976
1985	0	0	0	0	0	0	-134	2	618	1645	1700	0	3831
1986	76	-179	0	0	0	0	0	0	0	0	0	0	-103
1987	0	0	0	0	0	0	0	0	0	0	1304	0	1304
1988	59	0	0	0	0	-256	-137	2	576	1459	1479	542	3725
1989	63	-173	0	0	-242	-240	-78	2	605	0	1431	0	1368
1990	72	-178	-185	0	-231	-230	-179	2	529	900	1529	395	2424
1991	50	-221	0	0	-249	-219	-65	0	0	597	746	318	956
1992	46	-182	0	0	-263	0	-145	2	597	1230	1099	456	2840
1993	84	-200	0	0	-174	0	-165	2	605	0	427	0	558
1994	0	0	0	0	-234	-283	-134	2	589	0	1651	467	2060
Average	48	-138	-47	-30	-151	-132	-98	1	397	681	1019	278	1830

Table C.24
Conservation Cropping Patterns - Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-7	-5	-14	0	-37	-26	-16	29	640	1166	696	46	2472
1976	-5	-4	0	0	-20	-49	-5	29	488	466	121	24	1045
1977	-1	-1	-7	-12	-5	-23	-4	30	624	713	671	30	2036
1978	-3	-1	-2	-6	-5	0	-3	28	572	399	490	24	1493
1979	-2	-1	-4	-17	-22	-4	-5	20	336	0	777	32	1110
1980	-4	-12	0	0	0	0	0	0	0	940	769	33	1726
1981	0	-8	0	0	-15	-15	-5	30	495	725	0	33	1239
1982	-1	0	0	0	-26	-2	-1	29	627	1137	947	41	2751
1983	-1	-6	0	0	0	0	0	0	0	0	0	0	-7
1984	0	-49	0	0	0	0	0	0	0	0	550	0	501
1985	0	0	0	0	0	0	-5	30	593	1184	988	0	2790
1986	-34	-23	0	0	0	0	0	0	0	0	0	0	-57
1987	0	0	0	0	0	0	0	0	0	0	751	0	751
1988	-1	0	0	0	0	-39	-10	27	594	1057	839	46	2514
1989	-1	-1	0	0	-70	-24	-2	27	630	0	836	0	1397
1990	-1	-1	-10	0	-52	-35	-32	30	606	657	888	34	2064
1991	-1	-1	0	0	-39	-23	-2	0	0	440	437	27	839
1992	-1	-1	0	0	-76	0	-12	25	628	1006	645	39	2252
1993	-6	-6	0	0	-48	0	-15	30	629	0	427	0	1010
1994	0	0	0	0	-72	-44	-4	29	603	0	939	39	1491
Average	-3	-6	-2	-2	-24	-16	-6	20	403	495	590	27	1471

Table C.25
Conservation Cropping Patterns - Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-239	-328	-355	0	-520	-665	-224	245	4976	8842	5218	302	17231
1976	-232	-354	0	0	-553	-659	-104	245	3801	3543	911	151	6749
1977	-140	-291	-383	-390	-450	-432	-165	247	4876	5424	5040	320	13675
1978	-157	-319	-346	-377	-477	0	-57	240	4494	3030	3673	152	9856
1979	-62	-136	-253	-387	-316	-292	-121	207	3164	0	3825	207	7856
1980	-102	-196	0	0	0	0	0	0	0	7135	5763	208	12808
1981	-54	-179	0	0	-468	-389	-84	250	3855	5511	0	208	8649
1982	-93	-138	0	0	-640	-314	-43	245	4873	8624	7103	264	19879
1983	-178	-359	0	0	0	0	0	0	0	0	0	0	-537
1984	0	-629	0	0	0	0	0	0	0	0	4208	0	3579
1985	0	0	0	0	0	0	-113	246	4606	8978	7401	0	21118
1986	-515	-491	0	0	0	0	0	0	0	0	0	0	-1006
1987	0	0	0	0	0	0	0	0	0	0	5629	0	5629
1988	-172	0	0	0	0	-663	-176	228	4626	5380	6445	294	15962
1989	-83	-112	0	0	-664	-474	-61	223	4902	0	6272	0	10002
1990	-87	-89	-198	0	-570	-549	-322	253	4718	4988	6659	218	15021
1991	-115	-203	0	0	-470	-388	-48	0	0	3339	3276	175	5567
1992	-51	-91	0	0	-721	0	-188	209	4881	1230	4830	232	10350
1993	-305	-332	0	0	-470	0	-193	247	4888	0	427	0	4261
1994	0	0	0	0	-654	-567	-94	241	4697	0	7055	251	10927
Average	-129	-212	-77	-58	-348	-270	-100	166	3168	3301	4257	150	9879

Table C.26
Conservation Cropping Patterns - Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-608	-670	-584	0	-623	-849	-221	130	3444	7063	4034	20	11138
1976	-537	-734	0	0	-779	-717	-189	130	2638	2844	706	10	3372
1977	-481	-611	-689	-609	-654	-316	-191	132	3389	4368	3901	21	8060
1978	-457	-667	-676	-676	-757	0	-171	130	3152	2430	2844	10	5162
1979	-252	-437	-625	-632	-374	-500	-165	132	2563	0	4497	14	4221
1980	-247	-320	0	0	0	0	0	0	0	5713	4453	14	9612
1981	-283	-392	0	0	-707	-589	-100	133	2676	4414	0	14	5164
1982	-373	-537	0	0	-891	-602	-103	130	3377	6903	5489	17	13411
1983	-730	-744	0	0	0	0	0	0	0	0	0	0	-1474
1984	0	-892	0	0	0	0	0	0	0	0	3415	0	2523
1985	0	0	0	0	0	0	-208	132	3314	7183	5716	0	16138
1986	-896	-793	0	0	0	0	0	0	0	0	0	0	-1688
1987	0	0	0	0	0	0	0	0	0	0	4350	0	4350
1988	-517	0	0	0	0	-715	-202	121	3213	5380	4981	19	12281
1989	-326	-433	0	0	-723	-636	-102	119	3393	0	4848	0	6140
1990	-380	-452	-479	0	-625	-556	-265	134	3275	3989	5145	14	9800
1991	-383	-594	0	0	-575	-519	-73	0	0	2672	2532	11	3071
1992	-201	-435	0	0	-719	0	-197	111	3577	1230	3731	16	6915
1993	-681	-729	0	0	-507	0	-184	131	3384	0	427	0	1841
1994	0	0	0	0	-701	-705	-144	128	3260	0	5470	16	7326
Average	-368	-472	-153	-96	-432	-345	-126	90	2223	2709	3327	10	6368

Table C.27
Conservation Cropping Patterns - Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	31	75	388	613	373	0	1481
1976	0	0	0	0	0	0	29	75	296	245	65	0	710
1977	0	0	0	0	0	0	27	76	379	375	360	0	1218
1978	0	0	0	0	0	0	31	72	347	210	263	0	922
1979	0	0	0	0	0	0	31	50	203	0	417	0	702
1980	0	0	0	0	0	0	0	0	0	495	412	0	907
1981	0	0	0	0	0	0	30	77	300	382	0	0	788
1982	0	0	0	0	0	0	30	75	380	598	508	0	1591
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	295	0	295
1985	0	0	0	0	0	0	31	75	359	623	530	0	1618
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	403	0	403
1988	0	0	0	0	0	0	29	70	360	556	461	0	1476
1989	0	0	0	0	0	0	30	68	382	0	449	0	929
1990	0	0	0	0	0	0	31	77	367	346	477	0	1298
1991	0	0	0	0	0	0	27	0	0	231	234	0	493
1992	0	0	0	0	0	0	31	64	381	529	346	0	1350
1993	0	0	0	0	0	0	31	75	381	0	427	0	915
1994	0	0	0	0	0	0	31	74	366	0	504	0	974
Average	0	0	0	0	0	0	22	50	244	260	326	0	904

Table C.28
Conservation Cropping Patterns - Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	135	-525	-591	0	-689	-747	-595	-70	1384	4812	3924	1576	8614
1976	112	-502	0	0	-768	-721	-421	-74	1075	1961	704	780	2146
1977	142	-465	-561	-540	-636	-684	-560	-99	1362	2997	3809	1627	6391
1978	143	-511	-569	-661	-870	0	-507	-53	1285	1704	2827	784	3572
1979	105	-429	-627	-610	-511	-761	-486	-56	1017	0	4367	1043	3053
1980	114	-434	0	0	0	0	0	0	0	3893	4417	1062	9052
1981	124	-446	0	0	-657	-676	-235	-39	1063	3019	0	1060	3214
1982	137	-662	0	0	-802	-736	-288	-30	1357	4643	5408	1325	10352
1983	165	-577	0	0	0	0	0	0	0	0	0	0	-412
1984	0	-686	0	0	0	0	0	0	0	0	3860	0	3174
1985	0	0	0	0	0	0	-449	-97	1374	4863	5527	0	11216
1986	166	-575	0	0	0	0	0	0	0	0	0	0	-409
1987	0	0	0	0	0	0	0	0	0	0	4250	0	4250
1988	130	0	0	0	0	-787	-465	-152	1284	4312	4810	1484	10615
1989	139	-558	0	0	-736	-739	-270	-19	1347	0	4657	0	3820
1990	159	-575	-575	0	-705	-711	-587	-114	1302	2659	4974	1085	6912
1991	110	-714	0	0	-758	-675	-219	0	0	1762	2425	869	2799
1992	101	-585	0	0	-802	0	-490	-24	1335	1230	3568	1246	5579
1993	140	-644	0	0	-531	0	-542	-53	1349	0	427	0	145
1994	0	0	0	0	-714	-866	-440	-59	1311	0	5366	1278	5877
Average	106	-445	-146	-91	-459	-405	-328	-47	892	1893	3266	761	4998

Table C.29
Conservation Cropping Patterns - Reach 13
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	10	-227	-265	0	-305	-321	-252	-40	454	1647	1359	347	2607
1976	9	-217	0	0	-339	-310	-189	-45	354	676	243	270	452
1977	11	-201	-251	-243	-281	-294	-240	-60	448	1030	1315	565	1798
1978	11	-221	-255	-297	-385	0	-218	-27	421	582	975	272	858
1979	8	-185	-281	-274	-226	-327	-205	-32	334	0	1504	361	676
1980	9	-187	0	0	0	0	0	0	0	1336	1525	368	3050
1981	10	-193	0	0	-291	-291	-105	-23	351	1036	0	368	861
1982	11	-287	0	0	-355	-317	-129	-18	446	1597	1860	458	3266
1983	13	-249	0	0	0	0	0	0	0	0	0	0	-237
1984	0	-297	0	0	0	0	0	0	0	0	1327	0	1030
1985	0	0	0	0	0	0	-197	-61	452	1673	1911	0	3778
1986	13	-249	0	0	0	0	0	0	0	0	0	0	-236
1987	0	0	0	0	0	0	0	0	0	0	1474	0	1474
1988	10	0	0	0	0	-338	-206	-80	424	1489	1672	515	3488
1989	11	-242	0	0	-326	-317	-121	-12	446	0	1621	0	1059
1990	12	-249	-260	0	-312	-306	-230	-59	432	926	1727	382	2042
1991	8	-309	0	0	-336	-290	-97	0	0	608	849	302	736
1992	8	-233	0	0	-355	0	-216	-18	442	1230	1239	434	2510
1993	11	-279	0	0	-235	0	-232	-34	445	0	427	0	103
1994	0	0	0	0	-316	-372	-188	-37	434	0	1860	444	1824
Average	8	-192	-66	-41	-203	-174	-143	-27	294	692	1144	264	1557

Table C.30
Conservation Cropping Patterns - Reach 16
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-153	-148	-148	0	-181	-191	-158	-78	584	1679	1134	-18	2322
1976	-130	-144	0	0	-186	-189	-146	-80	458	699	205	-10	477
1977	-159	-150	-151	-158	-184	-196	-141	-105	580	1106	1094	-23	1512
1978	-170	-168	-161	-144	-192	0	-159	-89	543	628	812	-9	891
1979	-124	-149	-172	-162	-152	-200	-155	-83	430	0	1249	-13	468
1980	-140	-167	0	0	0	0	0	0	0	1492	1310	-15	2482
1981	-148	-147	0	0	-166	-185	-104	-77	457	1057	0	-17	669
1982	-163	-198	0	0	-200	-187	-148	-77	577	1636	1540	-18	2762
1983	-197	-166	0	0	0	0	0	0	0	0	0	0	-363
1984	0	-193	0	0	0	0	0	0	0	0	1099	0	905
1985	0	0	0	0	0	0	-146	-98	584	1708	1596	0	3645
1986	-190	-178	0	0	0	0	0	0	0	0	0	0	-368
1987	0	0	0	0	0	0	0	0	0	0	1231	0	1231
1988	-152	0	0	0	0	-189	-133	-104	551	1532	1408	-19	2895
1989	-113	-198	0	0	-191	-182	-132	-59	580	0	1360	0	1065
1990	-189	-182	-164	0	-196	-200	-153	-99	565	991	1452	-13	1813
1991	-140	-160	0	0	-194	-193	-128	0	0	639	720	-12	333
1992	-120	-188	0	0	-199	0	-143	-63	573	1230	1043	-15	2117
1993	-169	-180	0	0	-129	0	-153	-89	581	0	427	0	288
1994	0	0	0	0	-164	-197	-143	-84	568	0	1558	-21	1519
Average	-123	-136	-40	-23	-117	-105	-107	-59	382	720	962	-10	1343

Table C.31
Conservation Cropping Patterns - Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-412	-380	-378	0	-464	-489	-427	-330	1152	4192	2438	-157	4744
1976	-334	-369	0	0	-476	-483	-400	-334	910	1763	443	-81	638
1977	-422	-384	-387	-405	-471	-501	-381	-341	1148	2898	2349	-162	2940
1978	-441	-430	-413	-369	-491	0	-432	-334	1079	1661	1746	-85	1493
1979	-320	-384	-440	-414	-390	-512	-425	-334	846	0	2681	-112	196
1980	-362	-428	0	0	0	0	0	0	0	4060	2906	-111	6065
1981	-382	-377	0	0	-425	-475	-412	-338	906	2628	0	-110	1015
1982	-422	-509	0	0	-512	-479	-403	-321	1143	4107	3306	-133	5778
1983	-509	-425	0	0	0	0	0	0	0	0	0	0	-933
1984	0	-496	0	0	0	0	0	0	0	0	2358	0	1862
1985	0	0	0	0	0	0	-425	-338	1155	4254	3426	0	8073
1986	-506	-456	0	0	0	0	0	0	0	0	0	0	-962
1987	0	0	0	0	0	0	0	0	0	0	2643	0	2643
1988	-403	0	0	0	0	-494	-384	-323	1096	3813	3026	-154	6199
1989	-429	-511	0	0	-488	-467	-418	-302	1147	0	2920	0	1452
1990	-492	-468	-420	0	-500	-511	-436	-345	1122	2561	3120	-106	3524
1991	-374	-411	0	0	-497	-494	-380	0	0	1598	1552	-91	904
1992	-317	-482	0	0	-508	0	-433	-287	1133	1230	2241	-127	2431
1993	-441	-463	0	0	-335	0	-443	-343	1150	0	427	0	-446
1994	0	0	0	0	-420	-512	-440	-343	1127	0	3351	-133	2629
Average	-328	-349	-102	-39	-299	-270	-312	-231	756	1738	2047	-78	2513

Table C.32
Conservation Cropping Patterns - Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-376	-367	-346	0	-419	-448	-402	-332	1399	5011	2952	-123	6548
1976	-333	-373	0	0	-443	-446	-389	-334	1110	2113	543	-59	1389
1977	-386	-381	-353	-369	-440	-453	-381	-339	1390	3481	2841	-124	4485
1978	-399	-387	-395	-330	-449	0	-404	-335	1322	1995	2117	-61	2674
1979	-313	-369	-396	-371	-349	-459	-401	-335	1050	0	3241	-79	1219
1980	-328	-381	0	0	0	0	0	0	0	4885	3529	-82	7623
1981	-357	-356	0	0	-385	-442	-393	-336	1104	3122	0	-85	1873
1982	-379	-457	0	0	-459	-444	-389	-328	1386	4925	3999	-96	7758
1983	-455	-410	0	0	0	0	0	0	0	0	0	0	-865
1984	0	-450	0	0	0	0	0	0	0	0	2848	0	2397
1985	0	0	0	0	0	0	-401	-338	1397	5065	4137	0	9860
1986	-455	-433	0	0	0	0	0	0	0	0	0	0	-887
1987	0	0	0	0	0	0	0	0	0	0	3191	0	3191
1988	-361	0	0	0	0	-436	-367	-315	1338	4530	3656	-111	7935
1989	-418	-457	0	0	-437	-418	-395	-306	1389	0	3529	0	2487
1990	-446	-438	-376	0	-453	-458	-406	-342	1367	3082	3800	-84	5247
1991	-360	-367	0	0	-452	-450	-358	0	0	1916	1888	-66	1750
1992	-292	-430	0	0	-457	0	-404	-291	1375	1230	2710	-94	3348
1993	-407	-435	0	0	-300	0	-409	-340	1393	0	427	0	-70
1994	0	0	0	0	-376	-459	-408	-338	1371	0	4060	-96	3754
Average	-303	-325	-93	-53	-271	-246	-295	-231	920	2068	2473	-58	3586

Table C.33
Conservation Cropping Patterns - Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-475	-481	-458	0	-497	-517	-492	-457	1605	5513	4094	-272	7566
1976	-465	-493	0	0	-517	-517	-492	-458	1441	3952	2723	-197	4978
1977	-481	-495	-461	-470	-517	-516	-493	-460	1598	4693	4030	-271	6158
1978	-486	-478	-496	-445	-516	0	-492	-458	1565	3891	3619	-198	5506
1979	-450	-481	-483	-467	-455	-517	-492	-459	1420	0	4257	-216	1657
1980	-446	-472	0	0	0	0	0	0	0	5452	4426	-223	8737
1981	-469	-470	0	0	-478	-516	-489	-458	1437	4490	0	-229	2819
1982	-473	-516	0	0	-517	-517	-490	-458	1596	5469	4689	-236	8548
1983	-515	-506	0	0	0	0	0	0	0	0	0	0	-1021
1984	0	-516	0	0	0	0	0	0	0	0	4033	0	3516
1985	0	0	0	0	0	0	-492	-460	1601	5535	4765	0	10949
1986	-516	-516	0	0	0	0	0	0	0	0	0	0	-1033
1987	0	0	0	0	0	0	0	0	0	0	4227	0	4227
1988	-462	0	0	0	0	-505	-474	-440	1572	5245	4493	-250	9179
1989	-513	-516	0	0	-505	-494	-488	-440	1596	0	4421	0	3061
1990	-513	-516	-470	0	-517	-517	-491	-460	1586	4479	4593	-231	6943
1991	-475	-466	0	0	-517	-516	-466	0	0	3847	3491	-205	4693
1992	-428	-501	0	0	-517	0	-491	-430	1590	1230	3955	-234	4174
1993	-495	-516	0	0	-427	0	-492	-459	1599	0	427	0	-363
1994	0	0	0	0	-470	-517	-491	-456	1589	0	4726	-236	4143
Average	-383	-397	-118	-69	-323	-282	-366	-318	1090	2690	3349	-150	4722

Table C.34
Deficit Irrigation Practices- Reach 1
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	89	0	0	0	0	0	41	262	521	682	556	294	2445
1976	89	0	0	0	0	0	41	262	521	682	556	294	2445
1977	89	0	0	0	0	0	41	262	521	682	556	294	2445
1978	89	0	0	0	0	0	41	262	521	682	556	294	2445
1979	89	0	0	0	0	0	41	262	521	682	556	294	2445
1980	89	0	0	0	0	0	41	262	521	682	556	294	2445
1981	89	0	0	0	0	0	41	262	521	682	556	294	2445
1982	89	0	0	0	0	0	41	262	521	682	556	294	2445
1983	89	0	0	0	0	0	41	262	521	682	556	294	2445
1984	89	0	0	0	0	0	41	262	521	682	556	294	2445
1985	89	0	0	0	0	0	41	262	521	682	556	294	2445
1986	89	0	0	0	0	0	41	262	521	682	556	294	2445
1987	89	0	0	0	0	0	41	262	521	682	556	294	2445
1988	89	0	0	0	0	0	41	262	521	682	556	294	2445
1989	89	0	0	0	0	0	41	262	521	682	556	294	2445
1990	89	0	0	0	0	0	41	262	521	682	556	294	2445
1991	89	0	0	0	0	0	41	262	521	682	556	294	2445
1992	89	0	0	0	0	0	41	262	521	682	556	294	2445
1993	89	0	0	0	0	0	41	262	521	682	556	294	2445
1994	89	0	0	0	0	0	41	262	521	682	556	294	2445
Average	89	0	0	0	0	0	41	262	521	682	556	294	2445

Table C.35
Deficit Irrigation Practices- Reach 2
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1976	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1977	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1978	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1979	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1980	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1981	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1982	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1983	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1984	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1985	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1986	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1987	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1988	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1989	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1990	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1991	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1992	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1993	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
1994	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211
Average	233	0	0	0	0	0	58	555	1268	1778	1570	750	6211

Table C.36
Deficit Irrigation Practices- Reach 3
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	91	0	0	0	0	0	21	204	466	669	609	292	2351
1976	91	0	0	0	0	0	21	204	466	669	609	292	2351
1977	91	0	0	0	0	0	21	204	466	669	609	292	2351
1978	91	0	0	0	0	0	21	204	466	669	609	292	2351
1979	91	0	0	0	0	0	21	204	466	669	609	292	2351
1980	91	0	0	0	0	0	21	204	466	669	609	292	2351
1981	91	0	0	0	0	0	21	204	466	669	609	292	2351
1982	91	0	0	0	0	0	21	204	466	669	609	292	2351
1983	91	0	0	0	0	0	21	204	466	669	609	292	2351
1984	91	0	0	0	0	0	21	204	466	669	609	292	2351
1985	91	0	0	0	0	0	21	204	466	669	609	292	2351
1986	91	0	0	0	0	0	21	204	466	669	609	292	2351
1987	91	0	0	0	0	0	21	204	466	669	609	292	2351
1988	91	0	0	0	0	0	21	204	466	669	609	292	2351
1989	91	0	0	0	0	0	21	204	466	669	609	292	2351
1990	91	0	0	0	0	0	21	204	466	669	609	292	2351
1991	91	0	0	0	0	0	21	204	466	669	609	292	2351
1992	91	0	0	0	0	0	21	204	466	669	609	292	2351
1993	91	0	0	0	0	0	21	204	466	669	609	292	2351
1994	91	0	0	0	0	0	21	204	466	669	609	292	2351
Average	91	0	0	0	0	0	21	204	466	669	609	292	2351

Table C.37
Deficit Irrigation Practices- Reach 4
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	89	0	0	0	0	0	20	152	307	488	445	231	1732
1976	89	0	0	0	0	0	20	152	307	488	445	231	1732
1977	89	0	0	0	0	0	20	152	307	488	445	231	1732
1978	89	0	0	0	0	0	20	152	307	488	445	231	1732
1979	89	0	0	0	0	0	20	152	307	488	445	231	1732
1980	89	0	0	0	0	0	20	152	307	488	445	231	1732
1981	89	0	0	0	0	0	20	152	307	488	445	231	1732
1982	89	0	0	0	0	0	20	152	307	488	445	231	1732
1983	89	0	0	0	0	0	20	152	307	488	445	231	1732
1984	89	0	0	0	0	0	20	152	307	488	445	231	1732
1985	89	0	0	0	0	0	20	152	307	488	445	231	1732
1986	89	0	0	0	0	0	20	152	307	488	445	231	1732
1987	89	0	0	0	0	0	20	152	307	488	445	231	1732
1988	89	0	0	0	0	0	20	152	307	488	445	231	1732
1989	89	0	0	0	0	0	20	152	307	488	445	231	1732
1990	89	0	0	0	0	0	20	152	307	488	445	231	1732
1991	89	0	0	0	0	0	20	152	307	488	445	231	1732
1992	89	0	0	0	0	0	20	152	307	488	445	231	1732
1993	89	0	0	0	0	0	20	152	307	488	445	231	1732
1994	89	0	0	0	0	0	20	152	307	488	445	231	1732
Average	89	0	0	0	0	0	20	152	307	488	445	231	1732

Table C.38
Deficit Irrigation Practices- Reach 5
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1976	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1977	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1978	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1979	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1980	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1981	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1982	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1983	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1984	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1985	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1986	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1987	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1988	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1989	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1990	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1991	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1992	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1993	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
1994	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743
Average	60	-266	-275	-280	-281	-280	-236	23	598	1553	1548	578	2743

Table C.39
Deficit Irrigation Practices- Reach 6
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1976	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1977	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1978	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1979	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1980	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1981	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1982	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1983	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1984	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1985	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1986	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1987	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1988	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1989	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1990	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1991	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1992	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1993	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
1994	191	0	0	0	0	0	42	403	877	1157	1021	546	4237
Average	191	0	0	0	0	0	42	403	877	1157	1021	546	4237

Table C.40
Deficit Irrigation Practices- Reach 7
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1976	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1977	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1978	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1979	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1980	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1981	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1982	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1983	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1984	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1985	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1986	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1987	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1988	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1989	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1990	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1991	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1992	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1993	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
1994	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337
Average	-135	-143	-146	-148	-149	-148	-84	29	498	945	768	50	1337

Table C.41
Deficit Irrigation Practices- Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1976	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1977	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1978	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1979	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1980	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1981	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1982	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1983	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1984	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1985	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1986	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1987	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1988	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1989	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1990	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1991	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1992	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1993	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
1994	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922
Average	-955	-991	-997	-1004	-1012	-1011	-543	213	3667	6795	5459	303	9922

Table C.42
Deficit Irrigation Practices- Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1976	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1977	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1978	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1979	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1980	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1981	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1982	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1983	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1984	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1985	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1986	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1987	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1988	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1989	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1990	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1991	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1992	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1993	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
1994	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326
Average	-1011	-1006	-932	-859	-789	-731	-304	119	2459	5248	4081	50	6326

Table C.43
Deficit Irrigation Practices- Reach 11
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	32	79	380	624	517	0	1632
1976	0	0	0	0	0	0	32	79	380	624	517	0	1632
1977	0	0	0	0	0	0	32	79	380	624	517	0	1632
1978	0	0	0	0	0	0	32	79	380	624	517	0	1632
1979	0	0	0	0	0	0	32	79	380	624	517	0	1632
1980	0	0	0	0	0	0	32	79	380	624	517	0	1632
1981	0	0	0	0	0	0	32	79	380	624	517	0	1632
1982	0	0	0	0	0	0	32	79	380	624	517	0	1632
1983	0	0	0	0	0	0	32	79	380	624	517	0	1632
1984	0	0	0	0	0	0	32	79	380	624	517	0	1632
1985	0	0	0	0	0	0	32	79	380	624	517	0	1632
1986	0	0	0	0	0	0	32	79	380	624	517	0	1632
1987	0	0	0	0	0	0	32	79	380	624	517	0	1632
1988	0	0	0	0	0	0	32	79	380	624	517	0	1632
1989	0	0	0	0	0	0	32	79	380	624	517	0	1632
1990	0	0	0	0	0	0	32	79	380	624	517	0	1632
1991	0	0	0	0	0	0	32	79	380	624	517	0	1632
1992	0	0	0	0	0	0	32	79	380	624	517	0	1632
1993	0	0	0	0	0	0	32	79	380	624	517	0	1632
1994	0	0	0	0	0	0	32	79	380	624	517	0	1632
Average	0	0	0	0	0	0	32	79	380	624	517	0	1632

Table C.44
Deficit Irrigation Practices- Reach 12
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1976	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1977	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1978	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1979	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1980	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1981	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1982	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1983	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1984	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1985	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1986	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1987	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1988	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1989	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1990	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1991	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1992	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1993	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
1994	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467
Average	136	-877	-875	-875	-876	-879	-781	-329	1341	4683	5171	1627	7467

Table C.45
Deficit Irrigation Practices- Reach 13
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1976	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1977	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1978	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1979	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1980	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1981	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1982	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1983	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1984	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1985	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1986	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1987	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1988	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1989	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1990	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1991	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1992	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1993	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
1994	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873
Average	9	-364	-377	-378	-371	-361	-315	-149	414	1520	1702	542	1873

Table C.46
Deficit Irrigation Practices- Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1976	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1977	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1978	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1979	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1980	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1981	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1982	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1983	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1984	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1985	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1986	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1987	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1988	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1989	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1990	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1991	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1992	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1993	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
1994	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713
Average	-294	-294	-294	-294	-294	-294	-242	-184	907	2655	2419	-78	3713

Table C.47
Deficit Irrigation Practices- Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1976	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1977	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1978	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1979	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1980	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1981	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1982	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1983	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1984	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1985	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1986	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1987	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1988	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1989	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1990	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1991	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1992	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1993	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
1994	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197
Average	-726	-726	-725	-725	-724	-724	-630	-502	1712	6323	4964	-318	7197

Table C.48
Deficit Irrigation Practices- Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1976	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1977	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1978	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1979	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1980	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1981	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1982	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1983	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1984	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1985	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1986	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1987	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1988	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1989	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1990	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1991	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1992	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1993	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
1994	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144
Average	-640	-640	-640	-640	-640	-640	-574	-484	2042	7389	5874	-262	10144

Table C.49
Deficit Irrigation Practices- Reach 19
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1976	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1977	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1978	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1979	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1980	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1981	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1982	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1983	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1984	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1985	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1986	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1987	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1988	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1989	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1990	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1991	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1992	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1993	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
1994	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403
Average	-562	-562	-562	-562	-562	-563	-537	-502	1776	6139	5221	-322	8403

Table C.50
Deficit Irrigation Practices- Reach 1
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18	0	0	0	0	0	13	5	21	3	2	3	66
1976	6	0	0	0	0	0	4	5	5	0	0	2	23
1977	12	0	0	0	0	0	3	7	4	1	2	6	36
1978	40	0	0	0	0	0	2	12	2	1	1	1	59
1979	13	0	0	0	0	0	2	3	15	0	1	1	37
1980	5	0	0	0	0	0	0	0	0	1	2	3	10
1981	7	0	0	0	0	0	1	1	1	5	0	2	16
1982	8	0	0	0	0	0	1	2	3	1	2	3	22
1983	13	0	0	0	0	0	0	0	0	0	0	0	13
1984	0	0	0	0	0	0	0	0	0	0	9	0	9
1985	0	0	0	0	0	0	9	7	14	2	2	0	35
1986	11	0	0	0	0	0	0	0	0	0	0	0	11
1987	0	0	0	0	0	0	0	0	0	0	5	0	5
1988	43	0	0	0	0	0	7	25	5	3	2	7	93
1989	8	0	0	0	0	0	1	1	4	0	1	0	15
1990	38	0	0	0	0	0	3	15	1	0	3	2	62
1991	5	0	0	0	0	0	0	0	0	0	0	3	8
1992	5	0	0	0	0	0	1	3	3	5	2	2	19
1993	48	0	0	0	0	0	1	3	12	0	8	0	71
1994	0	0	0	0	0	0	2	4	3	0	1	4	14
Average	14	0	0	0	0	0	3	5	5	1	2	2	31

Table C.51
Deficit Irrigation Practices- Reach 2
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	47	0	0	0	0	0	18	11	52	7	5	13	153
1976	17	0	0	0	0	0	6	11	11	1	1	6	52
1977	31	0	0	0	0	0	7	14	11	2	5	15	87
1978	107	0	0	0	0	0	3	25	6	2	2	3	148
1979	35	0	0	0	0	0	3	7	37	0	4	3	90
1980	12	0	0	0	0	0	0	0	0	1	5	8	27
1981	19	0	0	0	0	0	1	1	2	12	0	5	40
1982	22	0	0	0	0	0	1	4	8	4	5	12	55
1983	33	0	0	0	0	0	0	0	0	0	0	0	33
1984	0	0	0	0	0	0	0	0	0	0	26	0	26
1985	0	0	0	0	0	0	13	15	34	6	7	0	75
1986	30	0	0	0	0	0	0	0	0	0	0	0	30
1987	0	0	0	0	0	0	0	0	0	0	14	0	14
1988	116	0	0	0	0	0	10	53	13	9	6	18	225
1989	21	0	0	0	0	0	1	2	9	0	4	0	37
1990	101	0	0	0	0	0	4	31	3	1	7	6	153
1991	13	0	0	0	0	0	0	0	0	1	1	7	22
1992	14	0	0	0	0	0	1	6	6	13	5	5	49
1993	127	0	0	0	0	0	1	6	29	0	22	0	186
1994	0	0	0	0	0	0	2	8	8	0	4	11	34
Average	37	0	0	0	0	0	4	10	11	3	6	6	77

Table C.52
Deficit Irrigation Practices- Reach 3
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	19	0	0	0	0	0	7	4	19	3	2	5	58
1976	7	0	0	0	0	0	2	4	4	0	0	2	20
1977	12	0	0	0	0	0	3	5	4	1	2	6	34
1978	43	0	0	0	0	0	1	9	2	1	1	1	58
1979	14	0	0	0	0	0	1	3	14	0	1	1	34
1980	5	0	0	0	0	0	0	0	0	1	2	3	11
1981	7	0	0	0	0	0	0	0	1	5	0	2	16
1982	8	0	0	0	0	0	0	2	3	1	2	5	21
1983	13	0	0	0	0	0	0	0	0	0	0	0	13
1984	0	0	0	0	0	0	0	0	0	0	10	0	10
1985	0	0	0	0	0	0	5	6	13	2	3	0	28
1986	12	0	0	0	0	0	0	0	0	0	0	0	12
1987	0	0	0	0	0	0	0	0	0	0	6	0	6
1988	46	0	0	0	0	0	4	20	3	4	3	7	87
1989	8	0	0	0	0	0	1	1	3	0	2	0	14
1990	40	0	0	0	0	0	2	12	1	0	3	2	60
1991	5	0	0	0	0	0	0	0	0	0	0	3	9
1992	5	0	0	0	0	0	0	2	2	5	2	2	19
1993	50	0	0	0	0	0	0	2	11	0	9	0	72
1994	0	0	0	0	0	0	1	3	3	0	1	5	13
Average	15	0	0	0	0	0	1	4	4	1	2	2	30

Table C.53
Deficit Irrigation Practices- Reach 4
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	18	0	0	0	0	0	7	3	13	2	1	4	48
1976	6	0	0	0	0	0	2	3	3	0	0	2	17
1977	12	0	0	0	0	0	3	4	3	1	1	5	29
1978	42	0	0	0	0	0	1	7	2	1	1	1	54
1979	14	0	0	0	0	0	1	2	9	0	1	1	28
1980	5	0	0	0	0	0	0	0	0	0	1	3	9
1981	7	0	0	0	0	0	0	0	1	3	0	2	13
1982	8	0	0	0	0	0	0	1	2	1	1	4	18
1983	13	0	0	0	0	0	0	0	0	0	0	0	13
1984	0	0	0	0	0	0	0	0	0	0	8	0	8
1985	0	0	0	0	0	0	5	4	9	2	2	0	21
1986	11	0	0	0	0	0	0	0	0	0	0	0	11
1987	0	0	0	0	0	0	0	0	0	0	4	0	4
1988	45	0	0	0	0	0	3	15	3	3	2	6	77
1989	8	0	0	0	0	0	1	1	2	0	1	0	13
1990	40	0	0	0	0	0	1	9	1	0	2	2	55
1991	5	0	0	0	0	0	0	0	0	0	0	2	8
1992	5	0	0	0	0	0	0	2	2	4	1	1	16
1993	50	0	0	0	0	0	0	2	7	0	6	0	65
1994	0	0	0	0	0	0	1	2	2	0	1	4	10
Average	15	0	0	0	0	0	1	3	3	1	2	2	26

Table C.54
Deficit Irrigation Practices- Reach 5
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	33	-137	-159	0	-190	-204	-151	2	65	18	17	70	-635
1976	19	-131	0	0	-212	-196	-101	2	19	3	3	31	-563
1977	28	-121	-151	-148	-175	-186	-140	3	23	6	19	64	-780
1978	29	-133	-153	-181	-240	0	-127	2	12	6	7	15	-762
1979	20	-112	-169	-167	-141	-207	-124	2	46	0	13	24	-815
1980	16	-113	0	0	0	0	0	0	0	4	18	40	-35
1981	21	-116	0	0	-180	-184	-56	1	4	32	0	27	-451
1982	29	-172	0	0	-221	-200	-69	1	11	9	17	62	-534
1983	27	-151	0	0	0	0	0	0	0	0	0	0	-124
1984	0	-179	0	0	0	0	0	0	0	0	55	0	-123
1985	0	0	0	0	0	0	-111	3	41	16	25	0	-26
1986	44	-150	0	0	0	0	0	0	0	0	0	0	-106
1987	0	0	0	0	0	0	0	0	0	0	63	0	63
1988	31	0	0	0	0	-215	-113	6	19	29	25	76	-142
1989	25	-145	0	0	-203	-201	-65	1	11	0	15	0	-563
1990	27	-149	-155	0	-194	-193	-148	3	9	2	25	17	-757
1991	24	-186	0	0	-209	-184	-54	0	0	3	5	25	-577
1992	11	-153	0	0	-221	0	-120	0	22	35	13	16	-393
1993	35	-168	0	0	-146	0	-137	1	53	0	79	0	-282
1994	0	0	0	0	-196	-236	-111	2	14	0	14	60	-453
Average	21	-116	-39	-25	-126	-110	-81	2	17	8	21	26	-403

Table C.55
Deficit Irrigation Practices- Reach 6
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	106	0	0	0	0	0	27	33	77	11	9	53	315
1976	60	0	0	0	0	0	18	31	22	2	1	23	157
1977	89	0	0	0	0	0	25	40	26	4	10	48	242
1978	91	0	0	0	0	0	23	36	15	4	4	11	183
1979	63	0	0	0	0	0	22	25	55	0	7	17	189
1980	52	0	0	0	0	0	0	0	0	2	10	30	94
1981	66	0	0	0	0	0	10	10	4	20	0	20	130
1982	91	0	0	0	0	0	11	11	14	6	8	48	187
1983	85	0	0	0	0	0	0	0	0	0	0	0	85
1984	0	0	0	0	0	0	0	0	0	0	33	0	33
1985	0	0	0	0	0	0	20	41	51	10	13	0	134
1986	139	0	0	0	0	0	0	0	0	0	0	0	139
1987	0	0	0	0	0	0	0	0	0	0	30	0	30
1988	92	0	0	0	0	0	20	92	23	18	13	61	318
1989	78	0	0	0	0	0	11	6	11	0	8	0	114
1990	86	0	0	0	0	0	26	22	7	1	13	13	167
1991	76	0	0	0	0	0	10	0	0	1	2	20	109
1992	36	0	0	0	0	0	21	4	10	22	8	12	112
1993	107	0	0	0	0	0	24	21	70	0	44	0	266
1994	0	0	0	0	0	0	20	25	17	0	7	46	114
Average	56	0	0	0	0	0	14	20	20	5	11	20	158

Table C.56
Deficit Irrigation Practices- Reach 7
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-5	-3	-10	0	-27	-19	-11	1	65	1	1	1	-6
1976	-3	-3	0	0	-14	-35	-4	0	1	0	0	0	-58
1977	0	-1	-5	-8	-4	-16	-3	0	1	0	1	0	-35
1978	-2	-1	-1	-4	-3	0	-2	0	1	0	0	0	-12
1979	-1	-1	-3	-12	-16	-3	-4	1	99	0	6	1	68
1980	-3	-8	0	0	0	0	0	0	0	0	0	1	-10
1981	0	-6	0	0	-10	-11	-4	0	4	1	0	0	-25
1982	-1	0	0	0	-18	-2	-1	0	1	2	0	1	-18
1983	-1	-4	0	0	0	0	0	0	0	0	0	0	-5
1984	0	-35	0	0	0	0	0	0	0	0	11	0	-24
1985	0	0	0	0	0	0	-3	6	39	3	2	0	47
1986	-24	-16	0	0	0	0	0	0	0	0	0	0	-41
1987	0	0	0	0	0	0	0	0	0	0	2	0	2
1988	-1	0	0	0	0	-42	-7	4	9	1	1	1	-34
1989	-1	-1	0	0	-50	-17	-1	0	2	0	1	0	-65
1990	-1	0	-7	0	-37	-39	-22	0	1	0	1	0	-104
1991	-1	-1	0	0	-28	-16	-1	0	0	0	0	0	-46
1992	-1	-1	0	0	-54	0	-8	0	6	5	7	1	-46
1993	-5	-4	0	0	-34	0	-10	0	3	0	2	0	-48
1994	0	0	0	0	-51	-31	-3	0	1	0	0	0	-83
Average	-2	-4	-1	-1	-17	-12	-4	1	12	1	2	0	-27

Table C.57
Deficit Irrigation Practices- Reach 8
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-162	-223	-241	0	-354	-452	-147	13	748	19	20	13	-765
1976	-157	-241	0	0	-376	-447	-68	6	18	3	1	7	-1257
1977	-95	-198	-260	-263	-292	-294	-108	12	80	9	16	9	-1387
1978	-107	-217	-235	-256	-324	0	-38	3	35	4	3	1	-1129
1979	-42	-92	-172	-263	-215	-198	-79	20	997	0	70	11	36
1980	-69	-133	0	0	0	0	0	0	0	9	9	9	-175
1981	-37	-122	0	0	-318	-264	-55	7	57	29	0	1	-700
1982	-65	-93	0	0	-435	-213	-28	2	45	38	9	12	-726
1983	-121	-244	0	0	0	0	0	0	0	0	0	0	-365
1984	0	-427	0	0	0	0	0	0	0	0	123	0	-304
1985	0	0	0	0	0	0	-74	60	461	48	45	0	540
1986	-349	-333	0	0	0	0	0	0	0	0	0	0	-682
1987	0	0	0	0	0	0	0	0	0	0	43	0	43
1988	-117	0	0	0	0	-450	-115	56	138	34	19	9	-427
1989	-56	-76	0	0	-451	-322	-40	1	58	0	15	0	-872
1990	-59	-60	-135	0	-387	-373	-211	8	23	2	25	3	-1164
1991	-78	-138	0	0	-319	-263	-31	0	0	3	4	8	-814
1992	-34	-62	0	0	-490	0	-124	2	142	169	118	13	-265
1993	-207	-225	0	0	-320	0	-126	6	85	0	47	0	-741
1994	0	0	0	0	-444	-385	-62	4	24	0	7	3	-853
Average	-88	-144	-52	-39	-236	-183	-65	10	146	18	29	5	-600

Table C.58
Deficit Irrigation Practices- Reach 9
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-403	-445	-388	0	-414	-364	-140	22	728	143	129	9	-1324
1976	-356	-488	0	0	-518	-477	-119	20	118	48	16	4	-1753
1977	-319	-406	-458	-405	-435	-343	-121	23	213	67	110	12	-2061
1978	-304	-443	-449	-450	-503	0	-108	12	74	48	55	3	-2065
1979	-167	-290	-415	-420	-249	-333	-104	21	872	0	97	5	-983
1980	-164	-213	0	0	0	0	0	0	0	42	111	6	-218
1981	-188	-261	0	0	-470	-391	-65	10	67	266	0	5	-1025
1982	-247	-357	0	0	-592	-400	-65	7	81	81	75	7	-1411
1983	-483	-495	0	0	0	0	0	0	0	0	0	0	-979
1984	0	-593	0	0	0	0	0	0	0	0	184	0	-409
1985	0	0	0	0	0	0	-132	45	552	204	208	0	876
1986	-594	-527	0	0	0	0	0	0	0	0	0	0	-1121
1987	0	0	0	0	0	0	0	0	0	0	212	0	212
1988	-343	0	0	0	0	-475	-128	51	186	293	194	9	-214
1989	-216	-288	0	0	-481	-423	-65	7	195	0	128	0	-1143
1990	-252	-300	-318	0	-416	-370	-168	23	110	33	165	3	-1490
1991	-254	-395	0	0	-383	-345	-46	0	0	34	37	3	-1348
1992	-133	-289	0	0	-478	0	-125	8	241	435	208	4	-129
1993	-452	-484	0	0	-357	0	-116	14	266	0	427	0	-683
1994	0	0	0	0	-466	-469	-91	17	159	0	111	9	-729
Average	-244	-314	-101	-64	-287	-230	-80	14	193	85	123	4	-900

Table C.59
Deficit Irrigation Practices- Reach 11
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	3	1	35	0	1	0	41
1976	0	0	0	0	0	0	1	0	0	0	0	0	2
1977	0	0	0	0	0	0	1	1	1	0	0	0	3
1978	0	0	0	0	0	0	1	0	1	0	0	0	2
1979	0	0	0	0	0	0	1	3	62	0	3	0	69
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	1	1	2	0	0	0	4
1982	0	0	0	0	0	0	0	0	1	1	0	0	2
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	1	10	21	1	1	0	35
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	0	0	0	0	0	0	2	7	5	1	0	0	14
1989	0	0	0	0	0	0	0	0	1	0	0	0	2
1990	0	0	0	0	0	0	7	1	1	0	1	0	9
1991	0	0	0	0	0	0	0	0	0	0	0	0	1
1992	0	0	0	0	0	0	2	0	3	2	3	0	11
1993	0	0	0	0	0	0	3	0	2	0	1	0	7
1994	0	0	0	0	0	0	1	0	0	0	0	0	2
Average	0	0	0	0	0	0	1	1	7	0	1	0	11

Table C.60
Deficit Irrigation Practices- Reach 12
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	78	-452	-509	0	-594	-643	-509	-55	253	117	152	349	-1813
1976	44	-433	0	0	-662	-621	-360	-58	81	34	20	157	-1798
1977	66	-401	-483	-465	-548	-589	-478	-77	97	51	145	337	-2347
1978	68	-440	-490	-570	-750	0	-433	-41	44	46	56	75	-2434
1979	45	-369	-540	-525	-441	-636	-415	-44	205	0	93	117	-2529
1980	38	-374	0	0	0	0	0	0	0	31	143	200	39
1981	51	-384	0	0	-566	-583	-201	-30	25	243	0	142	-1302
1982	68	-571	0	0	-691	-634	-246	-23	42	60	110	274	-1610
1983	63	-497	0	0	0	0	0	0	0	0	0	0	-434
1984	0	-591	0	0	0	0	0	0	0	0	266	0	-325
1985	0	0	0	0	0	0	-384	-76	167	151	205	0	64
1986	101	-496	0	0	0	0	0	0	0	0	0	0	-395
1987	0	0	0	0	0	0	0	0	0	0	351	0	351
1988	72	0	0	0	0	-678	-398	-118	80	241	215	350	-236
1989	58	-481	0	0	-634	-636	-231	-15	77	0	147	0	-1716
1990	63	-495	-495	0	-608	-612	-502	-89	47	24	215	95	-2357
1991	56	-615	0	0	-653	-581	-188	0	0	28	39	121	-1793
1992	26	-504	0	0	-691	0	-419	-19	122	263	176	90	-955
1993	87	-555	0	0	-458	0	-464	-41	182	0	427	0	-822
1994	0	0	0	0	-615	-746	-376	-46	66	0	115	281	-1321
Average	49	-383	-126	-78	-395	-349	-280	-37	74	65	144	129	-1187

Table C.61
Deficit Irrigation Practices- Reach 13
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	5	-188	-220	0	-253	-266	-208	-31	106	62	88	160	-745
1976	3	-180	0	0	-282	-257	-156	-35	37	22	11	72	-767
1977	4	-167	-208	-202	-233	-244	-199	-47	43	31	77	158	-987
1978	5	-184	-212	-247	-319	0	-180	-22	18	24	29	34	-1053
1979	3	-154	-233	-227	-187	-271	-170	-25	94	0	47	51	-1074
1980	3	-156	0	0	0	0	0	0	0	17	79	90	34
1981	3	-160	0	0	-242	-242	-87	-18	14	129	0	65	-537
1982	5	-238	0	0	-294	-263	-106	-14	18	32	54	116	-691
1983	4	-207	0	0	0	0	0	0	0	0	0	0	-203
1984	0	-246	0	0	0	0	0	0	0	0	113	0	-133
1985	0	0	0	0	0	0	-163	-48	75	90	113	0	68
1986	7	-206	0	0	0	0	0	0	0	0	0	0	-200
1987	0	0	0	0	0	0	0	0	0	0	156	0	156
1988	5	0	0	0	0	-280	-170	-65	35	146	124	155	-49
1989	4	-201	0	0	-270	-263	-100	-10	45	0	95	0	-701
1990	4	-207	-216	0	-259	-254	-207	-47	23	17	122	48	-975
1991	4	-257	0	0	-278	-241	-81	0	0	17	27	55	-752
1992	2	-210	0	0	-294	0	-179	-14	53	142	112	44	-344
1993	6	-232	0	0	-195	0	-191	-27	75	0	230	0	-334
1994	0	0	0	0	-262	-309	-155	-30	33	0	64	127	-532
Average	3	-160	-54	-34	-168	-144	-118	-22	33	37	77	59	-491

Table C.62
Deficit Irrigation Practices- Reach 16
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-223	-216	-215	0	-264	-278	-229	-112	647	1190	847	-38	1109
1976	-189	-209	0	0	-271	-275	-211	-115	379	536	219	-21	-158
1977	-232	-218	-220	-231	-268	-285	-205	-152	536	757	798	-47	233
1978	-248	-244	-235	-210	-279	0	-231	-128	394	449	572	-20	-180
1979	-180	-218	-250	-236	-222	-291	-226	-119	572	0	906	-27	-290
1980	-203	-242	0	0	0	0	0	0	0	953	930	-30	1407
1981	-216	-214	0	0	-242	-270	-151	-111	339	956	0	-36	56
1982	-238	-288	0	0	-291	-272	-214	-112	477	1080	1036	-37	1141
1983	-287	-241	0	0	0	0	0	0	0	0	0	0	-528
1984	0	-281	0	0	0	0	0	0	0	0	906	0	625
1985	0	0	0	0	0	0	-212	-141	529	1230	1187	0	2593
1986	-277	-259	0	0	0	0	0	0	0	0	0	0	-535
1987	0	0	0	0	0	0	0	0	0	0	957	0	957
1988	-221	0	0	0	0	-275	-193	-130	434	1373	1057	-39	1986
1989	-165	-288	0	0	-278	-266	-191	-85	506	0	1052	0	285
1990	-276	-265	-239	0	-285	-291	-223	-142	437	701	1089	-26	481
1991	-203	-233	0	0	-283	-280	-186	0	0	453	502	-25	-254
1992	-175	-273	0	0	-289	0	-211	-91	448	1127	908	-31	1413
1993	-247	-262	0	0	-188	0	-222	-128	513	0	427	0	-106
1994	0	0	0	0	-239	-287	-205	-121	450	0	1080	-43	635
Average	-179	-198	-58	-34	-170	-154	-155	-85	333	540	724	-21	544

Table C.63
Deficit Irrigation Practices- Reach 17
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-580	-535	-532	0	-653	-689	-600	-462	1599	5010	3025	-262	5322
1976	-470	-519	0	0	-670	-680	-562	-466	1215	2365	848	-136	925
1977	-593	-540	-545	-570	-663	-704	-535	-477	1538	3285	3034	-271	2958
1978	-620	-605	-581	-520	-690	0	-606	-467	1356	1942	2108	-141	1176
1979	-450	-540	-619	-583	-548	-720	-597	-467	1196	0	3515	-187	0
1980	-509	-602	0	0	0	0	0	0	0	4375	3397	-186	6475
1981	-538	-530	0	0	-598	-668	-579	-472	1211	3615	0	-183	1257
1982	-593	-717	0	0	-721	-673	-566	-448	1555	4927	4038	-222	6580
1983	-716	-598	0	0	0	0	0	0	0	0	0	0	-1313
1984	0	-697	0	0	0	0	0	0	0	0	3063	0	2366
1985	0	0	0	0	0	0	-596	-472	1559	5323	4455	0	10269
1986	-711	-642	0	0	0	0	0	0	0	0	0	0	-1353
1987	0	0	0	0	0	0	0	0	0	0	3519	0	3519
1988	-567	0	0	0	0	-681	-539	-449	1431	5113	4048	-258	8099
1989	-604	-719	0	0	-687	-657	-587	-422	1575	0	3858	0	1758
1990	-693	-658	-591	0	-704	-720	-612	-483	1506	3146	3886	-176	3901
1991	-526	-578	0	0	-699	-695	-533	0	0	2030	1952	-153	799
1992	-446	-678	0	0	-715	0	-607	-401	1474	1230	2956	-213	2601
1993	-620	-649	0	0	-471	0	-621	-479	1607	0	427	0	-808
1994	0	0	0	0	-591	-720	-618	-480	1522	0	4021	-221	2912
Average	-462	-490	-143	-84	-421	-380	-438	-322	1017	2118	2607	-130	2872

Table C.64
Deficit Irrigation Practices- Reach 18
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-523	-510	-481	0	-583	-623	-558	-460	1962	6491	3847	-237	8326
1976	-462	-519	0	0	-616	-620	-540	-462	1530	2889	886	-114	1972
1977	-537	-531	-491	-513	-612	-630	-528	-469	1918	4404	3774	-240	5545
1978	-555	-538	-530	-459	-624	0	-561	-462	1770	2558	2724	-117	3186
1979	-435	-513	-551	-515	-485	-638	-556	-464	1487	0	4336	-153	1513
1980	-457	-530	0	0	0	0	0	0	0	6047	4477	-159	9378
1981	-497	-495	0	0	-535	-614	-545	-465	1521	4320	0	-163	2527
1982	-527	-636	0	0	-638	-617	-540	-454	1926	6390	5174	-186	9893
1983	-633	-570	0	0	0	0	0	0	0	0	0	0	-1202
1984	0	-626	0	0	0	0	0	0	0	0	3793	0	3167
1985	0	0	0	0	0	0	-556	-467	1933	6699	5514	0	13123
1986	-632	-602	0	0	0	0	0	0	0	0	0	0	-1234
1987	0	0	0	0	0	0	0	0	0	0	4301	0	4301
1988	-502	0	0	0	0	-606	-510	-435	1824	5380	4939	-214	9877
1989	-582	-635	0	0	-608	-581	-547	-423	1939	0	4739	0	3301
1990	-621	-609	-522	0	-630	-637	-563	-472	1887	4044	4964	-163	6678
1991	-500	-511	0	0	-628	-626	-497	0	0	2553	2477	-128	2139
1992	-406	-599	0	0	-635	0	-560	-403	1870	1230	3637	-181	3953
1993	-566	-604	0	0	-417	0	-568	-470	1960	0	427	0	-237
1994	0	0	0	0	-523	-638	-566	-467	1899	0	5230	-186	4729
Average	-422	-451	-130	-74	-377	-341	-410	-319	1271	2650	3261	-112	4547

Table C.65
Deficit Irrigation Practices- Reach 19
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-515	-522	-497	0	-539	-561	-534	-496	1763	6014	4431	-319	8225
1976	-505	-536	0	0	-561	-561	-534	-497	1583	4312	2947	-232	5417
1977	-522	-538	-501	-511	-561	-561	-535	-499	1755	5120	4362	-318	6692
1978	-528	-520	-538	-483	-561	0	-534	-497	1719	4245	3917	-233	5988
1979	-489	-522	-525	-508	-494	-562	-534	-498	1560	0	4607	-253	1783
1980	-485	-513	0	0	0	0	0	0	0	5947	4790	-262	9478
1981	-509	-510	0	0	-519	-561	-531	-497	1579	4898	0	-268	3082
1982	-514	-561	0	0	-561	-561	-531	-497	1753	5966	5075	-277	9292
1983	-559	-550	0	0	0	0	0	0	0	0	0	0	-1109
1984	0	-561	0	0	0	0	0	0	0	0	4365	0	3804
1985	0	0	0	0	0	0	-534	-499	1758	6038	5158	0	11920
1986	-561	-561	0	0	0	0	0	0	0	0	0	0	-1121
1987	0	0	0	0	0	0	0	0	0	0	4575	0	4575
1988	-502	0	0	0	0	-549	-515	-478	1726	5380	4863	-293	9633
1989	-558	-560	0	0	-548	-537	-529	-477	1754	0	4785	0	3328
1990	-557	-560	-511	0	-561	-561	-534	-499	1742	4886	4971	-271	7545
1991	-516	-506	0	0	-561	-561	-506	0	0	4197	3778	-241	5085
1992	-464	-544	0	0	-561	0	-533	-467	1747	1230	4281	-275	4413
1993	-537	-560	0	0	-464	0	-534	-498	1756	0	427	0	-411
1994	0	0	0	0	-511	-562	-534	-495	1745	0	5115	-277	4482
Average	-416	-431	-129	-75	-350	-307	-398	-345	1197	2912	3622	-176	5105

Table C.66

Deficit Irrigation Practices- Reach 1

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	67	0	0	0	0	0	37	228	457	376	323	227	1918
1976	55	0	0	0	0	0	34	227	350	217	61	113	1057
1977	69	0	0	0	0	0	33	228	408	324	324	222	1608
1978	68	0	0	0	0	0	36	223	410	203	241	111	1291
1979	51	0	0	0	0	0	36	227	333	0	385	149	1180
1980	56	0	0	0	0	0	0	0	0	460	372	153	1040
1981	62	0	0	0	0	0	32	230	312	354	0	150	1140
1982	68	0	0	0	0	0	34	230	429	550	470	195	1976
1983	83	0	0	0	0	0	0	0	0	0	0	0	83
1984	0	0	0	0	0	0	0	0	0	0	342	0	342
1985	0	0	0	0	0	0	37	233	437	582	472	0	1761
1986	83	0	0	0	0	0	0	0	0	0	0	0	83
1987	0	0	0	0	0	0	0	0	0	0	354	0	354
1988	63	0	0	0	0	0	34	212	377	474	390	212	1761
1989	68	0	0	0	0	0	34	201	435	0	366	0	1104
1990	76	0	0	0	0	0	36	226	331	280	431	150	1531
1991	53	0	0	0	0	0	32	0	0	205	202	125	617
1992	48	0	0	0	0	0	35	173	433	489	302	178	1657
1993	68	0	0	0	0	0	37	229	448	0	427	0	1210
1994	0	0	0	0	0	0	36	220	406	0	445	180	1286
Average	52	0	0	0	0	0	26	154	278	236	295	108	1150

Table C.67

Deficit Irrigation Practices- Reach 2

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	177	0	0	0	0	0	52	485	1117	1509	936	595	4872
1976	147	0	0	0	0	0	48	484	857	572	176	295	2578
1977	186	0	0	0	0	0	46	486	1007	883	950	594	4151
1978	185	0	0	0	0	0	50	474	1002	532	694	293	3229
1979	137	0	0	0	0	0	51	482	814	0	1101	390	2974
1980	149	0	0	0	0	0	0	0	0	1212	1082	400	2844
1981	164	0	0	0	0	0	46	490	767	941	0	397	2805
1982	181	0	0	0	0	0	48	489	1049	1440	1343	502	5053
1983	218	0	0	0	0	0	0	0	0	0	0	0	218
1984	0	0	0	0	0	0	0	0	0	0	973	0	975
1985	0	0	0	0	0	0	52	495	1069	1535	1363	0	4513
1986	219	0	0	0	0	0	0	0	0	0	0	0	219
1987	0	0	0	0	0	0	0	0	0	0	1030	0	1030
1988	169	0	0	0	0	0	47	452	922	1255	1143	560	4549
1989	182	0	0	0	0	0	48	430	1068	0	1061	0	2789
1990	205	0	0	0	0	0	50	483	812	739	1246	394	3928
1991	141	0	0	0	0	0	45	0	0	544	585	328	1643
1992	130	0	0	0	0	0	49	370	1062	1230	879	466	4186
1993	183	0	0	0	0	0	52	488	1092	0	427	0	2242
1994	0	0	0	0	0	0	50	469	997	0	1308	481	3305
Average	139	0	0	0	0	0	37	329	682	620	815	285	2905

Table C.68

Deficit Irrigation Practices- Reach 3

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	70	0	0	0	0	0	19	180	415	576	377	234	1870
1976	58	0	0	0	0	0	18	180	319	226	69	116	987
1977	73	0	0	0	0	0	17	181	390	349	375	238	1621
1978	73	0	0	0	0	0	19	175	378	203	276	116	1239
1979	54	0	0	0	0	0	19	179	303	0	431	154	1141
1980	59	0	0	0	0	0	0	0	0	464	430	158	1111
1981	64	0	0	0	0	0	18	182	292	361	0	157	1073
1982	71	0	0	0	0	0	18	181	395	552	530	197	1943
1983	86	0	0	0	0	0	0	0	0	0	0	0	86
1984	0	0	0	0	0	0	0	0	0	0	382	0	382
1985	0	0	0	0	0	0	19	183	404	584	540	0	1730
1986	86	0	0	0	0	0	0	0	0	0	0	0	86
1987	0	0	0	0	0	0	0	0	0	0	411	0	411
1988	67	0	0	0	0	0	18	167	362	498	462	221	1795
1989	72	0	0	0	0	0	18	160	399	0	438	0	1087
1990	81	0	0	0	0	0	19	180	307	300	490	158	1534
1991	56	0	0	0	0	0	17	0	0	209	235	129	646
1992	52	0	0	0	0	0	19	142	395	493	349	185	1634
1993	72	0	0	0	0	0	19	180	404	0	427	0	1103
1994	0	0	0	0	0	0	19	174	381	0	523	190	1287
Average	55	0	0	0	0	0	14	122	257	241	337	113	1138

Table C.69
Deficit Irrigation Practices- Reach 4
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	69	0	0	0	0	0	19	135	276	426	285	157	1397
1976	57	0	0	0	0	0	18	135	214	174	51	93	741
1977	72	0	0	0	0	0	17	136	270	265	277	192	1229
1978	73	0	0	0	0	0	18	131	255	151	206	93	927
1979	53	0	0	0	0	0	18	135	203	0	318	124	851
1980	58	0	0	0	0	0	0	0	0	345	321	126	850
1981	63	0	0	0	0	0	17	137	199	267	0	126	810
1982	70	0	0	0	0	0	18	136	267	410	393	158	1452
1983	84	0	0	0	0	0	0	0	0	0	0	0	84
1984	0	0	0	0	0	0	0	0	0	0	282	0	282
1985	0	0	0	0	0	0	19	138	274	431	402	0	1263
1986	85	0	0	0	0	0	0	0	0	0	0	0	85
1987	0	0	0	0	0	0	0	0	0	0	308	0	308
1988	66	0	0	0	0	0	17	126	255	382	349	176	1371
1989	71	0	0	0	0	0	18	121	268	0	338	0	815
1990	81	0	0	0	0	0	18	137	209	235	361	128	1169
1991	56	0	0	0	0	0	16	0	0	156	176	103	508
1992	51	0	0	0	0	0	18	111	264	364	260	148	1216
1993	72	0	0	0	0	0	19	135	269	0	408	0	902
1994	0	0	0	0	0	0	18	132	261	0	391	152	954
Average	54	0	0	0	0	0	13	92	174	180	256	90	861

Table C.70
Deficit Irrigation Practices- Reach 5
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	47	-137	-159	0	-190	-204	-151	21	541	1364	997	471	2601
1976	39	-131	0	0	-212	-196	-101	21	420	356	179	233	808
1977	49	-121	-151	-148	-175	-186	-140	21	531	850	968	485	1982
1978	49	-133	-153	-181	-240	0	-127	21	502	483	719	234	1174
1979	36	-112	-169	-167	-141	-207	-124	21	398	0	1111	312	957
1980	39	-113	0	0	0	0	0	0	0	1104	1124	317	2471
1981	43	-116	0	0	-180	-184	-56	21	404	856	0	317	1104
1982	47	-172	0	0	-221	-200	-69	21	528	1314	1376	396	3021
1983	57	-151	0	0	0	0	0	0	0	0	0	0	-93
1984	0	-179	0	0	0	0	0	0	0	0	983	0	804
1985	0	0	0	0	0	0	-111	21	537	1378	1406	0	3231
1986	58	-150	0	0	0	0	0	0	0	0	0	0	-93
1987	0	0	0	0	0	0	0	0	0	0	1078	0	1078
1988	45	0	0	0	0	-215	-113	19	501	1223	1223	444	3126
1989	48	-145	0	0	-203	-201	-65	19	526	0	1183	0	1162
1990	55	-149	-155	0	-194	-193	-148	21	460	754	1264	323	2037
1991	38	-186	0	0	-209	-184	-54	0	0	500	617	260	782
1992	35	-153	0	0	-221	0	-120	17	519	1163	909	373	2522
1993	49	-168	0	0	-146	0	-137	21	526	0	427	0	571
1994	0	0	0	0	-196	-236	-111	20	512	0	1165	382	1736
Average	37	-116	-39	-25	-126	-110	-81	14	345	377	846	227	1549

Table C.71
Deficit Irrigation Practices- Reach 6
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	149	0	0	0	0	0	39	360	790	1013	655	444	3450
1976	123	0	0	0	0	0	37	360	612	413	118	220	1883
1977	156	0	0	0	0	0	35	363	774	631	636	457	3052
1978	157	0	0	0	0	0	38	349	733	359	473	221	2329
1979	115	0	0	0	0	0	38	360	581	0	731	293	2118
1980	125	0	0	0	0	0	0	0	0	819	739	299	1982
1981	136	0	0	0	0	0	36	346	510	630	0	297	1953
1982	150	0	0	0	0	0	32	347	713	967	831	372	3412
1983	181	0	0	0	0	0	0	0	0	0	0	0	181
1984	0	0	0	0	0	0	0	0	0	0	646	0	646
1985	0	0	0	0	0	0	39	365	779	1014	905	0	3102
1986	182	0	0	0	0	0	0	0	0	0	0	0	182
1987	0	0	0	0	0	0	0	0	0	0	629	0	629
1988	134	0	0	0	0	0	36	327	724	892	797	416	3326
1989	152	0	0	0	0	0	35	321	658	0	766	0	1932
1990	173	0	0	0	0	0	37	345	571	553	775	302	2756
1991	120	0	0	0	0	0	34	0	0	233	403	244	1033
1992	110	0	0	0	0	0	37	264	705	860	595	350	2921
1993	154	0	0	0	0	0	39	358	767	0	427	0	1744
1994	0	0	0	0	0	0	38	349	741	0	862	359	2349
Average	116	0	0	0	0	0	27	241	483	419	349	214	2049

Table C.72
Deficit Irrigation Practices- Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-5	-3	-10	0	-27	-19	-11	26	456	823	491	39	1760
1976	-3	-3	0	0	-14	-35	-4	26	347	329	86	20	749
1977	0	-3	-5	-8	-4	-16	-3	28	445	503	474	42	1453
1978	-2	-1	-1	-4	-3	0	-2	25	408	282	346	20	1068
1979	-1	-1	-3	-12	-16	-1	-4	17	239	0	549	27	794
1980	-3	-8	0	0	0	0	0	0	0	664	543	27	1223
1981	0	-6	0	0	-10	-11	-4	26	352	512	0	27	887
1982	-1	0	0	0	-18	-2	-1	26	447	803	669	34	1957
1983	-1	-4	0	0	0	0	0	0	0	0	0	0	-5
1984	0	-35	0	0	0	0	0	0	0	0	389	0	354
1985	0	0	0	0	0	0	-3	26	422	836	698	0	1979
1986	-24	-16	0	0	0	0	0	0	0	0	0	0	-41
1987	0	0	0	0	0	0	0	0	0	0	330	0	330
1988	-1	0	0	0	0	-42	-7	24	423	746	607	39	1790
1989	-1	-1	0	0	-30	-17	-1	24	449	0	591	0	995
1990	-1	0	-7	0	-37	-39	-22	27	432	464	627	29	1472
1991	-1	-1	0	0	-28	-16	-1	0	0	311	309	23	596
1992	-1	-1	0	0	-54	0	-8	22	447	710	455	33	1604
1993	-5	-4	0	0	-34	0	-10	26	448	0	427	0	848
1994	0	0	0	0	-31	-31	-3	25	430	0	663	33	1067
Average	-2	-4	-1	-1	-17	-12	-4	17	287	349	423	20	1054

Table C.73
Deficit Irrigation Practices- Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-162	-223	-241	0	-354	-452	-147	194	3377	5958	3518	239	11708
1976	-157	-241	0	0	-376	-447	-68	194	2580	2388	614	119	4606
1977	-95	-198	-260	-265	-292	-294	-108	196	3309	3655	3397	253	9300
1978	-107	-217	-235	-256	-324	0	-38	190	3050	2042	2476	120	6703
1979	-42	-92	-172	-263	-215	-198	-79	164	2148	0	3927	164	5341
1980	-69	-133	0	0	0	0	0	0	0	4808	3885	165	8656
1981	-37	-122	0	0	-318	-264	-55	198	2616	3714	0	164	5897
1982	-63	-93	0	0	-435	-213	-28	194	3307	5812	4789	206	13476
1983	-121	-244	0	0	0	0	0	0	0	0	0	0	-365
1984	0	-427	0	0	0	0	0	0	0	0	2837	0	2409
1985	0	0	0	0	0	0	-74	195	3126	6050	4990	0	14287
1986	-349	-333	0	0	0	0	0	0	0	0	0	0	-682
1987	0	0	0	0	0	0	0	0	0	0	3795	0	3795
1988	-117	0	0	0	0	-450	-115	181	3140	5380	4345	233	12596
1989	-56	-76	0	0	-451	-322	-40	177	3327	0	4228	0	6786
1990	-59	-60	-135	0	-387	-373	-211	200	3202	3361	4489	173	10201
1991	-78	-138	0	0	-319	-263	-31	0	0	2250	2208	138	3767
1992	-34	-62	0	0	-490	0	-124	166	3313	1230	3256	199	7454
1993	-207	-225	0	0	-320	0	-126	195	3318	0	427	0	3062
1994	0	0	0	0	-444	-385	-62	191	3188	0	4756	198	7442
Average	-88	-144	-52	-39	-236	-183	-65	132	2150	2332	2897	119	6822

Table C.74
Deficit Irrigation Practices- Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-403	-445	-388	0	-414	-564	-140	110	2290	4658	2660	41	7404
1976	-356	-488	0	0	-518	-477	-119	110	1754	1875	465	20	2266
1977	-319	-406	-458	-405	-435	-343	-121	111	2253	2881	2572	45	5373
1978	-304	-443	-449	-450	-503	0	-108	109	2096	1603	1875	20	3446
1979	-167	-290	-415	-420	-249	-333	-104	111	1704	0	2965	28	2829
1980	-164	-215	0	0	0	0	0	0	0	3767	2936	28	6353
1981	-188	-261	0	0	-470	-391	-63	112	1779	2911	0	28	3455
1982	-247	-357	0	0	-592	-400	-65	110	2245	4552	3620	33	8899
1983	-485	-495	0	0	0	0	0	0	0	0	0	0	-979
1984	0	-593	0	0	0	0	0	0	0	0	2252	0	1659
1985	0	0	0	0	0	0	-132	111	2203	4737	3769	0	10689
1986	-594	-527	0	0	0	0	0	0	0	0	0	0	-1121
1987	0	0	0	0	0	0	0	0	0	0	2868	0	2868
1988	-343	0	0	0	0	-475	-128	102	2136	4234	3285	39	8850
1989	-216	-288	0	0	-481	-423	-65	100	2256	0	3197	0	4080
1990	-252	-300	-318	0	-416	-370	-168	113	2177	2631	3392	29	6518
1991	-254	-395	0	0	-383	-343	-46	0	0	1762	1670	23	2032
1992	-133	-289	0	0	-478	0	-125	94	2245	1230	2461	34	5038
1993	-452	-484	0	0	-337	0	-116	110	2249	0	427	0	1397
1994	0	0	0	0	-466	-469	-91	108	2167	0	3607	33	4890
Average	-244	-314	-101	-64	-287	-230	-80	75	1478	1842	2201	20	4297

Table C.75
Deficit Irrigation Practices- Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	30	72	348	544	331	0	1325
1976	0	0	0	0	0	0	28	72	265	218	58	0	641
1977	0	0	0	0	0	0	26	73	340	333	320	0	1092
1978	0	0	0	0	0	0	29	69	311	186	233	0	829
1979	0	0	0	0	0	0	29	48	183	0	370	0	631
1980	0	0	0	0	0	0	0	0	0	439	366	0	805
1981	0	0	0	0	0	0	29	73	269	339	0	0	710
1982	0	0	0	0	0	0	29	72	341	530	451	0	1423
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	262	0	262
1985	0	0	0	0	0	0	29	72	322	552	470	0	1447
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	358	0	358
1988	0	0	0	0	0	0	28	67	323	493	409	0	1320
1989	0	0	0	0	0	0	28	65	343	0	398	0	835
1990	0	0	0	0	0	0	30	74	330	307	423	0	1163
1991	0	0	0	0	0	0	26	0	0	205	208	0	440
1992	0	0	0	0	0	0	30	61	342	469	307	0	1209
1993	0	0	0	0	0	0	30	72	342	0	427	0	872
1994	0	0	0	0	0	0	30	71	328	0	447	0	876
Average	0	0	0	0	0	0	22	48	219	231	292	0	812

Table C.76
Deficit Irrigation Practices- Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	107	-452	-509	0	-594	-643	-509	-55	1225	4146	3355	1336	7407
1976	89	-433	0	0	-662	-621	-360	-58	952	1690	602	661	1860
1977	112	-401	-483	-465	-548	-589	-478	-77	1206	2581	3257	1379	5493
1978	113	-440	-490	-570	-750	0	-433	-41	1138	1468	2417	665	3077
1979	83	-369	-540	-525	-441	-656	-415	-44	901	0	3735	884	2612
1980	90	-374	0	0	0	0	0	0	0	3354	3777	900	7747
1981	98	-384	0	0	-566	-583	-201	-30	941	2601	0	898	2775
1982	108	-571	0	0	-691	-634	-246	-23	1201	4000	4625	1123	8892
1983	130	-497	0	0	0	0	0	0	0	0	0	0	-367
1984	0	-591	0	0	0	0	0	0	0	0	3301	0	2710
1985	0	0	0	0	0	0	-384	-76	1216	4189	4726	0	9671
1986	131	-496	0	0	0	0	0	0	0	0	0	0	-364
1987	0	0	0	0	0	0	0	0	0	0	3635	0	3635
1988	103	0	0	0	0	-678	-398	-118	1137	3714	4113	1258	9130
1989	110	-481	0	0	-634	-636	-231	-15	1192	0	3982	0	3287
1990	126	-495	-495	0	-608	-612	-502	-89	1133	2291	4254	919	5941
1991	87	-615	0	0	-653	-581	-188	0	0	1518	2074	736	2378
1992	80	-504	0	0	-691	0	-419	-19	1182	1230	3052	1056	4967
1993	111	-555	0	0	-458	0	-464	-41	1194	0	427	0	214
1994	0	0	0	0	-615	-746	-376	-46	1161	0	4589	1083	5050
Average	84	-383	-126	-78	-395	-349	-280	-37	790	1639	2796	645	4306

Table C.77
Deficit Irrigation Practices- Reach 13
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	7	-188	-220	0	-253	-266	-208	-31	384	1369	1123	450	2166
1976	6	-180	0	0	-282	-257	-156	-35	300	562	201	222	380
1977	7	-167	-208	-202	-233	-244	-199	-47	379	856	1087	465	1495
1978	7	-184	-212	-247	-319	0	-180	-22	356	484	806	224	715
1979	5	-154	-233	-227	-187	-271	-170	-25	283	0	1243	297	561
1980	6	-156	0	0	0	0	0	0	0	1110	1261	303	2524
1981	6	-160	0	0	-242	-242	-87	-18	297	861	0	302	719
1982	7	-238	0	0	-294	-263	-106	-14	378	1327	1538	377	2711
1983	9	-207	0	0	0	0	0	0	0	0	0	0	-198
1984	0	-246	0	0	0	0	0	0	0	0	1097	0	851
1985	0	0	0	0	0	0	-163	-48	382	1390	1580	0	3142
1986	9	-206	0	0	0	0	0	0	0	0	0	0	-198
1987	0	0	0	0	0	0	0	0	0	0	1219	0	1219
1988	7	0	0	0	0	-280	-170	-63	359	1227	1383	423	2895
1989	7	-201	0	0	-270	-263	-100	-10	377	0	1341	0	881
1990	8	-207	-216	0	-259	-254	-207	-47	366	770	1428	314	1697
1991	6	-257	0	0	-278	-241	-81	0	0	505	702	249	606
1992	5	-210	0	0	294	0	-179	-14	374	1164	1023	357	2228
1993	7	-232	0	0	-195	0	-191	-27	377	0	427	0	166
1994	0	0	0	0	-262	-309	-155	-30	367	0	1538	366	1515
Average	6	-160	-54	-34	-168	-144	-118	-22	249	582	950	237	1304

Table C.78
Deficit Irrigation Practices- Reach 16
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-223	-216	-215	0	-264	-278	-229	-112	870	2466	1644	-38	3405
1976	-189	-209	0	0	-271	-275	-211	-115	682	1026	297	-21	714
1977	-232	-218	-220	-231	-268	-285	-205	-152	864	1624	1586	-47	2217
1978	-248	-244	-235	-210	-279	0	-231	-128	809	923	1177	-20	1313
1979	-180	-218	-250	-236	-222	-291	-226	-119	640	0	1810	-27	682
1980	-203	-242	0	0	0	0	0	0	0	2192	1900	-30	3615
1981	-216	-214	0	0	-242	-270	-131	-111	680	1552	0	-36	994
1982	-238	-288	0	0	-291	-272	-214	-112	860	2403	2232	-37	4043
1983	-287	-241	0	0	0	0	0	0	0	0	0	0	-528
1984	0	-281	0	0	0	0	0	0	0	0	1593	0	1311
1985	0	0	0	0	0	0	-212	-141	871	2509	2313	0	5340
1986	-277	-259	0	0	0	0	0	0	0	0	0	0	-535
1987	0	0	0	0	0	0	0	0	0	0	1784	0	1784
1988	-221	0	0	0	0	-275	-193	-150	822	2250	2042	-39	4235
1989	-165	-288	0	0	-278	-266	-191	-85	864	0	1972	0	1564
1990	-276	-265	-239	0	-285	-291	-223	-142	843	1456	2105	-26	2657
1991	-203	-235	0	0	-283	-280	-186	0	0	939	1044	-25	773
1992	-175	-273	0	0	-289	0	-211	-91	854	1230	1512	-31	2327
1993	-247	-262	0	0	-188	0	-222	-128	866	0	427	0	247
1994	0	0	0	0	-239	-287	-205	-123	846	0	2259	-43	2211
Average	-179	-198	-58	-34	-170	-154	-155	-85	569	1028	1383	-21	1929

Table C.79
Deficit Irrigation Practices- Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-580	-535	-532	0	-653	-689	-600	-462	1656	5940	3406	-262	6689
1976	-470	-519	0	0	-670	-680	-562	-466	1307	2498	619	-136	921
1977	-593	-540	-545	-570	-663	-704	-535	-477	1650	4106	3281	-271	4138
1978	-620	-605	-581	-520	-690	0	-606	-467	1551	2354	2459	-141	2115
1979	-450	-540	-619	-583	-548	-720	-597	-467	1216	0	3744	-187	249
1980	-509	-602	0	0	0	0	0	0	0	5754	4059	-186	8516
1981	-538	-530	0	0	-598	-668	-579	-472	1302	3724	0	-183	1458
1982	-593	-717	0	0	-721	-673	-566	-448	1643	5820	4618	-222	8141
1983	-716	-598	0	0	0	0	0	0	0	0	0	0	-1313
1984	0	-697	0	0	0	0	0	0	0	0	3293	0	2596
1985	0	0	0	0	0	0	-596	-472	1661	6028	4785	0	11406
1986	-711	-642	0	0	0	0	0	0	0	0	0	0	-1353
1987	0	0	0	0	0	0	0	0	0	0	3692	0	3692
1988	-567	0	0	0	0	-681	-539	-449	1576	5380	4227	-258	8689
1989	-604	-719	0	0	-687	-657	-587	-422	1648	0	4079	0	2052
1990	-693	-658	-591	0	-704	-720	-612	-483	1612	3629	4358	-176	4963
1991	-526	-578	0	0	-699	-695	-533	0	0	2265	2168	-153	1249
1992	-446	-678	0	0	-715	0	-607	-401	1629	1230	3131	-213	2931
1993	-620	-649	0	0	-471	0	-621	-479	1653	0	427	0	-761
1994	0	0	0	0	-591	-720	-618	-480	1619	0	4680	-221	3669
Average	-462	-490	-143	-84	-421	-380	-438	-322	1086	2436	2850	-130	1502

Table C.80
Deficit Irrigation Practices- Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-523	-510	-481	0	-583	-623	-558	-460	1997	7037	4074	-237	9134
1976	-462	-519	0	0	-616	-620	-540	-462	1585	2967	749	-114	1969
1977	-537	-531	-491	-513	-612	-630	-529	-469	1985	4888	3921	-240	6242
1978	-555	-538	-550	-459	-624	0	-561	-462	1887	2802	2921	-117	3744
1979	-435	-513	-551	-515	-485	-638	-556	-464	1499	0	4472	-153	1661
1980	-457	-530	0	0	0	0	0	0	0	6861	4871	-159	10587
1981	-497	-495	0	0	-535	-614	-545	-465	1577	4384	0	-163	2646
1982	-527	-636	0	0	-658	-617	-540	-454	1979	6916	5519	-186	10817
1983	-633	-570	0	0	0	0	0	0	0	0	0	0	-1202
1984	0	-626	0	0	0	0	0	0	0	0	3930	0	3304
1985	0	0	0	0	0	0	-556	-467	1994	7113	3710	0	11793
1986	-632	-602	0	0	0	0	0	0	0	0	0	0	-1234
1987	0	0	0	0	0	0	0	0	0	0	4403	0	4403
1988	-502	0	0	0	0	-606	-510	-435	1911	5380	5045	-214	10070
1989	-582	-635	0	0	-608	-581	-547	-423	1982	0	4870	0	3476
1990	-621	-609	-522	0	-630	-637	-563	-472	1951	4329	5245	-163	7308
1991	-500	-511	0	0	-628	-626	-497	0	0	2691	2605	-128	2406
1992	-406	-599	0	0	-635	0	-560	-403	1963	1230	3741	-181	4150
1993	-566	-604	0	0	-417	0	-568	-470	1988	0	427	0	-209
1994	0	0	0	0	-533	-638	-566	-467	1957	0	5603	-186	5180
Average	-422	-451	-130	-74	-377	-341	-410	-319	1513	2830	3405	-112	4912

Table C.81
Deficit Irrigation Practices- Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-515	-522	-497	0	-539	-561	-534	-496	1763	6014	4431	-319	8225
1976	-505	-536	0	0	-561	-561	-534	-497	1583	4312	2947	-232	5417
1977	-522	-538	-501	-511	-561	-561	-535	-499	1755	5120	4362	-318	6692
1978	-528	-520	-538	-483	-561	0	-534	-497	1719	4245	3917	-233	5988
1979	-489	-522	-525	-508	-494	-562	-534	-498	1560	0	4607	-253	1783
1980	-485	-513	0	0	0	0	0	0	0	5947	4790	-262	9478
1981	-509	-510	0	0	-519	-561	-531	-497	1579	4898	0	-268	3082
1982	-514	-561	0	0	-561	-561	-531	-497	1753	5966	5075	-277	9292
1983	-559	-550	0	0	0	0	0	0	0	0	0	0	-1109
1984	0	-561	0	0	0	0	0	0	0	0	4365	0	3804
1985	0	0	0	0	0	0	-534	-499	1758	6038	5158	0	11920
1986	-561	-561	0	0	0	0	0	0	0	0	0	0	-1121
1987	0	0	0	0	0	0	0	0	0	0	4575	0	4575
1988	-502	0	0	0	0	-549	-515	-478	1726	5380	4863	-293	9633
1989	-558	-560	0	0	-548	-537	-529	-477	1754	0	4785	0	3328
1990	-557	-560	-511	0	-561	-561	-534	-499	1742	4886	4971	-271	7545
1991	-516	-506	0	0	-561	-561	-506	0	0	4197	3778	-241	5085
1992	-464	-544	0	0	-561	0	-533	-467	1747	1230	4281	-275	4413
1993	-537	-560	0	0	-464	0	-534	-498	1756	0	427	0	-411
1994	0	0	0	0	-511	-562	-534	-495	1745	0	5115	-277	4482
Average	-416	-431	-129	-75	-350	-307	-398	-345	1197	2912	3622	-176	5105

Table C.82
Water District Structural Alternatives - Reach 1
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	100	0	0	0	0	0	46	293	583	764	622	329	2737
1976	100	0	0	0	0	0	46	293	583	764	622	329	2737
1977	100	0	0	0	0	0	46	293	583	764	622	329	2737
1978	100	0	0	0	0	0	46	293	583	764	622	329	2737
1979	100	0	0	0	0	0	46	293	583	764	622	329	2737
1980	100	0	0	0	0	0	46	293	583	764	622	329	2737
1981	100	0	0	0	0	0	46	293	583	764	622	329	2737
1982	100	0	0	0	0	0	46	293	583	764	622	329	2737
1983	100	0	0	0	0	0	46	293	583	764	622	329	2737
1984	100	0	0	0	0	0	46	293	583	764	622	329	2737
1985	100	0	0	0	0	0	46	293	583	764	622	329	2737
1986	100	0	0	0	0	0	46	293	583	764	622	329	2737
1987	100	0	0	0	0	0	46	293	583	764	622	329	2737
1988	100	0	0	0	0	0	46	293	583	764	622	329	2737
1989	100	0	0	0	0	0	46	293	583	764	622	329	2737
1990	100	0	0	0	0	0	46	293	583	764	622	329	2737
1991	100	0	0	0	0	0	46	293	583	764	622	329	2737
1992	100	0	0	0	0	0	46	293	583	764	622	329	2737
1993	100	0	0	0	0	0	46	293	583	764	622	329	2737
1994	100	0	0	0	0	0	46	293	583	764	622	329	2737
Average	100	0	0	0	0	0	46	293	583	764	622	329	2737

Table C.83
Water District Structural Alternatives - Reach 2
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1976	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1977	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1978	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1979	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1980	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1981	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1982	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1983	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1984	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1985	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1986	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1987	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1988	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1989	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1990	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1991	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1992	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1993	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
1994	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106
Average	191	0	0	0	0	0	47	456	1041	1461	1291	617	5106

Table C.84
Water District Structural Alternatives - Reach 3
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	27	0	0	0	0	0	6	62	141	202	184	88	710
1976	27	0	0	0	0	0	6	62	141	202	184	88	710
1977	27	0	0	0	0	0	6	62	141	202	184	88	710
1978	27	0	0	0	0	0	6	62	141	202	184	88	710
1979	27	0	0	0	0	0	6	62	141	202	184	88	710
1980	27	0	0	0	0	0	6	62	141	202	184	88	710
1981	27	0	0	0	0	0	6	62	141	202	184	88	710
1982	27	0	0	0	0	0	6	62	141	202	184	88	710
1983	27	0	0	0	0	0	6	62	141	202	184	88	710
1984	27	0	0	0	0	0	6	62	141	202	184	88	710
1985	27	0	0	0	0	0	6	62	141	202	184	88	710
1986	27	0	0	0	0	0	6	62	141	202	184	88	710
1987	27	0	0	0	0	0	6	62	141	202	184	88	710
1988	27	0	0	0	0	0	6	62	141	202	184	88	710
1989	27	0	0	0	0	0	6	62	141	202	184	88	710
1990	27	0	0	0	0	0	6	62	141	202	184	88	710
1991	27	0	0	0	0	0	6	62	141	202	184	88	710
1992	27	0	0	0	0	0	6	62	141	202	184	88	710
1993	27	0	0	0	0	0	6	62	141	202	184	88	710
1994	27	0	0	0	0	0	6	62	141	202	184	88	710
Average	27	0	0	0	0	0	6	62	141	202	184	88	710

Table C.85
Water District Structural Alternatives - Reach 4
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	27	0	0	0	0	0	6	47	94	149	135	70	528
1976	27	0	0	0	0	0	6	47	94	149	135	70	528
1977	27	0	0	0	0	0	6	47	94	149	135	70	528
1978	27	0	0	0	0	0	6	47	94	149	135	70	528
1979	27	0	0	0	0	0	6	47	94	149	135	70	528
1980	27	0	0	0	0	0	6	47	94	149	135	70	528
1981	27	0	0	0	0	0	6	47	94	149	135	70	528
1982	27	0	0	0	0	0	6	47	94	149	135	70	528
1983	27	0	0	0	0	0	6	47	94	149	135	70	528
1984	27	0	0	0	0	0	6	47	94	149	135	70	528
1985	27	0	0	0	0	0	6	47	94	149	135	70	528
1986	27	0	0	0	0	0	6	47	94	149	135	70	528
1987	27	0	0	0	0	0	6	47	94	149	135	70	528
1988	27	0	0	0	0	0	6	47	94	149	135	70	528
1989	27	0	0	0	0	0	6	47	94	149	135	70	528
1990	27	0	0	0	0	0	6	47	94	149	135	70	528
1991	27	0	0	0	0	0	6	47	94	149	135	70	528
1992	27	0	0	0	0	0	6	47	94	149	135	70	528
1993	27	0	0	0	0	0	6	47	94	149	135	70	528
1994	27	0	0	0	0	0	6	47	94	149	135	70	528
Average	27	0	0	0	0	0	6	47	94	149	135	70	528

Table C.86
Water District Structural Alternatives - Reach 5
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1976	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1977	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1978	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1979	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1980	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1981	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1982	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1983	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1984	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1985	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1986	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1987	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1988	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1989	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1990	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1991	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1992	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1993	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
1994	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794
Average	39	-10	-10	-11	-11	-11	-4	36	124	268	266	118	794

Table C.87
Water District Structural Alternatives - Reach 6
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	86	0	0	0	0	0	19	181	393	518	457	244	1898
1976	86	0	0	0	0	0	19	181	393	518	457	244	1898
1977	86	0	0	0	0	0	19	181	393	518	457	244	1898
1978	86	0	0	0	0	0	19	181	393	518	457	244	1898
1979	86	0	0	0	0	0	19	181	393	518	457	244	1898
1980	86	0	0	0	0	0	19	181	393	518	457	244	1898
1981	86	0	0	0	0	0	19	181	393	518	457	244	1898
1982	86	0	0	0	0	0	19	181	393	518	457	244	1898
1983	86	0	0	0	0	0	19	181	393	518	457	244	1898
1984	86	0	0	0	0	0	19	181	393	518	457	244	1898
1985	86	0	0	0	0	0	19	181	393	518	457	244	1898
1986	86	0	0	0	0	0	19	181	393	518	457	244	1898
1987	86	0	0	0	0	0	19	181	393	518	457	244	1898
1988	86	0	0	0	0	0	19	181	393	518	457	244	1898
1989	86	0	0	0	0	0	19	181	393	518	457	244	1898
1990	86	0	0	0	0	0	19	181	393	518	457	244	1898
1991	86	0	0	0	0	0	19	181	393	518	457	244	1898
1992	86	0	0	0	0	0	19	181	393	518	457	244	1898
1993	86	0	0	0	0	0	19	181	393	518	457	244	1898
1994	86	0	0	0	0	0	19	181	393	518	457	244	1898
Average	86	0	0	0	0	0	19	181	393	518	457	244	1898

Table C.88
Water District Structural Alternatives - Reach 7
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1976	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1977	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1978	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1979	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1980	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1981	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1982	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1983	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1984	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1985	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1986	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1987	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1988	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1989	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1990	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1991	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1992	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1993	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
1994	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183
Average	-12	-15	-15	-15	-15	-15	14	64	270	466	387	71	1183

Table C.89
Water District Structural Alternatives - Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1976	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1977	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1978	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1979	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1980	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1981	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1982	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1983	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1984	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1985	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1986	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1987	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1988	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1989	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1990	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1991	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1992	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1993	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
1994	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831
Average	-256	-274	-276	-278	-280	-278	-34	352	2097	3670	2993	396	7831

Table C.90
Water District Structural Alternatives - Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1976	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1977	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1978	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1979	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1980	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1981	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1982	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1983	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1984	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1985	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1986	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1987	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1988	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1989	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1990	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1991	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1992	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1993	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
1994	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930
Average	-233	-236	-219	-202	-185	-172	13	198	1242	2493	1997	234	4930

Table C.91
Water District Structural Alternatives - Reach 10
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1976	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1977	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1978	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1979	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1980	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1981	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1982	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1983	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1984	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1985	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1986	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1987	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1988	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1989	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1990	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1991	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1992	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1993	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
1994	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307
Average	-13	-11	-9	-8	-7	-6	1	5	102	236	148	-130	307

Table C.92
Water District Structural Alternatives - Reach 11
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	38	95	444	725	601	0	1904
1976	0	0	0	0	0	0	38	95	444	725	601	0	1904
1977	0	0	0	0	0	0	38	95	444	725	601	0	1904
1978	0	0	0	0	0	0	38	95	444	725	601	0	1904
1979	0	0	0	0	0	0	38	95	444	725	601	0	1904
1980	0	0	0	0	0	0	38	95	444	725	601	0	1904
1981	0	0	0	0	0	0	38	95	444	725	601	0	1904
1982	0	0	0	0	0	0	38	95	444	725	601	0	1904
1983	0	0	0	0	0	0	38	95	444	725	601	0	1904
1984	0	0	0	0	0	0	38	95	444	725	601	0	1904
1985	0	0	0	0	0	0	38	95	444	725	601	0	1904
1986	0	0	0	0	0	0	38	95	444	725	601	0	1904
1987	0	0	0	0	0	0	38	95	444	725	601	0	1904
1988	0	0	0	0	0	0	38	95	444	725	601	0	1904
1989	0	0	0	0	0	0	38	95	444	725	601	0	1904
1990	0	0	0	0	0	0	38	95	444	725	601	0	1904
1991	0	0	0	0	0	0	38	95	444	725	601	0	1904
1992	0	0	0	0	0	0	38	95	444	725	601	0	1904
1993	0	0	0	0	0	0	38	95	444	725	601	0	1904
1994	0	0	0	0	0	0	38	95	444	725	601	0	1904
Average	0	0	0	0	0	0	38	95	444	725	601	0	1904

Table C.93
Water District Structural Alternatives - Reach 12
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1976	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1977	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1978	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1979	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1980	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1981	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1982	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1983	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1984	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1985	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1986	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1987	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1988	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1989	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1990	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1991	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1992	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1993	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
1994	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311
Average	279	-62	-61	-61	-62	-62	-27	131	691	1803	1962	780	5311

Table C.94
Water District Structural Alternatives - Reach 13
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1976	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1977	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1978	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1979	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1980	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1981	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1982	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1983	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1984	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1985	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1986	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1987	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1988	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1989	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1990	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1991	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1992	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1993	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
1994	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224
Average	67	-17	-18	-18	-17	-17	-8	29	160	417	458	188	1224

Table C.95
Water District Structural Alternatives - Reach 14
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1976	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1977	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1978	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1979	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1980	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1981	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1982	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1983	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1984	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1985	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1986	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1987	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1988	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1989	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1990	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1991	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1992	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1993	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
1994	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320
Average	-6	-4	-3	-2	-2	-2	3	8	61	140	122	4	320

Table C.96
Water District Structural Alternatives - Reach 15
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1976	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1977	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1978	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1979	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1980	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1981	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1982	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1983	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1984	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1985	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1986	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1987	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1988	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1989	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1990	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1991	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1992	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1993	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
1994	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444
Average	-5	-5	-5	-5	-5	-5	-1	4	82	202	181	8	444

Table C.97
Water District Structural Alternatives - Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1976	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1977	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1978	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1979	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1980	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1981	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1982	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1983	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1984	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1985	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1986	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1987	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1988	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1989	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1990	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1991	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1992	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1993	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
1994	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549
Average	-5	-5	-5	-5	-5	-5	-1	4	96	245	225	12	549

Table C.98
Water District Structural Alternatives - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1976	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1977	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1978	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1979	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1980	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1981	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1982	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1983	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1984	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1985	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1986	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1987	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1988	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1989	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1990	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1991	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1992	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1993	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
1994	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196
Average	-223	-222	-222	-222	-222	-222	-183	-129	830	2827	2236	-51	4196

Table C.99
Water District Structural Alternatives - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1976	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1977	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1978	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1979	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1980	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1981	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1982	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1983	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1984	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1985	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1986	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1987	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1988	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1989	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1990	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1991	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1992	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1993	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
1994	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130
Average	-126	-126	-126	-126	-126	-126	-109	-87	573	1969	1571	-31	3130

Table C.100
Water District Structural Alternatives - Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1976	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1977	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1978	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1979	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1980	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1981	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1982	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1983	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1984	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1985	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1986	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1987	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1988	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1989	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1990	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1991	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1992	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1993	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
1994	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420
Average	-61	-61	-61	-61	-61	-61	-58	-53	272	893	761	-28	1420

Table C.101
Water District Structural Alternatives - Reach 1
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	20	0	0	0	0	0	14	6	24	3	2	6	74
1976	7	0	0	0	0	0	5	6	5	0	0	2	26
1977	13	0	0	0	0	0	6	8	5	1	2	6	41
1978	44	0	0	0	0	0	3	13	3	1	1	1	66
1979	15	0	0	0	0	0	2	4	17	0	1	1	41
1980	5	0	0	0	0	0	0	0	0	1	2	4	11
1981	8	0	0	0	0	0	1	1	1	5	0	2	17
1982	9	0	0	0	0	0	1	2	4	2	2	5	24
1983	14	0	0	0	0	0	0	0	0	0	0	0	14
1984	0	0	0	0	0	0	0	0	0	0	10	0	10
1985	0	0	0	0	0	0	10	8	15	3	3	0	39
1986	13	0	0	0	0	0	0	0	0	0	0	0	13
1987	0	0	0	0	0	0	0	0	0	0	5	0	5
1988	49	0	0	0	0	0	8	28	6	4	2	8	104
1989	9	0	0	0	0	0	1	1	4	0	2	0	17
1990	42	0	0	0	0	0	3	16	1	0	3	2	69
1991	5	0	0	0	0	0	0	0	0	0	0	3	9
1992	6	0	0	0	0	0	1	3	3	6	2	2	22
1993	53	0	0	0	0	0	1	3	13	0	9	0	79
1994	0	0	0	0	0	0	2	4	4	0	1	5	16
Average	16	0	0	0	0	0	3	5	5	1	2	2	33

Table C.102
Water District Structural Alternatives - Reach 2
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	39	0	0	0	0	0	15	9	42	6	4	11	126
1976	14	0	0	0	0	0	5	9	9	1	1	5	43
1977	26	0	0	0	0	0	6	12	9	2	4	13	71
1978	88	0	0	0	0	0	3	20	5	2	2	2	122
1979	29	0	0	0	0	0	3	6	31	0	3	3	74
1980	10	0	0	0	0	0	0	0	0	1	4	7	22
1981	15	0	0	0	0	0	1	1	2	10	0	4	33
1982	18	0	0	0	0	0	1	3	6	3	4	10	45
1983	27	0	0	0	0	0	0	0	0	0	0	0	27
1984	0	0	0	0	0	0	0	0	0	0	21	0	21
1985	0	0	0	0	0	0	11	13	28	5	6	0	62
1986	24	0	0	0	0	0	0	0	0	0	0	0	24
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	96	0	0	0	0	0	8	44	10	7	5	15	185
1989	17	0	0	0	0	0	1	2	7	0	3	0	31
1990	83	0	0	0	0	0	3	26	3	1	6	5	126
1991	11	0	0	0	0	0	0	0	0	1	1	5	18
1992	11	0	0	0	0	0	1	5	5	11	4	4	41
1993	105	0	0	0	0	0	1	5	24	0	18	0	153
1994	0	0	0	0	0	0	2	7	7	0	3	9	28
Average	31	0	0	0	0	0	3	8	9	2	5	5	63

Table C.103
Water District Structural Alternatives - Reach 3
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	6	0	0	0	0	0	2	1	6	1	1	2	18
1976	2	0	0	0	0	0	1	1	1	0	0	1	6
1977	4	0	0	0	0	0	1	2	1	0	1	2	10
1978	13	0	0	0	0	0	0	3	1	0	0	0	17
1979	4	0	0	0	0	0	0	1	4	0	0	0	10
1980	1	0	0	0	0	0	0	0	0	0	1	1	3
1981	2	0	0	0	0	0	0	0	0	1	0	1	5
1982	3	0	0	0	0	0	0	0	1	0	1	1	6
1983	4	0	0	0	0	0	0	0	0	0	0	0	4
1984	0	0	0	0	0	0	0	0	0	0	3	0	3
1985	0	0	0	0	0	0	1	2	4	1	1	0	9
1986	4	0	0	0	0	0	0	0	0	0	0	0	4
1987	0	0	0	0	0	0	0	0	0	0	2	0	2
1988	14	0	0	0	0	0	1	6	1	1	1	2	26
1989	3	0	0	0	0	0	0	0	1	0	0	0	4
1990	12	0	0	0	0	0	0	4	0	0	1	1	18
1991	2	0	0	0	0	0	0	0	0	0	0	1	3
1992	2	0	0	0	0	0	0	1	1	2	1	1	8
1993	15	0	0	0	0	0	0	1	3	0	3	0	22
1994	0	0	0	0	0	0	0	1	1	0	0	1	4
Average	4	0	0	0	0	0	0	1	1	0	1	1	9

Table C.104
Water District Structural Alternatives - Reach 4
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	6	0	0	0	0	0	2	1	4	1	0	1	15
1976	2	0	0	0	0	0	1	1	1	0	0	1	5
1977	4	0	0	0	0	0	1	1	1	0	0	2	9
1978	13	0	0	0	0	0	0	2	0	0	0	0	16
1979	4	0	0	0	0	0	0	1	3	0	0	0	9
1980	1	0	0	0	0	0	0	0	0	0	0	1	3
1981	2	0	0	0	0	0	0	0	0	1	0	0	4
1982	3	0	0	0	0	0	0	0	1	0	0	1	6
1983	4	0	0	0	0	0	0	0	0	0	0	0	4
1984	0	0	0	0	0	0	0	0	0	0	2	0	2
1985	0	0	0	0	0	0	1	1	3	1	1	0	7
1986	3	0	0	0	0	0	0	0	0	0	0	0	3
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	14	0	0	0	0	0	1	5	1	1	1	2	24
1989	2	0	0	0	0	0	0	0	1	0	0	0	4
1990	12	0	0	0	0	0	0	3	0	0	1	1	17
1991	2	0	0	0	0	0	0	0	0	0	0	1	2
1992	2	0	0	0	0	0	0	1	0	1	0	0	5
1993	15	0	0	0	0	0	0	1	2	0	2	0	20
1994	0	0	0	0	0	0	0	1	1	0	0	1	3
Average	4	0	0	0	0	0	0	1	1	0	1	1	8

Table C.105
Water District Structural Alternatives - Reach 5
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	22	-5	-6	0	-7	-8	-3	4	13	3	3	14	30
1976	12	-5	0	0	-8	-7	-2	4	4	1	0	6	5
1977	18	-5	-6	-6	-7	-7	-3	5	5	1	3	13	13
1978	19	-3	-6	-7	-9	0	-2	4	3	1	1	3	1
1979	13	-4	-6	-6	-5	-8	-2	3	10	0	2	5	0
1980	11	-4	0	0	0	0	0	0	0	1	3	8	18
1981	14	-4	0	0	-7	-7	-1	2	1	6	0	6	8
1982	19	-7	0	0	-8	-8	-1	1	2	2	3	13	16
1983	17	-6	0	0	0	0	0	0	0	0	0	0	12
1984	0	-7	0	0	0	0	0	0	0	0	10	0	3
1985	0	0	0	0	0	0	-2	5	8	3	4	0	18
1986	28	-6	0	0	0	0	0	0	0	0	0	0	23
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	20	0	0	0	0	-8	-2	10	4	5	4	16	48
1989	16	-6	0	0	-8	-8	-1	1	2	0	3	0	0
1990	18	-6	-6	0	-7	-7	-3	3	2	0	4	3	4
1991	16	-7	0	0	-8	-7	-1	0	0	0	1	3	-1
1992	7	-6	0	0	-8	0	-2	1	5	6	3	3	8
1993	23	-6	0	0	-6	0	-2	2	11	0	14	0	35
1994	0	0	0	0	-7	-9	-2	3	3	0	2	12	2
Average	14	-4	-1	-1	-3	-4	-1	2	4	1	4	5	13

Table C.106
Water District Structural Alternatives - Reach 6
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	47	0	0	0	0	0	12	15	34	5	4	24	141
1976	27	0	0	0	0	0	8	14	10	1	1	10	70
1977	40	0	0	0	0	0	11	18	12	2	5	21	108
1978	41	0	0	0	0	0	10	16	7	2	2	3	82
1979	28	0	0	0	0	0	10	11	25	0	3	7	85
1980	23	0	0	0	0	0	0	0	0	1	4	13	42
1981	30	0	0	0	0	0	4	4	2	9	0	9	58
1982	41	0	0	0	0	0	7	7	6	3	4	21	84
1983	38	0	0	0	0	0	0	0	0	0	0	0	38
1984	0	0	0	0	0	0	0	0	0	0	13	0	15
1985	0	0	0	0	0	0	8	18	23	4	6	0	60
1986	62	0	0	0	0	0	0	0	0	0	0	0	62
1987	0	0	0	0	0	0	0	0	0	0	13	0	13
1988	41	0	0	0	0	0	9	41	10	8	6	27	142
1989	35	0	0	0	0	0	5	3	5	0	3	0	51
1990	38	0	0	0	0	0	12	10	3	1	6	6	75
1991	34	0	0	0	0	0	4	0	0	0	1	9	49
1992	16	0	0	0	0	0	9	2	-4	10	4	3	30
1993	48	0	0	0	0	0	11	9	31	0	20	0	119
1994	0	0	0	0	0	0	9	11	7	0	3	21	51
Average	29	0	0	0	0	0	6	9	9	2	3	9	70

Table C.107
Water District Structural Alternatives - Reach 7
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	-1	0	-3	-2	2	2	35	0	1	1	35
1976	0	0	0	0	-1	-4	1	1	0	0	0	0	-4
1977	0	0	0	-1	0	-2	0	1	1	0	0	0	-1
1978	0	0	0	0	0	0	0	0	1	0	0	0	0
1979	0	0	0	-1	-2	0	1	3	54	0	3	1	58
1980	0	-1	0	0	0	0	0	0	0	0	0	1	0
1981	0	-1	0	0	-1	-1	1	1	2	0	0	0	1
1982	0	0	0	0	-2	0	0	0	1	1	0	1	1
1983	0	0	0	0	0	0	0	0	0	0	0	0	-1
1984	0	-4	0	0	0	0	0	0	0	0	6	0	2
1985	0	0	0	0	0	0	1	14	21	1	1	0	38
1986	-2	-2	0	0	0	0	0	0	0	0	0	0	-4
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	0	0	0	0	0	-4	1	8	5	1	0	1	12
1989	0	0	0	0	-5	-2	0	0	1	0	0	0	-5
1990	0	0	-1	0	-4	-4	4	1	1	0	1	0	-3
1991	0	0	0	0	-3	-2	0	0	0	0	0	1	-4
1992	0	0	0	0	-6	0	1	0	3	2	4	1	6
1993	0	0	0	0	-4	0	2	1	2	0	1	0	0
1994	0	0	0	0	-5	-3	0	0	0	0	0	0	-7
Average	0	0	0	0	-2	-1	1	2	6	0	1	0	6

Table C.108
Water District Structural Alternatives - Reach 8
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-43	-62	-67	0	-98	-124	-9	22	428	10	11	17	85
1976	-42	-67	0	0	-104	-123	-4	11	11	2	0	4	-312
1977	-25	-55	-72	-73	-81	-81	-7	20	46	5	9	12	-304
1978	-29	-60	-65	-71	-90	0	-2	6	20	2	2	1	-286
1979	-11	-25	-48	-73	-59	-34	-5	32	570	0	38	15	379
1980	-18	-37	0	0	0	0	0	0	0	5	5	12	-34
1981	-10	-34	0	0	-88	-73	-3	12	33	16	0	2	-145
1982	-17	-26	0	0	-120	-59	-2	4	26	20	5	15	-153
1983	-32	-68	0	0	0	0	0	0	0	0	0	0	-100
1984	0	-118	0	0	0	0	0	0	0	0	68	0	-51
1985	0	0	0	0	0	0	-5	99	263	26	25	0	409
1986	-93	-92	0	0	0	0	0	0	0	0	0	0	-186
1987	0	0	0	0	0	0	0	0	0	0	23	0	23
1988	-31	0	0	0	0	-124	-7	93	79	18	10	11	49
1989	-15	-21	0	0	-125	-89	-3	2	33	0	8	0	-209
1990	-16	-17	-37	0	-107	-103	-13	13	13	1	14	4	-248
1991	-21	-38	0	0	-88	-72	-2	0	0	2	2	10	-208
1992	-9	-17	0	0	-136	0	-8	3	81	91	65	18	88
1993	-55	-62	0	0	-88	0	-8	9	49	0	26	0	-130
1994	0	0	0	0	-123	-106	-4	7	14	0	4	4	-204
Average	-23	-40	-14	-11	-65	-50	-4	17	83	10	16	6	-77

Table C.109
Water District Structural Alternatives - Reach 9
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-93	-105	-91	0	-97	-133	6	37	367	68	83	44	66
1976	-82	-115	0	0	-122	-112	5	34	59	23	8	18	-284
1977	-74	-95	-108	-95	-102	-81	5	38	108	32	54	55	-262
1978	-70	-104	-106	-106	-118	0	5	20	38	23	27	15	-377
1979	-39	-68	-98	-99	-58	-78	4	35	441	0	47	25	112
1980	-38	-50	0	0	0	0	0	0	0	20	54	28	14
1981	-43	-61	0	0	-110	-92	3	17	34	126	0	23	-104
1982	-57	-84	0	0	-139	-94	3	12	41	38	57	34	-209
1983	-112	-116	0	0	0	0	0	0	0	0	0	0	-228
1984	0	-139	0	0	0	0	0	0	0	0	90	0	-49
1985	0	0	0	0	0	0	6	72	279	97	102	0	556
1986	-137	-124	0	0	0	0	0	0	0	0	0	0	-261
1987	0	0	0	0	0	0	0	0	0	0	104	0	104
1988	-79	0	0	0	0	-112	5	85	94	119	95	41	269
1989	-50	-68	0	0	-113	-99	3	11	98	0	63	0	-155
1990	-58	-71	-75	0	-98	-87	7	38	56	16	81	12	-179
1991	-59	-93	0	0	-90	-81	2	0	0	16	18	15	-270
1992	-31	-68	0	0	-112	0	3	13	121	206	102	19	257
1993	-104	-114	0	0	-79	0	3	23	134	0	215	0	80
1994	0	0	0	0	-109	-110	4	29	80	0	54	43	-9
Average	-56	-74	-24	-15	-67	-54	3	23	97	40	61	19	-46

Table C.110
Water District Structural Alternatives - Reach 10
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-7	-5	-5	0	-4	-5	0	2	39	13	10	-49	-12
1976	-5	-5	0	0	-5	-4	0	2	11	5	1	-19	-21
1977	-6	-5	-5	-4	-4	-4	0	2	16	6	9	-62	-57
1978	-6	-5	-5	-5	-5	0	0	1	6	5	4	-17	-27
1979	-4	-4	-6	-5	-3	-4	0	1	42	0	6	-22	2
1980	-3	-4	0	0	0	0	0	0	0	4	9	-31	-25
1981	-5	-4	0	0	-5	-4	0	1	4	25	0	-27	-14
1982	-6	-6	0	0	-6	-5	0	1	6	6	6	-33	-39
1983	-8	-6	0	0	0	0	0	0	0	0	0	0	-14
1984	0	-7	0	0	0	0	0	0	0	0	12	0	4
1985	0	0	0	0	0	0	0	2	33	19	16	0	71
1986	-9	-6	0	0	0	0	0	0	0	0	0	0	-15
1987	0	0	0	0	0	0	0	0	0	0	17	0	17
1988	-6	0	0	0	0	-5	0	2	12	31	16	-48	2
1989	-5	-5	0	0	-5	-4	0	1	16	0	11	0	8
1990	-6	-6	-5	0	-4	-4	0	2	10	4	15	-14	-9
1991	-5	-7	0	0	-5	-4	0	0	9	4	3	-16	-29
1992	-3	-6	0	0	-5	0	0	1	17	35	13	-15	37
1993	-8	-6	0	0	-4	0	0	1	22	0	33	0	39
1994	0	0	0	0	-5	-5	0	1	14	0	9	-50	-36
Average	-5	-4	-1	-1	-3	-2	0	1	12	8	9	-20	-6

Table C.111
Water District Structural Alternatives - Reach 11
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	4	2	41	1	1	0	48
1976	0	0	0	0	0	0	2	1	0	0	0	0	3
1977	0	0	0	0	0	0	1	1	1	0	0	0	4
1978	0	0	0	0	0	0	1	0	1	0	0	0	2
1979	0	0	0	0	0	0	1	4	72	0	3	0	81
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	1	1	3	0	0	0	5
1982	0	0	0	0	0	0	0	0	1	1	0	0	3
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	6	0	6
1985	0	0	0	0	0	0	1	12	25	1	1	0	41
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	0	0	0	0	0	0	2	8	5	1	0	0	17
1989	0	0	0	0	0	0	0	0	1	0	0	0	2
1990	0	0	0	0	0	0	9	1	1	0	1	0	11
1991	0	0	0	0	0	0	0	0	0	0	0	0	1
1992	0	0	0	0	0	0	3	0	3	3	4	0	13
1993	0	0	0	0	0	0	4	1	2	0	1	0	8
1994	0	0	0	0	0	0	1	0	0	0	0	0	2
Average	0	0	0	0	0	0	2	2	8	0	1	0	12

Table C.112
Water District Structural Alternatives - Reach 12
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	159	-32	-36	0	-42	-45	-18	22	130	45	58	167	409
1976	90	-30	0	0	-46	-44	-13	23	42	13	8	75	117
1977	135	-28	-34	-33	-38	-41	-17	31	50	20	55	161	260
1978	139	-31	-34	-40	-33	0	-15	16	23	18	21	36	80
1979	93	-26	-38	-37	-31	-46	-14	17	106	0	35	56	115
1980	79	-26	0	0	0	0	0	0	0	12	54	96	215
1981	104	-27	0	0	-40	-41	-7	12	13	94	0	68	176
1982	140	-40	0	0	-49	-45	-9	9	21	23	42	131	225
1983	129	-35	0	0	0	0	0	0	0	0	0	0	94
1984	0	-42	0	0	0	0	0	0	0	0	101	0	60
1985	0	0	0	0	0	0	-13	30	86	58	78	0	239
1986	206	-35	0	0	0	0	0	0	0	0	0	0	171
1987	0	0	0	0	0	0	0	0	0	0	133	0	133
1988	147	0	0	0	0	-48	-14	47	41	93	82	168	516
1989	118	-34	0	0	-45	-45	-8	8	40	0	56	0	88
1990	129	-35	-35	0	-43	-43	-17	35	24	9	82	45	152
1991	115	-43	0	0	-46	-41	-7	0	0	11	13	58	63
1992	54	-35	0	0	-49	0	-15	7	63	101	67	43	237
1993	178	-39	0	0	-32	0	-16	16	94	0	183	0	383
1994	0	0	0	0	-43	-52	-13	18	34	0	43	135	122
Average	101	-27	-9	-5	-28	-25	-10	15	38	25	56	62	193

Table C.113
Water District Structural Alternatives - Reach 13
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	39	-9	-10	0	-12	-12	-3	6	41	17	24	56	134
1976	22	-8	0	0	-13	-12	-4	7	14	6	3	25	39
1977	33	-8	-10	-9	-11	-11	-5	9	17	9	21	55	89
1978	35	-9	-10	-12	-15	0	-5	4	7	7	8	12	23
1979	22	-7	-11	-11	-9	-13	-4	5	36	0	13	18	39
1980	20	-7	0	0	0	0	0	0	0	5	21	31	70
1981	26	-7	0	0	-11	-11	-2	4	5	35	0	23	61
1982	35	-11	0	0	-14	-12	-3	3	7	9	14	40	69
1983	32	-10	0	0	0	0	0	0	0	0	0	0	22
1984	0	-12	0	0	0	0	0	0	0	0	30	0	19
1985	0	0	0	0	0	0	-4	9	29	25	31	0	89
1986	50	-10	0	0	0	0	0	0	0	0	0	0	40
1987	0	0	0	0	0	0	0	0	0	0	42	0	42
1988	36	0	0	0	0	-13	-4	12	14	40	33	54	172
1989	29	-9	0	0	-13	-12	-3	2	17	0	26	0	37
1990	32	-10	-10	0	-12	-12	-5	9	9	5	33	17	55
1991	29	-12	0	0	-13	-11	-2	0	0	5	7	19	22
1992	13	-10	0	0	-14	0	-5	3	20	39	30	15	93
1993	45	-11	0	0	-9	0	-5	5	29	0	62	0	116
1994	0	0	0	0	-12	-14	-4	6	13	0	17	44	49
Average	23	-7	-3	-2	-8	-7	-3	4	13	10	21	20	64

Table C.114
Water District Structural Alternatives - Reach 14
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-3	-2	-2	0	-1	-1	2	2	21	7	8	2	33
1976	-2	-2	0	0	-1	-1	2	2	7	3	1	1	8
1977	-3	-2	-2	-1	-1	-1	2	3	9	4	7	2	16
1978	-3	-2	-2	-1	-2	0	2	2	4	3	3	0	3
1979	-2	-2	-2	-1	-1	-1	2	2	21	0	4	1	20
1980	-2	-2	0	0	0	0	0	0	0	2	7	1	7
1981	-2	-2	0	0	-1	-1	1	1	3	15	0	1	14
1982	-3	-2	0	0	-2	-1	1	1	4	4	3	1	7
1983	-3	-2	0	0	0	0	0	0	0	0	0	0	-5
1984	0	-2	0	0	0	0	0	0	0	0	10	0	7
1985	0	0	0	0	0	0	2	3	17	11	12	0	45
1986	-4	-2	0	0	0	0	0	0	0	0	0	0	-6
1987	0	0	0	0	0	0	0	0	0	0	14	0	14
1988	-3	0	0	0	0	-1	2	4	7	19	12	1	40
1989	-2	-2	0	0	-1	-1	1	1	10	0	9	0	14
1990	-3	-2	-2	0	-1	-1	2	3	5	2	12	0	16
1991	-2	-3	0	0	-1	-1	1	0	0	2	3	1	-1
1992	-1	-2	0	0	-2	0	2	1	10	19	11	0	39
1993	-4	-2	0	0	-1	0	2	2	14	0	24	0	33
1994	0	0	0	0	-1	-1	1	2	7	0	6	1	16
Average	-2	-2	0	0	-1	-1	1	1	7	3	7	1	16

Table C.115
Water District Structural Alternatives - Reach 15
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-4	-3	-3	0	-4	-5	-1	1	38	17	16	2	55
1976	-3	-3	0	0	-5	-4	-1	1	11	5	2	1	5
1977	-3	-3	-3	-4	-4	-4	-1	2	19	9	11	4	22
1978	-4	-4	-4	-4	-5	0	-1	1	7	6	7	1	1
1979	-3	-3	-4	-4	-3	-5	-1	1	42	0	8	1	30
1980	-3	-3	0	0	0	0	0	0	0	5	14	2	15
1981	-3	-3	0	0	-4	-4	0	1	4	27	0	2	20
1982	-4	-4	0	0	-5	-4	-1	1	9	7	9	2	10
1983	-4	-4	0	0	0	0	0	0	0	0	0	0	-8
1984	0	-4	0	0	0	0	0	0	0	0	21	0	16
1985	0	0	0	0	0	0	-1	2	25	18	19	0	64
1986	-4	-4	0	0	0	0	0	0	0	0	0	0	-8
1987	0	0	0	0	0	0	0	0	0	0	20	0	20
1988	-3	0	0	0	0	-5	-1	2	11	39	17	2	63
1989	-2	-4	0	0	-5	-4	-1	0	16	0	17	0	17
1990	-4	-4	-4	0	-4	-5	-1	2	9	5	22	1	18
1991	-3	-4	0	0	-5	-4	-1	0	0	4	5	1	-6
1992	-2	-4	0	0	-5	0	-1	1	13	25	24	1	52
1993	-4	-4	0	0	-3	0	-1	1	19	0	35	0	43
1994	0	0	0	0	-4	-5	-1	1	11	0	14	3	19
Average	-3	-3	-1	-1	-3	-2	-1	1	12	8	13	1	22

Table C.116
Water District Structural Alternatives - Reach 16
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-4	-4	-4	0	-5	-5	-1	2	69	110	79	6	243
1976	-3	-4	0	0	-5	-5	-1	2	40	49	20	3	98
1977	-4	-4	-4	-4	-5	-5	-1	3	57	70	74	8	184
1978	-4	-4	-4	-4	-5	0	-1	3	42	41	53	3	119
1979	-3	-4	-5	-4	-4	-5	-1	2	61	0	84	4	125
1980	-4	-4	0	0	0	0	0	0	0	88	86	5	171
1981	-4	-4	0	0	-4	-5	-1	2	36	88	0	6	114
1982	-4	-5	0	0	-5	-5	-1	2	51	100	96	6	234
1983	-5	-4	0	0	0	0	0	0	0	0	0	0	-10
1984	0	-5	0	0	0	0	0	0	0	0	84	0	79
1985	0	0	0	0	0	0	-1	3	56	113	110	0	282
1986	-5	-5	0	0	0	0	0	0	0	0	0	0	-10
1987	0	0	0	0	0	0	0	0	0	0	89	0	89
1988	-4	0	0	0	0	-5	-1	3	46	127	98	6	270
1989	-3	-5	0	0	-5	-5	-1	2	54	0	98	0	134
1990	-5	-5	-4	0	-5	-5	-1	3	46	65	101	4	194
1991	-4	-4	0	0	-5	-5	-1	0	0	42	47	4	73
1992	-5	-5	0	0	-5	0	-1	2	48	104	84	5	228
1993	-4	-5	0	0	-3	0	-1	3	55	0	122	0	166
1994	0	0	0	0	-4	-5	-1	2	48	0	100	7	147
Average	-3	-4	-1	-1	-3	-3	-1	2	35	50	71	3	147

Table C.117
Water District Structural Alternatives - Reach 17
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-178	-164	-163	0	-200	-211	-174	-118	775	2240	1363	-42	3127
1976	-144	-159	0	0	-206	-209	-163	-120	589	1057	382	-22	1007
1977	-182	-166	-167	-175	-203	-216	-155	-122	746	1469	1367	-44	2152
1978	-190	-185	-178	-159	-212	0	-175	-120	658	868	950	-23	1233
1979	-138	-165	-190	-179	-168	-221	-173	-120	580	0	1584	-30	780
1980	-156	-184	0	0	0	0	0	0	0	1956	1530	-30	3116
1981	-165	-163	0	0	-183	-205	-168	-121	587	1616	0	-30	1169
1982	-182	-220	0	0	-221	-206	-164	-115	754	2203	1819	-36	3632
1983	-219	-183	0	0	0	0	0	0	0	0	0	0	-403
1984	0	-214	0	0	0	0	0	0	0	0	1380	0	1166
1985	0	0	0	0	0	0	-173	-121	756	2380	2007	0	4849
1986	-218	-197	0	0	0	0	0	0	0	0	0	0	-415
1987	0	0	0	0	0	0	0	0	0	0	1585	0	1585
1988	-174	0	0	0	0	-209	-156	-115	694	2286	1824	-42	4108
1989	-185	-220	0	0	-211	-201	-170	-108	764	0	1738	0	1406
1990	-212	-202	-181	0	-216	-223	-177	-124	730	1407	1750	-28	2526
1991	-161	-177	0	0	-214	-213	-154	0	0	908	879	-25	842
1992	-137	-208	0	0	-219	0	-176	-105	715	1230	1332	-34	2400
1993	-190	-199	0	0	-144	0	-180	-123	779	0	427	0	370
1994	0	0	0	0	-181	-223	-179	-123	738	0	1811	-36	1809
Average	-142	-150	-44	-26	-129	-117	-127	-83	495	981	1186	-21	1823

Table C.118
Water District Structural Alternatives - Reach 18
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-103	-100	-95	0	-113	-123	-106	-82	551	1729	1029	-28	2557
1976	-91	-102	0	0	-121	-122	-103	-83	429	770	237	-13	801
1977	-106	-104	-97	-101	-120	-124	-101	-84	538	1173	1009	-28	1856
1978	-109	-106	-108	-90	-123	0	-107	-83	497	682	729	-14	1167
1979	-86	-101	-108	-101	-95	-125	-106	-83	417	0	1160	-18	753
1980	-90	-104	0	0	0	0	0	0	0	1611	1197	-19	2595
1981	-98	-97	0	0	-105	-121	-104	-83	427	1151	0	-19	950
1982	-104	-125	0	0	-126	-121	-103	-81	541	1703	1384	-22	2945
1983	-125	-112	0	0	0	0	0	0	0	0	0	0	-237
1984	0	-123	0	0	0	0	0	0	0	0	1014	0	891
1985	0	0	0	0	0	0	-106	-84	543	1785	1474	0	3612
1986	-124	-118	0	0	0	0	0	0	0	0	0	0	-243
1987	0	0	0	0	0	0	0	0	0	0	1150	0	1150
1988	-99	0	0	0	0	-119	-97	-79	312	1650	1321	-25	3064
1989	-114	-125	0	0	-120	-114	-104	-76	544	0	1267	0	1158
1990	-122	-120	-103	0	-124	-125	-107	-85	330	1077	1328	-19	2129
1991	-98	-101	0	0	-124	-123	-95	0	0	680	662	-13	787
1992	-80	-118	0	0	-125	0	-107	-72	325	1230	973	-21	2205
1993	-111	-119	0	0	-82	0	-108	-64	550	0	427	0	473
1994	0	0	0	0	-103	-125	-108	-84	335	0	1393	-22	1485
Average	-83	-89	-26	-15	-74	-67	-75	-57	357	762	888	-13	1505

Table C.119
Water District Structural Alternatives - Reach 19
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-56	-57	-54	0	-59	-61	-57	-52	270	874	646	-27	1366
1976	-55	-58	0	0	-61	-61	-57	-52	242	627	430	-20	934
1977	-57	-59	-54	-56	-61	-61	-57	-52	269	744	636	-27	1164
1978	-57	-57	-59	-53	-61	0	-57	-52	263	617	571	-20	1035
1979	-53	-57	-57	-55	-54	-61	-57	-52	239	0	672	-22	441
1980	-53	-56	0	0	0	0	0	0	0	865	698	-23	1432
1981	-55	-56	0	0	-56	-61	-57	-52	241	712	0	-23	593
1982	-56	-61	0	0	-61	-61	-57	-52	268	868	740	-24	1503
1983	-61	-60	0	0	0	0	0	0	0	0	0	0	-121
1984	0	-61	0	0	0	0	0	0	0	0	636	0	575
1985	0	0	0	0	0	0	-57	-53	269	878	752	0	1789
1986	-61	-61	0	0	0	0	0	0	0	0	0	0	-122
1987	0	0	0	0	0	0	0	0	0	0	667	0	667
1988	-55	0	0	0	0	-60	-55	-50	264	832	709	-25	1560
1989	-61	-61	0	0	-60	-58	-57	-50	268	0	698	0	619
1990	-61	-61	-56	0	-61	-61	-57	-53	267	710	725	-23	1269
1991	-56	-55	0	0	-61	-61	-54	0	0	610	551	-21	853
1992	-51	-59	0	0	-61	0	-57	-49	267	805	624	-24	1395
1993	-58	-61	0	0	-50	0	-57	-52	269	0	427	0	416
1994	0	0	0	0	-56	-61	-57	-52	267	0	746	-24	763
Average	-45	-47	-14	-8	-38	-33	-43	-36	183	457	546	-15	907

Table C.120
Water District Structural Alternatives - Reach 1
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	75	0	0	0	0	0	42	255	512	644	364	254	2147
1976	61	0	0	0	0	0	39	255	392	243	68	126	1183
1977	78	0	0	0	0	0	37	255	457	362	363	249	1800
1978	76	0	0	0	0	0	40	249	458	227	270	124	1446
1979	57	0	0	0	0	0	40	254	373	0	431	166	1321
1980	63	0	0	0	0	0	0	0	0	513	416	171	1164
1981	69	0	0	0	0	0	36	257	350	396	0	168	1276
1982	76	0	0	0	0	0	38	258	480	615	526	218	2212
1983	93	0	0	0	0	0	0	0	0	0	0	0	93
1984	0	0	0	0	0	0	0	0	0	0	383	0	383
1985	0	0	0	0	0	0	42	260	489	652	529	0	1971
1986	93	0	0	0	0	0	0	0	0	0	0	0	93
1987	0	0	0	0	0	0	0	0	0	0	397	0	397
1988	71	0	0	0	0	0	38	238	422	330	436	237	1771
1989	76	0	0	0	0	0	38	225	487	0	410	0	1236
1990	85	0	0	0	0	0	40	253	371	314	482	168	1714
1991	59	0	0	0	0	0	36	0	0	229	227	140	691
1992	54	0	0	0	0	0	39	194	485	547	338	197	1854
1993	77	0	0	0	0	0	42	257	501	0	427	0	1303
1994	0	0	0	0	0	0	40	246	454	0	498	201	1440
Average	58	0	0	0	0	0	29	173	312	264	328	121	1285

Table C.121
Water District Structural Alternatives - Reach 2
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	146	0	0	0	0	0	43	399	918	1240	770	489	4005
1976	121	0	0	0	0	0	40	398	704	470	144	242	2119
1977	153	0	0	0	0	0	38	400	827	725	782	489	3413
1978	152	0	0	0	0	0	41	390	823	437	571	241	2655
1979	113	0	0	0	0	0	42	396	668	0	905	321	2445
1980	123	0	0	0	0	0	0	0	0	996	890	329	2338
1981	135	0	0	0	0	0	38	403	630	774	0	326	2306
1982	148	0	0	0	0	0	40	402	862	1183	1105	413	4154
1983	179	0	0	0	0	0	0	0	0	0	0	0	179
1984	0	0	0	0	0	0	0	0	0	0	800	0	800
1985	0	0	0	0	0	0	43	407	878	1261	1121	0	3710
1986	180	0	0	0	0	0	0	0	0	0	0	0	180
1987	0	0	0	0	0	0	0	0	0	0	848	0	848
1988	139	0	0	0	0	0	39	372	758	1031	941	460	3739
1989	149	0	0	0	0	0	40	353	878	0	873	0	2293
1990	168	0	0	0	0	0	41	397	667	607	1025	324	3230
1991	116	0	0	0	0	0	37	0	0	447	482	269	1351
1992	107	0	0	0	0	0	40	304	872	1063	723	384	3493
1993	150	0	0	0	0	0	43	401	897	0	427	0	1919
1994	0	0	0	0	0	0	42	385	819	0	1076	395	2717
Average	114	0	0	0	0	0	30	270	560	512	674	234	2395

Table C.122
Water District Structural Alternatives - Reach 3
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	21	0	0	0	0	0	6	54	125	174	114	71	565
1976	17	0	0	0	0	0	5	54	97	68	21	35	298
1977	22	0	0	0	0	0	5	55	118	105	113	72	490
1978	22	0	0	0	0	0	6	53	114	61	83	35	374
1979	16	0	0	0	0	0	6	54	92	0	130	47	344
1980	18	0	0	0	0	0	0	0	0	140	130	48	335
1981	19	0	0	0	0	0	5	55	88	109	0	47	324
1982	21	0	0	0	0	0	5	55	119	167	160	60	587
1983	26	0	0	0	0	0	0	0	0	0	0	0	26
1984	0	0	0	0	0	0	0	0	0	0	115	0	115
1985	0	0	0	0	0	0	6	55	122	176	163	0	523
1986	26	0	0	0	0	0	0	0	0	0	0	0	26
1987	0	0	0	0	0	0	0	0	0	0	124	0	124
1988	20	0	0	0	0	0	5	51	109	150	139	67	542
1989	22	0	0	0	0	0	5	48	121	0	132	0	328
1990	23	0	0	0	0	0	6	54	93	91	148	48	463
1991	17	0	0	0	0	0	5	0	0	61	71	39	195
1992	16	0	0	0	0	0	6	43	119	149	105	56	493
1993	22	0	0	0	0	0	6	55	122	0	167	0	371
1994	0	0	0	0	0	0	6	53	115	0	158	57	389
Average	17	0	0	0	0	0	4	37	78	73	104	34	346

Table C.123
Water District Structural Alternatives - Reach 4
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	21	0	0	0	0	0	6	41	84	130	87	57	426
1976	17	0	0	0	0	0	5	41	65	33	16	28	226
1977	22	0	0	0	0	0	5	42	83	81	84	59	375
1978	22	0	0	0	0	0	6	40	78	46	63	28	283
1979	16	0	0	0	0	0	6	41	62	0	97	38	260
1980	18	0	0	0	0	0	0	0	0	105	98	38	259
1981	19	0	0	0	0	0	5	42	61	82	0	38	247
1982	21	0	0	0	0	0	5	42	82	125	120	48	443
1983	26	0	0	0	0	0	0	0	0	0	0	0	26
1984	0	0	0	0	0	0	0	0	0	0	86	0	86
1985	0	0	0	0	0	0	6	42	84	131	122	0	385
1986	26	0	0	0	0	0	0	0	0	0	0	0	26
1987	0	0	0	0	0	0	0	0	0	0	94	0	94
1988	20	0	0	0	0	0	5	39	78	116	106	54	418
1989	22	0	0	0	0	0	5	37	82	0	103	0	249
1990	25	0	0	0	0	0	6	42	64	72	110	39	356
1991	17	0	0	0	0	0	5	0	0	48	54	31	155
1992	16	0	0	0	0	0	6	34	81	111	79	45	371
1993	22	0	0	0	0	0	6	41	82	0	124	0	275
1994	0	0	0	0	0	0	6	40	80	0	119	46	291
Average	16	0	0	0	0	0	4	28	53	55	78	27	262

Table C.124
Water District Structural Alternatives - Reach 5
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	30	-5	-6	0	-7	-8	-3	32	112	236	171	96	649
1976	25	-5	0	0	-8	-7	-2	32	87	96	31	48	297
1977	32	-5	-6	-6	-7	-7	-3	33	110	147	166	99	554
1978	32	-5	-6	-7	-9	0	-2	32	104	83	124	48	394
1979	24	-4	-6	-6	-5	-8	-2	32	82	0	191	64	360
1980	26	-4	0	0	0	0	0	0	0	191	193	65	470
1981	28	-4	0	0	-7	-7	-1	33	83	148	0	65	338
1982	31	-7	0	0	-8	-8	-1	33	109	227	236	81	693
1983	37	-6	0	0	0	0	0	0	0	0	0	0	31
1984	0	-7	0	0	0	0	0	0	0	0	169	0	162
1985	0	0	0	0	0	0	-2	33	111	238	241	0	621
1986	37	-6	0	0	0	0	0	0	0	0	0	0	32
1987	0	0	0	0	0	0	0	0	0	0	185	0	185
1988	29	0	0	0	0	-4	-2	30	104	211	210	91	664
1989	31	-6	0	0	-8	-8	-1	29	109	0	203	0	351
1990	36	-6	-6	0	-7	-7	-3	33	95	130	217	66	548
1991	25	-7	0	0	-8	-7	-1	0	0	86	106	53	247
1992	23	-6	0	0	-8	0	-2	27	107	201	156	76	573
1993	32	-6	0	0	-6	0	-2	32	109	0	245	0	403
1994	0	0	0	0	-7	-9	-2	32	106	0	235	78	432
Average	24	-4	-1	-1	-5	-4	-1	22	71	100	154	46	400

Table C.125
Water District Structural Alternatives - Reach 6
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	66	0	0	0	0	0	18	161	354	454	293	199	1545
1976	55	0	0	0	0	0	16	162	275	185	53	98	844
1977	70	0	0	0	0	0	15	163	347	282	285	204	1367
1978	70	0	0	0	0	0	17	157	328	161	212	99	1043
1979	52	0	0	0	0	0	17	161	260	0	327	131	949
1980	56	0	0	0	0	0	0	0	0	367	331	134	887
1981	61	0	0	0	0	0	16	155	229	282	0	133	875
1982	67	0	0	0	0	0	14	156	320	433	372	166	1528
1983	81	0	0	0	0	0	0	0	0	0	0	0	81
1984	0	0	0	0	0	0	0	0	0	0	289	0	289
1985	0	0	0	0	0	0	17	164	349	454	405	0	1390
1986	82	0	0	0	0	0	0	0	0	0	0	0	82
1987	0	0	0	0	0	0	0	0	0	0	281	0	281
1988	60	0	0	0	0	0	16	147	325	400	357	186	1490
1989	68	0	0	0	0	0	16	144	295	0	343	0	865
1990	78	0	0	0	0	0	17	155	256	248	347	135	1234
1991	54	0	0	0	0	0	15	0	0	105	180	109	462
1992	49	0	0	0	0	0	16	118	316	383	266	157	1308
1993	69	0	0	0	0	0	17	160	344	0	418	0	1009
1994	0	0	0	0	0	0	17	157	332	0	386	161	1052
Average	52	0	0	0	0	0	12	108	216	188	257	96	929

Table C.126
Water District Structural Alternatives - Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	-1	0	-3	-2	13	58	247	405	247	55	1019
1976	0	0	0	0	-1	-4	12	58	188	162	43	28	486
1977	0	0	0	-1	0	-2	11	58	241	248	239	59	853
1978	0	0	0	0	0	0	13	35	221	139	174	28	629
1979	0	0	0	-1	-2	0	13	39	130	0	277	38	493
1980	0	-1	0	0	0	0	0	0	0	327	273	39	638
1981	0	-1	0	0	-1	-1	12	59	191	252	0	39	550
1982	0	0	0	0	-2	0	12	58	242	395	337	48	1091
1983	0	0	0	0	0	0	0	0	0	0	0	0	-1
1984	0	-4	0	0	0	0	0	0	0	0	196	0	192
1985	0	0	0	0	0	0	13	58	229	412	351	0	1063
1986	-2	-2	0	0	0	0	0	0	0	0	0	0	-4
1987	0	0	0	0	0	0	0	0	0	0	267	0	267
1988	0	0	0	0	0	-4	12	54	229	368	306	55	1019
1989	0	0	0	0	-5	-2	12	52	243	0	297	0	599
1990	0	0	-1	0	-4	-4	13	60	234	229	316	41	883
1991	0	0	0	0	-3	-2	11	0	0	153	155	32	348
1992	0	0	0	0	-6	0	13	49	242	350	229	47	924
1993	0	0	0	0	-4	0	13	58	243	0	354	0	664
1994	0	0	0	0	-5	-3	13	57	233	0	334	46	675
Average	0	0	0	0	-2	-1	9	39	156	172	220	28	619

Table C.127
Water District Structural Alternatives - Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-43	-62	-67	0	-98	-124	-9	321	1931	3218	1929	313	7308
1976	-42	-67	0	0	-104	-123	-4	321	1475	1290	337	156	3238
1977	-25	-55	-72	-73	-81	-81	-7	325	1892	1974	1863	331	5991
1978	-29	-60	-65	-71	-90	0	-2	314	1744	1103	1338	157	4359
1979	-11	-25	-48	-73	-59	-34	-3	271	1228	0	2153	214	3590
1980	-18	-37	0	0	0	0	0	0	0	2597	2130	216	4887
1981	-10	-34	0	0	-88	-73	-3	328	1496	2006	0	215	3837
1982	-17	-26	0	0	-120	-59	-2	323	1891	3139	2626	270	8023
1983	-32	-68	0	0	0	0	0	0	0	0	0	0	-100
1984	0	-118	0	0	0	0	0	0	0	0	1555	0	1437
1985	0	0	0	0	0	0	-5	323	1787	3268	2736	0	8109
1986	-93	-92	0	0	0	0	0	0	0	0	0	0	-186
1987	0	0	0	0	0	0	0	0	0	0	2081	0	2081
1988	-31	0	0	0	0	-124	-7	299	1795	2921	2382	304	7539
1989	-15	-21	0	0	-125	-89	-3	292	1902	0	2318	0	4260
1990	-16	-17	-37	0	-107	-103	-13	331	1831	1815	2461	226	6372
1991	-21	-38	0	0	-88	-72	-2	0	0	1215	1211	181	2385
1992	-9	-17	0	0	-136	0	-8	274	1894	1230	1785	260	5274
1993	-35	-62	0	0	-88	0	-8	323	1897	0	427	0	2435
1994	0	0	0	0	-125	-106	-4	316	1822	0	2608	259	4772
Average	-25	-40	-14	-11	-65	-50	-4	218	1229	1289	1598	155	4281

Table C.128
Water District Structural Alternatives - Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-93	-105	-91	0	-97	-133	12	183	1156	2213	1301	192	4539
1976	-82	-115	0	0	-122	-112	12	183	886	891	228	94	1862
1977	-74	-95	-108	-95	-102	-81	11	185	1138	1368	1255	198	3605
1978	-70	-104	-106	-106	-118	0	12	182	1059	761	917	94	2522
1979	-39	-68	-98	-99	-58	-78	12	185	861	0	1451	128	2197
1980	-38	-50	0	0	0	0	0	0	0	1790	1436	129	3267
1981	-43	-61	0	0	-110	-92	12	186	898	1383	0	129	2301
1982	-57	-84	0	0	-139	-94	12	183	1134	2162	1771	161	5049
1983	-112	-116	0	0	0	0	0	0	0	0	0	0	-228
1984	0	-139	0	0	0	0	0	0	0	0	1102	0	963
1985	0	0	0	0	0	0	12	185	1113	2250	1844	0	5405
1986	-137	-124	0	0	0	0	0	0	0	0	0	0	-261
1987	0	0	0	0	0	0	0	0	0	0	1403	0	1403
1988	-79	0	0	0	0	-112	11	170	1079	2011	1607	182	4870
1989	-50	-68	0	0	-113	-99	12	166	1139	0	1564	0	2551
1990	-58	-71	-75	0	-98	-87	12	188	1099	1250	1660	135	3956
1991	-59	-93	0	0	-90	-81	11	0	0	837	817	108	1451
1992	-31	-68	0	0	-112	0	12	156	1134	1230	1204	156	3681
1993	-104	-114	0	0	-79	0	12	184	1136	0	427	0	1462
1994	0	0	0	0	-109	-110	12	180	1094	0	1765	156	2987
Average	-56	-74	-24	-13	-67	-54	9	126	746	907	1088	93	2679

Table C.129
Water District Structural Alternatives - Reach 10
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-7	-5	-5	0	-4	-5	1	4	97	214	99	-49	338
1976	-5	-5	0	0	-5	-4	1	4	75	87	17	-19	145
1977	-6	-5	-5	-4	-4	-4	1	4	96	134	95	-62	239
1978	-6	-5	-5	-5	-5	0	1	4	89	75	70	-17	196
1979	-4	-4	-6	-5	-3	-4	1	4	72	0	109	-22	139
1980	-3	-4	0	0	0	0	0	0	0	173	110	-31	245
1981	-5	-4	0	0	-5	-4	1	4	75	134	0	-27	170
1982	-6	-6	0	0	-6	-5	1	4	95	208	134	-35	385
1983	-8	-6	0	0	0	0	0	0	0	0	0	0	-14
1984	0	-7	0	0	0	0	0	0	0	0	91	0	84
1985	0	0	0	0	0	0	1	5	97	218	139	0	459
1986	-9	-6	0	0	0	0	0	0	0	0	0	0	-15
1987	0	0	0	0	0	0	0	0	0	0	107	0	107
1988	-6	0	0	0	0	-5	1	4	91	195	122	-48	353
1989	-5	-5	0	0	-5	-4	1	4	96	0	119	0	199
1990	-6	-6	-5	0	-4	-4	1	5	93	121	126	-14	306
1991	-5	-7	0	0	-5	-4	1	0	0	81	62	-16	108
1992	-3	-6	0	0	-5	0	1	4	95	183	91	-15	345
1993	-8	-6	0	0	-4	0	1	4	95	0	144	0	223
1994	0	0	0	0	-5	-5	1	4	93	0	135	-50	173
Average	-5	-4	-1	-1	-3	-2	0	3	63	91	88	-20	209

Table C.130
Water District Structural Alternatives - Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	36	87	407	632	385	0	1547
1976	0	0	0	0	0	0	34	86	310	253	67	0	750
1977	0	0	0	0	0	0	32	87	398	387	372	0	1275
1978	0	0	0	0	0	0	35	83	364	216	271	0	970
1979	0	0	0	0	0	0	35	58	213	0	430	0	737
1980	0	0	0	0	0	0	0	0	0	510	426	0	935
1981	0	0	0	0	0	0	35	88	315	393	0	0	831
1982	0	0	0	0	0	0	35	87	398	616	525	0	1660
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	305	0	305
1985	0	0	0	0	0	0	35	87	377	642	547	0	1688
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	416	0	416
1988	0	0	0	0	0	0	33	81	378	573	476	0	1540
1989	0	0	0	0	0	0	34	79	401	0	463	0	977
1990	0	0	0	0	0	0	36	89	385	356	492	0	1358
1991	0	0	0	0	0	0	32	0	0	239	242	0	512
1992	0	0	0	0	0	0	35	74	399	545	357	0	1411
1993	0	0	0	0	0	0	36	87	400	0	427	0	950
1994	0	0	0	0	0	0	36	85	383	0	520	0	1024
Average	0	0	0	0	0	0	26	58	256	268	326	0	944

Table C.131
Water District Structural Alternatives - Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	219	-32	-36	0	-42	-45	-18	119	631	1596	1273	640	4306
1976	182	-30	0	0	-46	-44	-13	119	490	651	228	317	1854
1977	229	-28	-34	-33	-38	-41	-17	120	621	994	1236	660	3670
1978	232	-31	-34	-40	-53	0	-15	119	586	565	917	319	2565
1979	170	-26	-38	-37	-31	-46	-14	119	464	0	1417	423	2402
1980	185	-26	0	0	0	0	0	0	0	1291	1433	431	3314
1981	201	-27	0	0	-40	-41	-7	121	485	1001	0	430	2124
1982	222	-40	0	0	-49	-45	-9	119	619	1540	1755	538	4651
1983	267	-35	0	0	0	0	0	0	0	0	0	0	232
1984	0	-42	0	0	0	0	0	0	0	0	1253	0	1211
1985	0	0	0	0	0	0	-13	121	627	1613	1793	0	4140
1986	269	-35	0	0	0	0	0	0	0	0	0	0	234
1987	0	0	0	0	0	0	0	0	0	0	1379	0	1379
1988	210	0	0	0	0	-48	-14	131	586	1430	1561	603	4459
1989	225	-34	0	0	-45	-45	-8	107	614	0	1511	0	2327
1990	257	-35	-33	0	-43	-43	-17	122	594	882	1614	440	3737
1991	177	-43	0	0	-46	-41	-7	0	0	593	797	333	1763
1992	163	-35	0	0	-49	0	-15	99	609	1230	1158	506	3666
1993	227	-39	0	0	-32	0	-16	119	615	0	427	0	1301
1994	0	0	0	0	-43	-52	-13	116	598	0	1741	519	2866
Average	172	-27	-9	-5	-23	-23	-10	81	407	669	1074	309	2609

Table C.132
Water District Structural Alternatives - Reach 13
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	53	-9	-10	0	-12	-12	-5	27	148	375	303	156	1012
1976	44	-8	0	0	-13	-12	-4	27	115	154	54	77	434
1977	55	-8	-10	-9	-11	-11	-5	27	140	235	293	161	863
1978	56	-9	-10	-12	-15	0	-5	27	137	133	217	78	598
1979	41	-7	-11	-11	-9	-13	-4	27	109	0	335	103	560
1980	44	-7	0	0	0	0	0	0	0	304	340	105	786
1981	48	-7	0	0	-11	-11	-3	27	114	236	0	105	499
1982	53	-11	0	0	-14	-12	-3	27	145	364	414	131	1095
1983	64	-10	0	0	0	0	0	0	0	0	0	0	54
1984	0	-12	0	0	0	0	0	0	0	0	296	0	284
1985	0	0	0	0	0	0	-4	27	147	381	426	0	977
1986	65	-10	0	0	0	0	0	0	0	0	0	0	55
1987	0	0	0	0	0	0	0	0	0	0	328	0	328
1988	51	0	0	0	0	-13	-4	25	138	339	372	147	1055
1989	54	-9	0	0	-13	-12	-3	24	145	0	361	0	548
1990	62	-10	-10	0	-12	-12	-3	28	141	211	385	109	886
1991	43	-12	0	0	-13	-11	-2	0	0	139	189	86	418
1992	39	-10	0	0	-14	0	-5	23	144	319	276	124	897
1993	55	-11	0	0	-9	0	-5	27	145	0	427	0	629
1994	0	0	0	0	-12	-14	-4	26	141	0	414	127	678
Average	41	-7	-3	-2	-8	-7	-3	19	96	160	271	75	633

Table C.133
Water District Structural Alternatives - Reach 14
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-3	-2	-2	0	-1	-1	3	7	58	129	82	4	272
1976	-2	-2	0	0	-1	-1	2	7	45	53	15	2	118
1977	-3	-2	-2	-1	-1	-1	2	7	57	81	79	4	220
1978	-3	-2	-2	-1	-2	0	3	7	54	45	59	2	159
1979	-2	-2	-2	-1	-1	-1	3	7	43	0	90	2	136
1980	-2	-2	0	0	0	0	0	0	0	104	92	2	195
1981	-2	-2	0	0	-1	-1	3	7	45	81	0	2	132
1982	-3	-2	0	0	-2	-1	3	7	57	125	111	3	298
1983	-3	-2	0	0	0	0	0	0	0	0	0	0	-5
1984	0	-2	0	0	0	0	0	0	0	0	79	0	77
1985	0	0	0	0	0	0	3	7	58	131	115	0	314
1986	-4	-2	0	0	0	0	0	0	0	0	0	0	-6
1987	0	0	0	0	0	0	0	0	0	0	89	0	89
1988	-5	0	0	0	0	-1	2	7	54	117	101	3	281
1989	-2	-2	0	0	-1	-1	3	7	57	0	98	0	157
1990	-3	-2	-2	0	-1	-1	3	7	56	73	104	2	237
1991	-2	-3	0	0	-1	-1	2	0	0	48	52	2	97
1992	-1	-2	0	0	-2	0	3	6	57	109	75	3	248
1993	-4	-2	0	0	-1	0	3	7	57	0	116	0	176
1994	0	0	0	0	-1	-1	3	7	56	0	112	3	178
Average	-2	-2	0	0	-1	-1	2	5	38	55	73	2	169

Table C.134
Water District Structural Alternatives - Reach 15
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-4	-3	-3	0	-4	-5	-1	4	78	186	122	7	377
1976	-3	-3	0	0	-5	-4	-1	4	61	77	22	3	151
1977	-3	-3	-3	-4	-4	-4	-1	4	77	117	118	7	300
1978	-4	-4	-4	-4	-5	0	-1	4	72	66	88	3	213
1979	-3	-3	-4	-4	-3	-5	-1	4	58	0	135	3	178
1980	-3	-3	0	0	0	0	0	0	0	151	137	5	287
1981	-3	-3	0	0	-4	-4	0	4	61	117	0	5	172
1982	-4	-4	0	0	-5	-4	-1	4	77	181	166	6	416
1983	-4	-4	0	0	0	0	0	0	0	0	0	0	-8
1984	0	-4	0	0	0	0	0	0	0	0	119	0	114
1985	0	0	0	0	0	0	-1	4	78	190	172	0	443
1986	-4	-4	0	0	0	0	0	0	0	0	0	0	-8
1987	0	0	0	0	0	0	0	0	0	0	133	0	133
1988	-3	0	0	0	0	-3	-1	5	74	170	152	7	396
1989	-2	-4	0	0	-5	-4	-1	5	78	0	147	0	212
1990	-4	-4	-4	0	-4	-5	-1	4	76	107	157	5	326
1991	-3	-4	0	0	-5	-4	-1	0	0	71	78	4	136
1992	-2	-4	0	0	-5	0	-1	3	77	159	113	6	345
1993	-4	-4	0	0	-3	0	-1	4	78	0	174	0	243
1994	0	0	0	0	-4	-3	-1	4	76	0	168	6	243
Average	-3	-3	-1	-1	-3	-2	-1	2	51	80	110	3	234

Table C.135
Water District Structural Alternatives - Reach 16
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-4	-4	-4	0	-5	-5	-1	4	92	227	153	11	464
1976	-3	-4	0	0	-5	-5	-1	4	72	95	28	5	185
1977	-4	-4	-4	-4	-5	-5	-1	4	92	150	147	11	376
1978	-4	-4	-4	-4	-5	0	-1	4	86	85	109	5	266
1979	-3	-4	-5	-4	-4	-5	-1	4	68	0	168	7	220
1980	-4	-4	0	0	0	0	0	0	0	202	176	7	378
1981	-4	-4	0	0	-4	-5	-1	4	72	143	0	7	208
1982	-4	-5	0	0	-5	-5	-1	4	91	222	207	9	312
1983	-5	-4	0	0	0	0	0	0	0	0	0	0	-10
1984	0	-5	0	0	0	0	0	0	0	0	148	0	143
1985	0	0	0	0	0	0	-1	4	92	231	215	0	541
1986	-5	-5	0	0	0	0	0	0	0	0	0	0	-10
1987	0	0	0	0	0	0	0	0	0	0	166	0	166
1988	-4	0	0	0	0	-5	-1	3	87	207	190	10	488
1989	-3	-5	0	0	-5	-5	-1	3	92	0	183	0	259
1990	-5	-5	-4	0	-5	-5	-1	4	89	134	195	8	405
1991	-4	-4	0	0	-5	-5	-1	0	0	87	97	6	171
1992	-3	-5	0	0	-5	0	-1	3	91	193	140	9	422
1993	-4	-5	0	0	-3	0	-1	4	92	0	217	0	299
1994	0	0	0	0	-4	-5	-1	4	90	0	210	9	302
Average	-3	-4	-1	-1	-3	-3	-1	2	60	99	137	3	289

Table C.136
Water District Structural Alternatives - Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-178	-164	-163	0	-200	-211	-174	-118	803	2655	1534	-42	3742
1976	-144	-159	0	0	-206	-209	-163	-120	634	1117	279	-22	1008
1977	-182	-166	-167	-175	-203	-216	-155	-122	800	1836	1478	-44	2684
1978	-190	-185	-178	-159	-212	0	-175	-120	752	1053	1099	-23	1661
1979	-138	-165	-190	-179	-168	-221	-173	-120	590	0	1687	-30	893
1980	-156	-184	0	0	0	0	0	0	0	2572	1828	-30	4030
1981	-165	-163	0	0	-183	-205	-168	-121	632	1665	0	-30	1262
1982	-182	-220	0	0	-221	-206	-164	-115	797	2602	2081	-36	4335
1983	-219	-183	0	0	0	0	0	0	0	0	0	0	-403
1984	0	-214	0	0	0	0	0	0	0	0	1484	0	1270
1985	0	0	0	0	0	0	-173	-121	805	2695	2156	0	5362
1986	-218	-197	0	0	0	0	0	0	0	0	0	0	-415
1987	0	0	0	0	0	0	0	0	0	0	1663	0	1663
1988	-174	0	0	0	0	-209	-156	-115	764	2416	1904	-42	4388
1989	-185	-220	0	0	-211	-201	-170	-108	799	0	1838	0	1541
1990	-232	-202	-181	0	-216	-221	-177	-124	782	1623	1963	-28	3006
1991	-161	-177	0	0	-214	-213	-154	0	0	1012	977	-25	1044
1992	-137	-208	0	0	-219	0	-176	-103	790	1230	1410	-34	2554
1993	-190	-199	0	0	-144	0	-180	-123	801	0	427	0	392
1994	0	0	0	0	-181	-221	-179	-123	785	0	2108	-36	2154
Average	-142	-150	-44	-26	-129	-117	-127	-83	527	1124	1296	-21	2109

Table C.137
Water District Structural Alternatives - Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-103	-100	-95	0	-115	-123	-106	-82	560	1875	1089	-28	2773
1976	-91	-102	0	0	-121	-122	-103	-83	445	791	200	-13	801
1977	-106	-104	-97	-101	-120	-124	-101	-84	557	1302	1048	-28	2043
1978	-109	-106	-108	-90	-123	0	-107	-83	530	746	783	-14	1317
1979	-86	-101	-108	-101	-95	-125	-106	-83	421	0	1196	-18	792
1980	-90	-104	0	0	0	0	0	0	0	1828	1303	-19	2918
1981	-98	-97	0	0	-105	-121	-104	-83	442	1168	0	-19	983
1982	-104	-125	0	0	-126	-123	-103	-81	555	1843	1476	-22	3192
1983	-125	-112	0	0	0	0	0	0	0	0	0	0	-237
1984	0	-123	0	0	0	0	0	0	0	0	1051	0	928
1985	0	0	0	0	0	0	-106	-84	560	1895	1527	0	3792
1986	-124	-118	0	0	0	0	0	0	0	0	0	0	-243
1987	0	0	0	0	0	0	0	0	0	0	1178	0	1178
1988	-99	0	0	0	0	-119	-97	-78	536	1695	1349	-25	3163
1989	-114	-125	0	0	-120	-114	-104	-76	556	0	1302	0	1205
1990	-122	-120	-103	0	-124	-125	-107	-85	548	1153	1405	-19	2298
1991	-98	-101	0	0	-124	-123	-95	0	0	717	697	-15	858
1992	-80	-118	0	0	-125	0	-107	-72	551	1230	1000	-21	2259
1993	-111	-119	0	0	-82	0	-108	-84	538	0	427	0	480
1994	0	0	0	0	-103	-125	-108	-84	549	0	1498	-22	1606
Average	-85	-89	-26	-15	-74	-67	-78	-57	368	812	976	-13	1605

Table C.138
Water District Structural Alternatives - Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-56	-57	-54	0	-59	-61	-57	-52	270	874	646	-27	1366
1976	-55	-58	0	0	-61	-61	-57	-52	242	627	430	-20	934
1977	-57	-59	-54	-56	-61	-61	-57	-52	269	744	636	-27	1164
1978	-57	-57	-59	-53	-61	0	-57	-52	263	617	571	-20	1035
1979	-53	-57	-57	-55	-54	-61	-57	-52	239	0	672	-22	441
1980	-53	-56	0	0	0	0	0	0	0	865	698	-23	1432
1981	-55	-56	0	0	-56	-61	-57	-52	241	712	0	-23	593
1982	-56	-61	0	0	-61	-61	-57	-52	268	868	740	-24	1503
1983	-61	-60	0	0	0	0	0	0	0	0	0	0	-121
1984	0	-61	0	0	0	0	0	0	0	0	636	0	575
1985	0	0	0	0	0	0	-57	-53	269	878	752	0	1789
1986	-61	-61	0	0	0	0	0	0	0	0	0	0	-122
1987	0	0	0	0	0	0	0	0	0	0	667	0	667
1988	-55	0	0	0	0	-60	-55	-50	264	832	709	-25	1560
1989	-61	-61	0	0	-60	-58	-57	-50	268	0	698	0	619
1990	-61	-61	-56	0	-61	-61	-57	-53	267	710	725	-23	1269
1991	-56	-55	0	0	-61	-61	-54	0	0	610	551	-21	853
1992	-51	-59	0	0	-61	0	-57	-49	267	805	624	-24	1395
1993	-58	-61	0	0	-50	0	-57	-52	269	0	427	0	416
1994	0	0	0	0	-56	-61	-57	-52	267	0	746	-24	763
Average	-45	-47	-14	-8	-38	-33	-43	-36	183	457	546	-15	907

Table C.139
On-Farm Changes in Irrigation Techniques - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1976	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1977	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1978	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1979	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1980	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1981	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1982	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1983	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1984	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1985	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1986	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1987	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1988	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1989	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1990	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1991	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1992	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1993	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
1994	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268
Average	-406	-406	-405	-405	-405	-405	-281	-114	2785	8901	7204	203	16268

Table C.140
On-Farm Changes in Irrigation Techniques - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1976	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1977	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1978	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1979	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1980	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1981	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1982	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1983	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1984	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1985	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1986	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1987	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1988	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1989	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1990	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1991	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1992	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1993	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
1994	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417
Average	-435	-435	-435	-435	-435	-435	-349	-231	3054	10122	8268	165	18417

Table C.141
On-Farm Changes in Irrigation Techniques - Reach 19
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1976	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1977	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1978	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1979	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1980	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1981	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1982	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1983	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1984	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1985	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1986	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1987	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1988	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1989	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1990	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1991	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1992	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1993	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
1994	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950
Average	-383	-383	-383	-383	-383	-384	-351	-306	2609	8232	7106	-41	14950

Table C.142

On-Farm Changes in Irrigation Techniques - Reach 17

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-324	-299	-297	0	-365	-383	-268	-105	2601	7054	4390	167	12170
1976	-263	-290	0	0	-375	-380	-251	-105	1977	3330	1231	87	4961
1977	-331	-302	-304	-318	-371	-394	-239	-108	2502	4625	4403	173	9337
1978	-346	-338	-325	-290	-386	0	-270	-106	2206	2734	3059	90	6028
1979	-252	-301	-346	-326	-306	-403	-266	-106	1946	0	5101	119	4861
1980	-284	-336	0	0	0	0	0	0	0	6159	4930	119	10587
1981	-301	-296	0	0	-334	-373	-258	-107	1970	5090	0	117	5507
1982	-331	-400	0	0	-403	-376	-252	-101	2530	6937	5860	142	13604
1983	-400	-334	0	0	0	0	0	0	0	0	0	0	-734
1984	0	-390	0	0	0	0	0	0	0	0	4446	0	4056
1985	0	0	0	0	0	0	-266	-107	2537	7495	6466	0	16125
1986	-397	-359	0	0	0	0	0	0	0	0	0	0	-756
1987	0	0	0	0	0	0	0	0	0	0	5107	0	5107
1988	-317	0	0	0	0	-380	-240	-102	2328	5380	5875	165	12708
1989	-337	-402	0	0	-384	-367	-262	-95	2563	0	5599	0	6315
1990	-387	-368	-330	0	-393	-402	-273	-109	2450	4430	5639	113	10368
1991	-294	-323	0	0	-390	-388	-238	0	0	2858	2832	97	4155
1992	-249	-379	0	0	-399	0	-271	-91	2399	1230	4290	136	6666
1993	-347	-363	0	0	-263	0	-277	-108	2614	0	427	0	1683
1994	0	0	0	0	-330	-403	-276	-109	2476	0	5835	141	7335
Average	-258	-274	-80	-47	-233	-213	-195	-73	1655	2866	3773	83	7004

Table C.143

On-Farm Changes in Irrigation Techniques - Reach 18

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-355	-347	-327	0	-396	-424	-339	-220	2934	8892	3415	149	14982
1976	-314	-353	0	0	-419	-421	-328	-221	2288	3958	1247	71	5507
1977	-365	-361	-334	-349	-416	-428	-322	-224	2869	6034	5312	151	11567
1978	-377	-366	-374	-312	-424	0	-341	-221	2647	3505	3834	73	7645
1979	-296	-349	-375	-350	-330	-434	-338	-222	2234	0	6103	96	5730
1980	-310	-360	0	0	0	0	0	0	0	8283	6301	100	14014
1981	-338	-336	0	0	-364	-418	-331	-222	2275	5919	0	103	6287
1982	-358	-432	0	0	-434	-419	-328	-217	2881	8754	7283	117	16845
1983	-430	-387	0	0	0	0	0	0	0	0	0	0	-817
1984	0	-426	0	0	0	0	0	0	0	0	5339	0	4914
1985	0	0	0	0	0	0	-338	-223	2891	9177	7761	0	19268
1986	-430	-409	0	0	0	0	0	0	0	0	0	0	-839
1987	0	0	0	0	0	0	0	0	0	0	6054	0	6054
1988	-341	0	0	0	0	-412	-310	-208	2727	5380	6952	134	13924
1989	-395	-432	0	0	-413	-395	-333	-202	2899	0	6670	0	7399
1990	-422	-414	-355	0	-429	-435	-342	-226	2822	5540	6987	102	12830
1991	-340	-347	0	0	-427	-425	-302	0	0	3497	3486	81	5222
1992	-276	-407	0	0	-432	0	-341	-193	2797	1230	5119	114	7612
1993	-385	-411	0	0	-283	0	-345	-225	2932	0	427	0	1710
1994	0	0	0	0	-355	-434	-344	-224	2840	0	7334	117	8934
Average	-287	-307	-88	-51	-256	-232	-249	-152	1901	3508	4581	70	8459

Table C.144

On-Farm Changes in Irrigation Techniques - Reach 19

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-351	-356	-339	0	-368	-383	-349	-302	2591	8064	6031	-41	14197
1976	-344	-365	0	0	-383	-383	-349	-303	2326	5782	4011	-30	9962
1977	-356	-367	-341	-348	-383	-382	-349	-304	2579	6865	5937	-41	12509
1978	-360	-354	-367	-329	-382	0	-349	-303	2526	5692	5331	-30	11075
1979	-353	-356	-358	-346	-337	-383	-349	-303	2292	0	6271	-32	5764
1980	-330	-350	0	0	0	0	0	0	0	7975	6520	-34	13781
1981	-347	-348	0	0	-354	-382	-347	-303	2319	6568	0	-34	6772
1982	-350	-382	0	0	-383	-383	-347	-303	2575	8001	6906	-35	13299
1983	-381	-375	0	0	0	0	0	0	0	0	0	0	-756
1984	0	-382	0	0	0	0	0	0	0	0	5940	0	5558
1985	0	0	0	0	0	0	-349	-304	2583	8097	7019	0	17046
1986	-382	-382	0	0	0	0	0	0	0	0	0	0	-763
1987	0	0	0	0	0	0	0	0	0	0	6227	0	6227
1988	-342	0	0	0	0	-374	-336	-291	2536	5380	6618	-38	13153
1989	-380	-382	0	0	-374	-366	-346	-291	2576	0	6512	0	6949
1990	-380	-382	-348	0	-383	-383	-349	-304	2560	6532	6765	-35	13314
1991	-352	-345	0	0	-383	-382	-330	0	0	5628	5142	-31	8947
1992	-317	-371	0	0	-383	0	-348	-285	2566	1230	5826	-35	7884
1993	-366	-382	0	0	-317	0	-349	-303	2380	0	427	0	1290
1994	0	0	0	0	-348	-383	-349	-302	2564	0	6961	-36	8108
Average	-284	-294	-85	-51	-229	-209	-260	-210	1759	3792	4922	-23	9816

Table C.145
On-Farm Changes in Irrigation Techniques - Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-324	-299	-297	0	-365	-385	-268	-105	2695	8362	4942	175	14133
1976	-265	-290	0	0	-375	-380	-251	-105	2127	3517	898	36	4965
1977	-331	-302	-304	-318	-371	-394	-239	-108	2684	5781	4761	182	11041
1978	-346	-338	-325	-290	-386	0	-270	-106	2523	3315	3540	88	7405
1979	-252	-301	-346	-326	-306	-403	-266	-106	1979	0	5434	116	5223
1980	-284	-336	0	0	0	0	0	0	0	8101	5890	119	13489
1981	-301	-296	0	0	-334	-373	-258	-107	2119	5244	0	118	5811
1982	-331	-400	0	0	-403	-376	-252	-101	2673	8193	6702	145	13849
1983	-400	-334	0	0	0	0	0	0	0	0	0	0	-734
1984	0	-390	0	0	0	0	0	0	0	0	4780	0	4390
1985	0	0	0	0	0	0	-266	-107	2702	8487	6945	0	17761
1986	-397	-359	0	0	0	0	0	0	0	0	0	0	-756
1987	0	0	0	0	0	0	0	0	0	0	5358	0	5358
1988	-317	0	0	0	0	-380	-240	-102	2564	5380	6134	166	13205
1989	-337	-402	0	0	-384	-367	-262	-95	2682	0	5920	0	6754
1990	-387	-368	-330	0	-393	-402	-273	-109	2624	5110	6324	126	11920
1991	-294	-323	0	0	-390	-388	-238	0	0	3188	3146	99	4800
1992	-249	-379	0	0	-399	0	-271	-91	2651	1230	4544	142	7178
1993	-347	-363	0	0	-263	0	-277	-108	2689	0	427	0	1758
1994	0	0	0	0	-330	-403	-276	-109	2635	0	6792	146	8456
Average	-258	-274	-80	-47	-235	-213	-195	-73	1767	3295	4127	85	7900

Table C.146
On-Farm Changes in Irrigation Techniques - Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-355	-347	-327	0	-396	-424	-339	-220	2986	9641	5734	152	16104
1976	-314	-353	0	0	-419	-421	-328	-221	2371	4065	1054	71	5505
1977	-365	-361	-334	-349	-416	-428	-322	-224	2969	6697	5519	154	12540
1978	-377	-366	-374	-312	-424	0	-341	-221	2822	3838	4112	73	8429
1979	-296	-349	-375	-350	-330	-434	-338	-222	2242	0	6295	94	5939
1980	-310	-360	0	0	0	0	0	0	0	9399	6856	100	15684
1981	-338	-336	0	0	-364	-418	-331	-222	2358	6006	0	103	6458
1982	-358	-432	0	0	-434	-419	-328	-217	2960	9475	7769	118	18132
1983	-430	-387	0	0	0	0	0	0	0	0	0	0	-817
1984	0	-426	0	0	0	0	0	0	0	0	5532	0	5106
1985	0	0	0	0	0	0	-338	-223	2982	9744	8037	0	20202
1986	-430	-409	0	0	0	0	0	0	0	0	0	0	-839
1987	0	0	0	0	0	0	0	0	0	0	6198	0	6198
1988	-341	0	0	0	0	-412	-310	-208	2858	5380	7102	135	14204
1989	-395	-432	0	0	-413	-395	-333	-202	2965	0	6855	0	7649
1990	-422	-414	-355	0	-429	-433	-342	-226	2918	5931	7382	108	13717
1991	-340	-347	0	0	-427	-425	-302	0	0	3686	3667	81	5592
1992	-276	-407	0	0	-432	0	-341	-193	2936	1230	5265	116	7900
1993	-385	-411	0	0	-283	0	-345	-225	2973	0	427	0	1752
1994	0	0	0	0	-355	-434	-344	-224	2927	0	7886	119	9576
Average	-287	-307	-88	-51	-256	-232	-249	-152	1963	3733	4785	71	8951

Table C.147
On-Farm Changes in Irrigation Techniques - Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-355	-347	-327	0	-396	-424	-339	-220	2986	9641	5734	152	16104
1976	-314	-353	0	0	-419	-421	-328	-221	2371	4065	1054	71	5505
1977	-365	-361	-334	-349	-416	-428	-322	-224	2969	6697	5519	154	12540
1978	-377	-366	-374	-312	-424	0	-341	-221	2822	3838	4112	73	8429
1979	-296	-349	-375	-350	-330	-434	-338	-222	2242	0	6295	94	5939
1980	-310	-360	0	0	0	0	0	0	0	9399	6856	100	15684
1981	-338	-336	0	0	-364	-418	-331	-222	2358	6006	0	103	6458
1982	-358	-432	0	0	-434	-419	-328	-217	2960	9475	7769	118	18132
1983	-430	-387	0	0	0	0	0	0	0	0	0	0	-817
1984	0	-426	0	0	0	0	0	0	0	0	5532	0	5106
1985	0	0	0	0	0	0	-338	-223	2982	9744	8037	0	20202
1986	-430	-409	0	0	0	0	0	0	0	0	0	0	-839
1987	0	0	0	0	0	0	0	0	0	0	6198	0	6198
1988	-341	0	0	0	0	-412	-310	-208	2858	5380	7102	135	14204
1989	-395	-432	0	0	-413	-395	-333	-202	2965	0	6855	0	7649
1990	-422	-414	-355	0	-429	-433	-342	-226	2918	5931	7382	108	13717
1991	-340	-347	0	0	-427	-425	-302	0	0	3686	3667	81	5592
1992	-276	-407	0	0	-432	0	-341	-193	2936	1230	5265	116	7900
1993	-385	-411	0	0	-283	0	-345	-225	2973	0	427	0	1752
1994	0	0	0	0	-355	-434	-344	-224	2927	0	7886	119	9576
Average	-287	-307	-88	-51	-256	-232	-249	-152	1963	3733	4785	71	8951

Table F.1
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 1
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	71	0	0	0	0	0	33	209	415	544	443	235	1950
1976	71	0	0	0	0	0	33	209	415	544	443	235	1950
1977	71	0	0	0	0	0	33	209	415	544	443	235	1950
1978	71	0	0	0	0	0	33	209	415	544	443	235	1950
1979	71	0	0	0	0	0	33	209	415	544	443	235	1950
1980	71	0	0	0	0	0	33	209	415	544	443	235	1950
1981	71	0	0	0	0	0	33	209	415	544	443	235	1950
1982	71	0	0	0	0	0	33	209	415	544	443	235	1950
1983	71	0	0	0	0	0	33	209	415	544	443	235	1950
1984	71	0	0	0	0	0	33	209	415	544	443	235	1950
1985	71	0	0	0	0	0	33	209	415	544	443	235	1950
1986	71	0	0	0	0	0	33	209	415	544	443	235	1950
1987	71	0	0	0	0	0	33	209	415	544	443	235	1950
1988	71	0	0	0	0	0	33	209	415	544	443	235	1950
1989	71	0	0	0	0	0	33	209	415	544	443	235	1950
1990	71	0	0	0	0	0	33	209	415	544	443	235	1950
1991	71	0	0	0	0	0	33	209	415	544	443	235	1950
1992	71	0	0	0	0	0	33	209	415	544	443	235	1950
1993	71	0	0	0	0	0	33	209	415	544	443	235	1950
1994	71	0	0	0	0	0	33	209	415	544	443	235	1950
Average	71	0	0	0	0	0	33	209	415	544	443	235	1950

Table F.2
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 2
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1976	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1977	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1978	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1979	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1980	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1981	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1982	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1983	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1984	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1985	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1986	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1987	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1988	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1989	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1990	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1991	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1992	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1993	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
1994	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990
Average	187	0	0	0	0	0	46	446	1018	1428	1262	603	4990

Table F.3
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 3
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	78	0	0	0	0	0	18	176	403	577	525	252	2030
1976	78	0	0	0	0	0	18	176	403	577	525	252	2030
1977	78	0	0	0	0	0	18	176	403	577	525	252	2030
1978	78	0	0	0	0	0	18	176	403	577	525	252	2030
1979	78	0	0	0	0	0	18	176	403	577	525	252	2030
1980	78	0	0	0	0	0	18	176	403	577	525	252	2030
1981	78	0	0	0	0	0	18	176	403	577	525	252	2030
1982	78	0	0	0	0	0	18	176	403	577	525	252	2030
1983	78	0	0	0	0	0	18	176	403	577	525	252	2030
1984	78	0	0	0	0	0	18	176	403	577	525	252	2030
1985	78	0	0	0	0	0	18	176	403	577	525	252	2030
1986	78	0	0	0	0	0	18	176	403	577	525	252	2030
1987	78	0	0	0	0	0	18	176	403	577	525	252	2030
1988	78	0	0	0	0	0	18	176	403	577	525	252	2030
1989	78	0	0	0	0	0	18	176	403	577	525	252	2030
1990	78	0	0	0	0	0	18	176	403	577	525	252	2030
1991	78	0	0	0	0	0	18	176	403	577	525	252	2030
1992	78	0	0	0	0	0	18	176	403	577	525	252	2030
1993	78	0	0	0	0	0	18	176	403	577	525	252	2030
1994	78	0	0	0	0	0	18	176	403	577	525	252	2030
Average	78	0	0	0	0	0	18	176	403	577	525	252	2030

Table F.4
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 4
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	82	0	0	0	0	0	19	142	286	454	413	214	1610
1976	82	0	0	0	0	0	19	142	286	454	413	214	1610
1977	82	0	0	0	0	0	19	142	286	454	413	214	1610
1978	82	0	0	0	0	0	19	142	286	454	413	214	1610
1979	82	0	0	0	0	0	19	142	286	454	413	214	1610
1980	82	0	0	0	0	0	19	142	286	454	413	214	1610
1981	82	0	0	0	0	0	19	142	286	454	413	214	1610
1982	82	0	0	0	0	0	19	142	286	454	413	214	1610
1983	82	0	0	0	0	0	19	142	286	454	413	214	1610
1984	82	0	0	0	0	0	19	142	286	454	413	214	1610
1985	82	0	0	0	0	0	19	142	286	454	413	214	1610
1986	82	0	0	0	0	0	19	142	286	454	413	214	1610
1987	82	0	0	0	0	0	19	142	286	454	413	214	1610
1988	82	0	0	0	0	0	19	142	286	454	413	214	1610
1989	82	0	0	0	0	0	19	142	286	454	413	214	1610
1990	82	0	0	0	0	0	19	142	286	454	413	214	1610
1991	82	0	0	0	0	0	19	142	286	454	413	214	1610
1992	82	0	0	0	0	0	19	142	286	454	413	214	1610
1993	82	0	0	0	0	0	19	142	286	454	413	214	1610
1994	82	0	0	0	0	0	19	142	286	454	413	214	1610
Average	82	0	0	0	0	0	19	142	286	454	413	214	1610

Table F.5
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 5
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1976	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1977	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1978	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1979	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1980	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1981	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1982	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1983	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1984	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1985	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1986	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1987	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1988	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1989	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1990	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1991	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1992	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1993	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
1994	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203
Average	69	-311	-321	-327	-329	-327	-275	37	707	1811	1798	672	3203

Table F.6
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 6
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	157	0	0	0	0	0	35	332	721	950	838	448	3480
1976	157	0	0	0	0	0	35	332	721	950	838	448	3480
1977	157	0	0	0	0	0	35	332	721	950	838	448	3480
1978	157	0	0	0	0	0	35	332	721	950	838	448	3480
1979	157	0	0	0	0	0	35	332	721	950	838	448	3480
1980	157	0	0	0	0	0	35	332	721	950	838	448	3480
1981	157	0	0	0	0	0	35	332	721	950	838	448	3480
1982	157	0	0	0	0	0	35	332	721	950	838	448	3480
1983	157	0	0	0	0	0	35	332	721	950	838	448	3480
1984	157	0	0	0	0	0	35	332	721	950	838	448	3480
1985	157	0	0	0	0	0	35	332	721	950	838	448	3480
1986	157	0	0	0	0	0	35	332	721	950	838	448	3480
1987	157	0	0	0	0	0	35	332	721	950	838	448	3480
1988	157	0	0	0	0	0	35	332	721	950	838	448	3480
1989	157	0	0	0	0	0	35	332	721	950	838	448	3480
1990	157	0	0	0	0	0	35	332	721	950	838	448	3480
1991	157	0	0	0	0	0	35	332	721	950	838	448	3480
1992	157	0	0	0	0	0	35	332	721	950	838	448	3480
1993	157	0	0	0	0	0	35	332	721	950	838	448	3480
1994	157	0	0	0	0	0	35	332	721	950	838	448	3480
Average	157	0	0	0	0	0	35	332	721	950	838	448	3480

Table F.7
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 7
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1976	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1977	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1978	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1979	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1980	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1981	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1982	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1983	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1984	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1985	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1986	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1987	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1988	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1989	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1990	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1991	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1992	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1993	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
1994	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349
Average	-238	-251	-256	-260	-262	-261	-145	55	875	1653	1343	95	2349

Table F.8
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1976	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1977	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1978	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1979	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1980	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1981	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1982	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1983	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1984	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1985	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1986	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1987	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1988	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1989	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1990	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1991	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1992	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1993	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
1994	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727
Average	-1801	-1871	-1881	-1895	-1910	-1907	-1004	433	6918	12769	10261	614	18727

Table F.9
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1976	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1977	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1978	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1979	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1980	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1981	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1982	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1983	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1984	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1985	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1986	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1987	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1988	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1989	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1990	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1991	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1992	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1993	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
1994	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157
Average	-1781	-1773	-1643	-1514	-1391	-1289	-522	233	4337	9212	7168	122	11157

Table F.10
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 10
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1976	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1977	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1978	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1979	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1980	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1981	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1982	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1983	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1984	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1985	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1986	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1987	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1988	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1989	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1990	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1991	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1992	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1993	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
1994	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442
Average	-372	-312	-263	-230	-203	-183	-126	-68	598	1585	1290	-272	1442

Table F.11
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 11
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	50	124	578	945	783	0	2480
1976	0	0	0	0	0	0	50	124	578	945	783	0	2480
1977	0	0	0	0	0	0	50	124	578	945	783	0	2480
1978	0	0	0	0	0	0	50	124	578	945	783	0	2480
1979	0	0	0	0	0	0	50	124	578	945	783	0	2480
1980	0	0	0	0	0	0	50	124	578	945	783	0	2480
1981	0	0	0	0	0	0	50	124	578	945	783	0	2480
1982	0	0	0	0	0	0	50	124	578	945	783	0	2480
1983	0	0	0	0	0	0	50	124	578	945	783	0	2480
1984	0	0	0	0	0	0	50	124	578	945	783	0	2480
1985	0	0	0	0	0	0	50	124	578	945	783	0	2480
1986	0	0	0	0	0	0	50	124	578	945	783	0	2480
1987	0	0	0	0	0	0	50	124	578	945	783	0	2480
1988	0	0	0	0	0	0	50	124	578	945	783	0	2480
1989	0	0	0	0	0	0	50	124	578	945	783	0	2480
1990	0	0	0	0	0	0	50	124	578	945	783	0	2480
1991	0	0	0	0	0	0	50	124	578	945	783	0	2480
1992	0	0	0	0	0	0	50	124	578	945	783	0	2480
1993	0	0	0	0	0	0	50	124	578	945	783	0	2480
1994	0	0	0	0	0	0	50	124	578	945	783	0	2480
Average	0	0	0	0	0	0	50	124	578	945	783	0	2480

Table F.12
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 12
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1976	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1977	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1978	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1979	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1980	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1981	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1982	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1983	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1984	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1985	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1986	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1987	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1988	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1989	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1990	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1991	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1992	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1993	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
1994	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392
Average	279	-1808	-1804	-1803	-1806	-1811	-1603	-635	2802	9628	10606	3348	15392

Table F.13
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 13
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1976	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1977	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1978	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1979	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1980	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1981	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1982	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1983	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1984	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1985	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1986	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1987	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1988	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1989	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1990	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1991	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1992	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1993	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
1994	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686
Average	21	-910	-942	-946	-929	-903	-785	-362	1046	3798	4246	1353	4686

Table F.14
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 14
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1976	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1977	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1978	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1979	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1980	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1981	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1982	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1983	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1984	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1985	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1986	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1987	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1988	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1989	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1990	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1991	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1992	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1993	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
1994	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617
Average	-240	-160	-121	-100	-85	-74	-25	21	534	1227	910	-270	1617

Table F.15
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 15
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1976	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1977	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1978	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1979	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1980	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1981	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1982	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1983	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1984	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1985	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1986	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1987	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1988	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1989	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1990	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1991	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1992	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1993	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
1994	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183
Average	-187	-187	-187	-189	-190	-191	-154	-111	575	1628	1445	-70	2183

Table F.16
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1976	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1977	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1978	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1979	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1980	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1981	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1982	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1983	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1984	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1985	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1986	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1987	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1988	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1989	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1990	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1991	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1992	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1993	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
1994	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695
Average	-292	-292	-292	-292	-292	-293	-243	-186	902	2648	2411	-84	3695

Table F.17
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1976	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1977	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1978	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1979	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1980	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1981	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1982	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1983	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1984	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1985	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1986	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1987	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1988	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1989	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1990	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1991	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1992	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1993	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
1994	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810
Average	-687	-687	-686	-686	-685	-685	-599	-481	1620	5996	4701	-312	6810

Table F.18
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1976	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1977	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1978	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1979	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1980	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1981	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1982	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1983	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1984	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1985	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1986	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1987	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1988	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1989	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1990	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1991	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1992	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1993	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
1994	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281
Average	-585	-585	-586	-586	-586	-586	-527	-448	1871	6775	5377	-252	9281

Table F.19
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1976	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1977	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1978	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1979	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1980	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1981	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1982	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1983	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1984	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1985	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1986	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1987	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1988	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1989	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1990	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1991	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1992	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1993	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
1994	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566
Average	-506	-506	-506	-506	-506	-506	-484	-453	1601	5533	4700	-294	7566

Table F.20
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 1
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	14	0	0	0	0	0	10	4	17	2	1	4	53
1976	5	0	0	0	0	0	3	4	4	0	0	2	18
1977	9	0	0	0	0	0	4	5	4	1	1	5	29
1978	32	0	0	0	0	0	2	9	2	1	1	1	47
1979	11	0	0	0	0	0	2	3	12	0	1	1	29
1980	4	0	0	0	0	0	0	0	0	0	1	3	8
1981	6	0	0	0	0	0	1	0	1	4	0	1	12
1982	6	0	0	0	0	0	1	2	3	1	1	4	17
1983	10	0	0	0	0	0	0	0	0	0	0	0	10
1984	0	0	0	0	0	0	0	0	0	0	7	0	7
1985	0	0	0	0	0	0	7	6	11	2	2	0	28
1986	9	0	0	0	0	0	0	0	0	0	0	0	9
1987	0	0	0	0	0	0	0	0	0	0	4	0	4
1988	35	0	0	0	0	0	5	20	4	3	2	5	74
1989	6	0	0	0	0	0	1	1	3	0	1	0	12
1990	30	0	0	0	0	0	2	12	1	0	2	2	49
1991	4	0	0	0	0	0	0	0	0	0	0	2	7
1992	4	0	0	0	0	0	0	2	2	4	1	1	15
1993	38	0	0	0	0	0	0	2	9	0	6	0	57
1994	0	0	0	0	0	0	1	3	3	0	1	3	11
Average	11	0	0	0	0	0	2	4	4	1	2	2	25

Table F.21
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 2
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	38	0	0	0	0	0	15	9	41	6	4	11	123
1976	13	0	0	0	0	0	5	9	9	1	1	5	42
1977	25	0	0	0	0	0	6	12	9	2	4	12	70
1978	86	0	0	0	0	0	3	20	5	2	1	2	119
1979	29	0	0	0	0	0	2	6	30	0	3	3	72
1980	10	0	0	0	0	0	0	0	0	1	4	7	21
1981	15	0	0	0	0	0	1	1	2	10	0	4	32
1982	17	0	0	0	0	0	1	3	6	3	4	9	44
1983	27	0	0	0	0	0	0	0	0	0	0	0	27
1984	0	0	0	0	0	0	0	0	0	0	21	0	21
1985	0	0	0	0	0	0	10	12	27	5	6	0	60
1986	24	0	0	0	0	0	0	0	0	0	0	0	24
1987	0	0	0	0	0	0	0	0	0	0	11	0	11
1988	93	0	0	0	0	0	8	43	10	7	5	14	181
1989	17	0	0	0	0	0	1	2	7	0	3	0	30
1990	81	0	0	0	0	0	3	25	3	1	6	5	123
1991	10	0	0	0	0	0	0	0	0	1	1	5	18
1992	11	0	0	0	0	0	1	5	5	11	4	4	40
1993	102	0	0	0	0	0	1	5	23	0	18	0	149
1994	0	0	0	0	0	0	2	6	7	0	3	9	27
Average	30	0	0	0	0	0	3	8	9	2	3	4	62

Table F.22
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 3
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	16	0	0	0	0	0	6	3	17	2	2	4	50
1976	6	0	0	0	0	0	2	4	4	0	0	2	17
1977	11	0	0	0	0	0	2	5	4	1	2	5	29
1978	37	0	0	0	0	0	1	8	2	1	1	1	50
1979	12	0	0	0	0	0	1	2	12	0	1	1	30
1980	4	0	0	0	0	0	0	0	0	0	2	3	9
1981	6	0	0	0	0	0	0	0	1	4	0	2	13
1982	7	0	0	0	0	0	0	1	3	1	2	4	18
1983	11	0	0	0	0	0	0	0	0	0	0	0	11
1984	0	0	0	0	0	0	0	0	0	0	9	0	9
1985	0	0	0	0	0	0	4	3	11	2	2	0	24
1986	10	0	0	0	0	0	0	0	0	0	0	0	10
1987	0	0	0	0	0	0	0	0	0	0	5	0	5
1988	40	0	0	0	0	0	3	17	4	3	2	6	75
1989	7	0	0	0	0	0	0	1	3	0	1	0	13
1990	35	0	0	0	0	0	1	10	1	0	2	2	52
1991	4	0	0	0	0	0	0	0	0	0	0	2	7
1992	5	0	0	0	0	0	0	2	2	4	2	2	16
1993	43	0	0	0	0	0	0	2	9	0	8	0	63
1994	0	0	0	0	0	0	1	3	3	0	1	4	11
Average	13	0	0	0	0	0	1	3	4	1	2	2	26

Table F.23
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 4
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	17	0	0	0	0	0	6	3	12	2	1	4	45
1976	6	0	0	0	0	0	2	3	3	0	0	2	16
1977	11	0	0	0	0	0	3	4	3	1	1	3	27
1978	39	0	0	0	0	0	1	6	1	1	1	1	50
1979	13	0	0	0	0	0	1	2	9	0	1	1	26
1980	4	0	0	0	0	0	0	0	0	0	1	2	8
1981	7	0	0	0	0	0	0	0	1	3	0	1	13
1982	8	0	0	0	0	0	0	1	2	1	1	3	17
1983	12	0	0	0	0	0	0	0	0	0	0	0	12
1984	0	0	0	0	0	0	0	0	0	0	7	0	7
1985	0	0	0	0	0	0	4	4	8	2	2	0	20
1986	11	0	0	0	0	0	0	0	0	0	0	0	11
1987	0	0	0	0	0	0	0	0	0	0	4	0	4
1988	42	0	0	0	0	0	3	14	3	3	2	5	72
1989	8	0	0	0	0	0	1	1	2	0	1	0	12
1990	37	0	0	0	0	0	1	8	1	0	2	2	51
1991	5	0	0	0	0	0	0	0	0	0	0	2	7
1992	5	0	0	0	0	0	0	2	1	4	1	1	15
1993	46	0	0	0	0	0	0	2	7	0	6	0	61
1994	0	0	0	0	0	0	1	2	2	0	1	3	9
Average	13	0	0	0	0	0	1	3	3	1	2	2	24

Table F.24
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 5
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	38	-160	-186	0	-222	-238	-176	4	77	21	20	81	-741
1976	22	-153	0	0	-247	-230	-117	4	22	4	3	36	-657
1977	32	-142	-177	-173	-205	-218	-163	5	27	7	22	75	-911
1978	33	-155	-179	-212	-280	0	-148	4	15	8	9	18	-890
1979	23	-131	-198	-196	-165	-243	-144	3	54	0	15	28	-952
1980	19	-132	0	0	0	0	0	0	0	5	20	47	-42
1981	24	-136	0	0	-211	-215	-65	2	5	37	0	32	-528
1982	33	-202	0	0	-258	-234	-80	1	15	10	19	72	-624
1983	31	-176	0	0	0	0	0	0	0	0	0	0	-145
1984	0	-209	0	0	0	0	0	0	0	0	64	0	-145
1985	0	0	0	0	0	0	-129	5	48	19	29	0	-28
1986	50	-176	0	0	0	0	0	0	0	0	0	0	-125
1987	0	0	0	0	0	0	0	0	0	0	73	0	73
1988	35	0	0	0	0	-251	-132	10	23	34	29	89	-163
1989	28	-170	0	0	-237	-236	-75	1	13	0	17	0	-658
1990	31	-175	-181	0	-227	-226	-173	5	10	2	30	20	-883
1991	28	-217	0	0	-244	-215	-63	0	0	3	3	30	-675
1992	13	-178	0	0	-258	0	-139	1	26	41	17	18	-459
1993	41	-196	0	0	-171	0	-159	2	63	0	92	0	-329
1994	0	0	0	0	-230	-276	-129	3	17	0	16	70	-529
Average	24	-135	-46	-29	-148	-129	-95	2	21	10	24	31	-471

Table F.25
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 6
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	87	0	0	0	0	0	22	27	63	9	8	43	259
1976	49	0	0	0	0	0	15	25	18	2	1	19	129
1977	73	0	0	0	0	0	21	33	21	3	8	39	199
1978	75	0	0	0	0	0	19	29	12	3	3	9	150
1979	52	0	0	0	0	0	18	20	46	0	6	14	155
1980	43	0	0	0	0	0	0	0	0	2	8	25	77
1981	54	0	0	0	0	0	8	8	3	17	0	17	107
1982	74	0	0	0	0	0	9	9	11	5	7	39	154
1983	69	0	0	0	0	0	0	0	0	0	0	0	69
1984	0	0	0	0	0	0	0	0	0	0	27	0	27
1985	0	0	0	0	0	0	16	33	42	8	11	0	110
1986	114	0	0	0	0	0	0	0	0	0	0	0	114
1987	0	0	0	0	0	0	0	0	0	0	24	0	24
1988	75	0	0	0	0	0	17	76	19	14	11	50	261
1989	64	0	0	0	0	0	9	5	9	0	6	0	94
1990	70	0	0	0	0	0	23	18	5	1	10	10	137
1991	63	0	0	0	0	0	8	0	0	1	1	17	89
1992	29	0	0	0	0	0	17	4	8	18	7	10	92
1993	88	0	0	0	0	0	20	17	58	0	36	0	219
1994	0	0	0	0	0	0	16	20	14	0	6	38	94
Average	54	0	0	0	0	0	12	16	16	4	9	16	128

Table F.26
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 7
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-9	-6	-17	0	-47	-33	-19	1	115	2	2	2	-9
1976	-6	-5	0	0	-25	-61	-6	0	1	0	0	0	-101
1977	-1	-2	-8	-14	-7	-28	-5	1	2	1	1	0	-61
1978	-3	-2	-2	-8	-6	0	-4	0	2	0	0	0	-21
1979	-2	-1	-5	-21	-28	-6	-6	3	173	0	11	1	120
1980	-5	-15	0	0	0	0	0	0	0	1	1	1	-17
1981	-1	-10	0	0	-18	-19	-6	1	7	1	0	0	-44
1982	-1	0	0	0	-33	-3	-1	0	2	3	1	1	-31
1983	-2	-7	0	0	0	0	0	0	0	0	0	0	-9
1984	0	-62	0	0	0	0	0	0	0	0	20	0	-42
1985	0	0	0	0	0	0	-5	12	68	5	4	0	84
1986	-43	-29	0	0	0	0	0	0	0	0	0	0	-71
1987	0	0	0	0	0	0	0	0	0	0	4	0	4
1988	-2	0	0	0	0	-73	-11	7	15	2	1	1	-60
1989	-1	-1	0	0	-87	-29	-2	0	4	0	1	0	-115
1990	-1	-1	-13	0	-65	-69	-38	1	2	0	2	0	-182
1991	-1	-1	0	0	-48	-29	-2	0	0	0	0	1	-80
1992	-1	-2	0	0	-95	0	-15	0	10	8	13	2	-80
1993	-8	-7	0	0	-61	0	-17	0	6	0	3	0	-84
1994	0	0	0	0	-90	-55	-5	0	1	0	1	0	-146
Average	-4	-7	-2	-2	-30	-20	-7	1	20	1	3	1	-47

Table F.27
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 8
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-306	-421	-455	0	-667	-852	-272	27	1412	36	37	27	-1434
1976	-296	-454	0	0	-709	-844	-126	13	35	6	2	6	-2367
1977	-179	-374	-491	-500	-551	-554	-200	24	150	16	29	19	-2610
1978	-201	-409	-443	-483	-611	0	-69	7	67	7	6	2	-2129
1979	-80	-174	-325	-496	-405	-374	-147	40	1881	0	132	23	75
1980	-130	-251	0	0	0	0	0	0	0	17	16	18	-330
1981	-70	-229	0	0	-600	-499	-101	15	108	55	0	3	-1318
1982	-118	-176	0	0	-820	-402	-52	5	85	71	17	24	-1367
1983	-228	-460	0	0	0	0	0	0	0	0	0	0	-688
1984	0	-807	0	0	0	0	0	0	0	0	232	0	-575
1985	0	0	0	0	0	0	-137	122	869	91	85	0	1030
1986	-658	-629	0	0	0	0	0	0	0	0	0	0	-1287
1987	0	0	0	0	0	0	0	0	0	0	80	0	80
1988	-220	0	0	0	0	-850	-213	114	260	64	35	18	-793
1989	-106	-143	0	0	-852	-608	-74	2	109	0	28	0	-1643
1990	-111	-114	-254	0	-731	-704	-390	16	44	4	47	6	-2186
1991	-147	-260	0	0	-603	-497	-58	0	0	6	8	15	-1534
1992	-65	-117	0	0	-925	0	-228	3	269	317	223	27	-495
1993	-391	-425	0	0	-603	0	-234	12	161	0	88	0	-1392
1994	0	0	0	0	-838	-727	-114	9	45	0	13	6	-1606
Average	-165	-272	-98	-74	-446	-345	-121	20	275	34	54	10	-1129

Table F.28
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 9
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-710	-785	-684	0	-731	-995	-240	43	1283	252	226	23	-2318
1976	-628	-859	0	0	-913	-841	-205	40	207	84	27	9	-3078
1977	-562	-716	-807	-714	-767	-605	-207	45	376	117	194	29	-3617
1978	-535	-781	-792	-793	-887	0	-186	23	131	84	96	8	-3632
1979	-294	-512	-732	-740	-438	-587	-179	41	1538	0	170	13	-1721
1980	-289	-375	0	0	0	0	0	0	0	74	195	14	-381
1981	-331	-460	0	0	-829	-690	-109	20	119	467	0	12	-1801
1982	-436	-629	0	0	-1045	-705	-111	14	142	142	132	18	-2479
1983	-854	-872	0	0	0	0	0	0	0	0	0	0	-1725
1984	0	-1045	0	0	0	0	0	0	0	0	323	0	-722
1985	0	0	0	0	0	0	-226	85	973	359	366	0	1557
1986	-1047	-929	0	0	0	0	0	0	0	0	0	0	-1976
1987	0	0	0	0	0	0	0	0	0	0	372	0	372
1988	-605	0	0	0	0	-838	-220	100	327	514	341	21	-358
1989	-381	-507	0	0	-848	-745	-111	13	344	0	225	0	-2010
1990	-444	-529	-561	0	-733	-652	-288	44	195	38	299	6	-2615
1991	-448	-696	0	0	-673	-609	-79	0	0	60	66	8	-2372
1992	-235	-509	0	0	-843	0	-214	16	424	763	366	10	-222
1993	-796	-854	0	0	-594	0	-199	27	469	0	427	0	-1520
1994	0	0	0	0	-821	-827	-156	34	281	0	195	23	-1272
Average	-430	-553	-179	-112	-506	-405	-137	27	340	149	200	10	-1595

Table F.29
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 10
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-210	-153	-132	0	-123	-139	-78	-23	228	38	69	-103	-558
1976	-154	-157	0	0	-145	-127	-78	-23	65	31	10	-41	-617
1977	-183	-137	-138	-116	-120	-106	-68	-25	92	42	79	-130	-809
1978	-174	-150	-140	-141	-155	0	-76	-14	36	32	36	-35	-782
1979	-112	-128	-156	-132	-84	-119	-62	-16	245	0	49	-46	-562
1980	-99	-101	0	0	0	0	0	0	0	25	77	-65	-162
1981	-131	-118	0	0	-131	-119	-40	-10	26	168	0	-57	-413
1982	-171	-185	0	0	-159	-130	-47	-9	34	42	53	-74	-646
1983	-223	-171	0	0	0	0	0	0	0	0	0	0	-394
1984	0	-200	0	0	0	0	0	0	0	0	100	0	-100
1985	0	0	0	0	0	0	-83	-33	195	127	136	0	342
1986	-259	-172	0	0	0	0	0	0	0	0	0	0	-432
1987	0	0	0	0	0	0	0	0	0	0	144	0	144
1988	-185	0	0	0	0	-135	-67	-36	68	207	138	-99	-111
1989	-142	-153	0	0	-142	-126	-43	-9	96	0	94	0	-423
1990	-163	-164	-139	0	-127	-114	-82	-26	59	24	127	-30	-636
1991	-148	-191	0	0	-130	-112	-30	0	0	24	29	-33	-592
1992	-75	-162	0	0	-143	0	-67	-40	97	231	113	-31	-45
1993	-228	-185	0	0	-100	0	-66	-15	130	0	288	0	-175
1994	0	0	0	0	-138	-147	-62	-21	80	0	74	-105	-317
Average	-133	-126	-35	-19	-85	-69	-47	-17	72	32	82	-42	-364

Table F.30
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 11
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	5	2	53	1	1	0	63
1976	0	0	0	0	0	0	2	1	1	0	0	0	3
1977	0	0	0	0	0	0	1	1	1	0	0	0	3
1978	0	0	0	0	0	0	1	0	1	0	0	0	3
1979	0	0	0	0	0	0	2	5	94	0	5	0	106
1980	0	0	0	0	0	0	0	0	0	0	0	0	1
1981	0	0	0	0	0	0	2	1	4	1	0	0	7
1982	0	0	0	0	0	0	0	0	1	2	0	0	3
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	8	0	8
1985	0	0	0	0	0	0	1	16	33	2	2	0	53
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	2	0	2
1988	0	0	0	0	0	0	3	10	7	1	1	0	22
1989	0	0	0	0	0	0	1	0	2	0	0	0	3
1990	0	0	0	0	0	0	12	1	1	0	1	0	15
1991	0	0	0	0	0	0	1	0	0	0	0	0	1
1992	0	0	0	0	0	0	3	0	5	4	3	0	17
1993	0	0	0	0	0	0	5	1	3	0	1	0	10
1994	0	0	0	0	0	0	1	1	1	0	0	0	3
Average	0	0	0	0	0	0	2	2	10	1	1	0	16

Table F.31
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 12
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	159	-932	-1049	0	-1223	-1326	-1043	-106	528	241	313	717	-3722
1976	90	-892	0	0	-1364	-1280	-739	-111	169	70	41	322	-3695
1977	135	-826	-996	-959	-1129	-1215	-981	-149	202	104	298	693	-4824
1978	139	-908	-1011	-1174	-1545	0	-889	-79	93	95	116	555	-5009
1979	93	-761	-1114	-1082	-908	-1352	-832	-84	429	0	190	241	-5200
1980	79	-770	0	0	0	0	0	0	0	63	293	412	78
1981	104	-792	0	0	-1166	-1201	-411	-58	53	501	0	291	-2679
1982	140	-1176	0	0	-1424	-1308	-504	-45	87	124	226	364	-3315
1983	129	-1025	0	0	0	0	0	0	0	0	0	0	-896
1984	0	-1218	0	0	0	0	0	0	0	0	546	0	-672
1985	0	0	0	0	0	0	-788	-147	350	310	421	0	146
1986	206	-1021	0	0	0	0	0	0	0	0	0	0	-815
1987	0	0	0	0	0	0	0	0	0	0	720	0	720
1988	147	0	0	0	0	-1398	-816	-229	167	496	441	720	-472
1989	118	-991	0	0	-1208	-1311	-474	-28	160	0	301	0	-3534
1990	129	-1020	-1020	0	-1253	-1262	-1030	-172	98	49	441	595	-4845
1991	115	-1268	0	0	-1346	-1198	-385	0	0	58	80	249	-3695
1992	54	-1059	0	0	-1424	0	-860	-36	255	541	362	184	-1963
1993	178	-1144	0	0	-943	0	-951	-79	380	0	427	0	-2133
1994	0	0	0	0	-1267	-1538	-772	-89	137	0	235	579	-2714
Average	101	-789	-259	-161	-815	-719	-575	-71	155	133	273	266	-2462

Table F.32
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 13
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	12	-471	-549	0	-632	-666	-520	-76	272	166	243	412	-1808
1976	7	-451	0	0	-705	-643	-390	-86	97	62	28	185	-1896
1977	11	-418	-521	-504	-583	-610	-496	-115	113	89	204	408	-2424
1978	11	-459	-329	-617	-799	0	-449	-53	46	64	77	87	-2621
1979	7	-385	-583	-569	-469	-679	-423	-61	245	0	122	130	-2664
1980	6	-389	0	0	0	0	0	0	0	48	212	230	107
1981	8	-401	0	0	-604	-605	-216	-44	38	334	0	166	-1324
1982	11	-595	0	0	-736	-658	-265	-35	48	84	139	296	-1710
1983	10	-518	0	0	0	0	0	0	0	0	0	0	-508
1984	0	-616	0	0	0	0	0	0	0	0	291	0	-326
1985	0	0	0	0	0	0	-406	-117	198	249	304	0	229
1986	16	-516	0	0	0	0	0	0	0	0	0	0	-500
1987	0	0	0	0	0	0	0	0	0	0	404	0	404
1988	12	0	0	0	0	-701	-425	-154	93	413	340	396	-28
1989	9	-502	0	0	-676	-658	-250	-25	128	0	275	0	-1698
1990	10	-518	-540	0	-648	-635	-516	-114	62	51	336	126	-2385
1991	9	-642	0	0	-697	-602	-201	0	0	49	80	143	-1861
1992	4	-526	0	0	-736	0	-446	-35	140	378	314	115	-791
1993	14	-579	0	0	-488	0	-478	-65	197	0	427	0	-972
1994	0	0	0	0	-655	-772	-388	-72	89	0	175	331	-1292
Average	8	-399	-136	-85	-421	-361	-293	-53	88	99	199	151	-1204

Table F.33
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 14
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-147	-83	-71	0	-58	-55	-17	6	187	64	63	-102	-213
1976	-91	-80	0	0	-65	-54	-14	7	60	24	7	-41	-248
1977	-126	-74	-67	-53	-33	-51	-16	8	76	33	55	-114	-383
1978	-128	-81	-68	-65	-73	0	-15	4	32	24	22	-27	-375
1979	-83	-68	-75	-60	-43	-56	-14	5	183	0	33	-37	-215
1980	-75	-69	0	0	0	0	0	0	0	19	54	-61	-133
1981	-97	-71	0	0	-55	-50	-8	3	24	127	0	-48	-175
1982	-131	-105	0	0	-68	-55	-9	3	31	33	37	-73	-337
1983	-116	-91	0	0	0	0	0	0	0	0	0	0	-208
1984	0	-109	0	0	0	0	0	0	0	0	74	0	-35
1985	0	0	0	0	0	0	-15	9	148	98	88	0	328
1986	-181	-91	0	0	0	0	0	0	0	0	0	0	-272
1987	0	0	0	0	0	0	0	0	0	0	103	0	103
1988	-133	0	0	0	0	-58	-14	10	59	164	93	-97	25
1989	-106	-89	0	0	-62	-55	-9	2	83	0	70	0	-165
1990	-118	-92	-70	0	-59	-53	-17	8	47	19	93	-31	-273
1991	-106	-113	0	0	-64	-50	-7	0	0	19	21	-35	-335
1992	-49	-93	0	0	-68	0	-15	3	88	167	83	-29	87
1993	-169	-102	0	0	-45	0	-15	5	120	0	177	0	-30
1994	0	0	0	0	-60	-64	-13	6	64	0	47	-89	-110
Average	-93	-71	-18	-9	-39	-30	-10	4	50	40	56	-39	-148

Table F.34
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 15
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-127	-117	-123	0	-150	-161	-128	-39	268	138	126	-21	-333
1976	-99	-113	0	0	-160	-158	-116	-38	75	44	15	-10	-560
1977	-123	-112	-122	-124	-146	-157	-114	-63	133	69	90	-32	-702
1978	-129	-125	-128	-129	-172	0	-119	-40	46	46	58	-7	-699
1979	-90	-109	-138	-132	-120	-167	-113	-35	291	0	64	-10	-557
1980	-95	-117	0	0	0	0	0	0	0	41	113	-16	-74
1981	-107	-109	0	0	-140	-152	-54	-25	28	219	0	-20	-360
1982	-127	-153	0	0	-170	-159	-99	-26	63	58	69	-20	-563
1983	-136	-130	0	0	0	0	0	0	0	0	0	0	-266
1984	0	-153	0	0	0	0	0	0	0	0	165	0	12
1985	0	0	0	0	0	0	-115	-64	178	149	151	0	299
1986	-156	-135	0	0	0	0	0	0	0	0	0	0	-291
1987	0	0	0	0	0	0	0	0	0	0	156	0	156
1988	-120	0	0	0	0	-164	-101	-71	74	314	134	-21	45
1989	-69	-143	0	0	-159	-156	-79	-13	111	0	133	0	-376
1990	-133	-138	-131	0	-158	-162	-121	-57	60	43	176	-9	-629
1991	-104	-140	0	0	-163	-155	-74	0	0	33	38	-11	-577
1992	-73	-141	0	0	-169	0	-105	-20	93	202	192	-9	-31
1993	-145	-143	0	0	-110	0	-113	-38	131	0	277	0	-141
1994	0	0	0	0	-144	-174	-98	-39	75	0	108	-29	-302
Average	-92	-104	-32	-19	-98	-88	-77	-28	81	68	103	-11	-298

Table F.35
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 16
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-222	-215	-214	0	-263	-277	-229	-114	644	1187	845	-40	1102
1976	-188	-208	0	0	-270	-273	-212	-116	377	534	218	-22	-160
1977	-231	-217	-219	-229	-267	-283	-205	-154	533	755	795	-51	228
1978	-247	-243	-234	-209	-278	0	-231	-130	392	448	570	-21	-182
1979	-179	-216	-249	-235	-221	-290	-226	-120	569	0	903	-29	-293
1980	-203	-241	0	0	0	0	0	0	0	951	927	-32	1402
1981	-215	-213	0	0	-241	-269	-152	-112	337	953	0	-38	52
1982	-237	-286	0	0	-290	-271	-215	-113	475	1077	1033	-40	1134
1983	-256	-240	0	0	0	0	0	0	0	0	0	0	-526
1984	0	-280	0	0	0	0	0	0	0	0	903	0	623
1985	0	0	0	0	0	0	-212	-143	526	1227	1183	0	2582
1986	-275	-258	0	0	0	0	0	0	0	0	0	0	-533
1987	0	0	0	0	0	0	0	0	0	0	954	0	954
1988	-220	0	0	0	0	-274	-193	-151	432	1370	1051	-42	1973
1989	-164	-287	0	0	-277	-264	-191	-86	503	0	1048	0	283
1990	-274	-264	-238	0	-283	-289	-223	-144	433	699	1085	-28	476
1991	-202	-232	0	0	-281	-279	-186	0	0	452	501	-27	-254
1992	-174	-272	0	0	-288	0	-211	-92	445	1124	905	-33	1405
1993	-245	-260	0	0	-187	0	-222	-129	511	0	427	0	-107
1994	0	0	0	0	-238	-288	-205	-122	448	0	1076	-46	627
Average	-178	-197	-58	-34	-169	-153	-156	-86	331	539	721	-22	539

Table F.36
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 17
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-548	-506	-503	0	-618	-652	-370	-443	1513	4751	2865	-237	5033
1976	-445	-491	0	0	-634	-643	-534	-447	1150	2243	803	-133	870
1977	-561	-511	-515	-539	-628	-666	-509	-457	1456	3115	2874	-266	2793
1978	-586	-572	-550	-492	-653	0	-376	-447	1283	1841	1997	-138	1107
1979	-426	-510	-586	-551	-519	-681	-367	-448	1132	0	3329	-183	-10
1980	-481	-569	0	0	0	0	0	0	0	4149	3218	-182	6135
1981	-509	-502	0	0	-566	-632	-350	-452	1146	3428	0	-180	1183
1982	-561	-678	0	0	-682	-637	-537	-430	1472	4672	3825	-218	8226
1983	-677	-566	0	0	0	0	0	0	0	0	0	0	-1243
1984	0	-660	0	0	0	0	0	0	0	0	2901	0	2242
1985	0	0	0	0	0	0	-567	-452	1476	5048	4220	0	9725
1986	-673	-607	0	0	0	0	0	0	0	0	0	0	-1280
1987	0	0	0	0	0	0	0	0	0	0	3333	0	3333
1988	-537	0	0	0	0	-644	-512	-430	1354	4849	3834	-253	7662
1989	-571	-681	0	0	-650	-623	-557	-404	1491	0	3654	0	3661
1990	-655	-623	-559	0	-666	-681	-582	-462	1425	2984	3680	-173	3689
1991	-498	-547	0	0	-661	-657	-506	0	0	1923	1849	-150	755
1992	-422	-641	0	0	-676	0	-577	-384	1395	1230	2800	-208	2517
1993	-587	-614	0	0	-445	0	-590	-459	1521	0	427	0	-748
1994	0	0	0	0	-559	-681	-587	-460	1440	0	3808	-217	2744
Average	-437	-404	-136	-79	-398	-360	-416	-309	963	2012	2471	-128	2720

Table F.37
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 18
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-478	-467	-440	0	-533	-570	-312	-425	1798	5951	3522	-228	7616
1976	-423	-473	0	0	-563	-567	-496	-428	1401	2649	811	-109	1800
1977	-491	-485	-449	-470	-560	-577	-486	-434	1757	4038	3455	-231	3068
1978	-508	-493	-503	-420	-571	0	-515	-428	1622	2346	2494	-113	2911
1979	-398	-469	-504	-472	-444	-584	-511	-429	1362	0	3969	-147	1374
1980	-418	-483	0	0	0	0	0	0	0	3544	4098	-153	8287
1981	-455	-453	0	0	-490	-562	-500	-430	1394	3961	0	-157	2308
1982	-482	-582	0	0	-584	-564	-496	-420	1765	5859	4736	-178	9053
1983	-579	-521	0	0	0	0	0	0	0	0	0	0	-1100
1984	0	-573	0	0	0	0	0	0	0	0	3472	0	2899
1985	0	0	0	0	0	0	-511	-432	1771	6142	5047	0	12017
1986	-578	-551	0	0	0	0	0	0	0	0	0	0	-1129
1987	0	0	0	0	0	0	0	0	0	0	3937	0	3937
1988	-459	0	0	0	0	-534	-468	-403	1671	5380	4521	-206	9482
1989	-532	-581	0	0	-556	-532	-503	-391	1776	0	4338	0	3018
1990	-568	-557	-478	0	-577	-583	-517	-437	1728	3708	4544	-156	8108
1991	-458	-467	0	0	-573	-572	-457	0	0	2340	2267	-123	1955
1992	-371	-548	0	0	-581	0	-515	-373	1714	1230	3329	-174	3711
1993	-517	-553	0	0	-581	0	-522	-434	1796	0	427	0	-183
1994	0	0	0	0	-478	-584	-520	-432	1740	0	4769	-179	4316
Average	-386	-413	-119	-68	-345	-512	-376	-295	1165	3457	2987	-108	4187

Table F.38

Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 19

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-464	-470	-447	0	-486	-505	-481	-448	1590	5420	3989	-292	7405
1976	-455	-483	0	0	-506	-505	-481	-448	1427	3886	2653	-212	4877
1977	-470	-484	-451	-460	-505	-505	-482	-450	1582	4614	3927	-291	6024
1978	-475	-468	-485	-435	-505	0	-481	-448	1550	3826	3526	-213	5391
1979	-440	-470	-473	-457	-445	-506	-481	-449	1406	0	4147	-232	1601
1980	-436	-462	0	0	0	0	0	0	0	5360	4312	-240	8534
1981	-458	-459	0	0	-467	-505	-478	-448	1423	4414	0	-246	2775
1982	-463	-505	0	0	-506	-505	-479	-449	1580	5377	4568	-253	8366
1983	-504	-495	0	0	0	0	0	0	0	0	0	0	-998
1984	0	-505	0	0	0	0	0	0	0	0	3929	0	3424
1985	0	0	0	0	0	0	-482	-451	1585	5442	4643	0	10737
1986	-505	-505	0	0	0	0	0	0	0	0	0	0	-1010
1987	0	0	0	0	0	0	0	0	0	0	4119	0	4119
1988	-452	0	0	0	0	-494	-464	-431	1556	5157	4377	-268	8981
1989	-502	-504	0	0	-494	-483	-477	-431	1581	0	4307	0	2996
1990	-502	-505	-460	0	-505	-505	-481	-451	1571	4403	4475	-248	6793
1991	-465	-455	0	0	-505	-505	-456	0	0	3782	3401	-220	4577
1992	-418	-490	0	0	-505	0	-480	-422	1574	1230	3854	-252	4091
1993	-484	-504	0	0	-418	0	-482	-449	1583	0	427	0	-327
1994	0	0	0	0	-460	-506	-481	-447	1573	0	4604	-254	4030
Average	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

Table F.39
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 1
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	53	0	0	0	0	0	30	182	365	459	260	181	1529
1976	44	0	0	0	0	0	27	181	279	173	49	90	843
1977	55	0	0	0	0	0	26	182	326	258	258	177	1283
1978	54	0	0	0	0	0	29	178	327	162	192	89	1030
1979	41	0	0	0	0	0	29	181	266	0	307	118	941
1980	45	0	0	0	0	0	0	0	0	367	297	122	830
1981	49	0	0	0	0	0	26	183	249	282	0	120	909
1982	54	0	0	0	0	0	27	184	342	438	375	155	1576
1983	66	0	0	0	0	0	0	0	0	0	0	0	66
1984	0	0	0	0	0	0	0	0	0	0	273	0	273
1985	0	0	0	0	0	0	30	186	348	464	377	0	1404
1986	66	0	0	0	0	0	0	0	0	0	0	0	66
1987	0	0	0	0	0	0	0	0	0	0	283	0	283
1988	50	0	0	0	0	0	27	169	300	378	311	169	1404
1989	54	0	0	0	0	0	27	160	347	0	292	0	881
1990	61	0	0	0	0	0	29	180	264	224	344	120	1221
1991	42	0	0	0	0	0	26	0	0	163	161	100	492
1992	39	0	0	0	0	0	28	138	345	390	241	141	1321
1993	55	0	0	0	0	0	30	183	357	0	392	0	1017
1994	0	0	0	0	0	0	29	175	324	0	355	143	1026
Average	41	0	0	0	0	0	21	123	222	188	238	86	920

Table F.40
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 2
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	143	0	0	0	0	0	42	390	897	1212	753	478	3914
1976	118	0	0	0	0	0	39	389	688	439	141	237	2071
1977	149	0	0	0	0	0	37	391	808	709	764	477	3335
1978	149	0	0	0	0	0	40	381	804	427	558	235	2594
1979	110	0	0	0	0	0	41	387	653	0	885	313	2390
1980	120	0	0	0	0	0	0	0	0	973	870	322	2285
1981	132	0	0	0	0	0	37	394	616	756	0	319	2254
1982	145	0	0	0	0	0	39	393	843	1157	1080	403	4059
1983	175	0	0	0	0	0	0	0	0	0	0	0	175
1984	0	0	0	0	0	0	0	0	0	0	782	0	782
1985	0	0	0	0	0	0	42	398	858	1232	1095	0	3625
1986	176	0	0	0	0	0	0	0	0	0	0	0	176
1987	0	0	0	0	0	0	0	0	0	0	828	0	828
1988	136	0	0	0	0	0	38	363	740	1008	919	450	3655
1989	146	0	0	0	0	0	39	345	858	0	853	0	2241
1990	164	0	0	0	0	0	40	388	652	594	1001	317	3156
1991	113	0	0	0	0	0	36	0	0	437	471	263	1320
1992	104	0	0	0	0	0	39	297	853	1039	706	375	3413
1993	147	0	0	0	0	0	42	392	877	0	427	0	1885
1994	0	0	0	0	0	0	41	377	801	0	1051	386	2655
Average	113	0	0	0	0	0	30	264	547	500	659	229	2341

Table F.41
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 3
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	60	0	0	0	0	0	17	155	358	497	323	202	1613
1976	50	0	0	0	0	0	16	155	276	196	60	100	852
1977	63	0	0	0	0	0	15	156	337	301	323	205	1400
1978	63	0	0	0	0	0	16	151	326	176	238	100	1070
1979	47	0	0	0	0	0	16	155	262	0	372	133	985
1980	51	0	0	0	0	0	0	0	0	401	371	136	959
1981	56	0	0	0	0	0	15	157	252	311	0	135	927
1982	61	0	0	0	0	0	16	156	341	476	457	170	1678
1983	74	0	0	0	0	0	0	0	0	0	0	0	74
1984	0	0	0	0	0	0	0	0	0	0	329	0	329
1985	0	0	0	0	0	0	17	158	349	504	466	0	1494
1986	74	0	0	0	0	0	0	0	0	0	0	0	74
1987	0	0	0	0	0	0	0	0	0	0	355	0	355
1988	58	0	0	0	0	0	17	145	313	430	399	190	1550
1989	62	0	0	0	0	0	16	138	345	0	378	0	939
1990	70	0	0	0	0	0	16	156	265	259	422	136	1325
1991	48	0	0	0	0	0	15	0	0	181	202	111	557
1992	45	0	0	0	0	0	16	123	341	425	301	159	1411
1993	62	0	0	0	0	0	17	156	349	0	427	0	1011
1994	0	0	0	0	0	0	16	151	329	0	451	164	1111
Average	47	0	0	0	0	0	13	106	222	208	294	97	986

Table F.42
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 4
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	64	0	0	0	0	0	18	126	257	396	264	173	1299
1976	53	0	0	0	0	0	16	126	199	161	47	86	690
1977	67	0	0	0	0	0	16	127	252	247	257	178	1143
1978	67	0	0	0	0	0	17	122	238	140	191	86	862
1979	50	0	0	0	0	0	17	126	189	0	295	115	791
1980	54	0	0	0	0	0	0	0	0	320	298	117	789
1981	59	0	0	0	0	0	16	128	186	249	0	117	754
1982	65	0	0	0	0	0	16	127	249	382	365	146	1350
1983	78	0	0	0	0	0	0	0	0	0	0	0	78
1984	0	0	0	0	0	0	0	0	0	0	261	0	261
1985	0	0	0	0	0	0	17	129	255	400	373	0	1175
1986	79	0	0	0	0	0	0	0	0	0	0	0	79
1987	0	0	0	0	0	0	0	0	0	0	286	0	286
1988	61	0	0	0	0	0	16	118	237	355	324	164	1275
1989	66	0	0	0	0	0	16	113	250	0	314	0	759
1990	75	0	0	0	0	0	17	128	195	219	335	119	1087
1991	52	0	0	0	0	0	15	0	0	145	164	96	471
1992	48	0	0	0	0	0	17	104	246	338	241	137	1131
1993	66	0	0	0	0	0	17	126	250	0	378	0	839
1994	0	0	0	0	0	0	17	123	243	0	363	141	887
Average	50	0	0	0	0	0	13	86	162	168	238	84	800

Table F.43
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 5
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	-160	-186	0	-222	-238	-176	33	640	1591	1158	548	3041
1976	45	-153	0	0	-247	-230	-117	33	496	648	208	272	954
1977	56	-142	-177	-173	-205	-218	-163	33	628	991	1124	565	2319
1978	57	-155	-179	-212	-280	0	-148	33	594	563	835	273	1379
1979	42	-131	-198	-196	-165	-243	-144	33	470	0	1290	363	1122
1980	45	-132	0	0	0	0	0	0	0	1287	1305	369	2874
1981	49	-136	0	0	-211	-215	-65	33	477	998	0	369	1300
1982	54	-202	0	0	-258	-234	-80	33	624	1532	1598	461	3530
1983	66	-176	0	0	0	0	0	0	0	0	0	0	-111
1984	0	-209	0	0	0	0	0	0	0	0	1142	0	932
1985	0	0	0	0	0	0	-129	34	635	1607	1632	0	3779
1986	66	-176	0	0	0	0	0	0	0	0	0	0	-109
1987	0	0	0	0	0	0	0	0	0	0	1252	0	1252
1988	52	0	0	0	0	-251	-132	31	592	1425	1420	517	3653
1989	55	-170	0	0	-237	-236	-75	30	622	0	1374	0	1364
1990	63	-175	-181	0	-227	-226	-173	34	544	879	1468	376	2383
1991	44	-217	0	0	-244	-215	-63	0	0	583	716	302	906
1992	40	-178	0	0	-258	0	-139	27	614	1230	1055	434	2824
1993	56	-196	0	0	-171	0	-159	33	622	0	427	0	611
1994	0	0	0	0	-230	-276	-129	32	606	0	1585	445	2033
Average	42	-135	-46	-29	-148	-129	-95	23	408	667	980	265	1802

Table F.44
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 6
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	122	0	0	0	0	0	32	296	650	832	538	364	2834
1976	101	0	0	0	0	0	30	296	503	339	97	181	1547
1977	128	0	0	0	0	0	28	299	636	318	522	375	2507
1978	129	0	0	0	0	0	32	287	602	295	388	181	1913
1979	95	0	0	0	0	0	32	296	477	0	600	241	1740
1980	103	0	0	0	0	0	0	0	0	673	606	245	1627
1981	111	0	0	0	0	0	29	284	419	517	0	243	1605
1982	123	0	0	0	0	0	26	286	586	794	682	305	2802
1983	148	0	0	0	0	0	0	0	0	0	0	0	148
1984	0	0	0	0	0	0	0	0	0	0	330	0	330
1985	0	0	0	0	0	0	32	300	640	833	742	0	2548
1986	150	0	0	0	0	0	0	0	0	0	0	0	150
1987	0	0	0	0	0	0	0	0	0	0	516	0	516
1988	110	0	0	0	0	0	29	269	595	733	654	341	2732
1989	125	0	0	0	0	0	29	264	541	0	628	0	1587
1990	142	0	0	0	0	0	31	284	469	454	636	248	2263
1991	98	0	0	0	0	0	28	0	0	192	330	200	848
1992	90	0	0	0	0	0	30	217	579	707	488	287	2399
1993	126	0	0	0	0	0	32	294	631	0	427	0	1510
1994	0	0	0	0	0	0	31	287	609	0	707	294	1929
Average	95	0	0	0	0	0	23	198	397	344	457	175	1687

Table F.45
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-9	-6	-17	0	-47	-33	-19	50	801	1440	860	72	3092
1976	-6	-5	0	0	-25	-61	-6	50	610	576	150	37	1319
1977	-1	-2	-8	-14	-7	-28	-5	50	782	880	829	79	2334
1978	-3	-2	-2	-8	-6	0	-4	48	716	492	605	37	1874
1979	-2	-1	-5	-21	-28	-6	-6	33	420	0	961	51	1396
1980	-5	-15	0	0	0	0	0	0	0	1161	950	51	2143
1981	-1	-10	0	0	-18	-19	-6	51	619	895	0	31	1562
1982	-1	0	0	0	-33	-3	-1	50	785	1404	1171	64	3435
1983	-2	-7	0	0	0	0	0	0	0	0	0	0	-9
1984	0	-62	0	0	0	0	0	0	0	0	680	0	618
1985	0	0	0	0	0	0	-5	50	742	1462	1220	0	3469
1986	-43	-29	0	0	0	0	0	0	0	0	0	0	-71
1987	0	0	0	0	0	0	0	0	0	0	928	0	928
1988	-2	0	0	0	0	-73	-11	46	743	1305	1062	73	3143
1989	-1	-3	0	0	-87	-29	-2	45	789	0	1033	0	1747
1990	-1	-2	-13	0	-65	-69	-38	51	758	812	1097	54	2583
1991	-1	-1	0	0	-48	-29	-2	0	0	543	540	43	1045
1992	-1	-2	0	0	-95	0	-15	42	786	1230	797	62	2804
1993	-8	-7	0	0	-61	0	-17	50	787	0	427	0	1171
1994	0	0	0	0	-90	-55	-5	49	755	0	1161	62	1877
Average	-4	-7	-2	-2	-30	-20	-7	33	505	610	723	37	1834

Table F.46
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-306	-421	-455	0	-667	-852	-272	395	6371	11198	6613	485	22090
1976	-296	-454	0	0	-709	-844	-126	395	4867	4488	1154	242	8717
1977	-179	-374	-491	-500	-551	-554	-200	399	6244	6870	6386	514	17564
1978	-201	-409	-443	-483	-611	0	-69	386	5735	3838	4655	244	12661
1979	-80	-174	-325	-496	-405	-374	-147	334	4052	0	7381	332	10099
1980	-130	-251	0	0	0	0	0	0	0	9037	7302	335	16292
1981	-70	-229	0	0	-600	-499	-101	403	4936	6979	0	334	11153
1982	-118	-176	0	0	-820	-402	-52	395	6240	10922	9001	419	25408
1983	-228	-460	0	0	0	0	0	0	0	0	0	0	-688
1984	0	-807	0	0	0	0	0	0	0	0	5333	0	4526
1985	0	0	0	0	0	0	-137	397	5898	11370	9579	0	26907
1986	-658	-629	0	0	0	0	0	0	0	0	0	0	-1287
1987	0	0	0	0	0	0	0	0	0	0	7133	0	7133
1988	-220	0	0	0	0	-850	-213	368	5924	5380	8167	472	19028
1989	-106	-143	0	0	-852	-608	-74	359	6277	0	7947	0	12801
1990	-111	-114	-254	0	-731	-704	-390	407	6041	6317	8439	351	19252
1991	-147	-260	0	0	-603	-497	-58	0	0	4229	4151	280	7097
1992	-65	-417	0	0	-925	0	-228	337	6250	1230	6121	404	13008
1993	-391	-425	0	0	-603	0	-234	398	6260	0	427	0	5432
1994	0	0	0	0	-838	-727	-114	389	6014	0	8939	403	14066
Average	-165	-272	-98	-74	-446	-345	-121	268	4056	4093	5426	241	12363

Table F.47
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-710	-785	-684	0	-731	-995	-240	215	4038	8176	4672	100	13056
1976	-628	-859	0	0	-913	-841	-205	215	3093	3292	817	49	4020
1977	-562	-716	-807	-714	-767	-605	-207	218	3973	5056	4517	103	9489
1978	-535	-781	-792	-793	-887	0	-186	215	3696	2813	3293	49	6092
1979	-294	-512	-732	-740	-438	-387	-179	218	3005	0	5297	66	5014
1980	-289	-375	0	0	0	0	0	0	0	6612	5156	67	11172
1981	-331	-460	0	0	-829	-690	-109	219	3137	3109	0	67	6114
1982	-436	-629	0	0	-1045	-705	-111	215	3960	7990	6556	84	15678
1983	-854	-872	0	0	0	0	0	0	0	0	0	0	-1725
1984	0	-1045	0	0	0	0	0	0	0	0	3954	0	2909
1985	0	0	0	0	0	0	-226	219	3886	8315	6619	0	18812
1986	-1047	-929	0	0	0	0	0	0	0	0	0	0	-1976
1987	0	0	0	0	0	0	0	0	0	0	5037	0	5037
1988	-605	0	0	0	0	-838	-220	201	3767	5380	5769	94	13548
1989	-381	-507	0	0	-848	-745	-111	196	3978	0	5614	0	7196
1990	-444	-529	-561	0	-733	-612	-288	222	3839	4617	3958	70	11499
1991	-448	-696	0	0	-675	-609	-79	0	0	3093	2932	56	3575
1992	-235	-509	0	0	-843	0	-214	184	3959	1230	4321	81	7975
1993	-796	-854	0	0	-394	0	-199	217	3967	0	427	0	2167
1994	0	0	0	0	-821	-827	-156	212	3822	0	6335	81	8645
Average	-430	-553	-179	-112	-506	-405	-137	148	2606	3084	3849	48	7415

Table F.48
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 10
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-210	-153	-132	0	-123	-139	-78	-23	564	1437	858	-103	1897
1976	-154	-157	0	0	-145	-127	-78	-23	437	587	152	-41	452
1977	-183	-137	-138	-116	-120	-106	-68	-25	558	898	829	-130	1262
1978	-174	-150	-140	-141	-155	0	-76	-14	521	501	610	-35	747
1979	-112	-128	-156	-132	-84	-119	-62	-16	418	0	951	-46	512
1980	-99	-101	0	0	0	0	0	0	0	1166	955	-65	1856
1981	-131	-118	0	0	-131	-119	-40	-10	440	903	0	-57	735
1982	-171	-185	0	0	-159	-130	-47	-9	556	1401	1167	-74	2350
1983	-223	-171	0	0	0	0	0	0	0	0	0	0	-394
1984	0	-200	0	0	0	0	0	0	0	0	790	0	590
1985	0	0	0	0	0	0	-83	-33	564	1464	1212	0	3123
1986	-259	-172	0	0	0	0	0	0	0	0	0	0	-432
1987	0	0	0	0	0	0	0	0	0	0	928	0	928
1988	-185	0	0	0	0	-135	-67	-36	529	1309	1062	-99	2377
1989	-142	-153	0	0	-142	-126	-43	-9	558	0	1031	0	976
1990	-163	-164	-139	0	-127	-114	-82	-26	541	817	1096	-30	1608
1991	-148	-191	0	0	-130	-112	-30	0	0	546	541	-33	443
1992	-75	-162	0	0	-143	0	-67	-10	553	1230	791	-31	2087
1993	-228	-185	0	0	-100	0	-66	-15	557	0	427	0	391
1994	0	0	0	0	-138	-147	-62	-21	541	0	1172	-105	1242
Average	-133	-126	-33	-19	-85	-69	-47	-13	367	613	729	-42	1138

Table F.49
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	47	113	530	823	502	0	2014
1976	0	0	0	0	0	0	44	113	404	329	88	0	977
1977	0	0	0	0	0	0	41	114	518	504	484	0	1661
1978	0	0	0	0	0	0	46	108	474	282	353	0	1263
1979	0	0	0	0	0	0	46	76	278	0	561	0	961
1980	0	0	0	0	0	0	0	0	0	664	554	0	1218
1981	0	0	0	0	0	0	45	115	410	512	0	0	1082
1982	0	0	0	0	0	0	45	113	519	803	683	0	2163
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	397	0	397
1985	0	0	0	0	0	0	46	113	491	836	712	0	2198
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	542	0	542
1988	0	0	0	0	0	0	43	105	492	746	620	0	2006
1989	0	0	0	0	0	0	45	102	522	0	603	0	1272
1990	0	0	0	0	0	0	47	116	502	464	641	0	1769
1991	0	0	0	0	0	0	41	0	0	311	315	0	667
1992	0	0	0	0	0	0	46	96	520	710	465	0	1837
1993	0	0	0	0	0	0	47	113	521	0	427	0	1108
1994	0	0	0	0	0	0	46	111	499	0	678	0	1334
Average	0	0	0	0	0	0	34	75	334	349	431	0	1224

Table F.50
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	219	-932	-1049	0	-1223	-1326	-1043	-106	2560	8524	6882	2748	15252
1976	182	-892	0	0	-1364	-1280	-739	-111	1988	3474	1234	1361	3853
1977	229	-826	-996	-959	-1129	-1215	-981	-149	2519	5308	6683	2836	11318
1978	232	-908	-1011	-1174	-1545	0	-889	-79	2377	3018	4958	1368	6347
1979	170	-761	-1114	-1082	-908	-1352	-852	-84	1881	0	7660	1818	5377
1980	185	-770	0	0	0	0	0	0	0	6896	7747	1851	15909
1981	201	-792	0	0	-1166	-1201	-411	-58	1966	5347	0	1848	5734
1982	222	-1176	0	0	-1424	-1308	-504	-45	2510	8224	9486	2310	18294
1983	267	-1025	0	0	0	0	0	0	0	0	0	0	-758
1984	0	-1218	0	0	0	0	0	0	0	0	6771	0	5553
1985	0	0	0	0	0	0	-788	-147	2540	8611	9694	0	19912
1986	269	-1021	0	0	0	0	0	0	0	0	0	0	-752
1987	0	0	0	0	0	0	0	0	0	0	7455	0	7455
1988	210	0	0	0	0	-1398	-816	-229	2375	5380	8436	2588	16546
1989	225	-991	0	0	-1308	-1311	-474	-28	2491	0	8168	0	6771
1990	257	-1020	-1020	0	-1253	-1262	-1030	-172	2408	4711	8724	1891	12235
1991	177	-1268	0	0	-1346	-1198	-385	0	0	3121	4234	1515	4870
1992	163	-1039	0	0	-1424	0	-860	-36	2469	1230	6259	2173	8935
1993	227	-1144	0	0	-943	0	-951	-79	2494	0	427	0	30
1994	0	0	0	0	-1267	-1538	-772	-89	2425	0	9411	2229	10400
Average	172	-789	-259	-161	-815	-719	-575	-71	1650	3192	5712	1327	8664

Table F.51
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 13
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	17	-471	-349	0	-632	-666	-520	-76	969	3420	2802	1123	5415
1976	14	-451	0	0	-705	-643	-390	-86	736	1403	502	356	956
1977	17	-418	-321	-504	-583	-610	-496	-115	957	2139	2712	1161	3739
1978	18	-459	-329	-617	-799	0	-449	-53	899	1208	2011	360	1789
1979	13	-385	-383	-569	-469	-679	-423	-61	713	0	3102	742	1401
1980	14	-389	0	0	0	0	0	0	0	2773	3145	756	6299
1981	15	-401	0	0	-604	-605	-216	-44	750	2151	0	755	1801
1982	17	-595	0	0	-736	-658	-265	-35	953	3515	3837	941	6773
1983	20	-518	0	0	0	0	0	0	0	0	0	0	-497
1984	0	-616	0	0	0	0	0	0	0	0	2737	0	2121
1985	0	0	0	0	0	0	-406	-117	965	3473	3942	0	7857
1986	21	-516	0	0	0	0	0	0	0	0	0	0	-496
1987	0	0	0	0	0	0	0	0	0	0	3041	0	3041
1988	16	0	0	0	0	-701	-425	-154	906	3091	3449	1057	7239
1989	17	-502	0	0	-676	-658	-250	-23	952	0	3345	0	2204
1990	20	-518	-340	0	-648	-635	-316	-114	922	1923	3563	783	4242
1991	14	-642	0	0	-697	-602	-201	0	0	1263	1752	621	1507
1992	12	-526	0	0	-736	0	-446	-35	943	1230	2556	892	3891
1993	17	-579	0	0	-488	0	-478	-65	950	0	427	0	-215
1994	0	0	0	0	-655	-772	-388	-72	926	0	3837	913	3789
Average	13	-399	-136	-85	-423	-361	-293	-53	628	1369	2338	543	3143

Table F.52
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 14
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-147	-83	-71	0	-58	-55	-17	20	504	1123	611	-102	1724
1976	-91	-80	0	0	-65	-54	-14	20	394	464	109	-41	642
1977	-126	-74	-67	-53	-33	-51	-16	20	499	705	590	-114	1259
1978	-128	-81	-68	-65	-73	0	-15	20	467	396	437	-27	862
1979	-83	-68	-75	-60	-43	-56	-14	20	372	0	673	-37	629
1980	-75	-69	0	0	0	0	0	0	0	912	683	-61	1392
1981	-97	-71	0	0	-55	-50	-8	20	393	708	0	-48	792
1982	-131	-105	0	0	-68	-55	-9	20	497	1091	832	-73	1999
1983	-116	-91	0	0	0	0	0	0	0	0	0	0	-208
1984	0	-109	0	0	0	0	0	0	0	0	593	0	484
1985	0	0	0	0	0	0	-15	20	503	1145	859	0	2512
1986	-181	-91	0	0	0	0	0	0	0	0	0	0	-272
1987	0	0	0	0	0	0	0	0	0	0	663	0	663
1988	-133	0	0	0	0	-58	-14	19	474	1024	757	-97	1972
1989	-106	-89	0	0	-62	-55	-9	18	500	0	733	0	951
1990	-118	-92	-70	0	-59	-53	-17	20	486	642	780	-31	1488
1991	-106	-113	0	0	-64	-50	-7	0	0	423	387	-35	434
1992	-49	-93	0	0	-68	0	-15	17	494	957	561	-29	1774
1993	-169	-102	0	0	-45	0	-15	20	498	0	427	0	613
1994	0	0	0	0	-60	-64	-13	20	487	0	839	-89	1118
Average	-95	-71	-18	-9	-39	-30	-10	14	325	480	527	-39	1040

Table F.53
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 15
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-127	-117	-123	0	-150	-161	-128	-39	548	1501	977	-21	2160
1976	-99	-113	0	0	-160	-158	-116	-38	428	619	175	-10	529
1977	-123	-112	-122	-124	-146	-157	-114	-65	545	942	943	-32	1434
1978	-129	-125	-128	-129	-172	0	-119	-40	508	329	699	-7	889
1979	-90	-109	-138	-132	-120	-167	-113	-35	404	0	1076	-10	567
1980	-93	-117	0	0	0	0	0	0	0	1219	1095	-16	2086
1981	-107	-109	0	0	-140	-152	-54	-25	428	946	0	-20	767
1982	-127	-153	0	0	-170	-159	-99	-26	541	1458	1325	-20	2573
1983	-136	-130	0	0	0	0	0	0	0	0	0	0	-266
1984	0	-153	0	0	0	0	0	0	0	0	947	0	794
1985	0	0	0	0	0	0	-115	-64	547	1330	1375	0	3273
1986	-156	-135	0	0	0	0	0	0	0	0	0	0	-291
1987	0	0	0	0	0	0	0	0	0	0	1059	0	1059
1988	-120	0	0	0	0	-164	-101	-71	516	1370	1212	-21	2620
1989	-69	-143	0	0	-159	-156	-79	-13	544	0	1172	0	1096
1990	-133	-138	-131	0	-158	-162	-121	-57	550	859	1249	-9	1729
1991	-104	-140	0	0	-163	-155	-74	0	0	572	619	-11	544
1992	-73	-141	0	0	-169	0	-105	-20	558	1230	898	-9	2148
1993	-145	-143	0	0	-110	0	-113	-38	545	0	427	0	422
1994	0	0	0	0	-144	-174	-98	-39	532	0	1341	-29	1388
Average	-92	-104	-32	-19	-98	-83	-77	-28	358	639	830	-11	1276

Table F.54
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 16
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-222	-215	-214	0	-263	-277	-229	-114	866	2460	1639	-40	3391
1976	-188	-208	0	0	-270	-273	-212	-116	679	1023	296	-22	709
1977	-231	-217	-219	-229	-267	-283	-205	-154	860	1620	1580	-51	2205
1978	-247	-243	-234	-209	-278	0	-231	-130	805	920	1173	-21	1307
1979	-179	-216	-249	-235	-221	-290	-226	-120	637	0	1804	-29	676
1980	-203	-241	0	0	0	0	0	0	0	2186	1893	-32	3604
1981	-215	-213	0	0	-241	-269	-152	-112	677	1548	0	-38	987
1982	-237	-286	0	0	-290	-271	-215	-113	856	2397	2225	-40	4027
1983	-286	-240	0	0	0	0	0	0	0	0	0	0	-526
1984	0	-280	0	0	0	0	0	0	0	0	1587	0	1307
1985	0	0	0	0	0	0	-212	-143	866	2503	2305	0	5320
1986	-275	-258	0	0	0	0	0	0	0	0	0	0	-533
1987	0	0	0	0	0	0	0	0	0	0	1778	0	1778
1988	-220	0	0	0	0	-274	-193	-151	818	2244	2035	-42	4217
1989	-164	-287	0	0	-277	-264	-191	-86	860	0	1966	0	1557
1990	-274	-264	-238	0	-283	-289	-223	-144	838	1452	2098	-28	2645
1991	-202	-232	0	0	-281	-279	-186	0	0	937	1040	-27	770
1992	-174	-272	0	0	-288	0	-211	-92	850	1230	1507	-33	2518
1993	-245	-260	0	0	-187	0	-222	-129	861	0	427	0	244
1994	0	0	0	0	-238	-286	-205	-122	842	0	2251	-46	2197
Average	-179	-197	-58	-34	-169	-153	-156	-86	566	1026	1380	-22	1920

Table F.55
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-548	-506	-503	0	-618	-652	-570	-443	1568	5633	3226	-257	6330
1976	-445	-491	0	0	-634	-643	-534	-447	1237	2369	586	-133	866
1977	-561	-511	-515	-539	-628	-666	-509	-457	1561	3894	3108	-266	3911
1978	-586	-572	-550	-492	-653	0	-576	-447	1468	2233	2310	-138	1996
1979	-426	-510	-586	-551	-519	-681	-567	-448	1151	0	3547	-183	226
1980	-481	-569	0	0	0	0	0	0	0	5456	3844	-182	8068
1981	-509	-502	0	0	-566	-632	-550	-452	1233	3532	0	-180	1374
1982	-561	-678	0	0	-682	-637	-537	-430	1555	5319	4374	-218	7705
1983	-677	-566	0	0	0	0	0	0	0	0	0	0	-1243
1984	0	-660	0	0	0	0	0	0	0	0	3120	0	2460
1985	0	0	0	0	0	0	-567	-452	1572	5717	4532	0	10802
1986	-673	-607	0	0	0	0	0	0	0	0	0	0	-1280
1987	0	0	0	0	0	0	0	0	0	0	3497	0	3497
1988	-537	0	0	0	0	-644	-512	-430	1491	5124	4004	-253	8244
1989	-571	-481	0	0	-650	-621	-557	-404	1560	0	3864	0	1939
1990	-655	-623	-559	0	-666	-681	-582	-462	1526	3442	4127	-173	4695
1991	-498	-547	0	0	-661	-637	-506	0	0	2148	2053	-150	1182
1992	-422	-641	0	0	-676	0	-577	-384	1542	1230	2966	-208	2829
1993	-587	-614	0	0	-445	0	-590	-459	1564	0	427	0	-705
1994	0	0	0	0	-559	-681	-587	-460	1533	0	4433	-217	3462
Average	-437	-464	-136	-79	-398	-360	-416	-309	1028	2315	2701	-128	3318

Table F.56
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-478	-467	-440	0	-533	-570	-512	-425	1829	6452	3729	-228	8356
1976	-423	-475	0	0	-563	-567	-496	-428	1452	2721	686	-109	1797
1977	-491	-485	-449	-470	-560	-577	-486	-434	1819	4482	3589	-231	5707
1978	-508	-493	-503	-420	-571	0	-515	-428	1729	2569	2674	-113	3422
1979	-598	-469	-504	-472	-444	-384	-511	-429	1373	0	4094	-147	1510
1980	-418	-485	0	0	0	0	0	0	0	6290	4459	-153	9694
1981	-455	-453	0	0	-490	-562	-500	-430	1444	4020	0	-157	2417
1982	-482	-582	0	0	-584	-564	-496	-420	1813	6341	5052	-179	9900
1983	-579	-521	0	0	0	0	0	0	0	0	0	0	-1100
1984	0	-573	0	0	0	0	0	0	0	0	3598	0	3025
1985	0	0	0	0	0	0	-511	-432	1827	8522	5227	0	12632
1986	-578	-551	0	0	0	0	0	0	0	0	0	0	-1129
1987	0	0	0	0	0	0	0	0	0	0	4031	0	4031
1988	-459	0	0	0	0	-554	-468	-403	1751	5380	4618	-206	9659
1989	-532	-581	0	0	-556	-552	-503	-391	1516	0	4458	0	3178
1990	-568	-557	-478	0	-577	-583	-517	-437	1787	3969	4801	-156	6685
1991	-458	-467	0	0	-575	-572	-457	0	0	2467	2383	-123	2200
1992	-571	-548	0	0	-581	0	-315	-373	1799	1230	3424	-174	3891
1993	-517	-553	0	0	-381	0	-322	-434	1823	0	427	0	-160
1994	0	0	0	0	-478	-584	-520	-432	1793	0	5129	-179	4729
Average	-386	-413	-119	-68	-345	-312	-376	-295	1203	2622	3119	-108	4522

Table F.57
Purchase Land and Irrigation Retirement OR Land Fallowing Programs - Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-464	-470	-447	0	-486	-505	-481	-448	1590	5420	3989	-292	7405
1976	-455	-483	0	0	-506	-505	-481	-448	1427	3886	2653	-212	4877
1977	-470	-484	-451	-460	-505	-505	-482	-450	1582	4614	3927	-291	6024
1978	-475	-468	-485	-435	-505	0	-481	-448	1550	3826	3526	-213	5391
1979	-440	-470	-473	-457	-445	-506	-481	-449	1406	0	4147	-232	1601
1980	-436	-462	0	0	0	0	0	0	0	5360	4312	-240	8534
1981	-458	-459	0	0	-467	-505	-478	-448	1423	4414	0	-246	2775
1982	-463	-505	0	0	-506	-505	-479	-449	1580	5377	4568	-253	8366
1983	-504	-495	0	0	0	0	0	0	0	0	0	0	-998
1984	0	-505	0	0	0	0	0	0	0	0	3929	0	3424
1985	0	0	0	0	0	0	-482	-451	1585	5442	4643	0	10737
1986	-505	-505	0	0	0	0	0	0	0	0	0	0	-1010
1987	0	0	0	0	0	0	0	0	0	0	4119	0	4119
1988	-452	0	0	0	0	-494	-464	-431	1556	5157	4377	-268	8981
1989	-502	-504	0	0	-494	-483	-477	-431	1581	0	4307	0	2996
1990	-502	-505	-460	0	-505	-505	-481	-451	1571	4403	4475	-248	6793
1991	-465	-455	0	0	-505	-505	-456	0	0	3782	3401	-220	4577
1992	-418	-490	0	0	-505	0	-480	-422	1574	1230	3854	-252	4091
1993	-484	-504	0	0	-418	0	-482	-449	1583	0	427	0	-327
1994	0	0	0	0	-460	-506	-481	-447	1573	0	4604	-254	4030
Average	-375	-388	-116	-68	-315	-276	-358	-311	1079	2646	3263	-161	4619

Table F.58
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 1
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	40	0	0	0	0	0	19	118	234	307	250	132	1100
1976	40	0	0	0	0	0	19	118	234	307	250	132	1100
1977	40	0	0	0	0	0	19	118	234	307	250	132	1100
1978	40	0	0	0	0	0	19	118	234	307	250	132	1100
1979	40	0	0	0	0	0	19	118	234	307	250	132	1100
1980	40	0	0	0	0	0	19	118	234	307	250	132	1100
1981	40	0	0	0	0	0	19	118	234	307	250	132	1100
1982	40	0	0	0	0	0	19	118	234	307	250	132	1100
1983	40	0	0	0	0	0	19	118	234	307	250	132	1100
1984	40	0	0	0	0	0	19	118	234	307	250	132	1100
1985	40	0	0	0	0	0	19	118	234	307	250	132	1100
1986	40	0	0	0	0	0	19	118	234	307	250	132	1100
1987	40	0	0	0	0	0	19	118	234	307	250	132	1100
1988	40	0	0	0	0	0	19	118	234	307	250	132	1100
1989	40	0	0	0	0	0	19	118	234	307	250	132	1100
1990	40	0	0	0	0	0	19	118	234	307	250	132	1100
1991	40	0	0	0	0	0	19	118	234	307	250	132	1100
1992	40	0	0	0	0	0	19	118	234	307	250	132	1100
1993	40	0	0	0	0	0	19	118	234	307	250	132	1100
1994	40	0	0	0	0	0	19	118	234	307	250	132	1100
Average	40	0	0	0	0	0	19	118	234	307	250	132	1100

Table F.59
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 2
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	105	0	0	0	0	0	26	250	571	801	708	339	2800
1976	105	0	0	0	0	0	26	250	571	801	708	339	2800
1977	105	0	0	0	0	0	26	250	571	801	708	339	2800
1978	105	0	0	0	0	0	26	250	571	801	708	339	2800
1979	105	0	0	0	0	0	26	250	571	801	708	339	2800
1980	105	0	0	0	0	0	26	250	571	801	708	339	2800
1981	105	0	0	0	0	0	26	250	571	801	708	339	2800
1982	105	0	0	0	0	0	26	250	571	801	708	339	2800
1983	105	0	0	0	0	0	26	250	571	801	708	339	2800
1984	105	0	0	0	0	0	26	250	571	801	708	339	2800
1985	105	0	0	0	0	0	26	250	571	801	708	339	2800
1986	105	0	0	0	0	0	26	250	571	801	708	339	2800
1987	105	0	0	0	0	0	26	250	571	801	708	339	2800
1988	105	0	0	0	0	0	26	250	571	801	708	339	2800
1989	105	0	0	0	0	0	26	250	571	801	708	339	2800
1990	105	0	0	0	0	0	26	250	571	801	708	339	2800
1991	105	0	0	0	0	0	26	250	571	801	708	339	2800
1992	105	0	0	0	0	0	26	250	571	801	708	339	2800
1993	105	0	0	0	0	0	26	250	571	801	708	339	2800
1994	105	0	0	0	0	0	26	250	571	801	708	339	2800
Average	105	0	0	0	0	0	26	250	571	801	708	339	2800

Table F.60
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 3
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	42	0	0	0	0	0	10	95	218	313	285	136	1100
1976	42	0	0	0	0	0	10	95	218	313	285	136	1100
1977	42	0	0	0	0	0	10	95	218	313	285	136	1100
1978	42	0	0	0	0	0	10	95	218	313	285	136	1100
1979	42	0	0	0	0	0	10	95	218	313	285	136	1100
1980	42	0	0	0	0	0	10	95	218	313	285	136	1100
1981	42	0	0	0	0	0	10	95	218	313	285	136	1100
1982	42	0	0	0	0	0	10	95	218	313	285	136	1100
1983	42	0	0	0	0	0	10	95	218	313	285	136	1100
1984	42	0	0	0	0	0	10	95	218	313	285	136	1100
1985	42	0	0	0	0	0	10	95	218	313	285	136	1100
1986	42	0	0	0	0	0	10	95	218	313	285	136	1100
1987	42	0	0	0	0	0	10	95	218	313	285	136	1100
1988	42	0	0	0	0	0	10	95	218	313	285	136	1100
1989	42	0	0	0	0	0	10	95	218	313	285	136	1100
1990	42	0	0	0	0	0	10	95	218	313	285	136	1100
1991	42	0	0	0	0	0	10	95	218	313	285	136	1100
1992	42	0	0	0	0	0	10	95	218	313	285	136	1100
1993	42	0	0	0	0	0	10	95	218	313	285	136	1100
1994	42	0	0	0	0	0	10	95	218	313	285	136	1100
Average	42	0	0	0	0	0	10	95	218	313	285	136	1100

Table F.61

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 4

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	0	0	0	0	0	12	92	187	296	269	140	1050
1976	54	0	0	0	0	0	12	92	187	296	269	140	1050
1977	54	0	0	0	0	0	12	92	187	296	269	140	1050
1978	54	0	0	0	0	0	12	92	187	296	269	140	1050
1979	54	0	0	0	0	0	12	92	187	296	269	140	1050
1980	54	0	0	0	0	0	12	92	187	296	269	140	1050
1981	54	0	0	0	0	0	12	92	187	296	269	140	1050
1982	54	0	0	0	0	0	12	92	187	296	269	140	1050
1983	54	0	0	0	0	0	12	92	187	296	269	140	1050
1984	54	0	0	0	0	0	12	92	187	296	269	140	1050
1985	54	0	0	0	0	0	12	92	187	296	269	140	1050
1986	54	0	0	0	0	0	12	92	187	296	269	140	1050
1987	54	0	0	0	0	0	12	92	187	296	269	140	1050
1988	54	0	0	0	0	0	12	92	187	296	269	140	1050
1989	54	0	0	0	0	0	12	92	187	296	269	140	1050
1990	54	0	0	0	0	0	12	92	187	296	269	140	1050
1991	54	0	0	0	0	0	12	92	187	296	269	140	1050
1992	54	0	0	0	0	0	12	92	187	296	269	140	1050
1993	54	0	0	0	0	0	12	92	187	296	269	140	1050
1994	54	0	0	0	0	0	12	92	187	296	269	140	1050
Average	54	0	0	0	0	0	12	92	187	296	269	140	1050

Table F.62

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 5

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1976	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1977	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1978	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1979	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1980	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1981	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1982	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1983	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1984	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1985	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1986	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1987	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1988	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1989	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1990	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1991	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1992	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1993	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
1994	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163
Average	47	-210	-217	-221	-222	-221	-186	25	477	1223	1214	454	2163

Table F.63

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 6

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	97	0	0	0	0	0	22	205	445	587	518	277	2150
1976	97	0	0	0	0	0	22	205	445	587	518	277	2150
1977	97	0	0	0	0	0	22	205	445	587	518	277	2150
1978	97	0	0	0	0	0	22	205	445	587	518	277	2150
1979	97	0	0	0	0	0	22	205	445	587	518	277	2150
1980	97	0	0	0	0	0	22	205	445	587	518	277	2150
1981	97	0	0	0	0	0	22	205	445	587	518	277	2150
1982	97	0	0	0	0	0	22	205	445	587	518	277	2150
1983	97	0	0	0	0	0	22	205	445	587	518	277	2150
1984	97	0	0	0	0	0	22	205	445	587	518	277	2150
1985	97	0	0	0	0	0	22	205	445	587	518	277	2150
1986	97	0	0	0	0	0	22	205	445	587	518	277	2150
1987	97	0	0	0	0	0	22	205	445	587	518	277	2150
1988	97	0	0	0	0	0	22	205	445	587	518	277	2150
1989	97	0	0	0	0	0	22	205	445	587	518	277	2150
1990	97	0	0	0	0	0	22	205	445	587	518	277	2150
1991	97	0	0	0	0	0	22	205	445	587	518	277	2150
1992	97	0	0	0	0	0	22	205	445	587	518	277	2150
1993	97	0	0	0	0	0	22	205	445	587	518	277	2150
1994	97	0	0	0	0	0	22	205	445	587	518	277	2150
Average	97	0	0	0	0	0	22	205	445	587	518	277	2150

Table F.64

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 7

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1976	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1977	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1978	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1979	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1980	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1981	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1982	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1983	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1984	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1985	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1986	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1987	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1988	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1989	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1990	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1991	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1992	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1993	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
1994	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652
Average	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1652

Table F.65

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 8

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1976	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1977	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1978	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1979	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1980	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1981	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1982	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1983	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1984	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1985	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1986	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1987	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1988	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1989	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1990	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1991	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1992	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1993	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
1994	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884
Average	-1239	-1287	-1294	-1304	-1314	-1312	-691	298	4760	8785	7060	423	12884

Table F.66

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 9

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1976	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1977	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1978	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1979	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1980	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1981	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1982	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1983	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1984	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1985	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1986	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1987	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1988	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1989	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1990	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1991	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1992	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1993	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
1994	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607
Average	-1214	-1209	-1120	-1032	-949	-879	-356	159	2957	6281	4887	83	7607

Table F.67

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 10

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1976	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1977	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1978	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1979	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1980	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1981	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1982	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1983	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1984	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1985	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1986	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1987	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1988	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1989	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1990	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1991	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1992	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1993	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1994	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
Average	-338	-284	-239	-209	-185	-167	-114	-62	543	1440	1173	-247	1311

Table F.68

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 11

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	33	83	385	628	521	0	1650
1976	0	0	0	0	0	0	33	83	385	628	521	0	1650
1977	0	0	0	0	0	0	33	83	385	628	521	0	1650
1978	0	0	0	0	0	0	33	83	385	628	521	0	1650
1979	0	0	0	0	0	0	33	83	385	628	521	0	1650
1980	0	0	0	0	0	0	33	83	385	628	521	0	1650
1981	0	0	0	0	0	0	33	83	385	628	521	0	1650
1982	0	0	0	0	0	0	33	83	385	628	521	0	1650
1983	0	0	0	0	0	0	33	83	385	628	521	0	1650
1984	0	0	0	0	0	0	33	83	385	628	521	0	1650
1985	0	0	0	0	0	0	33	83	385	628	521	0	1650
1986	0	0	0	0	0	0	33	83	385	628	521	0	1650
1987	0	0	0	0	0	0	33	83	385	628	521	0	1650
1988	0	0	0	0	0	0	33	83	385	628	521	0	1650
1989	0	0	0	0	0	0	33	83	385	628	521	0	1650
1990	0	0	0	0	0	0	33	83	385	628	521	0	1650
1991	0	0	0	0	0	0	33	83	385	628	521	0	1650
1992	0	0	0	0	0	0	33	83	385	628	521	0	1650
1993	0	0	0	0	0	0	33	83	385	628	521	0	1650
1994	0	0	0	0	0	0	33	83	385	628	521	0	1650
Average	0	0	0	0	0	0	33	83	385	628	521	0	1650

Table F.69

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 12

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1976	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1977	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1978	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1979	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1980	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1981	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1982	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1983	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1984	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1985	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1986	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1987	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1988	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1989	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1990	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1991	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1992	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1993	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
1994	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730
Average	176	-1143	-1140	-1140	-1142	-1145	-1013	-402	1771	6086	6705	2116	9730

Table F.70

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 13

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1976	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1977	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1978	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1979	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1980	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1981	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1982	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1983	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1984	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1985	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1986	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1987	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1988	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1989	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1990	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1991	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1992	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1993	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1994	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
Average	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214

Table F.71

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 14

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1976	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1977	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1978	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1979	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1980	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1981	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1982	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1983	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1984	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1985	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1986	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1987	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1988	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1989	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1990	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1991	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1992	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1993	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
1994	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533
Average	-228	-152	-115	-95	-81	-71	-24	20	507	1164	864	-256	1533

Table F.72

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 15

Net Hydrologic Effects

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1976	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1977	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1978	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1979	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1980	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1981	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1982	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1983	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1984	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1985	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1986	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1987	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1988	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1989	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1990	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1991	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1992	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1993	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1994	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
Average	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984

Table F.73
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1976	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1977	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1978	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1979	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1980	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1981	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1982	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1983	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1984	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1985	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1986	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1987	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1988	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1989	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1990	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1991	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1992	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1993	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1994	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
Average	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367

Table F.74
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1976	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1977	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1978	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1979	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1980	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1981	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1982	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1983	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1984	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1985	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1986	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1987	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1988	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1989	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1990	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1991	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1992	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1993	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
1994	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351
Average	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4385	-291	6351

Table F.75
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1976	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1977	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1978	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1979	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1980	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1981	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1982	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1983	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1984	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1985	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1986	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1987	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1988	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1989	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1990	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1991	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1992	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1993	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1994	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
Average	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827

Table F.76
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1976	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1977	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1978	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1979	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1980	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1981	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1982	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1983	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1984	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1985	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1986	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1987	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1988	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1989	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1990	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1991	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1992	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1993	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1994	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
Average	-467	-467	-467	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987

Table F.77

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 1

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	8	0	0	0	0	0	6	2	10	1	1	2	30
1976	3	0	0	0	0	0	2	2	2	0	0	1	10
1977	5	0	0	0	0	0	2	3	2	0	1	3	16
1978	18	0	0	0	0	0	1	5	1	0	0	0	26
1979	6	0	0	0	0	0	1	1	7	0	1	1	16
1980	2	0	0	0	0	0	0	0	0	0	1	1	4
1981	3	0	0	0	0	0	0	0	0	2	0	1	7
1982	4	0	0	0	0	0	0	1	1	1	1	2	10
1983	6	0	0	0	0	0	0	0	0	0	0	0	6
1984	0	0	0	0	0	0	0	0	0	0	4	0	4
1985	0	0	0	0	0	0	4	3	6	1	1	0	16
1986	5	0	0	0	0	0	0	0	0	0	0	0	5
1987	0	0	0	0	0	0	0	0	0	0	2	0	2
1988	20	0	0	0	0	0	3	11	2	2	1	3	42
1989	4	0	0	0	0	0	0	0	2	0	1	0	7
1990	17	0	0	0	0	0	1	7	1	0	1	1	28
1991	2	0	0	0	0	0	0	0	0	0	0	1	4
1992	2	0	0	0	0	0	0	1	1	2	1	1	9
1993	21	0	0	0	0	0	0	1	5	0	3	0	32
1994	0	0	0	0	0	0	1	2	2	0	1	2	6
Average	8	0	0	0	0	0	1	2	2	1	1	1	14

Table F.78

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 2

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	21	0	0	0	0	0	8	5	23	3	2	6	69
1976	8	0	0	0	0	0	3	5	5	1	0	3	24
1977	14	0	0	0	0	0	3	6	5	1	2	7	39
1978	48	0	0	0	0	0	2	11	3	1	1	1	67
1979	16	0	0	0	0	0	1	3	17	0	2	2	41
1980	5	0	0	0	0	0	0	0	0	1	2	4	12
1981	8	0	0	0	0	0	1	1	1	5	0	2	18
1982	10	0	0	0	0	0	1	2	4	2	2	5	25
1983	15	0	0	0	0	0	0	0	0	0	0	0	15
1984	0	0	0	0	0	0	0	0	0	0	12	0	12
1985	0	0	0	0	0	0	6	7	15	3	3	0	34
1986	13	0	0	0	0	0	0	0	0	0	0	0	13
1987	0	0	0	0	0	0	0	0	0	0	6	0	6
1988	52	0	0	0	0	0	4	24	6	4	3	8	101
1989	9	0	0	0	0	0	1	1	4	0	2	0	17
1990	46	0	0	0	0	0	2	14	1	0	3	3	69
1991	6	0	0	0	0	0	0	0	0	0	0	3	10
1992	6	0	0	0	0	0	0	3	3	6	2	2	22
1993	57	0	0	0	0	0	0	3	13	0	10	0	84
1994	0	0	0	0	0	0	1	4	4	0	2	5	15
Average	17	0	0	0	0	0	2	4	5	1	3	3	35

Table F.79

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 3

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	9	0	0	0	0	0	3	2	9	1	1	2	27
1976	3	0	0	0	0	0	1	2	2	0	0	1	9
1977	6	0	0	0	0	0	1	3	2	0	1	3	16
1978	20	0	0	0	0	0	1	4	1	0	0	1	27
1979	7	0	0	0	0	0	1	1	7	0	1	1	16
1980	2	0	0	0	0	0	0	0	0	0	1	2	5
1981	3	0	0	0	0	0	0	0	0	2	0	1	7
1982	4	0	0	0	0	0	0	1	1	1	1	2	10
1983	6	0	0	0	0	0	0	0	0	0	0	0	6
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	2	3	6	1	1	0	13
1986	5	0	0	0	0	0	0	0	0	0	0	0	5
1987	0	0	0	0	0	0	0	0	0	0	3	0	3
1988	23	0	0	0	0	0	2	9	2	2	1	3	41
1989	4	0	0	0	0	0	0	0	2	0	1	0	7
1990	19	0	0	0	0	0	1	5	1	0	1	1	28
1991	2	0	0	0	0	0	0	0	0	0	0	1	4
1992	3	0	0	0	0	0	0	1	1	2	1	1	9
1993	24	0	0	0	0	0	0	1	5	0	4	0	34
1994	0	0	0	0	0	0	0	1	2	0	1	2	6
Average	7	0	0	0	0	0	1	2	2	1	1	1	14

Table F.80

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 4

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	11	0	0	0	0	0	4	2	8	1	1	2	29
1976	4	0	0	0	0	0	1	2	2	0	0	1	10
1977	7	0	0	0	0	0	2	2	2	0	1	3	18
1978	26	0	0	0	0	0	1	4	1	0	0	1	33
1979	8	0	0	0	0	0	1	1	6	0	1	1	17
1980	3	0	0	0	0	0	0	0	0	0	1	2	6
1981	4	0	0	0	0	0	0	0	0	2	0	1	8
1982	5	0	0	0	0	0	0	1	1	1	1	2	11
1983	8	0	0	0	0	0	0	0	0	0	0	0	8
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	3	3	5	1	1	0	13
1986	7	0	0	0	0	0	0	0	0	0	0	0	7
1987	0	0	0	0	0	0	0	0	0	0	3	0	3
1988	27	0	0	0	0	0	2	9	2	2	1	3	47
1989	5	0	0	0	0	0	0	0	1	0	1	0	8
1990	24	0	0	0	0	0	1	5	0	0	1	1	33
1991	3	0	0	0	0	0	0	0	0	0	0	1	5
1992	3	0	0	0	0	0	0	1	1	2	1	1	9
1993	30	0	0	0	0	0	0	1	4	0	4	0	40
1994	0	0	0	0	0	0	1	1	1	0	1	2	6
Average	9	0	0	0	0	0	1	2	2	1	1	1	16

Table F.81

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 5

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	26	-108	-126	0	-150	-161	-119	3	52	14	14	55	-501
1976	15	-103	0	0	-167	-155	-79	2	15	3	2	24	-444
1977	22	-96	-119	-117	-138	-147	-110	3	18	5	15	50	-615
1978	22	-105	-121	-143	-189	0	-100	2	10	5	6	12	-601
1979	15	-88	-133	-132	-111	-164	-97	2	37	0	10	19	-643
1980	13	-89	0	0	0	0	0	0	0	3	14	32	-28
1981	16	-92	0	0	-142	-145	-44	1	3	25	0	21	-356
1982	22	-136	0	0	-174	-158	-54	1	9	7	13	49	-421
1983	21	-119	0	0	0	0	0	0	0	0	0	0	-98
1984	0	-141	0	0	0	0	0	0	0	0	43	0	-98
1985	0	0	0	0	0	0	-87	3	33	13	19	0	-19
1986	34	-119	0	0	0	0	0	0	0	0	0	0	-85
1987	0	0	0	0	0	0	0	0	0	0	49	0	49
1988	24	0	0	0	0	-169	-89	7	15	23	19	60	-110
1989	19	-115	0	0	-160	-159	-51	1	9	0	12	0	-444
1990	21	-118	-122	0	-153	-153	-117	4	7	2	20	13	-596
1991	19	-147	0	0	-165	-145	-43	0	0	2	2	20	-456
1992	9	-120	0	0	-174	0	-94	0	18	28	12	12	-310
1993	27	-133	0	0	-115	0	-108	2	42	0	62	0	-222
1994	0	0	0	0	-155	-186	-87	2	11	0	11	47	-357
Average	16	-91	-31	-20	-100	-87	-64	2	14	6	16	21	-318

Table F.82

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 6

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	0	0	0	0	0	14	17	39	6	5	27	160
1976	30	0	0	0	0	0	9	16	11	1	1	12	80
1977	45	0	0	0	0	0	13	20	13	2	5	24	123
1978	46	0	0	0	0	0	11	18	7	2	2	6	93
1979	32	0	0	0	0	0	11	13	28	0	4	8	96
1980	26	0	0	0	0	0	0	0	0	1	5	15	48
1981	34	0	0	0	0	0	3	5	2	10	0	10	66
1982	46	0	0	0	0	0	5	5	7	3	4	24	95
1983	43	0	0	0	0	0	0	0	0	0	0	0	43
1984	0	0	0	0	0	0	0	0	0	0	17	0	17
1985	0	0	0	0	0	0	10	21	26	5	7	0	68
1986	70	0	0	0	0	0	0	0	0	0	0	0	70
1987	0	0	0	0	0	0	0	0	0	0	15	0	15
1988	47	0	0	0	0	0	10	47	12	9	7	31	161
1989	40	0	0	0	0	0	6	3	6	0	4	0	58
1990	43	0	0	0	0	0	13	11	3	1	6	6	85
1991	39	0	0	0	0	0	5	0	0	1	1	10	55
1992	18	0	0	0	0	0	10	2	5	11	4	6	57
1993	54	0	0	0	0	0	12	11	36	0	22	0	135
1994	0	0	0	0	0	0	10	13	8	0	4	23	58
Average	23	0	0	0	0	0	7	10	10	3	6	10	79

Table F.83

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 7

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-6	-4	-12	0	-33	-23	-14	1	81	1	1	1	-6
1976	-4	-3	0	0	-18	-43	-4	0	1	0	0	0	-71
1977	-1	-1	-6	-10	-5	-20	-4	1	1	0	1	0	-43
1978	-2	-1	-1	-5	-4	0	-3	0	2	0	0	0	-13
1979	-1	-1	-3	-15	-20	-4	-5	2	122	0	8	1	84
1980	-3	-10	0	0	0	0	0	0	0	0	0	1	-12
1981	0	-7	0	0	-13	-13	-4	0	5	1	0	0	-31
1982	-1	0	0	0	-23	-2	-1	0	1	2	0	1	-22
1983	-1	-5	0	0	0	0	0	0	0	0	0	0	-6
1984	0	-43	0	0	0	0	0	0	0	0	14	0	-29
1985	0	0	0	0	0	0	-4	9	48	3	3	0	59
1986	-30	-20	0	0	0	0	0	0	0	0	0	0	-50
1987	0	0	0	0	0	0	0	0	0	0	3	0	3
1988	-1	0	0	0	0	-53	-8	5	11	2	1	1	-42
1989	-1	-1	0	0	-61	-21	-1	0	3	0	1	0	-81
1990	-1	-1	-9	0	-46	-48	-27	0	1	0	1	0	-128
1991	-1	-1	0	0	-34	-20	-1	0	0	0	0	1	-56
1992	-1	-1	0	0	-67	0	-10	0	7	6	9	1	-56
1993	-6	-3	0	0	-43	0	-12	0	4	0	2	0	-59
1994	0	0	0	0	-63	-38	-3	0	1	0	0	0	-103
Average	-3	-3	-2	-2	-21	-14	-3	1	14	1	2	0	-33

Table F.84

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 8

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-211	-290	-313	0	-459	-386	-187	18	971	24	26	18	-987
1976	-204	-312	0	0	-488	-381	-87	9	24	4	1	4	-1629
1977	-123	-257	-338	-344	-379	-381	-137	17	103	11	20	13	-1796
1978	-138	-282	-305	-332	-420	0	-48	5	46	5	4	1	-1465
1979	-55	-120	-223	-341	-279	-257	-101	27	1294	0	91	16	52
1980	-89	-173	0	0	0	0	0	0	0	12	11	13	-227
1981	-48	-158	0	0	-413	-343	-70	10	74	38	0	2	-907
1982	-81	-121	0	0	-564	-277	-36	3	58	49	12	16	-941
1983	-157	-317	0	0	0	0	0	0	0	0	0	0	-474
1984	0	-555	0	0	0	0	0	0	0	0	159	0	-396
1985	0	0	0	0	0	0	-94	84	598	62	59	0	709
1986	-453	-433	0	0	0	0	0	0	0	0	0	0	-886
1987	0	0	0	0	0	0	0	0	0	0	55	0	55
1988	-152	0	0	0	0	-585	-147	78	179	44	24	12	-545
1989	-73	-99	0	0	-586	-418	-51	2	75	0	19	0	-1131
1990	-76	-78	-175	0	-503	-484	-269	11	30	3	33	4	-1504
1991	-101	-179	0	0	-415	-342	-40	0	0	4	6	11	-1056
1992	-45	-80	0	0	-636	0	-157	2	185	218	153	19	-341
1993	-269	-293	0	0	-415	0	-161	8	111	0	61	0	-958
1994	0	0	0	0	-577	-500	-78	6	31	0	9	4	-1105
Average	-114	-187	-68	-31	-307	-238	-83	14	189	24	37	7	-776

Table F.85

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 9

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-484	-535	-467	0	-498	-678	-164	29	875	172	154	16	-1581
1976	-428	-586	0	0	-623	-573	-140	27	141	57	19	6	-2099
1977	-383	-488	-550	-487	-523	-412	-141	31	257	80	132	19	-2466
1978	-365	-535	-540	-540	-605	0	-127	16	89	57	65	5	-2476
1979	-201	-349	-499	-505	-299	-400	-122	28	1049	0	116	9	-1173
1980	-197	-256	0	0	0	0	0	0	0	50	133	10	-260
1981	-226	-313	0	0	-565	-470	-74	14	81	318	0	8	-1228
1982	-297	-429	0	0	-712	-481	-76	10	97	97	90	12	-1690
1983	-582	-594	0	0	0	0	0	0	0	0	0	0	-1176
1984	0	-712	0	0	0	0	0	0	0	0	220	0	-492
1985	0	0	0	0	0	0	-154	58	663	245	249	0	1062
1986	-714	-633	0	0	0	0	0	0	0	0	0	0	-1347
1987	0	0	0	0	0	0	0	0	0	0	254	0	234
1988	-412	0	0	0	0	-571	-150	69	223	351	233	15	-244
1989	-260	-346	0	0	-578	-508	-76	9	234	0	133	0	-1371
1990	-303	-161	-382	0	-500	-444	-196	30	133	39	197	4	-1783
1991	-305	-474	0	0	-460	-415	-54	0	0	41	45	5	-1618
1992	-160	-347	0	0	-574	0	-146	11	289	520	230	7	-151
1993	-543	-582	0	0	-405	0	-136	19	320	0	427	0	-901
1994	0	0	0	0	-560	-564	-106	23	191	0	133	15	-867
Average	-293	-377	-122	-77	-345	-276	-93	19	232	101	143	7	-1080

Table F.86

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 10

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-191	-139	-120	0	-112	-127	-71	-21	207	80	81	-94	-507
1976	-140	-142	0	0	-132	-115	-71	-21	59	28	9	-37	-561
1977	-166	-125	-126	-105	-109	-96	-62	-22	84	38	72	-118	-736
1978	-158	-136	-128	-128	-141	0	-69	-13	32	29	33	-32	-710
1979	-102	-117	-142	-120	-77	-108	-57	-15	222	0	45	-41	-511
1980	-90	-91	0	0	0	0	0	0	0	23	70	-59	-148
1981	-119	-108	0	0	-119	-108	-36	-9	24	153	0	-52	-375
1982	-155	-168	0	0	-145	-118	-43	-8	31	38	48	-67	-587
1983	-203	-155	0	0	0	0	0	0	0	0	0	0	-358
1984	0	-182	0	0	0	0	0	0	0	0	91	0	-91
1985	0	0	0	0	0	0	-76	-30	177	116	123	0	311
1986	-236	-157	0	0	0	0	0	0	0	0	0	0	-392
1987	0	0	0	0	0	0	0	0	0	0	131	0	131
1988	-169	0	0	0	0	-123	-61	-32	62	188	125	-90	-101
1989	-129	-139	0	0	-129	-114	-39	-8	87	0	86	0	-385
1990	-149	-149	-126	0	-115	-104	-74	-24	53	22	116	-27	-578
1991	-134	-174	0	0	-118	-101	-28	0	0	22	26	-30	-538
1992	-68	-148	0	0	-130	0	-60	-9	88	212	104	-28	-39
1993	-207	-168	0	0	-91	0	-60	-14	118	0	262	0	-159
1994	0	0	0	0	-125	-134	-56	-19	73	0	67	-95	-288
Average	-121	-115	-32	-18	-77	-62	-43	-12	66	47	74	-39	-331

Table F.87

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 11

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	4	1	36	0	1	0	42
1976	0	0	0	0	0	0	1	0	0	0	0	0	2
1977	0	0	0	0	0	0	1	1	1	0	0	0	3
1978	0	0	0	0	0	0	1	0	1	0	0	0	2
1979	0	0	0	0	0	0	1	3	63	0	3	0	70
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	1	1	2	0	0	0	5
1982	0	0	0	0	0	0	0	0	1	1	0	0	2
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	5	0	5
1985	0	0	0	0	0	0	1	10	22	1	1	0	35
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	1	0	1
1988	0	0	0	0	0	0	2	7	5	1	0	0	15
1989	0	0	0	0	0	0	0	0	1	0	0	0	2
1990	0	0	0	0	0	0	8	1	1	0	1	0	10
1991	0	0	0	0	0	0	0	0	0	0	0	0	1
1992	0	0	0	0	0	0	2	0	3	2	3	0	11
1993	0	0	0	0	0	0	3	1	2	0	1	0	7
1994	0	0	0	0	0	0	1	0	0	0	0	0	2
Average	0	0	0	0	0	0	1	1	7	0	1	0	11

Table F.88

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 12

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	100	-589	-663	0	-773	-838	-660	-67	334	153	198	453	-2353
1976	57	-564	0	0	-862	-809	-467	-70	107	44	26	204	-2335
1977	85	-522	-629	-607	-713	-768	-620	-94	128	66	188	438	-3049
1978	88	-574	-639	-742	-977	0	-562	-50	59	60	73	98	-3166
1979	59	-481	-704	-684	-374	-855	-539	-53	271	0	120	153	-3287
1980	50	-487	0	0	0	0	0	0	0	40	186	261	49
1981	66	-500	0	0	-737	-759	-260	-37	33	316	0	184	-1694
1982	88	-743	0	0	-900	-827	-319	-28	55	78	143	357	-2096
1983	81	-648	0	0	0	0	0	0	0	0	0	0	-567
1984	0	-770	0	0	0	0	0	0	0	0	345	0	-425
1985	0	0	0	0	0	0	-498	-93	221	196	266	0	93
1986	130	-646	0	0	0	0	0	0	0	0	0	0	-515
1987	0	0	0	0	0	0	0	0	0	0	455	0	455
1988	93	0	0	0	0	-884	-516	-145	105	314	279	455	-298
1989	74	-626	0	0	-827	-829	-300	-18	101	0	190	0	-2234
1990	82	-645	-645	0	-792	-798	-651	-109	62	31	279	123	-3063
1991	73	-802	0	0	-851	-757	-243	0	0	37	51	157	-2336
1992	34	-657	0	0	-900	0	-543	-23	161	342	229	117	-1241
1993	113	-723	0	0	-396	0	-601	-59	240	0	427	0	-1191
1994	0	0	0	0	-801	-972	-488	-56	87	0	149	366	-1716
Average	64	-499	-164	-102	-515	-455	-363	-45	98	84	180	168	-1548

Table F.89

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 13

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	11	-424	-494	0	-568	-598	-468	-69	240	139	198	359	-1674
1976	8	-406	0	0	-634	-578	-351	-77	83	49	24	161	-1722
1977	10	-376	-469	-454	-524	-548	-446	-104	97	70	172	355	-2216
1978	10	-413	-476	-535	-718	0	-404	-47	40	55	83	76	-2367
1979	6	-346	-524	-511	-422	-610	-381	-55	213	0	104	114	-2412
1980	8	-350	0	0	0	0	0	0	0	39	177	203	75
1981	7	-360	0	0	-543	-544	-194	-40	31	290	0	146	-1206
1982	10	-535	0	0	-662	-591	-238	-32	41	71	120	262	-1554
1983	9	-466	0	0	0	0	0	0	0	0	0	0	-456
1984	0	-554	0	0	0	0	0	0	0	0	254	0	-300
1985	0	0	0	0	0	0	-365	-105	170	203	254	0	158
1986	14	-464	0	0	0	0	0	0	0	0	0	0	-450
1987	0	0	0	0	0	0	0	0	0	0	350	0	350
1988	10	0	0	0	0	-631	-382	-139	80	328	278	348	-107
1989	8	-451	0	0	-608	-592	-225	-21	102	0	212	0	-1575
1990	9	-466	-485	0	-583	-571	-464	-103	52	38	275	107	-2190
1991	8	-577	0	0	-626	-542	-181	0	0	39	61	124	-1693
1992	4	-473	0	0	-662	0	-401	-32	121	319	252	100	-773
1993	13	-521	0	0	-439	0	-429	-59	171	0	427	0	-837
1994	0	0	0	0	-589	-694	-149	-65	74	0	144	286	-1194
Average	7	-359	-122	-76	-379	-325	-264	-47	76	82	168	132	-1107

Table F.90

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 14

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-139	-79	-67	0	-55	-52	-17	6	178	61	60	-97	-202
1976	-87	-76	0	0	-61	-51	-14	6	57	22	6	-39	-236
1977	-120	-70	-64	-51	-51	-48	-15	8	72	31	52	-108	-364
1978	-122	-77	-65	-62	-70	0	-14	4	30	23	21	-26	-356
1979	-78	-65	-71	-57	-41	-53	-13	4	174	0	32	-35	-204
1980	-71	-65	0	0	0	0	0	0	0	18	31	-58	-126
1981	-92	-67	0	0	-55	-48	-8	3	23	121	0	-46	-166
1982	-124	-100	0	0	-64	-52	-9	3	30	31	35	-69	-320
1983	-111	-87	0	0	0	0	0	0	0	0	0	0	-197
1984	0	-103	0	0	0	0	0	0	0	0	70	0	-33
1985	0	0	0	0	0	0	-14	9	140	93	83	0	311
1986	-172	-87	0	0	0	0	0	0	0	0	0	0	-258
1987	0	0	0	0	0	0	0	0	0	0	98	0	98
1988	-126	0	0	0	0	-55	-13	10	56	156	89	-92	24
1989	-101	-84	0	0	-59	-52	-8	2	79	0	66	0	-157
1990	-112	-87	-67	0	-56	-50	-16	8	45	18	88	-30	-259
1991	-101	-108	0	0	-61	-48	-6	0	0	18	20	-33	-318
1992	-47	-88	0	0	-64	0	-14	3	84	158	79	-28	82
1993	-160	-97	0	0	-43	0	-15	4	114	0	168	0	-29
1994	0	0	0	0	-57	-63	-13	6	60	0	45	-85	-104
Average	-58	-67	-17	-8	-57	-29	-9	4	57	38	53	-37	-141

Table F.91

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 15

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-115	-106	-112	0	-136	-147	-116	-35	244	126	114	-19	-303
1976	-90	-103	0	0	-145	-144	-105	-35	68	40	13	-9	-509
1977	-112	-102	-111	-113	-133	-143	-104	-37	121	63	81	-29	-638
1978	-117	-113	-116	-117	-156	0	-108	-36	43	41	53	-6	-635
1979	-82	-99	-123	-120	-109	-152	-103	-31	265	0	58	-9	-507
1980	-86	-106	0	0	0	0	0	0	0	38	103	-15	-67
1981	-97	-99	0	0	-127	-138	-49	-23	26	199	0	-18	-328
1982	-116	-139	0	0	-154	-144	-90	-24	57	53	63	-19	-512
1983	-124	-118	0	0	0	0	0	0	0	0	0	0	-242
1984	0	-139	0	0	0	0	0	0	0	0	150	0	11
1985	0	0	0	0	0	0	-104	-58	162	135	137	0	272
1986	-141	-123	0	0	0	0	0	0	0	0	0	0	-265
1987	0	0	0	0	0	0	0	0	0	0	142	0	142
1988	-109	0	0	0	0	-149	-92	-65	67	286	122	-20	41
1989	-63	-130	0	0	-145	-142	-72	-42	101	0	121	0	-342
1990	-123	-125	-119	0	-144	-147	-110	-32	54	39	160	-8	-572
1991	-94	-128	0	0	-148	-141	-68	0	0	30	34	-10	-524
1992	-67	-128	0	0	-154	0	-95	-18	85	183	174	-9	-29
1993	-132	-130	0	0	-100	0	-103	-34	119	0	252	0	-129
1994	0	0	0	0	-131	-159	-90	-36	68	0	98	-26	-275
Average	-83	-94	-29	-18	-89	-80	-70	-26	74	62	94	-10	-271

Table F.92

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 16

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-203	-196	-195	0	-240	-252	-209	-104	587	1082	770	-37	1004
1976	-171	-190	0	0	-246	-249	-193	-106	343	487	199	-20	-146
1977	-210	-197	-200	-209	-243	-258	-187	-140	486	688	725	-46	207
1978	-225	-221	-213	-191	-253	0	-211	-118	358	408	519	-19	-166
1979	-163	-197	-227	-214	-201	-264	-206	-110	319	0	823	-27	-267
1980	-185	-220	0	0	0	0	0	0	0	866	845	-29	1277
1981	-196	-194	0	0	-219	-245	-138	-102	307	869	0	-35	48
1982	-216	-261	0	0	-264	-247	-196	-103	433	982	941	-36	1033
1983	-260	-219	0	0	0	0	0	0	0	0	0	0	-479
1984	0	-255	0	0	0	0	0	0	0	0	823	0	568
1985	0	0	0	0	0	0	-193	-130	479	1118	1078	0	2352
1986	-251	-235	0	0	0	0	0	0	0	0	0	0	-486
1987	0	0	0	0	0	0	0	0	0	0	869	0	869
1988	-200	0	0	0	0	-250	-176	-138	394	1248	960	-38	1800
1989	-150	-261	0	0	-252	-241	-174	-78	459	0	955	0	258
1990	-250	-241	-217	0	-258	-264	-203	-131	397	637	989	-25	434
1991	-184	-211	0	0	-256	-234	-169	0	0	412	436	-24	-232
1992	-158	-248	0	0	-262	0	-192	-84	406	1024	825	-31	1280
1993	-224	-237	0	0	-170	0	-203	-118	465	0	427	0	-59
1994	0	0	0	0	-217	-261	-187	-111	408	0	980	-42	572
Average	-162	-179	-33	-31	-154	-139	-142	-79	302	491	659	-20	493

Table F.93

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 17

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-511	-472	-469	0	-576	-608	-532	-413	1411	4431	2672	-240	4694
1976	-415	-458	0	0	-592	-600	-498	-417	1073	2092	749	-124	811
1977	-523	-476	-481	-503	-585	-622	-474	-426	1357	2905	2680	-248	2605
1978	-547	-534	-513	-458	-609	0	-537	-417	1197	1717	1862	-129	1032
1979	-397	-476	-546	-514	-484	-636	-529	-418	1056	0	3105	-171	-9
1980	-449	-531	0	0	0	0	0	0	0	3869	3001	-170	5720
1981	-475	-468	0	0	-528	-590	-513	-422	1069	3197	0	-168	1104
1982	-523	-632	0	0	-636	-594	-501	-401	1373	4357	3567	-203	5806
1983	-631	-527	0	0	0	0	0	0	0	0	0	0	-1159
1984	0	-615	0	0	0	0	0	0	0	0	2706	0	2091
1985	0	0	0	0	0	0	-528	-422	1376	4708	3935	0	9069
1986	-628	-566	0	0	0	0	0	0	0	0	0	0	-1194
1987	0	0	0	0	0	0	0	0	0	0	3109	0	3109
1988	-501	0	0	0	0	-601	-477	-401	1263	4522	3576	-236	7146
1989	-533	-635	0	0	-606	-579	-520	-377	1391	0	3408	0	1549
1990	-611	-581	-522	0	-621	-635	-542	-431	1329	2783	3432	-161	3440
1991	-464	-510	0	0	-617	-613	-472	0	0	1796	1724	-140	704
1992	-393	-598	0	0	-631	0	-538	-359	1301	1230	2611	-194	2430
1993	-547	-573	0	0	-415	0	-551	-428	1418	0	427	0	-669
1994	0	0	0	0	-521	-636	-548	-429	1343	0	3552	-202	2559
Average	-407	-433	-127	-74	-371	-336	-388	-288	898	1880	2306	-119	2542

Table F.94

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 18

Reduction to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-455	-444	-418	0	-507	-543	-487	-404	1710	5660	3349	-217	7244
1976	-402	-452	0	0	-536	-539	-472	-407	1333	2519	771	-104	1712
1977	-467	-462	-427	-447	-533	-548	-462	-413	1671	3841	3286	-220	4820
1978	-483	-469	-478	-400	-543	0	-490	-407	1542	2231	2372	-107	2769
1979	-379	-446	-479	-448	-422	-555	-486	-408	1296	0	3775	-140	1307
1980	-397	-461	0	0	0	0	0	0	0	5273	3897	-145	8167
1981	-432	-431	0	0	-466	-534	-476	-409	1326	3767	0	-149	2195
1982	-458	-553	0	0	-555	-537	-472	-400	1678	5572	4504	-170	8610
1983	-551	-496	0	0	0	0	0	0	0	0	0	0	-1046
1984	0	-545	0	0	0	0	0	0	0	0	3303	0	2757
1985	0	0	0	0	0	0	-486	-411	1685	5842	4800	0	11429
1986	-550	-524	0	0	0	0	0	0	0	0	0	0	-1074
1987	0	0	0	0	0	0	0	0	0	0	3744	0	3744
1988	-437	0	0	0	0	-527	-445	-383	1589	5380	4300	-196	9282
1989	-506	-553	0	0	-529	-506	-478	-372	1689	0	4126	0	2871
1990	-540	-530	-435	0	-548	-555	-492	-415	1644	3526	4322	-149	3809
1991	-435	-445	0	0	-546	-544	-434	0	0	2226	2156	-117	1860
1992	-353	-521	0	0	-553	0	-489	-355	1630	1230	3166	-166	3590
1993	-492	-526	0	0	-363	0	-496	-413	1708	0	427	0	-155
1994	0	0	0	0	-455	-555	-494	-411	1654	0	4536	170	4105
Average	-367	-393	-113	-65	-328	-297	-358	-280	1108	2353	2842	-102	4000

Table F.95
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 19
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-429	-434	-413	0	-449	-467	-445	-414	1468	5005	3684	-269	6839
1976	-420	-446	0	0	-467	-467	-444	-414	1318	3589	2450	-196	4504
1977	-434	-447	-416	-425	-467	-466	-445	-416	1461	4261	3626	-269	5564
1978	-439	-432	-448	-402	-466	0	-445	-414	1431	3533	3257	-197	4979
1979	-406	-434	-437	-422	-411	-467	-444	-415	1299	0	3830	-214	1478
1980	-403	-427	0	0	0	0	0	0	0	4950	3983	-221	7882
1981	-423	-424	0	0	-432	-466	-442	-414	1314	4077	0	-227	2563
1982	-427	-466	0	0	-467	-467	-442	-415	1459	4966	4219	-234	7727
1983	-465	-457	0	0	0	0	0	0	0	0	0	0	-922
1984	0	-466	0	0	0	0	0	0	0	0	3629	0	3162
1985	0	0	0	0	0	0	-445	-416	1464	5026	4288	0	9916
1986	-466	-466	0	0	0	0	0	0	0	0	0	0	-933
1987	0	0	0	0	0	0	0	0	0	0	3804	0	3804
1988	-417	0	0	0	0	-456	-429	-398	1437	4763	4043	-248	8295
1989	-464	-466	0	0	-456	-446	-441	-398	1460	0	3978	0	2767
1990	-464	-466	-425	0	-467	-467	-444	-416	1451	4067	4133	-229	6273
1991	-429	-421	0	0	-467	-466	-421	0	0	3493	3141	-203	4227
1992	-386	-453	0	0	-467	0	-444	-389	1454	1230	3559	-232	3872
1993	-447	-466	0	0	-386	0	-445	-415	1462	0	427	0	-269
1994	0	0	0	0	-425	-467	-444	-413	1453	0	4252	-234	3722
Average	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

Table F.96
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 1
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	30	0	0	0	0	0	17	103	206	259	146	102	863
1976	25	0	0	0	0	0	15	102	158	98	27	51	476
1977	31	0	0	0	0	0	15	102	184	146	146	100	723
1978	31	0	0	0	0	0	16	100	184	91	109	50	581
1979	23	0	0	0	0	0	16	102	150	0	173	67	531
1980	25	0	0	0	0	0	0	0	0	207	167	69	468
1981	28	0	0	0	0	0	15	103	141	159	0	67	513
1982	31	0	0	0	0	0	15	104	193	247	211	88	889
1983	37	0	0	0	0	0	0	0	0	0	0	0	37
1984	0	0	0	0	0	0	0	0	0	0	154	0	154
1985	0	0	0	0	0	0	17	105	197	262	212	0	792
1986	37	0	0	0	0	0	0	0	0	0	0	0	37
1987	0	0	0	0	0	0	0	0	0	0	159	0	159
1988	28	0	0	0	0	0	15	96	169	213	175	95	792
1989	31	0	0	0	0	0	15	90	196	0	165	0	497
1990	34	0	0	0	0	0	16	102	149	126	194	68	689
1991	24	0	0	0	0	0	14	0	0	92	91	56	278
1992	22	0	0	0	0	0	16	78	195	220	136	79	745
1993	31	0	0	0	0	0	17	103	201	0	221	0	574
1994	0	0	0	0	0	0	16	99	183	0	200	81	579
Average	23	0	0	0	0	0	12	69	125	106	134	49	519

Table F.97
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 2
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	80	0	0	0	0	0	24	219	503	680	422	268	2196
1976	66	0	0	0	0	0	22	218	386	258	79	133	1162
1977	84	0	0	0	0	0	21	219	453	398	429	268	1872
1978	83	0	0	0	0	0	23	214	451	240	313	132	1456
1979	62	0	0	0	0	0	23	217	367	0	497	176	1341
1980	67	0	0	0	0	0	0	0	0	546	488	181	1282
1981	74	0	0	0	0	0	21	221	346	424	0	179	1264
1982	81	0	0	0	0	0	22	221	473	649	606	226	2278
1983	98	0	0	0	0	0	0	0	0	0	0	0	98
1984	0	0	0	0	0	0	0	0	0	0	439	0	439
1985	0	0	0	0	0	0	23	223	482	692	615	0	2034
1986	99	0	0	0	0	0	0	0	0	0	0	0	99
1987	0	0	0	0	0	0	0	0	0	0	465	0	465
1988	76	0	0	0	0	0	21	204	415	565	516	253	2051
1989	82	0	0	0	0	0	22	194	481	0	479	0	1257
1990	92	0	0	0	0	0	23	218	366	333	562	178	1771
1991	64	0	0	0	0	0	20	0	0	245	264	148	741
1992	59	0	0	0	0	0	22	167	478	583	396	210	1915
1993	82	0	0	0	0	0	23	220	492	0	427	0	1245
1994	0	0	0	0	0	0	23	211	449	0	590	217	1490
Average	63	0	0	0	0	0	17	148	307	281	379	128	1323

Table F.98
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 3
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	33	0	0	0	0	0	9	84	194	269	176	109	875
1976	27	0	0	0	0	0	8	84	150	106	32	54	462
1977	34	0	0	0	0	0	8	85	182	163	175	111	759
1978	34	0	0	0	0	0	9	82	177	95	129	54	580
1979	25	0	0	0	0	0	9	84	142	0	202	72	534
1980	28	0	0	0	0	0	0	0	0	217	201	74	520
1981	30	0	0	0	0	0	8	85	137	169	0	73	502
1982	33	0	0	0	0	0	8	85	185	258	248	92	909
1983	40	0	0	0	0	0	0	0	0	0	0	0	40
1984	0	0	0	0	0	0	0	0	0	0	178	0	178
1985	0	0	0	0	0	0	9	86	189	273	252	0	810
1986	40	0	0	0	0	0	0	0	0	0	0	0	40
1987	0	0	0	0	0	0	0	0	0	0	192	0	192
1988	31	0	0	0	0	0	9	78	170	233	216	103	840
1989	34	0	0	0	0	0	8	75	187	0	205	0	509
1990	38	0	0	0	0	0	9	84	144	140	229	74	718
1991	26	0	0	0	0	0	8	0	0	98	110	60	302
1992	24	0	0	0	0	0	9	67	185	230	165	86	764
1993	34	0	0	0	0	0	9	84	189	0	258	0	575
1994	0	0	0	0	0	0	9	82	178	0	244	89	602
Average	26	0	0	0	0	0	6	57	120	113	161	33	536

Table F.99

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 4

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	42	0	0	0	0	0	11	82	168	258	172	113	847
1976	35	0	0	0	0	0	11	82	130	105	31	56	450
1977	44	0	0	0	0	0	10	83	164	161	167	116	745
1978	44	0	0	0	0	0	11	80	155	91	124	56	562
1979	32	0	0	0	0	0	11	82	123	0	192	75	516
1980	35	0	0	0	0	0	0	0	0	209	194	76	515
1981	38	0	0	0	0	0	11	83	121	162	0	76	492
1982	42	0	0	0	0	0	11	83	162	249	238	95	880
1983	51	0	0	0	0	0	0	0	0	0	0	0	51
1984	0	0	0	0	0	0	0	0	0	0	170	0	170
1985	0	0	0	0	0	0	11	84	167	261	243	0	766
1986	51	0	0	0	0	0	0	0	0	0	0	0	51
1987	0	0	0	0	0	0	0	0	0	0	186	0	186
1988	40	0	0	0	0	0	10	77	155	232	211	107	832
1989	43	0	0	0	0	0	11	74	163	0	205	0	495
1990	49	0	0	0	0	0	11	83	127	143	219	77	709
1991	34	0	0	0	0	0	10	0	0	95	107	62	307
1992	31	0	0	0	0	0	11	68	160	220	157	90	737
1993	43	0	0	0	0	0	11	82	163	0	247	0	547
1994	0	0	0	0	0	0	11	80	159	0	236	92	578
Average	35	0	0	0	0	0	8	56	106	109	155	55	522

Table F.100

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 5

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	36	-108	-126	0	-150	-161	-119	22	432	1074	782	370	2054
1976	30	-103	0	0	-167	-155	-79	22	335	438	140	183	644
1977	38	-96	-119	-117	-138	-147	-110	22	424	869	759	381	1566
1978	38	-105	-121	-143	-189	0	-100	22	401	380	564	184	931
1979	28	-88	-133	-132	-111	-164	-97	22	318	0	871	245	758
1980	31	-89	0	0	0	0	0	0	0	869	881	249	1940
1981	33	-92	0	0	-142	-145	-44	23	322	674	0	249	878
1982	37	-126	0	0	-174	-158	-54	22	421	1035	1079	312	2383
1983	44	-119	0	0	0	0	0	0	0	0	0	0	-75
1984	0	-141	0	0	0	0	0	0	0	0	771	0	629
1985	0	0	0	0	0	0	-87	23	429	1085	1102	0	2551
1986	45	-119	0	0	0	0	0	0	0	0	0	0	-74
1987	0	0	0	0	0	0	0	0	0	0	845	0	845
1988	35	0	0	0	0	-169	-89	21	400	962	959	349	2467
1989	37	-115	0	0	-160	-159	-51	20	420	0	928	0	921
1990	43	-118	-122	0	-153	-153	-117	23	368	393	991	254	1609
1991	29	-147	0	0	-165	-145	-43	0	0	393	484	204	612
1992	27	-120	0	0	-174	0	-94	18	415	915	713	293	1992
1993	38	-133	0	0	-115	0	-108	22	420	0	427	0	551
1994	0	0	0	0	-155	-188	-87	22	409	0	1070	300	1373
Average	28	-91	-31	-20	-100	-87	-64	15	276	454	668	179	1228

Table F.101

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 6

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	75	0	0	0	0	0	20	183	401	314	332	225	1751
1976	62	0	0	0	0	0	19	183	311	209	60	112	956
1977	79	0	0	0	0	0	18	185	395	320	323	232	1549
1978	80	0	0	0	0	0	19	177	372	182	240	112	1182
1979	58	0	0	0	0	0	20	183	295	0	370	149	1075
1980	63	0	0	0	0	0	0	0	0	416	375	152	1005
1981	69	0	0	0	0	0	18	176	259	320	0	150	991
1982	76	0	0	0	0	0	16	177	362	491	421	189	1731
1983	92	0	0	0	0	0	0	0	0	0	0	0	92
1984	0	0	0	0	0	0	0	0	0	0	328	0	328
1985	0	0	0	0	0	0	20	186	396	515	459	0	1574
1986	92	0	0	0	0	0	0	0	0	0	0	0	92
1987	0	0	0	0	0	0	0	0	0	0	319	0	319
1988	68	0	0	0	0	0	18	166	368	453	404	211	1688
1989	77	0	0	0	0	0	18	163	334	0	388	0	980
1990	83	0	0	0	0	0	19	175	290	281	395	153	1398
1991	61	0	0	0	0	0	17	0	0	118	204	123	524
1992	36	0	0	0	0	0	19	154	358	437	302	177	1482
1993	78	0	0	0	0	0	20	182	390	0	427	0	1096
1994	0	0	0	0	0	0	19	178	376	0	437	182	1192
Average	59	0	0	0	0	0	14	122	245	213	289	108	1050

Table F.102
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-6	-4	-12	0	-33	-23	-14	35	563	1012	604	51	2174
1976	-4	-3	0	0	-18	-43	-4	35	429	405	105	26	928
1977	-1	-1	-6	-10	-5	-20	-4	35	550	619	583	55	1796
1978	-2	-1	-1	-5	-4	0	-3	33	503	346	425	26	1318
1979	-1	-1	-3	-15	-20	-4	-5	23	296	0	675	36	982
1980	-3	-10	0	0	0	0	0	0	0	816	668	36	1507
1981	0	-7	0	0	-13	-13	-4	36	435	630	0	36	1099
1982	-1	0	0	0	-23	-2	-1	35	552	987	823	45	2415
1983	-1	-5	0	0	0	0	0	0	0	0	0	0	-6
1984	0	-43	0	0	0	0	0	0	0	0	478	0	435
1985	0	0	0	0	0	0	-4	35	522	1028	858	0	2439
1986	-30	-20	0	0	0	0	0	0	0	0	0	0	-50
1987	0	0	0	0	0	0	0	0	0	0	652	0	652
1988	-1	0	0	0	0	-52	-8	32	523	918	746	51	2210
1989	-1	-1	0	0	-61	-21	-1	32	555	0	727	0	1228
1990	-1	-1	-9	0	-46	-48	-27	36	533	571	772	38	1818
1991	-1	-1	0	0	-34	-20	-1	0	0	382	380	30	734
1992	-1	-1	0	0	-67	0	-10	30	552	874	560	44	1980
1993	-6	-5	0	0	-43	0	-12	35	553	0	427	0	950
1994	0	0	0	0	-63	-38	-3	34	531	0	816	43	1320
Average	-3	-5	-2	-2	-21	-14	-5	23	355	429	513	26	1296

Table F.103
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-211	-290	-313	0	-459	-586	-187	272	4384	7704	4550	334	15198
1976	-204	-312	0	0	-488	-581	-87	272	3348	3088	794	167	5997
1977	-123	-257	-338	-344	-379	-381	-137	275	4296	4726	4394	354	12084
1978	-138	-282	-305	-332	-420	0	-48	266	3959	2640	3203	168	8711
1979	-55	-120	-223	-341	-279	-257	-101	230	2788	0	5078	229	6948
1980	-89	-173	0	0	0	0	0	0	0	6217	5024	230	11209
1981	-48	-158	0	0	-413	-343	-70	277	3396	4802	0	230	7674
1982	-81	-121	0	0	-564	-277	-36	272	4293	7514	6193	288	17481
1983	-157	-317	0	0	0	0	0	0	0	0	0	0	-474
1984	0	-555	0	0	0	0	0	0	0	0	3669	0	3114
1985	0	0	0	0	0	0	-94	273	4058	7823	6453	0	18512
1986	-453	-433	0	0	0	0	0	0	0	0	0	0	-886
1987	0	0	0	0	0	0	0	0	0	0	4908	0	4908
1988	-152	0	0	0	0	-585	-147	253	4076	5380	5619	325	14770
1989	-73	-99	0	0	-586	-418	-31	247	4319	0	5468	0	8808
1990	-76	-78	-175	0	-503	-484	-269	280	4156	4346	5806	241	13245
1991	-101	-179	0	0	-415	-342	-40	0	0	2910	2856	193	4883
1992	-45	-80	0	0	-636	0	-157	232	4300	1230	4211	278	9333
1993	-269	-293	0	0	-415	0	-161	274	4307	0	427	0	3870
1994	0	0	0	0	-577	-500	-78	267	4138	0	6150	277	9677
Average	-114	-187	-68	-51	-307	-238	-83	184	2791	2919	3740	166	8753

Table F.104
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-484	-535	-467	0	-498	-678	-164	147	2753	5574	3185	68	8902
1976	-428	-586	0	0	-623	-573	-140	147	2109	2244	557	33	2741
1977	-383	-488	-550	-487	-523	-412	-141	149	2709	3447	3080	70	6470
1978	-365	-533	-540	-540	-605	0	-127	146	2520	1918	2246	33	4154
1979	-201	-349	-499	-505	-299	-400	-122	149	2049	0	3550	45	3419
1980	-197	-256	0	0	0	0	0	0	0	4508	3516	46	7617
1981	-226	-313	0	0	-565	-470	-74	149	2139	3483	0	46	4168
1982	-297	-429	0	0	-712	-481	-76	147	2700	5448	4334	57	10690
1983	-582	-594	0	0	0	0	0	0	0	0	0	0	-1176
1984	0	-712	0	0	0	0	0	0	0	0	2696	0	1984
1985	0	0	0	0	0	0	-154	149	2649	5669	4513	0	12826
1986	-714	-633	0	0	0	0	0	0	0	0	0	0	-1347
1987	0	0	0	0	0	0	0	0	0	0	3434	0	3434
1988	-412	0	0	0	0	-571	-150	137	2568	5067	3933	64	10636
1989	-260	-346	0	0	-578	-508	-76	134	2712	0	3827	0	4906
1990	-303	-361	-382	0	-500	-444	-196	151	2618	3148	4062	48	7840
1991	-305	-474	0	0	-460	-415	-54	0	0	2109	1999	38	2437
1992	-160	-347	0	0	-574	0	-146	125	2700	1230	2946	55	5829
1993	-543	-582	0	0	-405	0	-136	148	2703	0	427	0	1613
1994	0	0	0	0	-560	-564	-106	144	2606	0	4319	55	5895
Average	-293	-377	-122	-77	-345	-276	-93	101	1777	2192	2631	33	5152

Table F.105
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 10
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-191	-139	-120	0	-112	-127	-71	-21	513	1306	780	-94	1725
1976	-140	-142	0	0	-132	-113	-71	-21	397	533	138	-37	411
1977	-166	-125	-126	-105	-109	-96	-62	-22	507	816	734	-118	1147
1978	-158	-136	-128	-128	-141	0	-69	-13	473	456	555	-32	679
1979	-102	-117	-142	-120	-77	-108	-37	-15	380	0	864	-41	466
1980	-90	-91	0	0	0	0	0	0	0	1060	868	-59	1687
1981	-119	-108	0	0	-119	-108	-36	-9	400	821	0	-52	668
1982	-155	-168	0	0	-145	-118	-43	-8	505	1274	1061	-67	2136
1983	-203	-155	0	0	0	0	0	0	0	0	0	0	-358
1984	0	-182	0	0	0	0	0	0	0	0	718	0	536
1985	0	0	0	0	0	0	-76	-30	512	1331	1101	0	2840
1986	-236	-157	0	0	0	0	0	0	0	0	0	0	-392
1987	0	0	0	0	0	0	0	0	0	0	844	0	844
1988	-169	0	0	0	0	-123	-61	-32	481	1190	965	-90	2161
1989	-129	-139	0	0	-129	-114	-39	-8	507	0	937	0	887
1990	-149	-149	-126	0	-115	-104	-74	-24	492	743	996	-27	1462
1991	-134	-174	0	0	-118	-101	-28	0	0	496	492	-30	403
1992	-68	-148	0	0	-130	0	-60	-9	503	1121	719	-28	1900
1993	-207	-168	0	0	-91	0	-60	-14	506	0	427	0	394
1994	0	0	0	0	-125	-134	-56	-19	492	0	1066	-95	1129
Average	-121	-115	-32	-18	-77	-62	-43	-12	333	557	664	-39	1036

Table F.106
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	31	75	352	548	334	0	1340
1976	0	0	0	0	0	0	29	75	269	219	58	0	650
1977	0	0	0	0	0	0	27	76	344	335	322	0	1105
1978	0	0	0	0	0	0	31	72	315	187	235	0	840
1979	0	0	0	0	0	0	31	50	185	0	373	0	639
1980	0	0	0	0	0	0	0	0	0	442	369	0	811
1981	0	0	0	0	0	0	30	76	273	341	0	0	720
1982	0	0	0	0	0	0	30	75	345	534	455	0	1439
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	264	0	264
1985	0	0	0	0	0	0	31	75	326	556	474	0	1463
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	360	0	360
1988	0	0	0	0	0	0	29	70	327	497	412	0	1335
1989	0	0	0	0	0	0	30	68	347	0	401	0	846
1990	0	0	0	0	0	0	31	77	334	309	426	0	1177
1991	0	0	0	0	0	0	27	0	0	207	210	0	444
1992	0	0	0	0	0	0	31	64	346	473	309	0	1222
1993	0	0	0	0	0	0	31	75	346	0	427	0	880
1994	0	0	0	0	0	0	31	74	332	0	451	0	888
Average	0	0	0	0	0	0	22	50	222	232	294	0	821

Table F.107
Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	138	-389	-663	0	-773	-838	-660	-67	1618	5388	4350	1737	9641
1976	115	-564	0	0	-862	-809	-467	-70	1237	2196	780	860	2436
1977	145	-522	-629	-607	-713	-768	-620	-94	1592	3353	4223	1793	7154
1978	147	-574	-639	-742	-977	0	-562	-50	1552	1908	3134	865	4012
1979	108	-481	-704	-684	-574	-855	-539	-53	1189	0	4842	1149	3399
1980	117	-487	0	0	0	0	0	0	0	4359	4897	1170	10056
1981	127	-500	0	0	-737	-759	-260	-37	1242	3380	0	1168	3625
1982	140	-743	0	0	-900	-827	-319	-28	1586	5198	5997	1460	11564
1983	169	-648	0	0	0	0	0	0	0	0	0	0	-479
1984	0	-770	0	0	0	0	0	0	0	0	4280	0	3510
1985	0	0	0	0	0	0	-498	-93	1606	5443	6128	0	12587
1986	170	-646	0	0	0	0	0	0	0	0	0	0	-476
1987	0	0	0	0	0	0	0	0	0	0	4712	0	4712
1988	133	0	0	0	0	-884	-516	-145	1505	4829	5333	1636	11856
1989	132	-626	0	0	-827	-829	-300	-18	1574	0	5163	0	4280
1990	165	-645	-645	0	-792	-798	-853	-109	1522	2978	3515	1195	7734
1991	112	-802	0	0	-854	-757	-243	0	0	1973	2669	954	3079
1992	103	-657	0	0	-900	0	-545	-23	1561	1230	3956	1373	6101
1993	143	-723	0	0	-596	0	-601	-50	1576	0	427	0	176
1994	0	0	0	0	-803	-972	-488	-56	1533	0	5949	1409	6574
Average	109	-499	-164	-102	-513	-455	-363	-45	1043	2112	3519	939	5579

Table F.108

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 13

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	15	-424	-494	0	-568	-598	-468	-69	871	3075	2519	1010	4869
1976	12	-406	0	0	-634	-578	-351	-77	680	1262	451	500	859
1977	16	-376	-469	-454	-524	-548	-446	-104	861	1923	2439	1044	3362
1978	16	-413	-476	-555	-718	0	-404	-47	808	1086	1808	503	1609
1979	12	-346	-524	-511	-422	-610	-381	-55	641	0	2789	867	1260
1980	13	-350	0	0	0	0	0	0	0	2493	2828	680	5664
1981	14	-360	0	0	-543	-544	-194	-40	674	1934	0	679	1620
1982	15	-535	0	0	-662	-591	-238	-32	857	2981	3450	846	6090
1983	18	-466	0	0	0	0	0	0	0	0	0	0	-447
1984	0	-554	0	0	0	0	0	0	0	0	2461	0	1907
1985	0	0	0	0	0	0	-365	-105	867	3123	3544	0	7065
1986	18	-464	0	0	0	0	0	0	0	0	0	0	-446
1987	0	0	0	0	0	0	0	0	0	0	2734	0	2734
1988	14	0	0	0	0	-631	-382	-139	815	2779	3102	951	6509
1989	15	-451	0	0	-608	-592	-225	-21	856	0	3008	0	1982
1990	18	-466	-483	0	-583	-571	-464	-103	829	1729	3204	705	3814
1991	12	-577	0	0	-626	-542	-181	0	0	1135	1575	559	1355
1992	11	-473	0	0	-662	0	-401	-32	848	1230	2298	802	3623
1993	16	-521	0	0	-439	0	-429	-59	854	0	427	0	-151
1994	0	0	0	0	-589	-694	-349	-65	833	0	3450	821	3407
Average	12	-359	-122	-76	-379	-325	-264	-47	565	1238	2104	488	2834

Table F.109

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 14

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-139	-79	-67	0	-55	-52	-17	19	478	1066	580	-97	1637
1976	-87	-76	0	0	-61	-51	-14	19	374	440	104	-39	609
1977	-120	-70	-64	-51	-51	-48	-15	19	474	669	560	-108	1195
1978	-122	-77	-65	-62	-70	0	-14	19	443	376	415	-26	819
1979	-78	-65	-71	-57	-41	-53	-13	19	353	0	639	-35	597
1980	-71	-63	0	0	0	0	0	0	0	866	650	-58	1321
1981	-92	-67	0	0	-53	-48	-8	19	373	672	0	-46	752
1982	-124	-100	0	0	-64	-52	-9	19	472	1036	789	-69	1898
1983	-111	-87	0	0	0	0	0	0	0	0	0	0	-197
1984	0	-103	0	0	0	0	0	0	0	0	563	0	459
1985	0	0	0	0	0	0	-14	19	478	1087	816	0	2385
1986	-172	-87	0	0	0	0	0	0	0	0	0	0	-258
1987	0	0	0	0	0	0	0	0	0	0	629	0	629
1988	-126	0	0	0	0	-55	-13	18	450	972	718	-92	1872
1989	-101	-84	0	0	-59	-52	-8	17	474	0	696	0	884
1990	-112	-87	-67	0	-56	-50	-16	19	461	610	741	-30	1413
1991	-101	-108	0	0	-61	-48	-6	0	0	402	367	-33	412
1992	-47	-88	0	0	-64	0	-14	16	469	908	532	-28	1685
1993	-160	-97	0	0	-43	0	-15	19	472	0	427	0	604
1994	0	0	0	0	-57	-61	-13	19	462	0	796	-85	1062
Average	-88	-67	-17	-8	-37	-29	-9	13	312	455	501	-37	989

Table F.110

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 15

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-115	-106	-112	0	-136	-147	-116	-35	498	1365	888	-19	1964
1976	-90	-103	0	0	-145	-144	-105	-35	389	563	159	-9	481
1977	-112	-102	-111	-113	-133	-143	-104	-57	494	857	857	-29	1304
1978	-117	-113	-116	-117	-156	0	-108	-36	462	481	636	-6	808
1979	-82	-99	-125	-120	-109	-152	-103	-31	368	0	978	-9	516
1980	-86	-106	0	0	0	0	0	0	0	1108	995	-15	1896
1981	-97	-99	0	0	-127	-138	-49	-23	389	860	0	-18	697
1982	-116	-139	0	0	-154	-144	-90	-24	492	1326	1207	-19	2340
1983	-124	-118	0	0	0	0	0	0	0	0	0	0	-242
1984	0	-139	0	0	0	0	0	0	0	0	861	0	721
1985	0	0	0	0	0	0	-104	-38	498	1391	1230	0	2976
1986	-141	-125	0	0	0	0	0	0	0	0	0	0	-265
1987	0	0	0	0	0	0	0	0	0	0	963	0	963
1988	-109	0	0	0	0	-149	-92	-65	469	1245	1102	-20	2382
1989	-63	-130	0	0	-143	-142	-72	-12	494	0	1066	0	997
1990	-121	-125	-119	0	-144	-147	-110	-52	481	781	1136	-8	1572
1991	-44	-128	0	0	-148	-141	-68	0	0	520	563	-10	495
1992	-67	-128	0	0	-154	0	-95	-18	489	1163	816	-9	1998
1993	-132	-130	0	0	-100	0	-103	-34	494	0	427	0	422
1994	0	0	0	0	-131	-139	-90	-36	483	0	1219	-26	1262
Average	-83	-94	-29	-18	-89	-80	-70	-26	325	583	756	-10	1164

Table F.111

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 16

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-203	-196	-195	0	-240	-252	-209	-104	789	2241	1493	-37	3090
1976	-171	-190	0	0	-246	-249	-193	-106	618	935	270	-20	646
1977	-210	-197	-200	-209	-245	-258	-187	-140	783	1476	1440	-46	2009
1978	-225	-221	-213	-191	-253	0	-211	-118	734	839	1069	-19	1191
1979	-163	-197	-227	-214	-201	-264	-206	-110	351	0	1644	-27	616
1980	-185	-220	0	0	0	0	0	0	0	1992	1725	-29	3284
1981	-196	-194	0	0	-219	-245	-138	-102	617	1411	0	-35	900
1982	-216	-261	0	0	-264	-247	-196	-103	780	2184	2027	-36	3669
1983	-260	-219	0	0	0	0	0	0	0	0	0	0	-479
1984	0	-255	0	0	0	0	0	0	0	0	1446	0	1191
1985	0	0	0	0	0	0	-193	-130	790	2281	2101	0	4848
1986	-251	-235	0	0	0	0	0	0	0	0	0	0	-486
1987	0	0	0	0	0	0	0	0	0	0	1620	0	1620
1988	-200	0	0	0	0	-250	-176	-138	745	2045	1854	-38	3842
1989	-150	-265	0	0	-252	-241	-174	-78	784	0	1791	0	1419
1990	-250	-241	-217	0	-258	-264	-203	-131	764	1323	1912	-25	2410
1991	-184	-211	0	0	-256	-254	-169	0	0	834	948	-24	702
1992	-158	-248	0	0	-262	0	-192	-84	775	1230	1373	-34	2403
1993	-224	-237	0	0	-170	0	-203	-118	785	0	427	0	260
1994	0	0	0	0	-217	-261	-187	-111	767	0	2051	-42	2002
Average	-162	-179	-53	-31	-134	-139	-142	-79	516	940	1260	-20	1757

Table F.112

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 17

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-511	-472	-469	0	-576	-608	-532	-413	1462	5253	3008	-240	5903
1976	-415	-458	0	0	-592	-600	-498	-417	1154	2209	547	-124	808
1977	-523	-476	-481	-503	-585	-622	-474	-426	1456	3631	2898	-248	3647
1978	-547	-534	-513	-458	-609	0	-537	-417	1369	2082	2135	-129	1862
1979	-397	-476	-546	-514	-484	-636	-529	-418	1073	0	3308	-171	211
1980	-449	-531	0	0	0	0	0	0	0	5088	3585	-170	7524
1981	-475	-468	0	0	-528	-590	-513	-422	1150	3294	0	-168	1281
1982	-523	-632	0	0	-636	-594	-501	-401	1450	5147	4079	-203	7186
1983	-631	-527	0	0	0	0	0	0	0	0	0	0	-1159
1984	0	-615	0	0	0	0	0	0	0	0	2909	0	2294
1985	0	0	0	0	0	0	-528	-422	1466	5331	4227	0	10074
1986	-628	-566	0	0	0	0	0	0	0	0	0	0	-1194
1987	0	0	0	0	0	0	0	0	0	0	3261	0	3261
1988	-501	0	0	0	0	-601	-477	-401	1391	4779	3734	-236	7688
1989	-533	-635	0	0	-606	-579	-520	-377	1455	0	3603	0	1808
1990	-611	-581	-522	0	-621	-635	-542	-431	1423	3210	3849	-161	4378
1991	-464	-510	0	0	-617	-613	-472	0	0	2003	1915	-140	1102
1992	-393	-598	0	0	-631	0	-538	-359	1438	1230	2766	-194	2721
1993	-547	-573	0	0	-415	0	-551	-428	1459	0	427	0	-628
1994	0	0	0	0	-521	-636	-548	-429	1429	0	4134	-202	3228
Average	-407	-453	-127	-74	-371	-356	-388	-288	959	2163	2520	-119	3100

Table F.113

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 18

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-455	-444	-418	0	-507	-543	-487	-404	1740	6137	3547	-217	7948
1976	-402	-452	0	0	-536	-539	-472	-407	1381	2588	652	-104	1709
1977	-467	-462	-427	-447	-533	-548	-462	-413	1730	4263	3413	-220	5428
1978	-483	-469	-478	-400	-543	0	-490	-407	1644	2445	2543	-107	3255
1979	-379	-446	-479	-448	-422	-555	-486	-408	1306	0	3894	-140	1436
1980	-397	-461	0	0	0	0	0	0	0	5983	4241	-145	9220
1981	-432	-431	0	0	-466	-534	-476	-409	1374	3825	0	-149	2299
1982	-458	-553	0	0	-555	-537	-472	-400	1724	6031	4805	-170	9416
1983	-551	-496	0	0	0	0	0	0	0	0	0	0	-1046
1984	0	-545	0	0	0	0	0	0	0	0	3422	0	2877
1985	0	0	0	0	0	0	-486	-411	1738	6203	4971	0	12014
1986	-550	-524	0	0	0	0	0	0	0	0	0	0	-1074
1987	0	0	0	0	0	0	0	0	0	0	3834	0	3834
1988	-457	0	0	0	0	-527	-445	-383	1665	5380	4393	-196	9450
1989	-506	-553	0	0	-529	-506	-478	-372	1727	0	4240	0	2023
1990	-540	-530	-455	0	-548	-555	-492	-415	1700	3775	4566	-149	6358
1991	-435	-445	0	0	-546	-544	-434	0	0	2346	2268	-117	2092
1992	-353	-525	0	0	-553	0	-489	-355	1711	1230	3256	-166	3761
1993	-492	-526	0	0	-363	0	-496	-413	1732	0	427	0	-131
1994	0	0	0	0	-455	-555	-494	-411	1706	0	4878	-170	4497
Average	-367	-393	-115	-65	-328	-297	-358	-280	1144	2510	2967	-102	4318

Table F.114

Permanent Acquisition of Agricultural Water Rights OR Temporary Leasing of Agricultural Water Supplies - Reach 19

Reduction to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-429	-434	-413	0	-449	-467	-445	-414	1468	5005	3684	-269	6839
1976	-420	-446	0	0	-467	-467	-444	-414	1318	3589	2450	-196	4504
1977	-434	-447	-416	-425	-467	-466	-445	-416	1461	4261	3626	-269	5564
1978	-439	-432	-448	-402	-466	0	-445	-414	1431	3533	3257	-197	4979
1979	-406	-434	-437	-422	-411	-467	-444	-415	1299	0	3830	-214	1478
1980	-403	-427	0	0	0	0	0	0	0	4950	3983	-221	7882
1981	-423	-424	0	0	-432	-466	-442	-414	1314	4077	0	-227	2563
1982	-427	-466	0	0	-467	-467	-442	-415	1459	4966	4219	-234	7727
1983	-465	-457	0	0	0	0	0	0	0	0	0	0	-922
1984	0	-466	0	0	0	0	0	0	0	0	3629	0	3162
1985	0	0	0	0	0	0	-445	-416	1464	5026	4288	0	9916
1986	-466	-466	0	0	0	0	0	0	0	0	0	0	-933
1987	0	0	0	0	0	0	0	0	0	0	3804	0	3804
1988	-417	0	0	0	0	-456	-429	-398	1437	4763	4043	-248	8295
1989	-464	-466	0	0	-456	-446	-441	-398	1460	0	3978	0	2767
1990	-464	-466	-425	0	-467	-467	-444	-416	1451	4067	4133	-229	6273
1991	-429	-421	0	0	-467	-466	-421	0	0	3493	3141	-203	4227
1992	-386	-453	0	0	-467	0	-444	-389	1454	1230	3559	-232	3872
1993	-447	-466	0	0	-386	0	-445	-415	1462	0	427	0	-269
1994	0	0	0	0	-425	-467	-444	-413	1453	0	4252	-234	3722
Average	-346	-359	-107	-62	-291	-255	-331	-287	997	2448	3015	-149	4273

Table F.115
Dry Year Leasing - Reach 1
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	40	0	0	0	0	0	19	118	234	307	250	132	1100
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	40	0	0	0	0	0	19	118	234	307	250	132	1100
1978	40	0	0	0	0	0	19	118	234	307	250	132	1100
1979	40	0	0	0	0	0	19	118	234	307	250	132	1100
1980	40	0	0	0	0	0	19	118	234	307	250	132	1100
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	40	0	0	0	0	0	19	118	234	307	250	132	1100
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	40	0	0	0	0	0	19	118	234	307	250	132	1100
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	14	0	0	0	0	0	7	41	82	107	88	46	385

Table F.116
Dry Year Leasing - Reach 2
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	105	0	0	0	0	0	26	250	571	801	708	339	2800
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	105	0	0	0	0	0	26	250	571	801	708	339	2800
1978	105	0	0	0	0	0	26	250	571	801	708	339	2800
1979	105	0	0	0	0	0	26	250	571	801	708	339	2800
1980	105	0	0	0	0	0	26	250	571	801	708	339	2800
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	105	0	0	0	0	0	26	250	571	801	708	339	2800
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	105	0	0	0	0	0	26	250	571	801	708	339	2800
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	37	0	0	0	0	0	9	88	200	280	248	119	980

Table F.117
Dry Year Leasing - Reach 3
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	42	0	0	0	0	0	10	95	218	313	285	136	1100
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	42	0	0	0	0	0	10	95	218	313	285	136	1100
1978	42	0	0	0	0	0	10	95	218	313	285	136	1100
1979	42	0	0	0	0	0	10	95	218	313	285	136	1100
1980	42	0	0	0	0	0	10	95	218	313	285	136	1100
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	42	0	0	0	0	0	10	95	218	313	285	136	1100
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	42	0	0	0	0	0	10	95	218	313	285	136	1100
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	15	0	0	0	0	0	3	33	76	109	100	48	385

Table F.118
Dry Year Leasing - Reach 4
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	0	0	0	0	0	12	92	187	296	269	140	1050
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	54	0	0	0	0	0	12	92	187	296	269	140	1050
1978	54	0	0	0	0	0	12	92	187	296	269	140	1050
1979	54	0	0	0	0	0	12	92	187	296	269	140	1050
1980	54	0	0	0	0	0	12	92	187	296	269	140	1050
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	54	0	0	0	0	0	12	92	187	296	269	140	1050
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	54	0	0	0	0	0	12	92	187	296	269	140	1050
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	19	0	0	0	0	0	4	32	65	104	94	49	368

Table F.119
Dry Year Leasing - Reach 5
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1978	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1979	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1980	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	47	-210	-217	-221	-222	-221	-186	25	478	1223	1214	454	2164
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	16	-74	-76	-77	-78	-77	-65	9	167	428	425	159	757

Table F.120
Dry Year Leasing - Reach 6
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	97	0	0	0	0	0	22	205	445	587	518	277	2150
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	97	0	0	0	0	0	22	205	445	587	518	277	2150
1978	97	0	0	0	0	0	22	205	445	587	518	277	2150
1979	97	0	0	0	0	0	22	205	445	587	518	277	2150
1980	97	0	0	0	0	0	22	205	445	587	518	277	2150
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	97	0	0	0	0	0	22	205	445	587	518	277	2150
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	97	0	0	0	0	0	22	205	445	587	518	277	2150
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	34	0	0	0	0	0	8	72	156	205	181	97	753

Table F.121
Dry Year Leasing - Reach 7
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1978	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1979	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1980	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-167	-176	-180	-183	-184	-183	-102	38	615	1163	944	67	1653
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-58	-62	-63	-64	-64	-64	-36	13	215	407	330	23	578

Table F.122
Dry Year Leasing - Reach 8
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1978	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1979	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1980	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-1241	-1288	-1295	-1305	-1316	-1313	-692	297	4759	8784	7058	421	12870
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-434	-451	-453	-457	-460	-460	-242	104	1666	3075	2470	148	4504

Table F.123
Dry Year Leasing - Reach 9
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1978	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1979	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1980	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-1214	-1209	-1120	-1032	-948	-879	-356	159	2957	6281	4887	83	7608
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-425	-423	-392	-361	-332	-308	-125	56	1035	2198	1710	29	2663

Table F.124
Dry Year Leasing - Reach 10
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1978	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1979	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1980	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-338	-284	-240	-209	-185	-167	-114	-62	543	1440	1173	-247	1311
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-118	-99	-84	-73	-65	-58	-40	-22	190	504	410	-87	459

Table F.125
Dry Year Leasing - Reach 11
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	33	83	385	628	521	0	1650
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	33	83	385	628	521	0	1650
1978	0	0	0	0	0	0	33	83	385	628	521	0	1650
1979	0	0	0	0	0	0	33	83	385	628	521	0	1650
1980	0	0	0	0	0	0	33	83	385	628	521	0	1650
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	33	83	385	628	521	0	1650
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	33	83	385	628	521	0	1650
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	12	29	135	220	182	0	578

Table F.126
Dry Year Leasing - Reach 12
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1978	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1979	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1980	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	176	-1143	-1141	-1140	-1142	-1145	-1013	-402	1771	6086	6704	2116	9729
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	62	-400	-399	-399	-400	-401	-355	-141	620	2130	2347	741	3405

Table F.127
Dry Year Leasing - Reach 13
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1978	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1979	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1980	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	19	-819	-847	-850	-835	-812	-706	-326	940	3415	3818	1217	4214
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	7	-287	-296	-298	-292	-284	-247	-114	329	1195	1336	426	1475

Table F.128
Dry Year Leasing - Reach 14
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1978	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1979	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1980	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-228	-152	-115	-95	-80	-71	-24	20	507	1165	864	-256	1536
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-80	-53	-40	-33	-28	-25	-8	7	178	408	302	-90	538

Table F.129
Dry Year Leasing - Reach 15
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1978	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1979	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1980	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-170	-170	-170	-171	-173	-174	-140	-101	523	1480	1314	-64	1984
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-60	-59	-60	-60	-60	-61	-49	-35	183	518	460	-22	694

Table F.130
Dry Year Leasing - Reach 16
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1978	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1979	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1980	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-266	-266	-266	-267	-267	-267	-221	-169	822	2413	2197	-76	3367
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-93	-93	-93	-93	-93	-93	-77	-59	288	845	769	-27	1178

Table F.131
Dry Year Leasing - Reach 17
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1978	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1979	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1980	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-641	-640	-640	-639	-639	-639	-558	-449	1511	5592	4384	-291	6350
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-224	-224	-224	-224	-224	-224	-195	-157	529	1957	1535	-102	2223

Table F.132
Dry Year Leasing - Reach 18
Net Hydrologic Effects
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1978	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1979	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1980	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-557	-557	-557	-557	-557	-557	-502	-426	1779	6443	5114	-240	8827
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-195	-195	-195	-195	-195	-195	-176	-149	623	2255	1790	-84	3090

Table F.133
Dry Year Leasing - Reach 19
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1978	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1979	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1980	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-467	-467	-468	-468	-468	-468	-447	-419	1479	5110	4341	-272	6987
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-164	-164	-164	-164	-164	-164	-156	-146	518	1788	1519	-95	2445

Table F.134
Dry Year Leasing - Reach 1
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	8	0	0	0	0	0	6	2	10	1	1	2	30
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	5	0	0	0	0	0	2	3	2	0	1	3	16
1978	18	0	0	0	0	0	1	5	1	0	0	0	26
1979	6	0	0	0	0	0	1	1	7	0	1	1	16
1980	2	0	0	0	0	0	0	0	0	0	1	1	4
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	17	0	0	0	0	0	1	7	1	0	1	1	28
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	21	0	0	0	0	0	0	3	5	0	3	0	32
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	4	0	0	0	0	0	1	1	1	0	0	0	8

Table F.135
Dry Year Leasing - Reach 2
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	21	0	0	0	0	0	8	5	23	3	2	6	69
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	14	0	0	0	0	0	3	6	5	1	2	7	39
1978	48	0	0	0	0	0	2	11	3	1	1	1	67
1979	16	0	0	0	0	0	1	3	17	0	2	2	41
1980	5	0	0	0	0	0	0	0	0	1	2	4	12
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	46	0	0	0	0	0	2	14	1	0	3	3	69
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	57	0	0	0	0	0	0	3	13	0	10	0	84
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	10	0	0	0	0	0	1	2	3	0	1	1	19

Table F.136
Dry Year Leasing - Reach 3
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	9	0	0	0	0	0	3	2	9	1	1	2	27
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	6	0	0	0	0	0	1	3	2	0	1	3	16
1978	20	0	0	0	0	0	1	4	1	0	0	1	27
1979	7	0	0	0	0	0	1	1	7	0	1	1	16
1980	2	0	0	0	0	0	0	0	0	0	1	2	5
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	19	0	0	0	0	0	1	5	1	0	1	1	25
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	24	0	0	0	0	0	0	1	5	0	4	0	34
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	4	0	0	0	0	0	0	1	1	0	0	0	8

Table F.137
Dry Year Leasing - Reach 4
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	11	0	0	0	0	0	4	2	8	1	1	2	29
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	7	0	0	0	0	0	2	2	2	0	1	3	18
1978	26	0	0	0	0	0	1	4	1	0	0	1	33
1979	8	0	0	0	0	0	1	1	6	0	1	1	17
1980	3	0	0	0	0	0	0	0	0	0	1	2	6
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	24	0	0	0	0	0	1	5	0	0	1	1	33
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	30	0	0	0	0	0	0	1	4	0	4	0	40
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	5	0	0	0	0	0	0	1	1	0	0	0	9

Table F.138
Dry Year Leasing - Reach 5
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	26	-108	-126	0	-150	-161	-119	3	52	14	14	55	-500
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	22	-96	-119	-117	-138	-147	-110	3	18	5	13	50	-614
1978	22	-105	-121	-143	-189	0	-100	2	10	5	6	12	-601
1979	15	-88	-133	-132	-111	-164	-97	2	37	0	10	19	-642
1980	13	-89	0	0	0	0	0	0	0	3	14	32	-28
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	21	-118	-122	0	-153	-152	-117	4	7	2	20	13	-596
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	27	-132	0	0	-115	0	-108	2	42	0	62	0	-222
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	7	-37	-31	-20	-43	-31	-33	1	8	1	7	9	-160

Table F.139
Dry Year Leasing - Reach 6
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	54	0	0	0	0	0	14	17	39	6	5	27	160
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	45	0	0	0	0	0	13	20	13	2	5	24	123
1978	46	0	0	0	0	0	11	18	7	2	2	6	93
1979	32	0	0	0	0	0	11	13	28	0	4	8	96
1980	26	0	0	0	0	0	0	0	0	1	5	15	48
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	43	0	0	0	0	0	13	11	3	1	6	9	85
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	54	0	0	0	0	0	12	11	36	0	22	0	135
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	15	0	0	0	0	0	4	4	6	1	2	4	37

Table F.140
Dry Year Leasing - Reach 7
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-6	-4	-12	0	-33	-23	-14	1	81	1	1	1	-6
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-1	-1	-6	-10	-5	-20	-4	1	1	0	1	0	-43
1978	-2	-1	-1	-3	-4	0	-3	0	2	0	0	0	-15
1979	-1	-1	-3	-15	-20	-4	-5	2	122	0	8	1	84
1980	-3	-10	0	0	0	0	0	0	0	0	0	1	-12
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-1	-1	-9	0	-46	-48	-27	0	1	0	1	0	-128
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-6	-5	0	0	-43	0	-12	0	4	0	2	0	-59
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-1	-1	-2	-2	-7	-3	-3	0	11	0	1	0	-9

Table F.141
Dry Year Leasing - Reach 8
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-211	-290	-313	0	-459	-587	-187	18	971	24	26	18	-989
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-124	-257	-338	-344	-379	-382	-138	17	103	11	20	13	-1798
1978	-138	-282	-305	-332	-421	0	-48	5	46	5	4	1	-1466
1979	-55	-120	-223	-342	-279	-257	-101	27	1294	0	91	15	50
1980	-90	-173	0	0	0	0	0	0	0	12	11	13	-227
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-76	-79	-175	0	-503	-485	-269	11	30	3	33	4	-1506
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-269	-293	0	0	-415	0	-161	8	111	0	61	0	-959
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-48	-75	-68	-51	-123	-86	-45	4	128	3	12	3	-345

Table F.142
Dry Year Leasing - Reach 9
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-484	-535	-467	0	-498	-678	-164	29	875	172	154	16	-1580
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-383	-488	-550	-487	-523	-412	-141	31	257	80	132	20	-2466
1978	-365	-533	-540	-540	-605	0	-127	16	89	57	65	5	-2476
1979	-201	-349	-499	-505	-299	-400	-122	28	1049	0	116	9	-1173
1980	-197	-256	0	0	0	0	0	0	0	50	133	10	-260
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-303	-361	-382	0	-500	-444	-196	30	133	39	197	4	-1783
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-543	-582	0	0	-405	0	-136	19	520	0	427	0	-901
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-124	-155	-122	-77	-141	-97	-44	8	136	20	61	3	-532

Table F.143
Dry Year Leasing - Reach 10
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-191	-139	-120	0	-112	-127	-71	-21	207	80	81	-94	-507
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-166	-125	-126	-105	-109	-96	-62	-22	84	38	72	-118	-736
1978	-158	-136	-128	-128	-141	0	-69	-13	32	29	33	-32	-711
1979	-102	-117	-142	-120	-77	-108	-57	-15	222	0	45	-41	-511
1980	-90	-91	0	0	0	0	0	0	0	23	70	-59	-148
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-149	-149	-126	0	-115	-104	-74	-24	53	22	116	-27	-578
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-207	-168	0	0	-91	0	-60	-14	118	0	262	0	-159
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-33	-46	-32	-18	-32	-22	-20	-5	36	10	34	-19	-168

Table F.144
Dry Year Leasing - Reach 11
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	4	1	36	0	1	0	42
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	1	1	1	0	0	0	3
1978	0	0	0	0	0	0	1	0	1	0	0	0	2
1979	0	0	0	0	0	0	1	3	63	0	3	0	70
1980	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	8	1	1	0	1	0	10
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	3	1	2	0	1	0	7
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	1	0	5	0	0	0	7

Table F.145
Dry Year Leasing - Reach 12
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	100	-589	-663	0	-773	-838	-660	-67	334	153	198	453	-2353
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	85	-522	-630	-607	-713	-768	-620	-94	128	66	188	438	-3050
1978	88	-574	-639	-742	-977	0	-562	-30	59	60	73	98	-3166
1979	59	-481	-704	-684	-574	-855	-539	-53	271	0	120	155	-3287
1980	50	-487	0	0	0	0	0	0	0	40	186	261	49
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	82	-645	-645	0	-792	-798	-651	-109	62	31	279	123	-3063
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	113	-723	0	0	-596	0	-601	-50	240	0	427	0	-1191
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	29	-201	-164	-102	-223	-163	-182	-21	55	17	74	76	-403

Table F.146
Dry Year Leasing - Reach 13
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	11	-424	-494	0	-568	-598	-468	-69	240	139	198	360	-1673
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	10	-376	-469	-454	-524	-548	-446	-104	97	70	172	355	-2216
1978	10	-413	-476	-555	-718	0	-403	-47	40	55	65	76	-2366
1979	6	-346	-524	-511	-421	-610	-381	-55	213	0	104	114	-2411
1980	6	-350	0	0	0	0	0	0	0	39	177	203	75
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	9	-466	-485	0	-583	-571	-464	-103	52	38	275	107	-2190
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	13	-521	0	0	-439	0	-429	-59	171	0	427	0	-837
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	3	-145	-122	-76	-163	-116	-130	-22	41	17	71	61	-581

Table F.147
Dry Year Leasing - Reach 14
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-139	-79	-67	0	-55	-52	-16	6	178	61	60	-97	-202
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-120	-70	-64	-51	-51	-48	-15	8	72	31	52	-108	-363
1978	-122	-77	-65	-62	-69	0	-14	4	30	23	21	-26	-356
1979	-78	-65	-71	-57	-41	-53	-13	4	174	0	32	-35	-204
1980	-71	-65	0	0	0	0	0	0	0	18	51	-58	-126
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-112	-87	-67	0	-56	-50	-16	8	45	18	88	-30	-259
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-160	-97	0	0	-42	0	-15	4	114	0	168	0	-28
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-40	-27	-17	-8	-16	-10	-4	2	31	8	24	-18	-77

Table F.148
Dry Year Leasing - Reach 15
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-115	-106	-112	0	-137	-147	-116	-35	244	126	114	-19	-303
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-112	-102	-111	-113	-133	-143	-104	-37	121	63	81	-29	-638
1978	-117	-113	-116	-117	-157	0	-108	-36	41	41	53	-6	-635
1979	-82	-99	-125	-120	-109	-152	-103	-31	265	0	58	-9	-507
1980	-86	-106	0	0	0	0	0	0	0	38	103	-13	-67
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-121	-125	-119	0	-144	-147	-110	-52	54	59	160	-8	-572
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-132	-130	0	0	-100	0	-103	-34	119	0	252	0	-129
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-38	-39	-29	-18	-39	-29	-32	-12	42	15	41	-4	-143

Table F.149
Dry Year Leasing - Reach 16
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-203	-196	-195	0	-240	-252	-209	-104	587	1082	770	-37	1004
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-210	-197	-200	-209	-243	-258	-187	-140	486	688	723	-46	208
1978	-225	-221	-213	-191	-253	0	-211	-118	358	408	519	-19	-166
1979	-163	-197	-227	-214	-201	-264	-206	-110	519	0	823	-27	-267
1980	-185	-220	0	0	0	0	0	0	0	866	845	-29	1277
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-250	-241	-217	0	-238	-264	-203	-131	397	637	989	-23	434
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-224	-237	0	0	-170	0	-205	-118	465	0	427	0	-59
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-73	-75	-53	-31	-68	-52	-61	-36	141	184	255	-9	122

Table F.150
Dry Year Leasing - Reach 17
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-511	-472	-469	0	-576	-608	-532	-413	1411	4431	2672	-240	4693
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-523	-477	-481	-503	-585	-622	-474	-426	1357	2905	2680	-248	2604
1978	-547	-534	-513	-459	-609	0	-537	-417	1197	1717	1862	-129	1032
1979	-397	-476	-546	-514	-484	-636	-529	-418	1056	0	3105	-171	-10
1980	-449	-531	0	0	0	0	0	0	0	3869	3001	-170	5720
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-611	-581	-522	0	-621	-633	-542	-431	1329	2783	3432	-161	3439
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-547	-573	0	0	-413	0	-551	-428	1418	0	427	0	-670
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-179	-182	-127	-74	-163	-125	-158	-127	388	785	859	-56	840

Table F.151
Dry Year Leasing - Reach 18
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-455	-444	-418	0	-507	-543	-487	-404	1710	5660	3349	-217	7244
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-467	-462	-427	-447	-533	-548	-462	-413	1671	3841	3286	-220	4820
1978	-483	-469	-478	-400	-543	0	-490	-407	1542	2231	2372	-107	2769
1979	-379	-446	-479	-448	-422	-555	-486	-408	1296	0	3773	-140	1307
1980	-397	-461	0	0	0	0	0	0	0	5273	3897	-145	8167
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-540	-570	-455	0	-548	-555	-492	-415	1644	3526	4322	-149	5769
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-492	-526	0	0	-363	0	-496	-413	1708	0	427	0	-155
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-161	-167	-113	-65	-146	-110	-146	-123	479	1027	1071	-49	1498

Table F.152
Dry Year Leasing - Reach 19
Reduction to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-429	-434	-413	0	-449	-467	-445	-414	1468	5005	3684	-269	6839
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-434	-447	-416	-425	-467	-467	-445	-416	1461	4261	3626	-269	5563
1978	-439	-432	-448	-402	-466	0	-445	-414	1431	3533	3257	-197	4979
1979	-406	-434	-437	-422	-411	-467	-444	-415	1299	0	3830	-214	1478
1980	-403	-427	0	0	0	0	0	0	0	4950	3983	-221	7882
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-464	-466	-425	0	-467	-467	-444	-416	1451	4067	4133	-229	6273
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-447	-466	0	0	-386	0	-445	-415	1462	0	427	0	-269
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-151	-155	-107	-62	-132	-93	-133	-125	429	1091	1147	-70	1637

Table F.153
Dry Year Leasing - Reach 1
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	30	0	0	0	0	0	17	103	206	259	146	102	863
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	31	0	0	0	0	0	15	102	184	146	146	100	723
1978	31	0	0	0	0	0	16	100	184	91	109	50	581
1979	23	0	0	0	0	0	16	102	150	0	173	67	531
1980	25	0	0	0	0	0	0	0	0	207	167	69	468
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	34	0	0	0	0	0	16	102	149	126	194	68	689
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	31	0	0	0	0	0	17	103	201	0	223	0	574
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	10	0	0	0	0	0	5	31	54	41	58	23	221

Table F.154
Dry Year Leasing - Reach 2
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	80	0	0	0	0	0	24	219	503	680	422	268	2196
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	84	0	0	0	0	0	21	219	453	398	429	268	1872
1978	83	0	0	0	0	0	23	214	451	240	313	132	1456
1979	62	0	0	0	0	0	23	217	367	0	497	176	1341
1980	67	0	0	0	0	0	0	0	0	546	488	181	1282
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	92	0	0	0	0	0	23	218	366	333	562	178	1771
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	82	0	0	0	0	0	23	220	492	0	427	0	1245
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	28	0	0	0	0	0	7	65	132	110	157	60	558

Table F.155
Dry Year Leasing - Reach 3
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	33	0	0	0	0	0	9	84	194	269	176	109	875
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	34	0	0	0	0	0	8	85	182	163	175	111	759
1978	34	0	0	0	0	0	9	82	177	95	129	54	580
1979	25	0	0	0	0	0	9	84	142	0	202	72	534
1980	28	0	0	0	0	0	0	0	0	217	201	74	520
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	38	0	0	0	0	0	9	84	144	140	229	74	718
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	34	0	0	0	0	0	9	84	189	0	258	0	575
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	11	0	0	0	0	0	3	25	51	44	69	25	228

Table F.156
Dry Year Leasing - Reach 4
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	42	0	0	0	0	0	11	82	168	258	172	113	847
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	44	0	0	0	0	0	10	83	164	161	167	116	745
1978	44	0	0	0	0	0	11	80	155	91	124	56	562
1979	32	0	0	0	0	0	11	82	123	0	192	75	516
1980	35	0	0	0	0	0	0	0	0	209	194	76	515
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	49	0	0	0	0	0	11	83	127	143	219	77	709
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	43	0	0	0	0	0	11	82	163	0	247	0	547
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	14	0	0	0	0	0	3	25	45	43	66	26	222

Table F.157
Dry Year Leasing - Reach 5
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	36	-108	-126	0	-150	-161	-119	22	432	1074	782	370	2054
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	38	-96	-119	-117	-138	-147	-110	23	424	669	759	381	1567
1978	38	-105	-121	-143	-189	0	-100	22	401	380	564	184	932
1979	28	-88	-133	-132	-111	-164	-97	22	318	0	871	245	758
1980	31	-89	0	0	0	0	0	0	0	869	881	249	1941
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	43	-118	-122	0	-153	-152	-117	23	368	593	992	254	1609
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	38	-132	0	0	-115	0	-108	22	420	0	427	0	552
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	13	-37	-31	-20	-43	-31	-33	7	118	179	264	84	471

Table F.158
Dry Year Leasing - Reach 6
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	75	0	0	0	0	0	20	183	401	514	332	225	1751
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	79	0	0	0	0	0	18	185	393	320	323	232	1549
1978	80	0	0	0	0	0	19	177	372	182	240	112	1182
1979	58	0	0	0	0	0	20	183	295	0	370	149	1075
1980	63	0	0	0	0	0	0	0	0	416	375	152	1005
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	88	0	0	0	0	0	19	175	290	281	393	153	1399
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	78	0	0	0	0	0	20	182	390	0	427	0	1096
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	26	0	0	0	0	0	6	54	107	86	123	51	453

Table F.159
Dry Year Leasing - Reach 7
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-6	-4	-12	0	-33	-23	-14	35	563	1012	605	31	2174
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-1	-1	-6	-10	-5	-20	-4	35	550	619	583	35	1796
1978	-2	-1	-1	-3	-4	0	-3	33	503	346	425	26	1318
1979	-1	-1	-3	-13	-20	-4	-5	23	296	0	673	36	982
1980	-3	-10	0	0	0	0	0	0	0	817	668	36	1507
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-1	-1	-9	0	-46	-48	-27	36	533	571	772	38	1818
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-6	-5	0	0	-43	0	-12	35	553	0	427	0	950
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-1	-1	-2	-2	-7	-5	-3	10	150	168	208	12	527

Table F.160
Dry Year Leasing - Reach 8
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-211	-290	-313	0	-459	-587	-187	271	4383	7703	4549	333	15191
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-124	-257	-338	-344	-379	-382	-138	274	4295	4726	4393	353	12078
1978	-138	-282	-305	-332	-421	0	-48	265	3958	2640	3202	167	8706
1979	-55	-120	-223	-342	-279	-257	-101	229	2787	0	5078	228	6944
1980	-90	-173	0	0	0	0	0	0	0	6216	5023	230	11207
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-76	-79	-175	0	-503	-485	-269	279	4155	4346	5805	241	13239
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-269	-293	0	0	-415	0	-161	272	4306	0	427	0	3867
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-48	-75	-68	-51	-123	-86	-45	79	1194	1282	1424	78	3562

Table F.161
Dry Year Leasing - Reach 9
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-484	-535	-467	0	-498	-678	-164	147	2753	5574	3185	68	8902
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-383	-488	-550	-487	-523	-412	-141	149	2709	3447	3080	70	6470
1978	-363	-533	-540	-540	-605	0	-127	147	2520	1918	2246	33	4154
1979	-201	-349	-499	-505	-299	-400	-122	149	2049	0	3550	45	3419
1980	-197	-256	0	0	0	0	0	0	0	4508	3516	46	7617
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-303	-361	-382	0	-300	-444	-196	151	2618	3148	4062	48	7841
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-343	-582	0	0	-405	0	-136	148	2705	0	427	0	1614
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-124	-155	-122	-77	-141	-97	-44	44	768	930	1003	16	2001

Table F.162
Dry Year Leasing - Reach 10
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-191	-139	-120	0	-112	-127	-71	-21	513	1306	780	-94	1724
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-166	-125	-126	-105	-109	-96	-62	-22	507	816	754	-118	1147
1978	-158	-136	-128	-128	-141	0	-69	-13	473	436	555	-32	679
1979	-102	-117	-142	-120	-77	-108	-57	-15	380	0	864	-41	466
1980	-90	-91	0	0	0	0	0	0	0	1060	868	-59	1687
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-149	-149	-126	0	-115	-104	-74	-24	492	743	996	-27	1462
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-207	-168	0	0	-91	0	-60	-14	506	0	427	0	394
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-53	-46	-32	-18	-32	-22	-20	-5	144	219	262	-19	378

Table F.163
Dry Year Leasing - Reach 11
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	31	75	352	548	334	0	1340
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	27	76	344	335	322	0	1105
1978	0	0	0	0	0	0	31	72	315	187	235	0	840
1979	0	0	0	0	0	0	31	50	185	0	373	0	639
1980	0	0	0	0	0	0	0	0	0	442	369	0	811
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	31	77	334	309	426	0	1177
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	0	0	0	0	0	0	31	75	346	0	427	0	880
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	0	0	0	0	0	0	9	21	94	91	124	0	340

Table F.164
Dry Year Leasing - Reach 12
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	138	-589	-663	0	-773	-838	-660	-67	1618	5388	4350	1737	9641
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	145	-522	-630	-607	-713	-768	-620	-94	1592	3355	4223	1793	7154
1978	147	-574	-639	-742	-977	0	-562	-50	1502	1908	3134	865	4012
1979	108	-481	-704	-684	-574	-855	-539	-53	1189	0	4842	1149	3399
1980	117	-487	0	0	0	0	0	0	0	4359	4897	1170	10056
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	163	-645	-645	0	-792	-798	-651	-109	1522	2978	5515	1195	7734
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	143	-723	0	0	-596	0	-601	-50	1576	0	427	0	176
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	48	-201	-164	-102	-223	-163	-182	-21	450	899	1369	395	2109

Table F.165
Dry Year Leasing - Reach 13
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	15	-424	-494	0	-568	-598	-468	-69	872	3075	2519	1010	4870
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	16	-376	-469	-454	-524	-548	-446	-104	861	1923	2439	1044	3362
1978	16	-413	-476	-555	-718	0	-403	-47	809	1086	1808	503	1609
1979	12	-346	-524	-511	-421	-610	-381	-55	641	0	2789	667	1260
1980	13	-350	0	0	0	0	0	0	0	2493	2828	680	3664
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	18	-466	-485	0	-583	-571	-464	-103	829	1729	3204	706	3815
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	16	-521	0	0	-419	0	-429	-59	855	0	427	0	-150
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	5	-145	-122	-76	-163	-116	-130	-22	243	515	801	231	1021

Table F.166
Dry Year Leasing - Reach 14
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-139	-79	-67	0	-55	-52	-16	19	478	1066	580	-97	1638
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-120	-70	-64	-51	-51	-48	-15	19	474	670	560	-108	1196
1978	-122	-77	-65	-62	-69	0	-14	19	443	376	415	-26	819
1979	-78	-65	-71	-57	-41	-53	-13	19	353	0	639	-35	597
1980	-71	-65	0	0	0	0	0	0	0	866	650	-58	1322
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-112	-87	-67	0	-56	-50	-16	20	461	610	741	-30	1414
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-160	-97	0	0	-42	0	-15	19	472	0	427	0	604
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-40	-27	-17	-8	-16	-10	-4	6	134	179	201	-18	380

Table F.167
Dry Year Leasing - Reach 15
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-115	-106	-112	0	-137	-147	-116	-35	498	1365	888	-19	1964
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-112	-102	-111	-113	-133	-143	-104	-57	494	857	857	-29	1303
1978	-117	-113	-116	-117	-157	0	-108	-36	462	481	636	-6	808
1979	-82	-99	-125	-120	-109	-152	-103	-31	368	0	978	-9	516
1980	-86	-106	0	0	0	0	0	0	0	1108	995	-15	1896
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-121	-125	-119	0	-144	-147	-110	-52	485	781	1136	-8	1572
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-132	-130	0	0	-100	0	-103	-34	494	0	427	0	422
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-38	-39	-29	-13	-39	-29	-32	-12	140	230	296	-4	424

Table F.168
Dry Year Leasing - Reach 16
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-203	-196	-195	0	-240	-252	-209	-104	789	2241	1493	-37	3090
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-210	-197	-200	-209	-243	-258	-187	-140	783	1476	1440	-46	2009
1978	-225	-221	-213	-191	-253	0	-211	-118	734	839	1069	-19	1191
1979	-163	-197	-227	-214	-201	-264	-206	-110	381	0	1644	-27	616
1980	-185	-220	0	0	0	0	0	0	0	1992	1725	-29	3284
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-250	-241	-217	0	-258	-264	-203	-131	764	1323	1912	-25	2410
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-224	-237	0	0	-170	0	-203	-118	785	0	427	0	260
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-73	-75	-53	-31	-68	-52	-61	-36	222	394	486	-9	643

Table F.169
Dry Year Leasing - Reach 17
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-511	-472	-469	0	-576	-608	-532	-413	1462	5253	3008	-240	5902
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-523	-477	-481	-503	-585	-622	-474	-426	1456	3631	2898	-248	3647
1978	-547	-534	-513	-459	-609	0	-537	-417	1369	2082	2155	-129	1861
1979	-397	-476	-546	-514	-484	-636	-529	-418	1073	0	3308	-171	210
1980	-449	-531	0	0	0	0	0	0	0	3088	3585	-170	7524
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-611	-581	-522	0	-621	-635	-542	-431	1423	3210	3849	-161	4378
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-547	-573	0	0	-415	0	-551	-428	1459	0	427	0	-629
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-179	-182	-127	-74	-165	-125	-158	-127	412	963	961	-56	1145

Table F.170
Dry Year Leasing - Reach 18
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-455	-444	-418	0	-507	-543	-487	-404	1740	6137	3547	-217	7948
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-467	-462	-427	-447	-533	-548	-462	-413	1730	4263	3413	-220	5428
1978	-483	-469	-478	-400	-543	0	-490	-407	1644	2443	2543	-107	3255
1979	-379	-446	-479	-448	-422	-555	-486	-408	1306	0	3894	-140	1436
1980	-397	-461	0	0	0	0	0	0	0	5983	4241	-145	9220
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-540	-530	-455	0	-548	-555	-492	-415	1700	3775	4566	-149	6358
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-492	-526	0	0	-363	0	-496	-413	1732	0	427	0	-131
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-161	-167	-113	-65	-146	-110	-146	-123	493	1130	1132	-49	1676

Table F.171
Dry Year Leasing - Reach 19
Reduction to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	-429	-434	-413	0	-449	-467	-445	-414	1468	5005	3684	-269	6839
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	-434	-447	-416	-425	-467	-467	-445	-416	1461	4261	3626	-269	5563
1978	-439	-432	-448	-402	-466	0	-445	-414	1431	3533	3257	-197	4979
1979	-406	-434	-437	-422	-411	-467	-444	-415	1299	0	3830	-214	1478
1980	-403	-427	0	0	0	0	0	0	0	4950	3983	-221	7882
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	-464	-466	-425	0	-467	-467	-444	-416	1451	4067	4133	-229	6273
1991	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	0	0	0	0	0	0	0	0	0	0
1993	-447	-466	0	0	-386	0	-445	-415	1462	0	427	0	-269
1994	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	-151	-155	-107	-62	-132	-93	-133	-125	429	1091	1147	-70	1637

Table G.1
Middle of Reach 5: SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-5657	1606	711	411	278	202	156	125	103	-2064
1976	87	75	-4915	-2643	1975	997	627	450	342	273	226	191	-2316
1977	165	145	128	115	104	94	86	79	73	68	63	59	1178
1978	55	52	49	46	44	-5319	1620	741	443	307	234	186	-1543
1979	155	131	114	101	91	82	75	69	64	59	55	52	1047
1980	49	46	-4558	-3937	-4685	-5052	-4119	4732	2496	1641	1210	938	-11240
1981	763	638	-4	254	604	464	390	341	304	274	250	230	4508
1982	212	197	-964	-799	704	416	304	249	213	188	170	156	1047
1983	144	135	-1351	-971	-526	-678	-7289	3130	1499	946	688	533	-3739
1984	-7907	2912	-6797	-4866	-3971	-3468	-3116	5478	3086	2128	1626	1300	-13594
1985	-7259	-4874	-3853	-3319	-2945	-2689	5720	3413	2421	1879	1543	1301	-8662
1986	1128	995	-2139	-3466	-2800	-2676	-4545	4763	2676	1880	1472	1209	-1504
1987	-7308	-4845	-3826	-1433	2591	-1764	-4281	5093	2983	2150	1710	1420	-7508
1988	1222	-1338	-552	-294	-331	2023	1352	1075	910	799	719	655	6239
1989	605	563	-1983	-1220	1538	968	742	627	551	498	459	427	3776
1990	401	379	360	-1829	945	588	460	398	358	330	310	293	2992
1991	279	267	-1703	-1383	1156	676	494	406	351	313	289	268	1414
1992	252	239	-2096	-1314	1185	-1631	1169	697	512	415	357	316	102
1993	287	265	-2038	-1198	1156	-2048	1282	745	538	431	367	323	110
1994	-2153	-1524	-986	-1036	1585	940	674	537	448	388	346	312	-469
Average	-941	-277	-1856	-1742	1	-868	-397	1665	1023	756	611	314	-1511

Table G.2
Middle of Reach 5: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1416	660	382	250	183	137	81	84	3193
1976	56	54	0	0	1791	911	544	403	240	98	26	77	4201
1977	135	107	95	89	93	90	71	72	65	37	39	49	942
1978	46	42	39	32	41	0	1478	656	372	96	109	75	2985
1979	94	98	96	81	67	79	68	62	42	0	40	28	754
1980	32	37	0	0	0	0	0	0	0	1166	878	515	2628
1981	547	451	0	0	484	412	340	311	205	151	0	126	3027
1982	168	189	0	0	683	371	267	224	188	159	151	107	2508
1983	137	109	0	0	0	0	0	0	0	0	0	0	246
1984	0	2741	0	0	0	0	0	0	0	0	1033	0	3774
1985	0	0	0	0	0	0	4889	3115	2175	1667	1401	0	13248
1986	1081	854	0	0	0	0	0	0	0	0	0	0	1936
1987	0	0	0	0	0	0	0	0	0	0	1191	0	1191
1988	913	0	0	0	0	1864	1143	899	762	629	568	503	7282
1989	485	543	0	0	1426	850	645	506	485	0	351	0	5291
1990	367	333	283	0	895	562	419	364	276	160	253	164	4075
1991	176	207	0	0	1085	622	398	0	0	101	115	121	2825
1992	146	218	0	0	1141	0	1053	518	444	311	210	204	4245
1993	232	230	0	0	713	0	1186	669	473	0	338	0	3842
1994	0	0	0	0	1262	903	613	470	384	0	305	206	4143
Average	231	311	26	10	555	366	675	426	315	236	354	113	3617

Table G.3
Middle of Reach 5: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1084	518	263	29	22	2	1	12	1931
1976	27	37	0	0	1486	700	267	44	11	1	0	10	2583
1977	77	66	70	61	64	63	51	10	3	0	1	7	473
1978	26	26	27	30	37	0	872	72	9	1	1	5	1107
1979	51	55	70	61	45	61	39	6	5	0	0	2	396
1980	13	20	0	0	0	0	0	0	0	4	14	65	116
1981	268	278	0	0	388	305	93	16	2	6	0	11	1365
1982	102	128	0	0	552	297	89	9	4	1	2	17	1201
1983	64	76	0	0	0	0	0	0	0	0	0	0	140
1984	0	1956	0	0	0	0	0	0	0	0	58	0	2014
1985	0	0	0	0	0	0	2682	425	166	20	25	0	3317
1986	823	561	0	0	0	0	0	0	0	0	0	0	1385
1987	0	0	0	0	0	0	0	0	0	0	69	0	69
1988	626	0	0	0	0	1552	647	287	30	15	11	86	3254
1989	250	307	0	0	1110	697	203	14	10	0	4	0	2595
1990	181	213	203	0	652	406	289	38	5	0	5	9	2021
1991	112	186	0	0	857	443	113	0	0	1	1	12	1725
1992	47	137	0	0	930	0	593	13	19	9	3	9	1760
1993	169	167	0	0	601	0	743	47	48	0	19	0	1794
1994	0	0	0	0	1107	792	317	41	11	0	3	32	2303
Average	142	211	19	8	446	292	363	53	17	3	11	14	1577

Table G.4
Middle of Reach 5: SDF = 120 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-6349	1290	777	492	347	259	203	165	137	-2679
1976	117	101	-5602	-3520	1814	1143	771	572	445	360	301	256	-3243
1977	223	196	174	157	142	129	118	109	101	93	87	82	1611
1978	77	72	68	64	61	-6014	1331	821	537	389	303	245	-2046
1979	206	177	154	138	124	112	103	95	88	82	76	72	1426
1980	68	64	-5196	-4931	-5904	-6460	-5517	4540	2931	2046	1553	1226	-15580
1981	1010	852	104	331	737	611	524	463	414	375	344	316	6080
1982	293	273	-1037	-982	706	509	395	331	287	256	233	214	1458
1983	199	186	-1513	-1226	-735	-880	-8445	2707	1713	1169	881	697	-5246
1984	-8871	2501	-7732	-6283	-5312	-4710	-4269	3503	3708	2696	2113	1716	-18961
1985	-8004	-6199	-5111	-4483	-4023	-3697	5939	-4153	3097	2461	2050	1745	-12071
1986	1524	1350	-2248	-4037	-3561	-3465	-5635	4700	3228	2401	1931	1612	-2200
1987	-8056	-6166	-5070	-2353	2495	-1978	-5140	5169	3646	2768	2254	1897	-10535
1988	1649	-1274	-657	-380	-416	2242	1723	1423	1225	1086	984	901	8507
1989	834	778	-2138	-1524	1610	1210	977	844	751	684	633	591	5249
1990	556	527	300	-1960	953	737	610	540	491	456	429	407	4246
1991	388	372	-1880	-1708	1148	825	642	542	476	431	398	371	2005
1992	350	333	-2338	-1680	1169	-1794	1180	855	664	553	483	431	206
1993	394	365	-2269	-1544	1148	-2265	1269	906	694	572	495	439	204
1994	-2370	-1918	-1333	-1362	1626	1145	867	708	601	525	471	428	-612
Average	-971	-371	-2158	-2182	-246	-1091	-603	1766	1268	980	809	689	-2109

Table G.5
Middle of Reach 5: SDF = 120 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1137	721	437	311	235	178	106	112	3238
1976	76	72	0	0	1645	1044	669	513	312	129	35	103	4599
1977	182	145	129	122	127	124	97	99	89	51	55	68	1287
1978	63	59	53	44	57	0	1215	727	451	121	141	99	3031
1979	125	131	130	109	92	108	94	85	58	0	35	39	1026
1980	44	52	0	0	0	0	0	0	0	1454	1127	673	3350
1981	724	602	0	0	590	543	457	421	280	207	0	173	3997
1982	231	261	0	0	683	454	346	299	254	237	207	147	3101
1983	190	150	0	0	0	0	0	0	0	0	0	0	340
1984	0	2354	0	0	0	0	0	0	0	0	1342	0	3696
1985	0	0	0	0	0	0	4889	3791	2782	2184	1861	0	15507
1986	1460	1160	0	0	0	0	0	0	0	0	0	0	2620
1987	0	0	0	0	0	0	0	0	0	0	1369	0	1369
1988	1232	0	0	0	0	2066	1458	1190	1026	855	777	692	9296
1989	669	750	0	0	1492	1062	849	681	661	0	484	0	6648
1990	508	463	393	0	902	705	556	493	378	221	351	227	5199
1991	245	289	0	0	1078	759	517	0	0	139	158	167	3352
1992	203	303	0	0	1126	0	1063	635	577	414	283	278	4882
1993	319	318	0	0	708	0	1174	813	611	0	427	0	4370
1994	0	0	0	0	1294	1099	788	621	515	0	415	283	5015
Average	314	355	35	14	547	434	731	534	411	308	470	153	4307

Table G.6
Middle of Reach 5: SDF = 120 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	871	565	315	36	28	2	2	17	1835
1976	37	50	0	0	1365	802	329	56	14	1	1	14	2666
1977	104	89	96	83	88	86	70	14	4	0	1	9	645
1978	37	36	38	42	52	9	717	80	11	2	1	6	1021
1979	68	74	95	83	62	83	54	8	7	0	1	3	537
1980	18	27	0	0	0	0	0	0	0	5	18	85	153
1981	354	371	0	0	473	402	125	21	3	8	0	13	1771
1982	140	176	0	0	554	364	115	12	5	1	3	23	1394
1983	89	105	0	0	0	0	0	0	0	0	0	0	194
1984	0	1680	0	0	0	0	0	0	0	0	76	0	1756
1985	0	0	0	0	0	0	2784	517	212	26	33	0	3572
1986	1114	761	0	0	0	0	0	0	0	0	0	0	1875
1987	0	0	0	0	0	0	0	0	0	0	91	0	91
1988	844	0	0	0	0	1720	925	380	40	20	16	119	3963
1989	344	424	0	0	1161	871	267	18	14	0	6	0	3107
1990	231	295	292	0	655	509	383	78	7	1	7	12	2484
1991	136	259	0	0	852	541	147	0	0	1	1	16	1974
1992	66	190	0	0	917	0	598	16	24	13	5	12	1841
1993	232	230	0	0	597	0	735	57	62	0	25	0	1938
1994	0	0	0	0	1136	965	408	54	14	0	4	44	2625
Average	193	238	26	10	439	345	394	67	22	4	14	19	1772

Table G.7
Middle of Reach 5: SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-6590	525	614	486	381	304	248	208	176	-3648
1976	153	134	-5867	-4448	1094	1033	822	661	541	453	388	336	-4700
1977	297	264	237	215	196	179	165	153	142	132	124	116	2218
1978	109	103	97	92	87	-6261	607	686	555	445	368	310	-2803
1979	267	234	208	188	170	156	143	133	124	115	109	102	1948
1980	97	92	-5442	-5852	-7179	-8061	-7331	3152	2826	2256	1834	1514	-22095
1981	1283	1106	306	446	864	782	696	628	569	519	479	443	8120
1982	412	385	-1019	-1116	583	559	488	431	387	352	324	301	2086
1983	282	265	-1526	-1450	-1004	-1132	-9110	1517	1554	1265	1037	865	-7437
1984	-9131	1447	-8341	-7795	-7031	-6431	-5942	4312	3806	3101	2576	2172	-27257
1985	-7997	-7431	-6638	-6048	-3560	-5189	4986	4413	3653	3066	2639	2299	-17808
1986	2041	1831	-1981	-4312	-4302	-4373	-6763	3670	3382	2835	2419	2094	-3459
1987	-8020	-7384	-6564	-3800	1607	-2319	-5930	4332	3946	3327	2853	2481	-15471
1988	2202	-878	-639	-437	-494	2258	2068	1833	1638	1483	1363	1260	11658
1989	1175	1103	-1978	-1726	1467	1402	1249	1128	1031	954	892	839	7537
1990	795	756	720	-1841	864	872	799	737	687	646	614	585	6235
1991	561	539	-1834	-1951	931	905	797	713	648	598	560	527	2994
1992	501	479	-2335	-2001	917	-1852	996	943	819	722	650	593	433
1993	550	515	-2261	-1852	914	-2341	1027	979	846	739	661	600	375
1994	-2339	-2253	-1754	-1775	1349	1230	1042	901	792	710	647	594	-856
Average	-838	-435	-2331	-2603	-700	-1398	-935	1585	1412	1198	1037	910	-3097

Table G.8
Middle of Reach 5: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	463	570	452	342	275	218	134	144	2597
1976	99	96	0	0	992	944	713	593	380	162	45	136	4160
1977	242	195	175	167	175	172	136	138	126	72	77	97	1773
1978	90	84	76	63	81	0	554	607	466	138	171	125	2457
1979	162	174	174	149	126	150	131	119	82	0	78	55	1400
1980	63	74	0	0	0	0	0	0	0	1603	1331	831	3902
1981	920	781	0	0	692	695	608	571	384	286	0	243	5180
1982	325	369	0	0	565	499	427	389	341	298	288	207	3709
1983	268	214	0	0	0	0	0	0	0	0	0	0	482
1984	0	1362	0	0	0	0	0	0	0	0	1636	0	2997
1985	0	0	0	0	0	0	4583	4028	3281	2721	2396	0	17009
1986	1956	1573	0	0	0	0	0	0	0	0	0	0	3529
1987	0	0	0	0	0	0	0	0	0	0	1986	0	1986
1988	1645	0	0	0	0	2081	1749	1533	1372	1167	1076	968	11591
1989	942	1062	0	0	1361	1231	1086	911	907	0	682	0	8183
1990	726	664	566	0	818	834	728	674	529	314	501	327	6682
1991	354	418	0	0	874	833	642	0	0	192	223	237	3774
1992	291	436	0	0	883	0	897	700	712	540	382	383	5223
1993	445	448	0	0	564	0	950	879	744	0	427	0	4456
1994	0	0	0	0	1074	1181	947	790	679	0	570	393	5634
Average	426	397	50	19	433	460	730	614	514	386	600	207	4836

Table G.9
Middle of Reach 5: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	355	447	311	39	33	3	2	21	1211
1976	48	66	0	0	823	726	350	64	17	1	1	18	2113
1977	139	120	130	114	122	119	98	20	5	0	2	13	883
1978	52	51	54	60	75	0	327	67	11	2	2	8	708
1979	88	98	128	112	85	115	75	11	10	0	1	4	727
1980	26	39	0	0	0	0	0	0	0	6	21	105	197
1981	450	482	0	0	554	514	166	29	4	11	0	21	2230
1982	197	249	0	0	457	400	142	16	7	2	4	32	1506
1983	125	150	0	0	0	0	0	0	0	0	0	0	275
1984	0	972	0	0	0	0	0	0	0	0	92	0	1064
1985	0	0	0	0	0	0	2338	550	250	32	42	0	3211
1986	1491	1032	0	0	0	0	0	0	0	0	0	0	2523
1987	0	0	0	0	0	0	0	0	0	0	116	0	116
1988	1128	0	0	0	0	1732	990	489	53	28	22	166	4608
1989	485	601	0	0	1059	1010	341	25	19	0	8	0	3549
1990	359	424	407	0	596	603	501	107	10	1	10	17	3034
1991	226	376	0	0	690	594	183	0	0	1	1	23	2094
1992	94	274	0	0	720	0	505	18	30	16	6	16	1679
1993	323	324	0	0	475	0	595	62	75	0	34	0	1888
1994	0	0	0	0	943	1036	490	68	19	0	6	62	2623
Average	262	263	36	14	348	365	371	78	27	5	18	25	1812

Table G.10
Middle of Reach 7: SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-8482	2409	1067	616	417	303	233	188	155	-3094
1976	131	113	-8110	-5713	3630	1805	1125	802	607	482	398	335	-4396
1977	289	233	222	200	180	164	149	137	126	117	109	102	2049
1978	95	90	84	80	75	-8271	2527	1158	695	483	369	294	-2321
1979	245	209	182	162	145	132	120	111	102	-8113	2683	1204	-2819
1980	739	521	-7813	-5479	-4389	-3784	-3367	-3074	-2840	3554	3243	2252	-18436
1981	1726	1391	-7056	-4812	4407	2489	1731	1346	1099	950	810	714	4774
1982	640	580	-7680	-3549	3502	1933	1324	1023	834	708	620	550	485
1983	498	453	-7792	-5412	-4294	-3674	-3248	-2951	-2715	-2529	-2381	-2254	-36299
1984	-2148	6286	-4433	-3022	-2482	-2216	-2044	-1925	-1831	6453	4055	-3219	-8527
1985	-3346	-2639	-2265	-2050	-1892	-1780	6518	4129	3069	2470	2088	-6402	-2101
1986	4194	2581	-6249	-4154	-3229	-308	-3133	-2514	-2210	6191	3867	-3352	-10315
1987	-3441	-2688	-2297	-2068	3374	-3439	-2394	-2021	-1814	6528	4162	-5092	-11189
1988	3136	-5037	-3208	-2549	-2171	6400	3969	2992	2428	2060	1808	1611	13437
1989	1461	1338	-6975	-4649	4627	2745	2013	1643	1408	1246	1129	-7174	-1187
1990	3555	2043	1504	-7231	3495	2043	1508	1245	1077	962	879	812	11889
1991	739	713	-4831	-6041	3789	2102	1478	1178	-7235	3380	1906	1369	-1455
1992	1109	951	-7369	-5036	4253	-5955	4132	2415	1734	1379	1165	1012	-210
1993	904	821	-7455	-5099	4207	-5991	4103	2390	1714	1361	1148	-7210	-9108
1994	1066	-3652	-4031	-3352	3292	3121	2222	1756	1454	1247	1102	986	5209
Average	681	116	-4279	-3913	1246	-571	967	513	-99	1557	1467	-1365	-3679

Table G.11
Middle of Reach 7: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2143	997	577	378	278	203	120	118	4815
1976	83	81	0	0	3299	1668	982	726	423	168	44	131	7606
1977	234	186	165	156	162	158	123	125	113	62	67	84	1635
1978	78	73	67	55	71	0	2322	1009	569	144	166	116	4669
1979	146	156	154	129	99	128	111	68	49	0	1920	647	3605
1980	482	422	0	0	0	0	0	0	0	3900	2294	1220	8318
1981	1240	986	0	0	3583	2242	1555	1245	778	503	0	385	12517
1982	505	529	0	0	3433	1753	1190	927	748	601	540	373	10601
1983	474	367	0	0	0	0	0	0	0	0	0	0	841
1984	0	5944	0	0	0	0	0	0	0	0	2053	0	7997
1985	0	0	0	0	0	0	4889	3767	2603	2184	1898	0	15340
1986	4032	2069	0	0	0	0	0	0	0	0	0	0	6101
1987	0	0	0	0	0	0	0	0	0	0	2875	0	2875
1988	3840	0	0	0	0	5943	3444	2528	2062	1627	1429	1232	22104
1989	1179	1300	0	0	4349	2431	1792	1354	1270	0	869	0	14544
1990	3299	1810	1213	0	3349	1985	1410	1163	934	472	718	460	16814
1991	485	557	0	0	3587	1956	1219	0	0	1110	766	622	10303
1992	646	872	0	0	4121	0	3813	1864	1558	1036	691	662	15263
1993	737	721	0	0	2634	0	3856	2179	1542	0	427	0	12095
1994	0	0	0	0	4266	1700	2060	1564	1254	0	952	642	12438
Average	873	803	80	17	1755	1048	1467	945	709	601	892	335	9524

Table G.12
Middle of Reach 7: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	431	133	82	10	40	0	0	3	699
1976	3	2	0	0	349	424	49	7	1	0	0	1	836
1977	1	2	7	11	5	18	3	2	0	0	0	0	52
1978	1	1	1	2	2	0	70	4	2	0	0	0	83
1979	2	1	3	13	15	3	5	5	20	0	23	16	108
1980	13	31	0	0	0	0	0	0	0	2	1	26	75
1981	4	54	0	0	306	181	74	14	9	1	0	1	645
1982	3	1	0	0	435	22	13	3	2	1	0	6	485
1983	4	13	0	0	0	0	0	0	0	0	0	0	16
1984	0	1550	0	0	0	0	0	0	0	0	61	0	1611
1985	0	0	0	0	0	0	245	921	240	7	6	0	1419
1986	756	294	0	0	0	0	0	0	0	0	0	0	1049
1987	0	0	0	0	0	0	0	0	0	0	12	0	12
1988	35	0	0	0	0	1801	310	397	41	3	2	16	2605
1989	6	5	0	0	1541	310	25	3	6	0	1	0	1897
1990	22	6	76	0	872	536	394	13	2	0	1	3	1926
1991	4	4	0	0	702	230	19	0	0	1	0	13	973
1992	6	7	0	0	1547	0	417	6	20	7	11	17	2038
1993	31	23	0	0	973	0	489	21	11	0	3	0	1551
1994	0	0	0	0	1811	654	71	12	2	0	0	4	2555
Average	45	100	4	1	449	216	113	71	25	1	6	5	1032

Table G.13
Middle of Reach 7: SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9881	788	921	729	572	455	371	312	265	-5469
1976	229	201	-9686	-8917	1914	1836	1458	1170	954	796	681	589	-8775
1977	318	461	412	374	339	311	285	264	245	227	213	199	3847
1978	187	177	167	158	150	-9731	958	1079	875	703	582	492	-4203
1979	426	373	332	300	272	250	230	214	199	-9677	1007	1143	-4932
1980	936	760	-9236	-8539	-7629	-6926	-6360	-5922	-5553	4619	4051	3300	-36499
1981	2741	2322	-7872	-7325	3316	3089	2584	2193	1887	1652	1472	1322	7379
1982	1202	1101	-8852	-6082	2480	2331	1952	1661	1436	1266	1137	1029	658
1983	941	869	-9058	-8321	-7385	-6669	-6095	-5655	-5286	-4980	-4730	-4509	-60876
1984	-4322	5717	-4827	-4833	-4513	-4242	-4019	-3844	-3693	6299	5586	-5157	-21849
1985	-5000	-4561	-4195	-3933	-3715	-3546	6462	5757	4883	4201	3695	-6580	-6532
1986	3796	3684	-6611	-6167	-5477	-2070	-4771	-4494	-4177	3946	5329	-5337	-20350
1987	-5123	-4625	-4224	-3937	2638	-4043	-3978	-3721	-3495	6548	5866	-4855	-22949
1988	5189	-5036	-4817	-4367	-3979	6180	5578	4805	4176	3694	3528	3023	17773
1989	2780	2575	-7469	-6827	3883	3701	3227	2856	2561	2332	2154	-7862	3910
1990	2708	2753	2453	-7672	2795	2774	2452	2191	1983	1820	1693	1584	17533
1991	1495	1415	-5270	-8033	2680	2632	2278	1999	-8080	2475	2473	2164	-1793
1992	1914	1724	-8293	-7619	3129	-6889	3369	3159	2700	2336	2070	1860	-540
1993	1699	1568	-8408	-7708	3058	-6947	3320	3117	2662	2302	2040	-8032	-11329
1994	-360	-7116	-6555	-5938	4456	4039	3398	2915	2541	2237	2040	1860	3538
Average	598	218	-5100	-5764	-40	-1150	653	516	-136	1739	2050	-1175	-7573

Table G.14
Middle of Reach 7: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	701	861	683	519	417	323	199	202	3905
1976	145	144	0	0	1740	1696	1273	1060	666	277	76	231	7307
1977	420	339	304	291	305	300	235	241	218	121	131	165	3071
1978	153	144	132	110	141	0	880	940	716	209	262	194	3881
1979	253	278	280	239	186	243	212	131	96	0	720	614	3252
1980	611	615	0	0	0	0	0	0	0	3244	2865	1788	9124
1981	1968	1645	0	0	2695	2782	2322	2028	1336	894	0	713	16384
1982	948	1003	0	0	2431	2114	1755	1506	1288	1075	991	698	13809
1983	898	704	0	0	0	0	0	0	0	0	0	0	1601
1984	0	5405	0	0	0	0	0	0	0	0	2828	0	8233
1985	0	0	0	0	0	0	4889	5252	4143	3715	3357	0	21356
1986	3650	2954	0	0	0	0	0	0	0	0	0	0	6603
1987	0	0	0	0	0	0	0	0	0	0	4053	0	4053
1988	3879	0	0	0	0	5739	4840	4060	3548	2916	2631	2312	29925
1989	2244	2501	0	0	3650	3277	2874	2351	2310	0	1657	0	20864
1990	2514	2439	1978	0	2678	2696	2293	2048	1719	893	1383	899	21540
1991	956	1105	0	0	2538	2449	1879	0	0	813	994	983	11717
1992	1115	1581	0	0	3032	0	3109	2439	2425	1230	1228	1217	17376
1993	1384	1376	0	0	1915	0	3120	2841	2396	0	427	0	13459
1994	0	0	0	0	3592	1700	3151	2596	2193	0	1763	1211	16207
Average	1057	1112	135	32	1280	1193	1676	1401	1174	786	1278	561	11684

Table G.15
Middle of Reach 7: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	141	115	97	14	60	0	0	5	432
1976	6	4	0	0	184	431	63	10	1	0	0	2	701
1977	2	3	13	21	9	34	10	4	1	0	0	1	97
1978	3	1	1	5	3	0	26	4	2	0	0	0	47
1979	4	2	6	25	29	5	10	10	39	0	8	15	154
1980	19	45	0	0	0	0	0	0	0	2	2	38	105
1981	7	91	0	0	230	225	110	22	16	1	0	2	705
1982	5	2	0	0	308	27	18	4	3	2	1	11	381
1983	7	25	0	0	0	0	0	0	0	0	0	0	31
1984	0	1410	0	0	0	0	0	0	0	0	83	0	1493
1985	0	0	0	0	0	0	243	1284	382	11	11	0	1932
1986	684	419	0	0	0	0	0	0	0	0	0	0	1103
1987	0	0	0	0	0	0	0	0	0	0	16	0	16
1988	36	0	0	0	0	1739	435	637	71	5	3	30	2957
1989	11	9	0	0	1293	418	40	5	12	0	2	0	1790
1990	17	8	124	0	697	728	641	23	4	0	3	5	2251
1991	9	8	0	0	496	283	29	0	0	0	1	23	851
1992	11	13	0	0	1138	0	340	8	31	12	20	31	1602
1993	38	44	0	0	707	0	396	27	17	0	5	0	1254
1994	0	0	0	0	1525	847	108	20	3	0	1	7	2512
Average	44	104	7	3	338	243	128	104	32	2	8	8	1021

Table G.16
Middle of Reach 7: SDF = 300 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-9881	681	882	729	580	471	388	-6153
1979	327	279	242	213	189	169	152	138	126	-9763	793	1008	-6128
1980	847	691	568	481	411	-9526	-8883	-8034	-7307	3148	2919	2394	-22292
1981	1978	1661	1413	1232	1078	958	856	774	703	642	591	545	12430
1982	507	472	441	415	389	367	347	329	312	296	282	269	4425
1983	257	246	235	226	217	-9676	-8997	-8122	-7373	-6779	-6314	-5918	-51998
1984	-5596	4564	4123	3470	2900	-7407	-7058	-6433	-5891	4414	4064	-6444	-15293
1985	-6266	-5774	4545	4225	3599	-6792	3366	3238	2848	2490	2213	-7895	-185
1986	2488	2562	2272	2020	1802	-5371	-7906	-7198	-6498	3938	3687	-6742	-14948
1987	-6502	-5945	4412	4122	3521	-6849	-6551	-5963	-5451	4851	4463	-6062	-21972
1988	3987	-6075	4007	3820	3335	2930	2599	2343	2127	1949	1803	1674	24499
1989	1566	1471	1383	1313	1243	1182	1126	1075	1028	984	945	-8970	4348
1990	1561	1736	1569	1397	1252	1143	1054	983	923	872	829	790	14128
1991	757	726	697	674	650	629	609	591	-9305	1268	1451	1277	21
1992	1115	989	890	818	756	-9177	1347	1514	1330	1154	1022	918	2676
1993	839	776	722	680	641	-9275	1261	1438	1262	1092	966	-9013	-8611
1994	-1390	-8052	2371	2348	1998	1705	1473	1302	1163	1053	966	891	5829
Average	-176	-483	1495	1373	1199	-3244	-1226	-1056	-1464	605	1057	-2044	-3961

Table G.17
Middle of Reach 7: SDF = 300 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	625	768	597	173	212	153	2528
1979	195	208	204	170	129	164	140	84	60	0	567	541	2463
1980	553	559	0	0	0	0	0	0	0	2211	2064	1297	6685
1981	1420	1177	0	0	876	883	770	716	497	347	0	294	6961
1982	400	430	0	0	382	333	312	298	279	251	246	182	3114
1983	245	199	0	0	0	0	0	0	0	0	0	0	443
1984	0	4315	0	0	0	0	0	0	0	0	2058	0	6373
1985	0	0	0	0	0	0	3098	2972	2416	2202	2011	0	12698
1986	2392	2054	0	0	0	0	0	0	0	0	0	0	4446
1987	0	0	0	0	0	0	0	0	0	0	3083	0	3083
1988	2981	0	0	0	0	2721	2253	1979	1807	1539	1426	1281	15989
1989	1264	1429	0	0	1168	1047	1002	885	927	0	727	0	8451
1990	1449	1556	1266	0	1200	1111	985	919	800	428	677	448	10839
1991	484	567	0	0	613	585	502	0	0	417	583	580	4333
1992	649	907	0	0	733	0	1243	1169	1195	867	607	601	7970
1993	684	681	0	0	402	0	1185	1311	1136	0	427	0	5825
1994	0	0	0	0	1611	1631	1366	1159	1004	0	835	580	8206
Average	636	704	73	9	356	424	674	613	536	422	776	298	5520

Table G.18
Middle of Reach 7: SDF = 300 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	19	3	2	0	0	0	25
1979	3	1	4	18	29	4	7	7	25	0	7	15	108
1980	17	41	0	0	0	0	0	0	0	1	1	28	88
1981	5	65	0	0	75	70	37	8	6	0	0	1	266
1982	2	1	0	0	48	4	3	1	1	1	0	3	64
1983	2	7	0	0	0	0	0	0	0	0	0	0	9
1984	0	1125	0	0	0	0	0	0	0	0	61	0	1186
1985	0	0	0	0	0	0	127	727	223	7	7	0	1089
1986	448	291	0	0	0	0	0	0	0	0	0	0	740
1987	0	0	0	0	0	0	0	0	0	0	12	0	12
1988	27	0	0	0	0	823	203	310	36	3	2	17	1423
1989	6	5	0	0	414	133	14	2	5	0	1	0	580
1990	10	5	80	0	312	300	275	10	2	0	1	3	999
1991	4	4	0	0	120	69	8	0	0	0	0	12	218
1992	6	7	0	0	275	0	136	4	15	6	10	15	474
1993	29	22	0	0	148	0	150	13	8	0	2	0	372
1994	0	0	0	0	684	357	47	9	2	0	0	3	1103
Average	28	79	4	1	105	88	51	55	16	1	5	5	438

Table G.19
Middle of Reach 8: SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-8482	2409	1067	616	417	303	233	188	155	-3094
1976	131	113	-8110	-5713	3630	1805	1125	802	607	482	398	335	-4396
1977	289	253	223	200	180	164	149	137	126	117	109	102	2049
1978	95	90	84	80	75	-8271	2527	1158	695	483	369	294	-2321
1979	245	209	182	162	145	132	120	111	102	-8113	2683	1204	-2819
1980	739	521	-7813	-5479	-4389	-3784	-3367	-3074	-2840	5554	3243	2252	-18436
1981	1726	1391	-7056	-4812	4407	2489	1731	1346	1099	930	810	714	4774
1982	640	580	-7680	-3549	3502	1933	1324	1023	834	708	620	550	485
1983	498	453	-7792	-5412	-4294	-3674	-3248	-2951	-2715	-2529	-2381	-2254	-36299
1984	-2148	6286	-4433	-3022	-2482	-2216	-2044	-1925	-1831	6453	4055	-5219	-8527
1985	-3346	-2639	-2265	-2050	-1892	-1780	6518	4129	3069	2470	2088	-6402	-2101
1986	4194	2581	-6249	-4154	-3229	-308	-3133	-2514	-2210	6191	3867	-5352	-10315
1987	-3441	-2688	-2297	-2068	3374	-3439	-2394	-2021	-1814	6528	4162	-5092	-11189
1988	5136	-5037	-3208	-2549	-2171	6400	3969	2992	2426	2060	1808	1611	13437
1989	1461	1338	-6975	-4649	4627	2745	2013	1645	1408	1246	1129	-7174	-1187
1990	3555	2043	1504	-7231	3495	2043	1508	1245	1077	962	879	812	11889
1991	759	713	-4831	-6041	3789	2102	1478	1178	-7215	3380	1906	1369	-1415
1992	1109	951	-7369	-5036	4253	-5955	4132	2415	1734	1379	1165	1012	-210
1993	904	821	-7455	-5099	4207	-5991	4103	2390	1714	1361	1148	-7210	-9108
1994	1066	-5652	-4031	-3352	5292	3121	2222	1756	1454	1247	1102	986	5209
Average	681	116	-4279	-3913	1246	-571	967	513	-99	1557	1467	-1365	-3679

Table G.20
Middle of Reach 8: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2145	999	580	380	279	205	121	122	4833
1976	83	81	0	0	3306	1671	990	731	427	169	45	132	7635
1977	235	186	165	156	162	158	124	126	114	63	68	85	1642
1978	78	73	67	55	71	0	2342	1033	578	145	167	117	4726
1979	147	156	154	129	99	128	111	85	60	0	1930	651	3650
1980	485	422	0	0	0	0	0	0	0	3930	2308	1227	8373
1981	1244	987	0	0	3587	2248	1568	1252	784	508	0	388	12567
1982	507	560	0	0	3437	1758	1198	933	752	605	544	375	10669
1983	475	367	0	0	0	0	0	0	0	0	0	0	842
1984	0	5952	0	0	0	0	0	0	0	0	2107	0	8059
1985	0	0	0	0	0	0	4889	3783	2616	2199	1909	0	15396
1986	4046	2159	0	0	0	0	0	0	0	0	0	0	6205
1987	0	0	0	0	0	0	0	0	0	0	2893	0	2893
1988	3852	0	0	0	0	5957	3461	2543	2078	1640	1439	1239	22208
1989	1183	1302	0	0	4350	2437	1804	1364	1278	0	874	0	14592
1990	3312	1813	1213	0	3352	1989	1417	1170	940	476	723	463	16870
1991	487	558	0	0	3595	1963	1227	0	0	1119	771	625	10344
1992	648	873	0	0	4130	0	3836	1877	1567	1043	695	666	15336
1993	740	721	0	0	2635	0	3877	2194	1550	0	427	0	12144
1994	0	0	0	0	4269	1700	2072	1574	1263	0	960	646	12484
Average	876	811	80	17	1757	1050	1475	952	714	605	899	337	9573

Table G.21
Middle of Reach 8: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	841	477	167	26	62	1	1	7	1580
1976	22	27	0	0	1347	799	141	24	3	0	0	3	2367
1977	29	51	58	53	52	48	30	8	3	0	0	3	333
1978	11	20	20	20	24	0	175	19	7	0	0	1	296
1979	11	19	31	42	31	26	18	10	28	0	34	44	295
1980	53	70	0	0	0	0	0	0	0	7	5	68	203
1981	67	171	0	0	1385	651	174	47	17	4	0	3	2518
1982	42	55	0	0	1503	408	68	12	10	4	1	21	2124
1983	63	112	0	0	0	0	0	0	0	0	0	0	175
1984	0	2711	0	0	0	0	0	0	0	0	91	0	2802
1985	0	0	0	0	0	0	889	1159	385	18	17	0	2469
1986	1532	868	0	0	0	0	0	0	0	0	0	0	2400
1987	0	0	0	0	0	0	0	0	0	0	32	0	32
1988	628	0	0	0	0	2852	843	786	91	10	6	46	5263
1989	86	103	0	0	2063	875	148	8	22	0	3	0	3307
1990	218	125	203	0	1337	754	586	46	7	0	4	8	3288
1991	62	99	0	0	1195	547	85	0	0	2	2	35	2026
1992	40	59	0	0	2058	0	940	17	67	34	25	45	3287
1993	196	187	0	0	1328	0	955	64	40	0	10	0	2779
1994	0	0	0	0	2322	1190	232	36	9	0	1	10	3821
Average	153	234	16	6	774	431	273	113	38	4	12	15	2068

Table G.22
Middle of Reach 8: SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9881	788	921	729	372	455	371	312	265	-3469
1976	229	201	-9686	-8917	1914	1836	1458	1170	954	796	681	589	-8773
1977	518	461	412	374	339	311	285	264	245	227	213	199	3847
1978	187	177	167	158	150	-9731	958	1079	875	703	382	492	-4203
1979	426	373	332	300	272	250	230	214	199	-9677	1007	1143	-4932
1980	936	760	-9236	-8539	-7629	-6926	-6360	-5922	-5553	4619	4051	3300	-36499
1981	2741	2322	-7872	-7325	3316	3089	2584	2193	1887	1652	1472	1322	7379
1982	1202	1101	-8852	-6082	2480	2331	1952	1661	1436	1266	1137	1029	658
1983	943	869	-9058	-8321	-7385	-6669	-6095	-5655	-5286	-4980	-4730	-4509	-60876
1984	-4322	5717	-4827	-4833	-4513	-4242	-4019	-3844	-3693	6299	5586	-5157	-21849
1985	-5000	-4561	-4195	-3933	-3715	-3546	6462	5757	4883	4201	3695	-6580	-6532
1986	3796	3684	-6611	-6167	-5477	-2070	-4771	-4494	-4177	3946	5329	-5337	-20350
1987	-5123	-4625	-4224	-3937	2638	-4043	-3978	-3721	-3495	6548	5866	-4855	-22949
1988	5189	-5036	-4817	-4367	-3979	6180	5378	4805	4176	3694	3328	3023	17773
1989	2780	2575	-7469	-6827	3883	3701	3227	2856	2561	2332	2134	-7862	3910
1990	2708	2753	2453	-7672	2795	2774	2452	2191	1983	1820	1693	1584	17533
1991	1495	1415	-5270	-8053	2680	2632	2278	1999	-8080	2475	2473	2164	-1793
1992	1914	1724	-8293	-7619	3129	-6889	3369	3159	2700	2336	2070	1860	-540
1993	1699	1568	-8408	-7708	3058	-6947	3320	3117	2662	2302	2040	-8032	-11329
1994	-360	-7116	-6555	-5938	4456	4029	3399	2915	2541	2257	2040	1860	3538
Average	398	218	-5100	-3764	-40	-1130	653	516	-136	1759	2050	-1175	-7573

Table G.23
Middle of Reach 8: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	702	863	687	522	419	326	201	209	3927
1976	146	144	0	0	1743	1700	1283	1067	671	280	77	232	7342
1977	421	339	304	291	305	301	237	243	221	122	132	167	3084
1978	154	144	132	110	141	0	887	962	727	211	264	195	3929
1979	255	279	280	239	186	243	214	165	117	0	724	618	3319
1980	614	616	0	0	0	0	0	0	0	3269	2883	1798	9180
1981	1974	1648	0	0	2699	2790	2342	2039	1346	903	0	718	16459
1982	952	1062	0	0	2434	2120	1767	1515	1295	1083	997	701	13925
1983	900	704	0	0	0	0	0	0	0	0	0	0	1605
1984	0	5413	0	0	0	0	0	0	0	0	2903	0	8315
1985	0	0	0	0	0	0	4889	5275	4163	3741	3377	0	21445
1986	3662	3083	0	0	0	0	0	0	0	0	0	0	6745
1987	0	0	0	0	0	0	0	0	0	0	4078	0	4078
1988	3892	0	0	0	0	5752	4864	4084	3575	2940	2649	2324	30081
1989	2252	2505	0	0	3651	3286	2893	2368	2324	0	1668	0	20946
1990	2524	2443	1979	0	2681	2701	2305	2060	1731	900	1392	904	21623
1991	959	3107	0	0	2543	2437	1891	0	0	820	1000	988	11766
1992	1119	3582	0	0	3039	0	3128	2456	2439	1230	1235	1224	17451
1993	1389	3377	0	0	1915	0	3137	2860	2409	0	427	0	13516
1994	0	0	0	0	3594	1700	3168	2614	2209	0	1778	1219	16283
Average	1061	1122	135	32	1282	1196	1685	1411	1182	791	1289	365	11751

Table G.24
Middle of Reach 8: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	275	412	197	35	93	1	1	12	1026
1976	38	49	0	0	711	813	183	36	5	0	0	6	1839
1977	52	92	108	99	98	90	57	15	5	0	1	6	621
1978	21	39	39	40	48	0	66	17	8	0	0	1	282
1979	19	35	57	79	58	49	34	20	54	0	13	42	458
1980	68	102	0	0	0	0	0	0	0	6	6	99	281
1981	106	235	0	0	1042	807	260	76	29	7	0	6	2619
1982	78	104	0	0	1064	492	101	19	18	7	2	40	1925
1983	119	214	0	0	0	0	0	0	0	0	0	0	333
1984	0	2465	0	0	0	0	0	0	0	0	126	0	2591
1985	0	0	0	0	0	0	881	1617	613	30	31	0	3172
1986	1387	1239	0	0	0	0	0	0	0	0	0	0	2626
1987	0	0	0	0	0	0	0	0	0	0	46	0	46
1988	635	0	0	0	0	2734	1185	1263	157	18	31	86	6110
1989	163	197	0	0	1731	1179	237	14	40	0	6	0	3568
1990	166	168	331	0	1069	1023	953	81	17	1	8	16	3829
1991	122	197	0	0	846	683	131	0	0	1	2	55	2038
1992	69	108	0	0	1514	0	766	23	105	58	45	83	2770
1993	368	357	0	0	965	0	773	83	62	0	18	0	2626
1994	0	0	0	0	1953	1339	385	60	17	0	3	20	3978
Average	171	282	27	11	369	492	310	168	61	7	16	24	2137

Table G.25
Middle of Reach 8: SDF = 300 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-9885	681	882	729	580	471	388	-6155
1979	327	279	242	213	189	169	152	138	126	-9763	793	1008	-6128
1980	847	691	568	481	411	-9526	-8883	-8034	-7307	3148	2919	2394	-22292
1981	1978	1661	1413	1232	1078	958	856	774	703	642	591	545	12430
1982	507	472	441	415	389	367	347	329	312	296	282	269	4425
1983	257	246	235	226	217	-9676	-8997	-8122	-7373	-6779	-6314	-5918	-51998
1984	-5596	4564	4123	3470	2900	-7407	-7058	-6433	-5891	4414	4064	-6444	-15293
1985	-6266	-5774	4545	4225	3599	-6792	3366	3258	2848	2490	2213	-7895	-185
1986	2488	2562	2272	2020	1802	-5371	-7906	-7198	-6498	3938	3687	-6742	-14948
1987	-6502	-5945	4412	4122	3521	-6849	-6551	-5963	-5451	4831	4463	-6062	-21972
1988	3987	-6075	4007	3820	3335	2930	2599	2343	2127	1949	1803	1674	24499
1989	1566	1471	1385	1313	1243	1182	1126	1075	1028	984	945	-8970	4348
1990	1561	1736	1569	1397	1252	1143	1054	983	923	872	829	790	14128
1991	757	726	697	674	650	629	609	591	-9305	1268	1451	1277	21
1992	1115	989	890	818	756	-9177	1347	1514	1330	1154	1022	918	2676
1993	839	776	722	680	641	-9275	1261	1438	1262	1092	966	-9013	-8611
1994	-1390	-8052	2371	2348	1998	1705	1473	1302	1163	1053	966	891	5829
Average	-176	-483	1495	1373	1199	-3244	-1226	-1056	-1464	608	1057	-2044	-3961

Table G.26
Middle of Reach 8: SDF = 300 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	631	787	606	174	214	154	2565
1979	196	208	204	170	129	165	141	106	74	0	571	545	2508
1980	556	560	0	0	0	0	0	0	0	2228	2077	1305	6726
1981	1425	1179	0	0	878	865	776	720	501	351	0	296	6991
1982	401	456	0	0	382	334	314	300	281	253	247	183	3152
1983	245	199	0	0	0	0	0	0	0	0	0	0	444
1984	0	4321	0	0	0	0	0	0	0	0	2112	0	6433
1985	0	0	0	0	0	0	3115	2985	2428	2217	2023	0	12767
1986	2400	2143	0	0	0	0	0	0	0	0	0	0	4544
1987	0	0	0	0	0	0	0	0	0	0	3102	0	3102
1988	2991	0	0	0	0	2728	2266	1991	1821	1551	1435	1288	16071
1989	1269	1431	0	0	1169	1050	1009	892	932	0	732	0	8484
1990	1455	1558	1266	0	1201	1113	990	925	806	431	682	451	10878
1991	486	567	0	0	617	587	505	0	0	420	587	583	4352
1992	652	908	0	0	735	0	1250	1177	1201	873	610	604	8010
1993	686	681	0	0	402	0	1192	1320	1142	0	427	0	5849
1994	0	0	0	0	1612	1656	1374	1167	1011	0	842	584	8246
Average	638	711	74	9	356	425	678	618	540	425	783	300	5556

Table G.27
Middle of Reach 8: SDF = 300 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	47	14	7	0	0	1	70
1979	14	26	42	56	40	33	22	13	34	0	10	37	327
1980	61	93	0	0	0	0	0	0	0	4	5	72	235
1981	76	204	0	0	339	250	86	27	11	3	0	3	999
1982	35	45	0	0	167	78	18	4	4	2	0	10	360
1983	33	60	0	0	0	0	0	0	0	0	0	0	93
1984	0	1968	0	0	0	0	0	0	0	0	92	0	2060
1985	0	0	0	0	0	0	459	913	358	18	18	0	1768
1986	909	862	0	0	0	0	0	0	0	0	0	0	1771
1987	0	0	0	0	0	0	0	0	0	0	35	0	35
1988	488	0	0	0	0	1306	552	616	80	10	6	48	3105
1989	92	113	0	0	554	377	93	5	16	0	3	0	1242
1990	96	107	212	0	479	422	410	36	6	0	4	8	1779
1991	62	101	0	0	205	164	35	0	0	1	1	32	600
1992	40	62	0	0	366	0	306	11	52	29	22	41	928
1993	182	176	0	0	202	0	294	38	29	0	8	0	930
1994	0	0	0	0	877	650	167	27	8	0	1	9	1739
Average	104	191	11	3	161	164	124	85	30	3	10	13	902

Table G.28
Middle of Reach 9: SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-8482	2409	1067	616	417	303	233	188	155	-3094
1976	131	113	-8110	-5713	3630	1805	1125	802	607	482	398	335	-4596
1977	289	253	223	200	180	164	149	137	126	117	109	102	2049
1978	95	90	84	80	75	-8271	2527	1158	695	483	369	294	-2321
1979	245	209	182	162	145	132	120	111	102	-8113	2683	1204	-2819
1980	739	521	-7813	-5479	-4389	-3784	-3367	-3074	-2840	3554	3243	2252	-18436
1981	1726	1391	-7056	-4812	4407	2489	1731	1346	1099	930	810	714	4774
1982	640	580	-7680	-3549	3502	1953	1324	1023	834	708	620	350	485
1983	498	453	-7792	-5412	-4294	-3674	-3248	-2951	-2715	-2529	-2383	-2254	-36299
1984	-2148	6286	-4433	-3022	-2482	-2216	-2044	-1925	-1831	6453	4055	-5219	-4527
1985	-3346	-2639	-2265	-2050	-1892	-1780	6518	4129	3069	2470	2088	-6402	-2101
1986	4194	2581	-6249	-4154	-3229	-308	-3133	-2514	-2210	6191	3867	-3352	-10315
1987	-3441	-2688	-2297	-2068	1374	-3439	-2394	-2021	-1834	6528	4162	-5092	-11189
1988	5136	-5037	-3208	-2549	-2171	6400	3969	2992	2426	2060	1808	1611	13437
1989	1463	1338	-6975	-4649	4627	2745	2013	1645	1408	1246	1129	-7174	-1187
1990	3555	2043	1504	-7231	3495	2043	1508	1245	1077	962	879	812	11889
1991	759	713	-4831	-6041	3789	2102	1478	1178	-7215	3380	1906	1369	-1415
1992	1109	951	-7369	-5036	4253	-5955	4132	2415	1734	1379	1165	1012	-210
1993	904	821	-7455	-5099	4207	-5991	4103	2390	1714	1361	1148	-7210	-9108
1994	1066	-5652	-4031	-3352	5292	3121	2222	1756	1454	1247	1102	886	5209
Average	653	116	-4279	-3913	1246	-371	967	513	-99	1557	1467	-1365	-3679

Table G.29
Middle of Reach 9: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2149	1003	586	384	283	207	122	127	4863
1976	84	81	0	0	3319	1679	1002	739	433	172	45	134	7688
1977	236	187	165	156	163	159	128	128	116	64	69	86	1655
1978	79	73	67	55	71	0	2374	1065	392	148	169	119	4812
1979	148	156	154	129	99	129	113	103	71	0	1949	658	3709
1980	490	423	0	0	0	0	0	0	0	3987	2333	1240	8473
1981	1249	991	0	0	3595	2259	1590	1264	795	516	0	392	12651
1982	510	561	0	0	3443	1764	1210	943	761	614	550	378	10735
1983	477	368	0	0	0	0	0	0	0	0	0	0	846
1984	0	5971	0	0	0	0	0	0	0	0	2237	0	8208
1985	0	0	0	0	0	0	4885	3865	2749	2229	1928	0	15662
1986	4071	2200	0	0	0	0	0	0	0	0	0	0	6271
1987	0	0	0	0	0	0	0	0	0	0	2924	0	2924
1988	3875	0	0	0	0	5982	3494	2572	2107	1662	1455	1251	22397
1989	1191	1305	0	0	4352	2449	1826	1380	1292	0	884	0	14678
1990	3333	1818	1215	0	3358	1997	1430	1181	953	482	730	468	16966
1991	490	559	0	0	3607	1974	1239	0	0	1135	780	632	10415
1992	653	874	0	0	4145	0	3878	1901	1583	1056	702	673	15466
1993	746	723	0	0	2636	0	3915	2218	1567	0	427	0	12232
1994	0	0	0	0	4273	1700	2093	1592	1281	0	973	655	12568
Average	882	815	80	17	1760	1055	1488	967	729	614	914	341	9661

Table G.30
Middle of Reach 9: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1263	823	283	77	90	6	6	29	2580
1976	46	55	0	0	2383	1178	441	137	29	4	2	25	4300
1977	91	102	110	94	99	77	59	27	11	1	3	24	698
1978	29	39	41	42	48	0	900	115	21	4	5	18	1263
1979	41	60	81	79	46	60	41	19	36	0	64	127	654
1980	120	110	0	0	0	0	0	0	0	44	68	264	631
1981	321	361	0	0	2626	1332	361	116	30	47	0	70	5263
1982	157	206	0	0	2630	1057	282	63	27	11	11	80	4525
1983	239	223	0	0	0	0	0	0	0	0	0	0	461
1984	0	3704	0	0	0	0	0	0	0	0	183	0	3887
1985	0	0	0	0	0	0	2818	1509	689	96	107	0	5219
1986	2465	1352	0	0	0	0	0	0	0	0	0	0	3817
1987	0	0	0	0	0	0	0	0	0	0	216	0	216
1988	1744	0	0	0	0	4161	1669	1288	183	115	86	284	9531
1989	312	783	0	0	2820	1587	428	94	112	0	35	0	5771
1990	887	610	313	0	1841	1033	832	237	48	6	35	41	6082
1991	191	280	0	0	1837	993	223	0	0	22	17	90	3654
1992	146	273	0	0	2576	0	1690	163	170	114	59	83	5275
1993	404	395	0	0	1797	0	1567	279	185	0	123	0	4751
1994	0	0	0	0	3125	1700	664	256	94	0	30	183	6052
Average	360	408	37	11	1155	700	613	219	86	24	54	66	3751

Table G.31
Middle of Reach 9: SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9881	788	921	729	572	455	371	312	265	-5469
1976	229	201	-9686	-8917	1914	1836	1458	1170	954	796	681	589	-8775
1977	518	461	412	374	339	311	285	264	245	227	213	199	3847
1978	187	177	167	158	150	-9731	958	1079	875	703	582	492	-4203
1979	426	373	332	300	272	250	230	214	199	-9677	1007	1143	-4932
1980	936	760	-9236	-8539	-7629	-6926	-6360	-3922	-5553	4619	4051	3300	-36499
1981	2741	2322	-7872	-7325	3316	3089	2584	2193	1887	1652	1472	1322	7379
1982	1202	1101	-8852	-6082	2480	2331	1952	1661	1436	1266	1137	1029	658
1983	943	869	-9058	-8321	-7383	-6669	-6095	-5655	-5286	-4980	-4730	-4509	-60876
1984	-4322	5717	-4827	-4833	-4513	-4242	-4019	-3844	-3693	6299	5586	-5157	-21849
1985	-5000	-4561	-4195	-3933	-3715	-3546	6462	5757	4883	4201	3695	-6580	-6532
1986	3796	3684	-6611	-6167	-5477	-2070	-4771	-4494	-4177	5946	5329	-5337	-20350
1987	-5123	-4625	-4224	-3937	2638	-4043	-3978	-3721	-3495	6548	5866	-4855	-22949
1988	5189	-5036	-4817	-4367	-3979	6180	3578	4805	4176	3694	3328	3023	17773
1989	2780	2575	-7469	-6827	3883	3701	3227	2856	2561	2332	2154	-7862	3910
1990	2708	2753	2453	-7672	2795	2774	2452	2191	1983	1820	1693	1584	17533
1991	1495	1415	-5270	-8053	2680	2632	2278	1999	-8080	2475	2473	2164	-1793
1992	1914	1724	-8293	-7619	3129	-6889	3369	3159	2700	2336	2070	1860	-340
1993	1699	1568	-8408	-7708	3058	-6947	3320	3117	2662	2302	2040	-8032	-11329
1994	-360	-7116	-6555	-5938	4456	4039	3398	2913	2541	2257	2040	1860	3538
Average	598	218	-3100	-5764	-40	-1150	653	516	-136	1759	2050	-1175	-7573

Table G.32
Middle of Reach 9: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	703	867	693	527	424	330	203	217	3964
1976	148	145	0	0	1750	1707	1299	1078	680	284	78	235	7405
1977	424	341	305	292	306	303	240	247	224	125	134	169	3108
1978	156	145	132	110	141	0	900	992	745	215	268	198	4001
1979	257	279	280	239	186	244	216	200	138	0	731	625	3396
1980	621	617	0	0	0	0	0	0	0	3316	2914	1817	9286
1981	1983	1655	0	0	2705	2803	2374	2059	1365	916	0	727	16586
1982	957	1065	0	0	2438	2127	1785	1531	1311	1098	1008	707	14027
1983	905	706	0	0	0	0	0	0	0	0	0	0	1611
1984	0	5430	0	0	0	0	0	0	0	0	3081	0	8512
1985	0	0	0	0	0	0	4889	5390	4375	3792	3412	0	21858
1986	3685	3141	0	0	0	0	0	0	0	0	0	0	6826
1987	0	0	0	0	0	0	0	0	0	0	4122	0	4122
1988	3915	0	0	0	0	5776	4910	4131	3627	2980	2678	2347	30363
1989	2266	2511	0	0	3652	3302	2928	2396	2349	0	1687	0	21090
1990	2539	2450	1981	0	2686	2712	2326	2079	1755	912	1407	914	21762
1991	965	1110	0	0	2552	2472	1910	0	0	831	1012	999	11849
1992	1126	1585	0	0	3050	0	3162	2487	2465	1230	1248	1237	17590
1993	1400	1381	0	0	1916	0	3168	2892	2433	0	427	0	13621
1994	0	0	0	0	3598	1700	3201	2644	2240	0	1803	1236	16421
Average	1067	1128	135	32	1284	1201	1700	1433	1207	801	1311	571	11870

Table G.33
Middle of Reach 9: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	414	711	335	106	135	10	10	50	1770
1976	81	97	0	0	1257	1198	572	200	46	7	3	44	3504
1977	163	186	202	176	187	146	113	51	21	3	6	47	1302
1978	56	78	80	83	96	0	341	108	26	6	8	31	913
1979	70	108	148	147	86	114	79	37	71	0	24	121	1004
1980	152	161	0	0	0	0	0	0	0	37	110	393	853
1981	509	602	0	0	1975	1653	538	188	52	84	0	129	5732
1982	294	391	0	0	1862	1275	416	103	47	20	21	149	4577
1983	452	427	0	0	0	0	0	0	0	0	0	0	879
1984	0	3369	0	0	0	0	0	0	0	0	252	0	3620
1985	0	0	0	0	0	0	2794	2105	1096	164	189	0	6346
1986	2231	1930	0	0	0	0	0	0	0	0	0	0	4161
1987	0	0	0	0	0	0	0	0	0	0	305	0	305
1988	1762	0	0	0	0	4018	2346	2068	315	206	158	534	11407
1989	594	736	0	0	2366	2140	686	161	203	0	67	0	6957
1990	676	822	837	0	1472	1402	1353	417	89	11	68	79	7226
1991	376	555	0	0	1300	1244	344	0	0	16	23	142	3999
1992	253	495	0	0	1895	0	1378	213	264	193	106	152	4949
1993	759	755	0	0	1307	0	1268	363	288	0	219	0	4959
1994	0	0	0	0	2631	1700	1016	426	164	0	56	345	6337
Average	421	336	63	20	842	780	678	327	141	38	81	111	4040

Table G.34
Middle of Reach 9: SDF = 300 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	-9885	681	882	729	580	471	388	-6155
1979	327	279	242	213	189	169	152	138	126	-9763	793	1008	-6128
1980	847	691	568	481	411	-9526	-8883	-8034	-7307	3148	2919	2394	-22292
1981	1978	1661	1413	1232	1078	958	856	774	703	642	591	545	12430
1982	507	472	441	415	389	367	347	329	312	296	282	269	4425
1983	257	246	235	226	217	-9676	-8997	-8122	-7373	-6779	-6314	-5918	-51998
1984	-5596	4564	4123	3470	2900	-7407	-7058	-6433	-5891	4414	4064	-6444	-15293
1985	-6266	-5774	4545	4225	3599	-6792	3366	3258	2848	2490	2213	-7895	-185
1986	2488	2562	2272	2020	1802	-5371	-7906	-7198	-6498	3938	3687	-6742	-14948
1987	-6502	-5945	4412	4122	3521	-6849	-6551	-5963	-5451	4831	4463	-6062	-21972
1988	3987	-6075	4007	3820	3335	2930	2599	2343	2127	1949	1803	1674	24499
1989	1566	1471	1385	1313	1243	1182	1126	1075	1028	984	945	-8970	4348
1990	1561	1756	1569	1397	1252	1143	1054	983	923	872	829	790	14128
1991	757	726	697	674	650	629	609	591	-9305	1268	1451	1277	21
1992	1115	989	890	818	756	-9177	1347	1514	1330	1154	1022	918	2676
1993	839	776	722	680	641	-9275	1261	1438	1262	1092	966	-9013	-8611
1994	-1390	-8052	2371	2348	1998	1705	1473	1302	1163	1053	966	891	5829
Average	-176	-483	1495	1373	1199	-3244	-1226	-1056	-1464	608	1057	-2044	-3961

Table G.35
Middle of Reach 9: SDF = 300 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	639	811	621	177	216	156	2621
1979	198	209	204	170	129	165	143	129	87	0	576	551	2561
1980	562	561	0	0	0	0	0	0	0	2260	2100	1318	6801
1981	1431	1184	0	0	879	869	787	727	508	356	0	300	7041
1982	403	457	0	0	383	335	317	303	284	257	250	185	3175
1983	246	200	0	0	0	0	0	0	0	0	0	0	446
1984	0	4335	0	0	0	0	0	0	0	0	2242	0	6577
1985	0	0	0	0	0	0	3156	3050	2552	2247	2043	0	13048
1986	2415	2184	0	0	0	0	0	0	0	0	0	0	4599
1987	0	0	0	0	0	0	0	0	0	0	3136	0	3136
1988	3008	0	0	0	0	2739	2288	2014	1848	1572	1451	1300	16220
1989	1277	1435	0	0	1169	1055	1021	902	943	0	740	0	8542
1990	1464	1563	1267	0	1203	1118	999	933	817	437	689	456	10946
1991	489	569	0	0	619	591	510	0	0	426	593	589	4386
1992	656	910	0	0	737	0	1264	1192	1214	884	616	611	8083
1993	692	683	0	0	402	0	1203	1334	1154	0	427	0	5896
1994	0	0	0	0	1614	1666	1388	1181	1025	0	854	592	8318
Average	642	714	74	9	357	427	686	629	553	431	797	303	5620

Table G.36
Middle of Reach 9: SDF = 300 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	242	88	22	5	6	24	388
1979	54	80	108	104	59	77	52	24	45	0	19	106	729
1980	137	146	0	0	0	0	0	0	0	25	79	285	673
1981	368	431	0	0	642	513	178	67	19	33	0	33	2303
1982	124	168	0	0	292	201	74	20	10	5	5	39	938
1983	123	121	0	0	0	0	0	0	0	0	0	0	244
1984	0	2689	0	0	0	0	0	0	0	0	183	0	2872
1985	0	0	0	0	0	0	1455	1191	639	97	113	0	3495
1986	1462	1342	0	0	0	0	0	0	0	0	0	0	2804
1987	0	0	0	0	0	0	0	0	0	0	232	0	232
1988	1334	0	0	0	0	1905	1093	1008	161	109	86	296	6011
1989	335	421	0	0	758	684	239	61	51	0	30	0	2608
1990	389	524	536	0	659	578	381	187	41	5	33	40	3574
1991	190	285	0	0	315	297	92	0	0	9	13	84	1285
1992	147	284	0	0	458	0	551	102	130	96	32	75	1895
1993	375	374	0	0	274	0	482	168	136	0	104	0	1912
1994	0	0	0	0	1180	1093	440	190	75	0	26	165	3171
Average	253	343	32	5	232	267	274	155	68	19	49	38	1757

Table G.37
Bottom of Reach 9: SDF = 60 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-8482	2409	1067	616	417	303	233	188	155	-3094
1976	131	113	-8110	-5713	3630	1805	1125	802	607	482	398	335	-4396
1977	289	253	223	200	180	164	149	137	126	117	109	102	2049
1978	95	90	84	80	75	-8271	2527	1158	695	483	369	294	-2321
1979	245	209	182	162	145	132	120	111	102	-8113	2683	1204	-2819
1980	739	521	-7813	-5479	-4389	-3784	-3367	-3074	-2840	5534	3243	2232	-18436
1981	1726	1391	-7056	-4812	4407	2489	1731	1346	1099	930	810	714	4774
1982	640	580	-7680	-3549	3502	1933	1324	1023	834	708	620	550	485
1983	498	453	-7792	-3412	-4294	-3674	-3248	-2951	-2715	-2529	-2381	-2254	-36299
1984	-2148	6286	-4433	-3022	-2482	-2216	-2044	-1925	-1831	6453	4055	-5219	-8527
1985	-3346	-2639	-2265	-2050	-1892	-1780	6518	4129	3069	2470	2088	-6402	-2101
1986	4194	2581	-6249	-4154	-3229	-308	-3133	-2514	-2210	6191	3867	-5552	-10515
1987	-3441	-2688	-2297	-2068	3374	-3439	-2394	-2021	-1814	6528	4162	-5092	-11189
1988	5136	-5037	-3208	-2549	-2171	6400	3969	2992	2426	2060	1808	1611	13437
1989	1461	1338	-6975	-4649	4627	2745	2013	1645	1408	1246	1129	-7174	-1187
1990	3555	2043	1504	-7231	3495	2043	1508	1245	1077	962	879	812	11889
1991	759	713	-4831	-6041	3789	2102	1478	1178	-7215	3380	1906	1369	-1415
1992	1109	951	-7369	-5036	4253	-5955	4132	2415	1734	1379	1165	1012	-210
1993	904	821	-7455	-5099	4207	-5991	4103	2390	1714	1361	1148	-7210	-9108
1994	1066	-5652	-4031	-3352	3292	3121	2222	1756	1454	1247	1102	986	3209
Average	681	116	-4279	-3913	1246	-571	967	513	-99	1557	1467	-1363	-3679

Table G.38
Bottom of Reach 9: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2151	1009	589	387	285	209	123	128	4881
1976	85	81	0	0	3328	1684	1010	744	436	174	46	135	7724
1977	237	188	166	156	163	160	127	129	117	65	69	87	1664
1978	80	74	67	55	71	0	2394	1075	598	149	171	120	4853
1979	149	157	154	129	99	129	113	104	71	0	1961	662	3729
1980	494	424	0	0	0	0	0	0	0	4022	2348	1249	8536
1981	1253	994	0	0	3601	2266	1604	1271	802	520	0	395	12706
1982	512	562	0	0	3448	1768	1218	949	768	619	553	381	10779
1983	479	369	0	0	0	0	0	0	0	0	0	0	848
1984	0	5985	0	0	0	0	0	0	0	0	2316	0	8301
1985	0	0	0	0	0	0	4889	3937	2875	2249	1940	0	15890
1986	4089	2240	0	0	0	0	0	0	0	0	0	0	6329
1987	0	0	0	0	0	0	0	0	0	0	2944	0	2944
1988	3892	0	0	0	0	5998	3516	2591	2126	1675	1464	1259	22522
1989	1196	1308	0	0	4353	2457	1841	1390	1301	0	890	0	14735
1990	3346	1822	1215	0	3362	2003	1439	1187	962	486	735	471	17028
1991	492	560	0	0	3615	1982	1246	0	0	1144	785	636	10461
1992	655	875	0	0	4135	0	3907	1916	1594	1064	707	678	15552
1993	750	725	0	0	2637	0	3940	2233	1579	0	427	0	12291
1994	0	0	0	0	4275	1700	2107	1604	1293	0	982	661	12622
Average	386	818	60	17	1763	1058	1497	976	740	619	923	343	9720

Table G.39
Bottom of Reach 9: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1279	827	323	116	99	12	11	48	2714
1976	53	57	0	0	2421	1183	660	234	53	8	3	43	4719
1977	126	105	110	95	100	77	66	41	17	3	5	42	786
1978	38	40	42	45	50	0	1536	198	31	8	10	36	2034
1979	62	83	103	88	47	71	53	24	38	0	86	186	840
1980	150	111	0	0	0	0	0	0	0	77	168	434	939
1981	513	437	0	0	2791	1546	460	155	37	87	0	134	6161
1982	233	304	0	0	2891	1322	447	106	37	16	21	124	5390
1983	355	237	0	0	0	0	0	0	0	0	0	0	591
1984	0	3784	0	0	0	0	0	0	0	0	251	0	4035
1985	0	0	0	0	0	0	4136	1666	890	166	188	0	7046
1986	2668	1377	0	0	0	0	0	0	0	0	0	0	4044
1987	0	0	0	0	0	0	0	0	0	0	384	0	384
1988	2272	0	0	0	0	4420	1991	1466	237	214	162	498	11260
1989	461	566	0	0	3055	1740	593	175	187	0	66	0	6843
1990	1261	477	710	0	1904	1098	898	398	86	12	65	69	7579
1991	263	366	0	0	1986	1138	303	0	0	43	32	127	4256
1992	220	435	0	0	2584	0	1944	300	229	170	83	99	6063
1993	451	444	0	0	1912	0	1750	458	304	0	231	0	5550
1994	0	0	0	0	3416	1700	910	457	172	0	38	330	7064
Average	461	466	48	11	1212	736	804	290	121	41	91	110	4410

Table G.40
Bottom of Reach 9: SDF = 270 Days
Net Hydrologic Effect
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	-9881	788	921	729	572	455	371	312	265	-5469
1976	229	201	-9686	-8917	1914	1836	1458	1170	954	796	681	589	-8775
1977	518	461	412	374	339	311	285	264	245	227	213	199	3847
1978	187	177	167	158	150	-9731	958	1079	875	703	582	492	-4203
1979	426	373	332	300	272	250	230	214	199	-9677	1007	1143	-4932
1980	936	760	-9236	-8539	-7629	-6926	-6360	-5922	-5553	4619	4051	3300	-36499
1981	2741	2322	-7872	-7325	3316	3089	2584	2193	1887	1652	1472	1322	7379
1982	1202	1101	-8852	-6082	2480	2331	1952	1661	1436	1266	1137	1029	658
1983	943	869	-9058	-8321	-7385	-6669	-6095	-5655	-5286	-4980	-4730	-4509	-60876
1984	-4322	5717	-4827	-4833	-4513	-4242	-4019	-3844	-3693	6299	5586	-5157	-21849
1985	-5000	-4561	-4195	-3933	-3715	-3546	6462	5757	4883	4201	3695	-6580	-6512
1986	3796	3684	-6611	-6167	-3477	-2070	-4771	-4494	-4177	3946	3329	-5337	-20350
1987	-5123	-4625	-4224	-3937	2638	-4043	-3978	-3721	-3495	6548	5866	-4855	-22949
1988	5189	-5036	-4817	-4367	-3979	6180	5578	4805	4176	3694	3328	3023	17773
1989	2780	2575	-7469	-6827	3883	3701	3227	2856	2561	2332	2154	-7862	3910
1990	2708	2753	2453	-7672	2795	2774	2452	2191	1983	1820	1693	1584	17533
1991	1495	1415	-5270	-8053	2680	2632	2278	1999	-8080	2475	2473	2164	-1793
1992	1914	1724	-8293	-7619	3129	-6889	3369	3159	2700	2336	2070	1860	-340
1993	1699	1568	-8408	-7708	3058	-6947	3320	3117	2662	2302	2040	-8032	-11329
1994	-360	-7136	-6555	-5938	4856	4039	3398	2915	2541	2257	2040	1860	3538
Average	598	218	-3100	-5764	-40	-1150	653	516	-136	1759	2050	-1175	-7573

Table G.41
Bottom of Reach 9: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	704	871	697	531	427	332	204	218	3984
1976	150	145	0	0	1755	1713	1309	1086	686	287	78	237	7446
1977	426	342	306	292	307	304	242	249	226	126	135	170	3125
1978	157	146	133	110	141	0	907	1001	753	217	270	200	4034
1979	259	280	280	239	187	245	218	201	139	0	736	629	3411
1980	625	618	0	0	0	0	0	0	0	3345	2933	1830	9352
1981	1990	1659	0	0	2709	2815	2395	2071	1376	924	0	732	16668
1982	961	1067	0	0	2441	2132	1796	1541	1323	1108	1015	712	14095
1983	908	708	0	0	0	0	0	0	0	0	0	0	1616
1984	0	5443	0	0	0	0	0	0	0	0	3190	0	8633
1985	0	0	0	0	0	0	4889	5489	4575	3826	3433	0	22211
1986	3701	3198	0	0	0	0	0	0	0	0	0	0	6899
1987	0	0	0	0	0	0	0	0	0	0	4149	0	4149
1988	3932	0	0	0	0	5792	4941	4162	3659	3003	2695	2362	30547
1989	2276	2516	0	0	3655	3313	2952	2413	2366	0	1698	0	21186
1990	2550	2455	1982	0	2689	2719	2341	2090	1771	919	1416	920	21851
1991	969	1112	0	0	2557	2481	1921	0	0	838	1018	1005	11904
1992	1131	1587	0	0	3057	0	3185	2506	2482	1230	1256	1246	17681
1993	1409	1385	0	0	1917	0	3189	2912	2453	0	427	0	13691
1994	0	0	0	0	3600	1700	3223	2663	2260	0	1819	1247	16511
Average	1072	1133	135	32	1286	1204	1710	1446	1225	808	1324	575	11950

Table G.42
Bottom of Reach 9: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	418	714	383	138	148	19	18	82	1940
1976	93	101	0	0	1277	1205	856	341	83	14	5	78	4053
1977	226	191	203	176	188	147	126	79	33	5	11	83	1467
1978	74	80	84	90	99	0	582	185	39	12	15	39	1318
1979	107	147	188	164	88	135	101	46	74	0	32	177	1259
1980	190	162	0	0	0	0	0	0	0	64	209	635	1261
1981	815	729	0	0	2099	1919	687	252	64	155	0	249	6970
1982	437	576	0	0	1906	1594	659	173	63	28	39	231	5705
1983	672	454	0	0	0	0	0	0	0	0	0	0	1126
1984	0	3441	0	0	0	0	0	0	0	0	346	0	3787
1985	0	0	0	0	0	0	4100	2224	1416	283	332	0	8455
1986	2415	1965	0	0	0	0	0	0	0	0	0	0	4380
1987	0	0	0	0	0	0	0	0	0	0	541	0	541
1988	2295	0	0	0	0	4269	2798	2354	408	383	299	934	13739
1989	877	1088	0	0	2564	2346	952	305	340	0	126	0	8597
1990	1037	1317	1158	0	1523	1491	1460	701	158	22	123	134	9128
1991	518	726	0	0	1405	1424	467	0	0	31	42	201	4814
1992	380	789	0	0	1901	0	1585	392	357	288	147	181	6019
1993	848	847	0	0	1390	0	1416	397	472	0	411	0	5981
1994	0	0	0	0	2877	1700	1392	759	301	0	107	661	7797
Average	549	631	82	21	887	847	878	413	198	65	140	185	4917

Table G.43
Middle of Reach 10: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1092	513	300	198	145	107	63	66	2484
1976	44	41	0	0	2276	1085	631	456	265	106	28	80	5012
1977	139	109	96	90	93	92	73	74	67	38	40	50	959
1978	45	42	38	31	40	0	36	34	30	10	15	12	334
1979	18	21	22	20	18	23	22	21	15	0	15	11	205
1980	13	15	0	0	0	0	0	0	0	3849	2195	1132	7203
1981	1106	859	0	0	1963	1314	974	793	512	340	0	262	8122
1982	339	372	0	0	1162	647	484	399	338	284	262	184	4471
1983	236	184	0	0	0	0	0	0	0	0	0	0	420
1984	0	5900	0	0	0	0	0	0	0	0	2743	0	8643
1985	0	0	0	0	0	0	4889	3929	2864	2252	1930	0	15864
1986	2388	1554	0	0	0	0	0	0	0	0	0	0	3942
1987	0	0	0	0	0	0	0	0	0	0	2992	0	2992
1988	3818	0	0	0	0	5341	3078	2262	1862	1479	1297	1113	20250
1989	1054	1152	0	0	4239	2358	1758	1317	1224	0	832	0	13934
1990	1794	1136	833	0	3110	1792	1268	1039	845	429	646	415	13307
1991	430	488	0	0	3906	2124	1318	0	0	1165	797	637	10865
1992	651	859	0	0	3898	0	3813	1863	1530	1017	675	644	14949
1993	709	682	0	0	2612	0	3921	2215	1561	0	427	0	12127
1994	0	0	0	0	4317	1700	2135	1630	1318	0	996	668	12763
Average	639	671	49	7	1436	849	1235	811	629	554	798	264	7942

Table G.44
Middle of Reach 10: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	742	411	195	70	59	7	7	30	1520
1976	27	29	0	0	1772	801	431	161	39	6	2	29	3298
1977	82	64	67	58	61	54	46	28	11	2	4	27	505
1978	25	24	25	27	32	0	23	8	2	1	1	4	173
1979	9	11	16	15	10	15	11	5	9	0	1	3	105
1980	5	6	0	0	0	0	0	0	0	82	177	479	748
1981	534	454	0	0	1547	934	333	125	30	63	0	98	4118
1982	193	226	0	0	923	501	195	54	21	8	12	72	2207
1983	146	124	0	0	0	0	0	0	0	0	0	0	270
1984	0	3970	0	0	0	0	0	0	0	0	347	0	4318
1985	0	0	0	0	0	0	4301	1953	989	196	216	0	7655
1986	1700	988	0	0	0	0	0	0	0	0	0	0	2688
1987	0	0	0	0	0	0	0	0	0	0	464	0	464
1988	2489	0	0	0	0	4192	1853	1347	239	233	168	514	11036
1989	487	575	0	0	3136	1802	645	194	210	0	76	0	7126
1990	831	668	542	0	2014	1139	859	409	91	12	75	78	6719
1991	261	378	0	0	2616	1367	376	0	0	51	42	167	5259
1992	221	483	0	0	2800	0	2124	328	269	192	98	110	6625
1993	520	455	0	0	2049	0	2126	511	364	0	249	0	6275
1994	0	0	0	0	3619	1700	1097	531	196	0	63	376	7583
Average	377	423	33	5	1066	646	731	286	126	43	100	99	3935

Table G.45

Middle of Reach 10: SDF = 270 Days

Reductions to Target Flow Shortages without Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	357	443	355	271	218	171	105	112	2032
1976	77	74	0	0	954	1023	788	650	411	172	47	140	4335
1977	248	197	176	167	176	173	139	142	129	73	77	97	1795
1978	89	82	75	62	80	0	73	68	60	21	30	25	665
1979	36	42	45	41	36	47	44	42	30	0	30	22	417
1980	26	30	0	0	0	0	0	0	0	2984	2631	1609	7280
1981	1714	1405	0	0	1706	1754	1521	1330	896	613	0	489	11428
1982	639	709	0	0	996	881	778	692	613	528	497	354	6687
1983	457	361	0	0	0	0	0	0	0	0	0	0	818
1984	0	5260	0	0	0	0	0	0	0	0	3431	0	8690
1985	0	0	0	0	0	0	4889	5454	4539	3816	3403	0	22101
1986	3104	2573	0	0	0	0	0	0	0	0	0	0	5678
1987	0	0	0	0	0	0	0	0	0	0	4186	0	4186
1988	3884	0	0	0	0	4912	4282	3632	3213	2661	2396	2095	27076
1989	2013	2222	0	0	3426	3115	2782	2266	2212	0	1582	0	19617
1990	1937	1791	1482	0	2274	2355	2035	1818	1552	812	1245	811	18113
1991	847	969	0	0	2719	2590	1982	0	0	846	1025	997	11975
1992	1114	1545	0	0	2800	0	3023	2408	2364	1230	1196	1180	16860
1993	1328	1298	0	0	1864	0	3125	2861	2408	0	427	0	13312
1994	0	0	0	0	3642	1700	3253	2696	2294	0	1838	1255	16679
Average	876	928	89	14	1051	950	1453	1217	1047	696	1207	459	9987

Table G.46

Middle of Reach 10: SDF = 270 Days

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	243	355	230	96	88	10	11	51	1084
1976	48	51	0	0	743	756	539	230	61	9	3	51	2490
1977	147	116	124	108	115	102	88	54	21	3	7	54	939
1978	49	48	50	55	64	0	46	15	4	1	2	8	342
1979	18	23	32	30	21	31	23	11	18	0	2	7	214
1980	10	12	0	0	0	0	0	0	0	64	212	681	978
1981	827	742	0	0	1345	1248	519	209	53	114	0	183	5240
1982	365	431	0	0	792	682	313	94	38	16	23	138	2891
1983	283	242	0	0	0	0	0	0	0	0	0	0	525
1984	0	3540	0	0	0	0	0	0	0	0	434	0	3974
1985	0	0	0	0	0	0	4239	2711	1568	332	381	0	9230
1986	2211	1635	0	0	0	0	0	0	0	0	0	0	3846
1987	0	0	0	0	0	0	0	0	0	0	649	0	649
1988	2532	0	0	0	0	3855	2578	2162	413	420	310	968	13239
1989	930	1109	0	0	2535	2381	1021	333	379	0	145	0	8833
1990	898	1053	965	0	1473	1497	1379	716	168	24	144	152	8468
1991	515	752	0	0	1821	1667	565	0	0	37	54	262	5672
1992	378	870	0	0	2011	0	1684	424	416	324	173	201	6481
1993	975	867	0	0	1462	0	1695	660	562	0	427	0	6648
1994	0	0	0	0	3053	1700	1672	879	341	0	116	707	8469
Average	509	575	59	10	784	714	830	430	206	68	155	173	4511

Table G.47
Middle of Reach 13: SDF = 60 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	2141	1003	584	383	281	210	124	128	4855
1976	86	81	0	0	3319	1673	1003	737	439	178	47	138	7700
1977	239	188	166	156	163	159	126	128	116	66	70	87	1663
1978	80	74	67	55	71	0	2379	1068	597	154	175	122	4840
1979	151	157	154	129	108	129	113	102	70	0	65	46	1222
1980	53	60	0	0	0	0	0	0	0	1374	1043	617	3146
1981	659	544	0	0	3294	1980	1340	1040	639	421	0	312	10231
1982	399	434	0	0	3348	1676	1126	867	687	551	494	335	9918
1983	416	317	0	0	0	0	0	0	0	0	0	0	733
1984	0	3269	0	0	0	0	0	0	0	0	1197	0	4466
1985	0	0	0	0	0	0	4889	3334	2359	1836	1548	0	13967
1986	1206	955	0	0	0	0	0	0	0	0	0	0	2162
1987	0	0	0	0	0	0	0	0	0	0	1439	0	1439
1988	1100	0	0	0	0	5262	2880	2058	1646	1287	1111	942	16285
1989	881	961	0	0	4052	2193	1571	1162	1062	0	715	0	12597
1990	705	625	523	0	2862	1575	1070	866	689	350	527	335	10126
1991	346	396	0	0	3434	1811	1093	0	0	241	266	267	7853
1992	316	456	0	0	3861	0	3629	1705	1384	912	595	557	13416
1993	612	588	0	0	2537	0	3783	2091	1451	0	427	0	11489
1994	0	0	0	0	3914	1700	1808	1354	1087	0	826	549	11237
Average	362	455	45	17	1655	958	1370	845	625	379	533	222	7467

Table G.48
Middle of Reach 13: SDF = 60 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	1639	787	408	88	77	9	10	46	3063
1976	44	56	0	0	2753	1286	559	190	54	7	2	44	4994
1977	145	116	123	107	113	110	94	44	13	2	5	30	903
1978	50	45	47	52	65	0	1444	168	30	8	6	18	1934
1979	82	88	112	97	73	99	65	19	23	0	2	8	669
1980	23	32	0	0	0	0	0	0	0	22	65	184	326
1981	357	336	0	0	2639	1465	404	136	30	63	0	67	5498
1982	264	294	0	0	2707	1342	417	91	33	13	17	103	5282
1983	207	222	0	0	0	0	0	0	0	0	0	0	429
1984	0	2333	0	0	0	0	0	0	0	0	124	0	2456
1985	0	0	0	0	0	0	3030	1147	463	119	111	0	4871
1986	930	627	0	0	0	0	0	0	0	0	0	0	1556
1987	0	0	0	0	0	0	0	0	0	0	184	0	184
1988	787	0	0	0	0	4380	1791	1024	162	152	100	345	8740
1989	471	543	0	0	3153	1798	557	89	126	0	50	0	6788
1990	362	399	375	0	2086	1138	749	289	43	8	45	51	5544
1991	231	356	0	0	2712	1291	337	0	0	8	10	59	5005
1992	107	287	0	0	3145	0	2212	213	197	111	65	69	6406
1993	501	426	0	0	2139	0	2419	408	290	0	140	0	6323
1994	0	0	0	0	3435	1700	953	299	96	0	34	191	6708
Average	228	308	33	13	1333	770	772	210	82	26	49	61	3884

Table G.49
Middle of Reach 13: SDF = 270 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	700	866	691	525	422	334	206	220	3964
1976	150	145	0	0	1750	1702	1300	1075	690	294	80	242	7429
1977	428	343	306	291	306	302	241	246	224	128	136	171	3123
1978	157	145	132	109	141	0	901	995	752	224	276	203	4036
1979	262	280	280	239	203	244	216	197	136	0	128	91	2276
1980	104	120	0	0	0	0	0	0	0	1934	1607	1009	4775
1981	1120	951	0	0	2194	2307	1922	1647	1075	737	0	573	12527
1982	743	819	0	0	2234	1950	1617	1378	1162	971	896	619	12389
1983	781	603	0	0	0	0	0	0	0	0	0	0	1384
1984	0	2288	0	0	0	0	0	0	0	0	1953	0	4240
1985	0	0	0	0	0	0	4889	4406	3622	3043	2684	0	18645
1986	2206	1777	0	0	0	0	0	0	0	0	0	0	3983
1987	0	0	0	0	0	0	0	0	0	0	2415	0	2415
1988	1989	0	0	0	0	4502	3805	3178	2756	2261	2015	1746	22252
1989	1660	1834	0	0	3083	2795	2424	1961	1889	0	1344	0	16991
1990	1364	1221	1028	0	1861	1969	1670	1489	1251	656	1009	651	14171
1991	679	785	0	0	2207	2143	1618	0	0	439	497	509	8877
1992	611	892	0	0	2529	0	2719	2125	2081	1230	1035	1006	14228
1993	1133	1109	0	0	1735	0	2915	2644	2201	0	427	0	12165
1994	0	0	0	0	3031	1700	2695	2208	1875	0	1517	1028	14054
Average	669	666	87	32	1099	1024	1481	1204	1007	613	911	403	9196

Table G.50
Middle of Reach 13: SDF = 270 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	536	679	483	121	116	15	16	78	2044
1976	77	100	0	0	1452	1308	724	277	84	11	4	78	4115
1977	260	211	228	199	213	210	180	84	25	5	10	58	1683
1978	98	89	94	103	129	0	547	157	38	11	10	31	1306
1979	143	158	205	180	137	188	124	36	45	0	5	16	1237
1980	46	63	0	0	0	0	0	0	0	30	100	301	541
1981	606	587	0	0	1758	1707	580	216	50	110	0	123	5737
1982	491	554	0	0	1806	1561	599	145	56	23	31	191	5457
1983	389	422	0	0	0	0	0	0	0	0	0	0	811
1984	0	1632	0	0	0	0	0	0	0	0	201	0	1834
1985	0	0	0	0	0	0	2729	1516	712	198	193	0	5346
1986	1700	1166	0	0	0	0	0	0	0	0	0	0	2866
1987	0	0	0	0	0	0	0	0	0	0	309	0	309
1988	1423	0	0	0	0	3748	2366	1581	271	267	181	640	10476
1989	888	1037	0	0	2399	2292	860	151	224	0	95	0	7945
1990	700	780	738	0	1356	1422	1169	497	78	15	87	99	6940
1991	455	706	0	0	1743	1528	498	0	0	15	19	114	5077
1992	207	561	0	0	2060	0	1657	265	296	183	113	125	5468
1993	927	803	0	0	1463	0	1864	515	441	0	245	0	6258
1994	0	0	0	0	2660	1700	1421	487	166	0	63	357	6855
Average	420	443	63	24	886	817	790	302	130	44	84	111	4115

Table G.51
Middle of Reach 13: SDF = 300 Days
Reductions to Target Flow Shortages without Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	641	813	627	184	223	160	2648
1979	201	209	204	170	141	165	143	127	86	0	78	54	1578
1980	61	69	0	0	0	0	0	0	0	1010	832	515	2486
1981	564	473	0	0	365	365	332	309	217	157	0	133	2914
1982	178	201	0	0	170	149	141	136	128	116	115	85	1420
1983	112	91	0	0	0	0	0	0	0	0	0	0	203
1984	0	1279	0	0	0	0	0	0	0	0	1011	0	2290
1985	0	0	0	0	0	0	2024	2029	1712	1448	1280	0	8493
1986	1051	845	0	0	0	0	0	0	0	0	0	0	1896
1987	0	0	0	0	0	0	0	0	0	0	1452	0	1452
1988	1167	0	0	0	0	1432	1176	1036	948	812	749	667	7988
1989	648	729	0	0	589	532	512	454	472	0	376	0	4312
1990	411	379	327	0	366	361	337	328	297	166	267	179	3416
1991	193	229	0	0	257	247	214	0	0	80	97	105	1423
1992	133	202	0	0	201	0	819	835	830	587	394	375	4377
1993	415	400	0	0	221	0	945	1085	918	0	427	0	4410
1994	0	0	0	0	1047	1071	878	738	640	0	533	364	5271
Average	257	255	27	8	168	216	408	395	344	228	392	132	2829

Table G.52
Middle of Reach 13: SDF = 300 Days
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	389	128	31	9	8	24	590
1979	110	118	150	128	95	127	82	23	28	0	3	9	873
1980	27	36	0	0	0	0	0	0	0	16	52	154	285
1981	305	292	0	0	292	270	100	40	10	24	0	29	1362
1982	118	136	0	0	137	119	52	14	6	3	4	26	616
1983	56	63	0	0	0	0	0	0	0	0	0	0	119
1984	0	913	0	0	0	0	0	0	0	0	104	0	1017
1985	0	0	0	0	0	0	1111	698	336	94	92	0	2331
1986	810	554	0	0	0	0	0	0	0	0	0	0	1364
1987	0	0	0	0	0	0	0	0	0	0	186	0	186
1988	835	0	0	0	0	1192	732	516	93	96	67	244	3775
1989	346	412	0	0	458	436	181	35	56	0	27	0	1952
1990	211	242	235	0	267	260	235	110	19	4	23	27	1632
1991	129	206	0	0	203	176	66	0	0	3	4	23	810
1992	45	127	0	0	164	0	499	104	118	72	43	46	1219
1993	339	289	0	0	186	0	604	212	184	0	98	0	1913
1994	0	0	0	0	919	940	463	163	57	0	22	127	2690
Average	167	169	19	6	136	176	226	102	47	16	37	36	1137

Table G.53

Scenario 1 - Groundwater Pumping from the Mound in Reach 10

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2970	2484	1517	0	3218	3618	3370	1807	2046	286	372	2086	23773
1976	2144	2548	0	0	3831	3654	3272	1836	633	108	42	823	18891
1977	2426	2080	507	2403	2832	2987	2818	1856	774	133	318	2398	21532
1978	2550	2447	1233	3147	4100	0	2940	1161	348	107	144	649	18826
1979	1777	2214	1044	3127	2543	1549	2820	1310	2300	0	225	927	19836
1980	3190	4118	0	0	0	0	0	0	0	174	668	2780	10929
1981	2236	2421	0	0	3704	3801	2030	994	285	654	0	1287	17412
1982	2711	3277	0	0	4053	3726	2052	738	340	151	237	1574	18860
1983	5408	5945	0	0	0	0	0	0	0	0	0	0	11353
1984	0	5746	0	0	0	0	0	0	0	0	938	0	6684
1985	0	0	0	0	0	0	3344	5578	3701	949	1224	0	14796
1986	6221	5947	0	0	0	0	0	0	0	0	0	0	12168
1987	0	0	0	0	0	0	0	0	0	0	1323	0	1323
1988	3526	0	0	0	0	5035	3665	3529	820	810	778	2659	20822
1989	2743	3440	0	0	4618	4619	2372	891	1151	0	535	0	20370
1990	2235	2608	2635	0	3169	3198	3204	1954	518	79	543	605	20749
1991	2775	4378	0	0	4638	4203	1722	0	0	110	166	929	18920
1992	1319	2744	0	0	4973	0	3688	996	1192	203	658	821	16593
1993	5876	5304	0	0	4386	0	5027	1996	2086	0	103	0	24778
1994	0	0	0	0	5775	1445	4532	2730	1206	0	503	3341	19531
Average	2505	2885	347	434	2592	1892	2343	1369	870	188	439	1044	16907

Table G.54

Scenario 1 - Groundwater Pumping from the Mound in Reach 17

Reductions to Target Flow Shortages with Diversions

(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3856	3562	1970	0	4357	4595	4600	4443	4513	3829	2944	3978	42647
1976	3303	3645	0	0	4721	4789	4548	4734	3621	1908	871	2171	34311
1977	3719	3387	695	3579	4170	4428	3868	4323	4090	2365	2783	3872	41281
1978	4165	4066	1774	3499	4650	0	4691	4535	3865	1498	2072	2161	36976
1979	3250	3898	1450	4217	3968	2107	4967	4878	3663	0	3713	3074	39184
1980	7148	8456	0	0	0	0	0	0	0	7058	6981	5952	35594
1981	4199	4142	0	0	4680	5230	5204	5328	4008	3240	0	3264	39295
1982	4166	5037	0	0	5076	4743	4578	4553	4633	3974	4149	3557	44465
1983	14784	12355	0	0	0	0	0	0	0	0	0	0	27139
1984	0	8217	0	0	0	0	0	0	0	0	9257	0	17474
1985	0	0	0	0	0	0	4627	10836	10502	9706	10347	0	46018
1986	8210	11033	0	0	0	0	0	0	0	0	0	0	19244
1987	0	0	0	0	0	0	0	0	0	0	10635	0	10635
1988	5092	0	0	0	0	6127	5571	5824	5448	4351	5315	5273	43001
1989	5300	6319	0	0	6049	5781	5936	5353	5868	0	4955	0	45561
1990	4423	4206	3780	0	4506	4606	4504	4455	4078	2307	3629	2565	43060
1991	4621	5075	0	0	6151	6117	5391	0	0	2047	2507	3056	34964
1992	3938	4521	0	0	6335	0	6188	5129	5528	953	3823	4285	40701
1993	7200	7540	0	0	5480	0	8313	8045	7912	0	407	0	44896
1994	0	0	0	0	6700	1691	8062	7852	7305	0	6656	5708	43974
Average	4369	4773	483	565	3342	2511	4052	4014	3752	2162	4052	2446	36521

Table G.55
Scenario 1 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	3948	3854	2017	0	4398	4703	4695	4590	4643	4244	3165	4367	44622
1976	3686	4137	0	0	4904	4934	4800	4871	3821	1994	769	2210	36127
1977	3819	3774	709	3650	4353	4480	4195	4413	4277	2714	2925	4171	43479
1978	4233	4105	1901	3502	4753	0	4764	4663	4229	1689	2263	2179	38281
1979	3567	4201	1462	4221	3974	2110	5082	5026	3818	0	3870	3053	40383
1980	6067	7036	0	0	0	0	0	0	0	6956	6478	5155	31692
1981	4401	4382	0	0	4739	5434	5378	5446	4222	3313	0	3534	40850
1982	4199	5069	0	0	5081	4912	4794	4787	4811	4411	4492	3618	46174
1983	8406	7566	0	0	0	0	0	0	0	0	0	0	15973
1984	0	8320	0	0	0	0	0	0	0	0	5489	0	13810
1985	0	0	0	0	0	0	4739	8209	8048	7706	7979	0	36682
1986	8279	7993	0	0	0	0	0	0	0	0	0	0	16272
1987	0	0	0	0	0	0	0	0	0	0	6224	0	6224
1988	5110	0	0	0	0	6164	5784	5861	5821	4508	5480	5323	44052
1989	5795	6331	0	0	6055	5788	6079	5568	6053	0	5143	0	46812
1990	4499	4410	3784	0	4565	4614	4546	4524	4284	2537	3918	2877	44558
1991	4987	5090	0	0	6253	6228	5521	0	0	2202	2688	3120	36089
1992	4069	4531	0	0	6367	0	6263	5345	5879	973	3974	4435	41836
1993	7452	7961	0	0	5485	0	8340	8181	8092	0	414	0	45924
1994	0	0	0	0	6706	1693	8097	7937	7641	0	7288	5842	45206
Average	4126	4438	494	569	3382	2553	4154	3971	3782	2162	3628	2494	35752

Table G.56
Scenario 1 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	4145	4241	2152	0	4494	4811	4790	4737	4773	4662	3578	4758	47141
1976	4213	4694	0	0	5087	5079	5053	5008	4150	2496	1290	2651	39721
1977	4005	4215	752	3839	4536	4531	4522	4502	4461	3256	3267	4474	46358
1978	4375	4246	2054	3699	4857	0	4836	4791	4611	2296	2789	2571	41126
1979	4072	4607	1505	4368	4157	2112	5193	5169	4148	0	4186	3337	42855
1980	6496	7229	0	0	0	0	0	0	0	8044	7297	5787	34854
1981	4751	4769	0	0	4919	5638	5553	5564	4587	3701	0	4062	43544
1982	4351	5077	0	0	5087	5081	5012	5017	4986	4854	4854	3875	48193
1983	8434	8181	0	0	0	0	0	0	0	0	0	0	16615
1984	0	8473	0	0	0	0	0	0	0	0	6108	0	14581
1985	0	0	0	0	0	0	4849	8426	8353	8260	8322	0	38211
1986	8347	8472	0	0	0	0	0	0	0	0	0	0	16819
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	5321	0	0	0	0	6243	6064	5975	6205	4753	5750	5525	45836
1989	6292	6343	0	0	6104	5875	6224	5843	6236	0	5461	0	48378
1990	4575	4613	3907	0	4623	4620	4588	4592	4486	3013	4255	3384	46656
1991	5487	5282	0	0	6355	6340	5741	0	0	2915	3353	3625	39098
1992	4507	4580	0	0	6399	0	6339	5655	6235	1023	4436	4824	43997
1993	7796	8384	0	0	5906	0	8365	8308	8267	0	421	0	47446
1994	0	0	0	0	6924	1695	8131	8025	7971	0	7930	6278	46955
Average	4358	4670	519	595	3472	2601	4263	4081	3973	2464	4000	2758	37754

Table G.57
Scenario 2 - Groundwater Pumping from the Mound in Reach 10
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2079	1738	1517	0	2252	2532	2358	1264	1432	200	261	1460	17094
1976	1534	1824	0	0	2742	2615	2342	1314	453	77	30	589	13520
1977	1724	1477	507	1707	2012	2122	2002	1319	550	94	226	1703	15444
1978	1792	1720	1233	2212	2881	0	2066	816	245	75	101	456	13597
1979	1231	1533	1044	2166	1761	1549	1953	907	1593	0	156	642	14537
1980	2283	2947	0	0	0	0	0	0	0	124	478	1990	7822
1981	1600	1733	0	0	2651	2720	1453	711	204	468	0	921	12462
1982	1941	2345	0	0	2901	2666	1469	528	244	108	170	1127	13498
1983	5408	5945	0	0	0	0	0	0	0	0	0	0	11353
1984	0	5746	0	0	0	0	0	0	0	0	938	0	6684
1985	0	0	0	0	0	0	3344	4198	2786	714	921	0	11963
1986	6221	5947	0	0	0	0	0	0	0	0	0	0	12168
1987	0	0	0	0	0	0	0	0	0	0	1323	0	1323
1988	2469	0	0	0	0	3525	2566	2470	574	687	545	1861	14696
1989	1963	2462	0	0	3305	3306	1698	637	824	0	383	0	14578
1990	1600	1866	1886	0	2268	2289	2293	1399	370	57	389	433	14850
1991	1986	3133	0	0	3319	3008	1232	0	0	79	119	665	13541
1992	906	2498	0	0	3416	0	2533	684	819	203	452	564	12075
1993	4191	3783	0	0	3128	0	3586	1424	1488	0	103	0	17703
1994	0	0	0	0	4076	1445	3199	1927	851	0	355	2358	14211
Average	1946	2335	309	304	1836	1389	1705	980	622	144	347	738	12656

Table G.58
Scenario 2 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2699	2493	1970	0	3049	3216	3220	3110	3158	2680	2061	2784	30439
1976	2364	2609	0	0	3379	3428	3255	3388	2591	1365	624	1554	24556
1977	2642	2406	695	2543	2963	3146	2748	3071	2906	1680	1977	2751	29529
1978	2927	2858	1774	2459	3268	0	3297	3187	2716	1053	1456	1519	26514
1979	2251	2700	1450	2921	2749	2107	3440	3379	2537	0	2572	2130	28236
1980	5116	6052	0	0	0	0	0	0	0	5051	4996	4260	25474
1981	3005	2964	0	0	3350	3743	3724	3813	2869	2319	0	2336	28123
1982	2982	3605	0	0	3633	3394	3276	3258	3316	2844	2969	2546	31823
1983	14784	12355	0	0	0	0	0	0	0	0	0	0	27139
1984	0	8217	0	0	0	0	0	0	0	0	9257	0	17474
1985	0	0	0	0	0	0	4627	7429	7200	6654	7093	0	33002
1986	8210	11033	0	0	0	0	0	0	0	0	0	0	19244
1987	0	0	0	0	0	0	0	0	0	0	10635	0	10635
1988	3565	0	0	0	0	4289	3900	4077	3814	3690	3721	3691	30748
1989	3793	4522	0	0	4329	4137	4249	3831	4199	0	3546	0	32607
1990	3165	3010	2705	0	3225	3297	3223	3188	2919	1651	2598	1836	30817
1991	3307	3632	0	0	4402	4378	3858	0	0	1465	1794	2187	25023
1992	2705	4117	0	0	4352	0	4250	3523	3797	953	2626	2944	29267
1993	5136	5378	0	0	3909	0	5930	5738	5643	0	407	0	32140
1994	0	0	0	0	4730	1691	5691	5543	5157	0	4698	4029	31538
Average	3433	3898	430	396	2367	1841	2934	2827	2641	1570	3151	1728	27216

Table G.59
Scenario 2 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2763	2697	2017	0	3078	3292	3286	3212	3249	2970	2215	3056	31836
1976	2638	2961	0	0	3510	3531	3435	3486	2734	1427	551	1582	25856
1977	2713	2681	709	2593	3092	3183	2980	3135	3038	1928	2078	2963	31094
1978	2975	2885	1901	2461	3341	0	3348	3277	2972	1187	1590	1531	27468
1979	2471	2910	1462	2924	2752	2110	3520	3481	2645	0	2681	2115	29071
1980	5211	6042	0	0	0	0	0	0	0	5974	5564	4427	27218
1981	3150	3136	0	0	3392	3889	3849	3897	3022	2371	0	2529	29236
1982	3005	3627	0	0	3637	3516	3431	3426	3443	3157	3215	2589	33046
1983	8406	7566	0	0	0	0	0	0	0	0	0	0	15973
1984	0	8320	0	0	0	0	0	0	0	0	5489	0	13810
1985	0	0	0	0	0	0	4739	7633	7483	7165	7418	0	34437
1986	8279	7993	0	0	0	0	0	0	0	0	0	0	16272
1987	0	0	0	0	0	0	0	0	0	0	6224	0	6224
1988	3577	0	0	0	0	4315	4049	4103	4075	3823	3837	3727	31507
1989	4147	4531	0	0	4334	4143	4351	3985	4332	0	3681	0	33503
1990	3220	3156	2708	0	3267	3302	3253	3238	3066	1816	2804	2059	31890
1991	3569	3643	0	0	4475	4457	3951	0	0	1576	1924	2233	25828
1992	2795	4125	0	0	4374	0	4302	3671	4038	973	2730	3046	30055
1993	5315	5678	0	0	3912	0	5949	5835	5772	0	414	0	32876
1994	0	0	0	0	4734	1693	5716	5603	5393	0	5145	4124	32408
Average	3212	3598	440	399	2395	1872	3008	2899	2763	1718	2878	1799	26980

Table G.60
Scenario 2 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	2901	2968	2152	0	3145	3367	3352	3315	3340	3263	2504	3330	33639
1976	3015	3360	0	0	3641	3635	3616	3584	2970	1786	923	1897	28428
1977	2845	2994	752	2727	3222	3219	3212	3199	3169	2313	2321	3178	33152
1978	3075	2984	2054	2600	3413	0	3399	3367	3241	1614	1960	1807	29513
1979	2821	3191	1505	3026	2879	2112	3597	3581	2873	0	2899	2312	30797
1980	5579	6209	0	0	0	0	0	0	0	6909	6267	4970	29934
1981	3400	3413	0	0	3520	4035	3974	3982	3283	2649	0	2907	31164
1982	3114	3633	0	0	3640	3636	3587	3591	3568	3474	3474	2773	34491
1983	8434	8181	0	0	0	0	0	0	0	0	0	0	16615
1984	0	8473	0	0	0	0	0	0	0	0	6108	0	14581
1985	0	0	0	0	0	0	4849	7834	7767	7680	7738	0	35867
1986	8347	8472	0	0	0	0	0	0	0	0	0	0	16819
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	3725	0	0	0	0	4371	4245	4183	4344	4031	4025	3868	32792
1989	4503	4539	0	0	4368	4205	4455	4182	4463	0	3908	0	34624
1990	3274	3302	2797	0	3309	3306	3284	3286	3210	2156	3045	2422	33391
1991	3927	3780	0	0	4548	4537	4109	0	0	2086	2400	2594	27982
1992	3096	4170	0	0	4396	0	4354	3884	4283	1023	3047	3314	31566
1993	5561	5980	0	0	4213	0	5966	5926	5897	0	421	0	33963
1994	0	0	0	0	4888	1695	5740	5665	5626	0	5598	4431	33643
Average	3381	3782	463	418	2459	1906	3087	2979	2902	1949	3167	1990	28483

Table G.61
Scenario 3 - Groundwater Pumping from the Mound in Reach 10
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	810	678	745	0	878	987	919	493	558	78	102	569	6817
1976	609	724	0	0	1089	1039	930	522	180	31	12	234	5371
1977	658	564	507	652	768	810	764	503	210	36	86	650	6207
1978	689	661	734	850	1108	0	794	314	94	29	39	175	5488
1979	447	557	811	786	639	964	709	329	578	0	57	233	6110
1980	907	1171	0	0	0	0	0	0	0	49	190	790	3107
1981	636	688	0	0	1053	1081	577	283	81	186	0	366	4951
1982	771	932	0	0	1152	1059	583	210	97	43	67	448	5362
1983	3734	4105	0	0	0	0	0	0	0	0	0	0	7839
1984	0	4871	0	0	0	0	0	0	0	0	647	0	5519
1985	0	0	0	0	0	0	1983	1541	1022	262	338	0	5146
1986	5382	4106	0	0	0	0	0	0	0	0	0	0	9489
1987	0	0	0	0	0	0	0	0	0	0	1323	0	1323
1988	981	0	0	0	0	1400	1019	981	228	273	216	739	5838
1989	780	978	0	0	1313	1313	674	253	327	0	152	0	5791
1990	635	741	749	0	901	909	911	556	147	23	154	172	5899
1991	789	1245	0	0	1319	1195	489	0	0	31	47	264	5379
1992	341	940	0	0	1285	0	953	257	308	203	170	212	4670
1993	1635	1476	0	0	1220	0	1399	556	580	0	103	0	6969
1994	0	0	0	0	1499	1445	1177	709	313	0	130	867	6141
Average	990	1222	177	114	711	610	694	375	236	62	192	286	5671

Table G.62
Scenario 3 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1052	972	967	0	1189	1254	1255	1212	1231	1045	803	1085	12065
1976	939	1036	0	0	1342	1362	1293	1346	1029	542	248	617	9755
1977	1008	918	695	970	1131	1200	1049	1172	1109	641	754	1050	11697
1978	1125	1099	1056	945	1256	0	1267	1225	1044	405	560	584	10568
1979	817	980	1125	1060	998	1311	1249	1226	921	0	933	773	11395
1980	2032	2404	0	0	0	0	0	0	0	2007	1985	1692	10120
1981	1194	1178	0	0	1331	1487	1480	1515	1140	921	0	928	11172
1982	1185	1432	0	0	1443	1348	1301	1294	1317	1130	1180	1011	12642
1983	7145	5972	0	0	0	0	0	0	0	0	0	0	13117
1984	0	6966	0	0	0	0	0	0	0	0	4474	0	11440
1985	0	0	0	0	0	0	2745	2726	2642	2442	2603	0	13157
1986	7103	6410	0	0	0	0	0	0	0	0	0	0	13513
1987	0	0	0	0	0	0	0	0	0	0	10281	0	10281
1988	1416	0	0	0	0	1704	1549	1620	1515	1466	1478	1466	12215
1989	1507	1796	0	0	1720	1644	1688	1522	1668	0	1409	0	12954
1990	1257	1196	1075	0	1281	1310	1281	1267	1159	656	1032	729	12242
1991	1314	1443	0	0	1749	1739	1533	0	0	582	713	869	9941
1992	1018	1549	0	0	1637	0	1599	1326	1429	953	988	1107	11606
1993	2003	2098	0	0	1525	0	2313	2239	2202	0	407	0	12787
1994	0	0	0	0	1740	1691	2093	2039	1897	0	1728	1482	12669
Average	1606	1872	246	149	917	802	1185	1086	1015	639	1579	670	11767

Table G.63
Scenario 3 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1077	1051	990	0	1200	1283	1281	1252	1267	1158	863	1191	12614
1976	1048	1176	0	0	1394	1403	1365	1385	1086	567	219	628	10271
1977	1035	1023	709	990	1180	1214	1137	1196	1159	736	793	1131	12304
1978	1144	1109	1132	946	1284	0	1287	1260	1143	456	611	589	10962
1979	897	1056	1135	1061	999	1313	1278	1264	960	0	973	768	11704
1980	2070	2400	0	0	0	0	0	0	0	2373	2210	1759	10813
1981	1251	1246	0	0	1347	1545	1529	1548	1200	942	0	1005	11614
1982	1194	1441	0	0	1445	1397	1363	1361	1368	1254	1277	1029	13128
1983	7170	6454	0	0	0	0	0	0	0	0	0	0	13624
1984	0	7097	0	0	0	0	0	0	0	0	4682	0	11779
1985	0	0	0	0	0	0	2811	2801	2746	2629	2722	0	13709
1986	7163	6818	0	0	0	0	0	0	0	0	0	0	13980
1987	0	0	0	0	0	0	0	0	0	0	6224	0	6224
1988	1421	0	0	0	0	1714	1609	1630	1619	1519	1524	1480	12516
1989	1647	1800	0	0	1722	1646	1728	1583	1721	0	1462	0	13309
1990	1279	1254	1076	0	1298	1312	1292	1286	1218	721	1114	818	12668
1991	1418	1447	0	0	1778	1771	1570	0	0	626	764	887	10261
1992	1052	1552	0	0	1646	0	1619	1381	1519	973	1027	1146	11914
1993	2074	2215	0	0	1526	0	2321	2276	2252	0	414	0	13078
1994	0	0	0	0	1741	1693	2102	2061	1984	0	1892	1517	12991
Average	1647	1957	252	150	928	815	1215	1114	1062	698	1439	697	11973

Table G.64
Scenario 3 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	1131	1157	1056	0	1226	1313	1307	1292	1302	1272	976	1298	13331
1976	1198	1335	0	0	1446	1444	1437	1424	1180	710	367	754	11293
1977	1086	1143	752	1041	1230	1228	1226	1221	1209	883	886	1213	13115
1978	1182	1147	1223	999	1312	0	1307	1295	1246	621	753	695	11780
1979	1024	1158	1169	1098	1045	1315	1306	1300	1043	0	1052	839	12349
1980	2216	2466	0	0	0	0	0	0	0	2745	2490	1975	11891
1981	1351	1356	0	0	1399	1603	1579	1582	1304	1052	0	1155	12380
1982	1237	1443	0	0	1446	1445	1425	1426	1417	1380	1380	1102	13702
1983	7194	6978	0	0	0	0	0	0	0	0	0	0	14172
1984	0	7227	0	0	0	0	0	0	0	0	5210	0	12437
1985	0	0	0	0	0	0	2876	2875	2850	2818	2839	0	14259
1986	7221	7226	0	0	0	0	0	0	0	0	0	0	14448
1987	0	0	0	0	0	0	0	0	0	0	6696	0	6696
1988	1480	0	0	0	0	1736	1687	1662	1726	1601	1599	1537	13027
1989	1789	1803	0	0	1735	1670	1770	1661	1773	0	1553	0	13755
1990	1301	1312	1111	0	1314	1314	1304	1306	1275	857	1210	962	13265
1991	1560	1502	0	0	1807	1803	1632	0	0	829	953	1031	11116
1992	1165	1569	0	0	1654	0	1638	1461	1611	1023	1146	1247	12515
1993	2169	2333	0	0	1644	0	2328	2312	2300	0	421	0	13507
1994	0	0	0	0	1798	1695	2111	2084	2070	0	2059	1630	13446
Average	1715	2058	266	157	953	828	1247	1145	1115	789	1580	772	12624

Table G.65
Scenario 4 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	138	1334	2573	3907	2739	597	11288
1976	0	0	0	0	0	0	129	1346	1956	1844	768	309	6352
1977	0	0	0	0	0	0	123	1377	2475	2562	2748	617	9902
1978	0	0	0	0	0	0	139	1348	2183	1514	1909	321	7414
1979	0	0	0	0	0	0	137	1349	1925	0	3183	425	7020
1980	0	0	0	0	0	0	0	0	0	3411	3076	423	6911
1981	0	0	0	0	0	0	133	1363	1949	2819	0	418	6682
1982	0	0	0	0	0	0	130	1294	2503	3842	3657	506	11932
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	2774	0	2774
1985	0	0	0	0	0	0	137	1363	2510	4151	4035	0	12195
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3187	0	3187
1988	0	0	0	0	0	0	124	1296	2303	3987	3666	587	11962
1989	0	0	0	0	0	0	135	1217	2536	0	3494	0	7382
1990	0	0	0	0	0	0	141	1393	2423	2453	3519	401	10331
1991	0	0	0	0	0	0	123	0	0	1583	1767	348	3821
1992	0	0	0	0	0	0	140	1159	2373	1230	2677	484	8063
1993	0	0	0	0	0	0	143	1384	2586	0	427	0	4540
1994	0	0	0	0	0	0	142	1386	2449	0	3641	504	8122
Average	0	0	0	0	0	0	101	930	1637	1665	2363	297	6994

Table G.66
Scenario 4 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	141	1377	2647	4331	2944	655	12096
1976	0	0	0	0	0	0	136	1385	2064	1928	678	314	6505
1977	0	0	0	0	0	0	134	1406	2588	2939	2888	664	10619
1978	0	0	0	0	0	0	142	1386	2388	1707	2085	324	8031
1979	0	0	0	0	0	0	141	1390	2006	0	3318	422	7277
1980	0	0	0	0	0	0	0	0	0	4034	3426	440	7900
1981	0	0	0	0	0	0	138	1393	2053	2883	0	452	6919
1982	0	0	0	0	0	0	136	1361	2599	4264	3959	514	12834
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	2903	0	2903
1985	0	0	0	0	0	0	141	1400	2609	4470	4219	0	12839
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3291	0	3291
1988	0	0	0	0	0	0	129	1304	2461	4131	3780	592	12397
1989	0	0	0	0	0	0	138	1266	2616	0	3627	0	7647
1990	0	0	0	0	0	0	142	1415	2546	2698	3799	450	11050
1991	0	0	0	0	0	0	126	0	0	1703	1895	355	4079
1992	0	0	0	0	0	0	141	1207	2524	1230	2783	501	8387
1993	0	0	0	0	0	0	143	1407	2645	0	427	0	4623
1994	0	0	0	0	0	0	143	1401	2562	0	3987	516	8608
Average	0	0	0	0	0	0	104	955	1715	1816	2501	310	7400

Table G.67
Scenario 4 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	144	1422	2722	4757	3329	714	13087
1976	0	0	0	0	0	0	144	1424	2242	2413	1137	377	7736
1977	0	0	0	0	0	0	144	1434	2700	3526	3226	712	11742
1978	0	0	0	0	0	0	144	1424	2604	2321	2569	382	9444
1979	0	0	0	0	0	0	144	1430	2180	0	3589	461	7803
1980	0	0	0	0	0	0	0	0	0	4666	3859	494	9018
1981	0	0	0	0	0	0	142	1424	2230	3220	0	520	7535
1982	0	0	0	0	0	0	142	1426	2693	4692	4279	551	13783
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	3230	0	3230
1985	0	0	0	0	0	0	144	1437	2708	4791	4401	0	13481
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	3541	0	3541
1988	0	0	0	0	0	0	135	1329	2623	4355	3966	615	13023
1989	0	0	0	0	0	0	142	1329	2695	0	3851	0	8016
1990	0	0	0	0	0	0	143	1436	2666	3204	4126	529	12104
1991	0	0	0	0	0	0	131	0	0	2254	2364	412	5161
1992	0	0	0	0	0	0	143	1277	2676	1230	3106	545	8978
1993	0	0	0	0	0	0	144	1429	2702	0	427	0	4702
1994	0	0	0	0	0	0	143	1416	2673	0	4338	554	9124
Average	0	0	0	0	0	0	106	982	1806	2071	2767	343	8076

Table G.68
Scenario 5 - Groundwater Pumping from the Mound in Reach 17
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	486	4690	9050	13741	9634	2100	39702
1976	0	0	0	0	0	0	455	4734	6879	6487	2701	1085	22342
1977	0	0	0	0	0	0	433	4843	8707	9010	9664	2169	34827
1978	0	0	0	0	0	0	490	4740	7677	5325	6714	1130	26076
1979	0	0	0	0	0	0	483	4745	6770	0	11196	1495	24690
1980	0	0	0	0	0	0	0	0	0	11998	10820	1488	24306
1981	0	0	0	0	0	0	468	4795	6854	9915	0	1469	23502
1982	0	0	0	0	0	0	458	4553	8803	13513	12861	1778	41966
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	9757	0	9757
1985	0	0	0	0	0	0	.483	4794	8828	14599	14190	0	42894
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	11209	0	11209
1988	0	0	0	0	0	0	436	4557	8101	5380	12894	2063	33431
1989	0	0	0	0	0	0	475	4282	8919	0	12259	0	25964
1990	0	0	0	0	0	0	495	4900	8523	8629	12376	1411	36336
1991	0	0	0	0	0	0	431	0	0	5568	6217	1223	13439
1992	0	0	0	0	0	0	492	4075	8346	1230	9416	1703	25262
1993	0	0	0	0	0	0	503	4868	9095	0	427	0	14893
1994	0	0	0	0	0	0	500	4874	8615	0	12807	1771	28567
Average	0	0	0	0	0	0	354	3273	5758	5270	8259	1044	23958

Table G.69
Scenario 5 - Groundwater Pumping from the Mound in Reach 18
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	496	4845	9311	15232	10356	2305	42544
1976	0	0	0	0	0	0	480	4871	7259	6780	2385	1105	22880
1977	0	0	0	0	0	0	470	4944	9103	10336	10158	2336	37348
1978	0	0	0	0	0	0	498	4875	8400	6004	7332	1139	28248
1979	0	0	0	0	0	0	494	4889	7057	0	11671	1485	25597
1980	0	0	0	0	0	0	0	0	0	14190	12050	1547	27786
1981	0	0	0	0	0	0	484	4901	7220	10139	0	1590	24334
1982	0	0	0	0	0	0	479	4787	9142	14996	13926	1809	45139
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	10210	0	10210
1985	0	0	0	0	0	0	494	4926	9175	15721	14840	0	45157
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	11576	0	11576
1988	0	0	0	0	0	0	453	4586	8655	5380	13295	2083	34451
1989	0	0	0	0	0	0	486	4455	9200	0	12756	0	26897
1990	0	0	0	0	0	0	500	4977	8953	9490	13362	1582	38865
1991	0	0	0	0	0	0	442	0	0	5990	6666	1248	14347
1992	0	0	0	0	0	0	498	4247	8876	1230	9789	1762	26402
1993	0	0	0	0	0	0	505	4950	9303	0	427	0	15185
1994	0	0	0	0	0	0	503	4926	9011	0	14024	1813	30277
Average	0	0	0	0	0	0	364	3359	6033	5774	8741	1090	25362

Table G.70
Scenario 5 - Groundwater Pumping from the Mound in Reach 19
Reductions to Target Flow Shortages with Diversions
(ac-ft)

Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
1975	0	0	0	0	0	0	506	5000	9572	16732	11708	2511	46029
1976	0	0	0	0	0	0	505	5008	7885	8486	3999	1325	27208
1977	0	0	0	0	0	0	507	5044	9496	12401	11347	2506	41301
1978	0	0	0	0	0	0	506	5009	9158	8162	9037	1344	33216
1979	0	0	0	0	0	0	505	5029	7667	0	12622	1623	27446
1980	0	0	0	0	0	0	0	0	0	16411	13573	1736	31720
1981	0	0	0	0	0	0	500	5008	7843	11325	0	1828	26504
1982	0	0	0	0	0	0	501	5017	9473	16505	15049	1937	48480
1983	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	11361	0	11361
1985	0	0	0	0	0	0	506	5056	9523	16851	15480	0	47415
1986	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0	0	0	12455	0	12455
1988	0	0	0	0	0	0	475	4675	9226	5380	13949	2162	35867
1989	0	0	0	0	0	0	498	4674	9479	0	13544	0	28195
1999	0	0	0	0	0	0	505	5051	9375	11269	14511	1861	42571
1991	0	0	0	0	0	0	459	0	0	7929	8316	1450	18154
1992	0	0	0	0	0	0	504	4493	9414	1230	10926	1917	28483
1993	0	0	0	0	0	0	506	5027	9504	0	427	0	15464
1994	0	0	0	0	0	0	505	4981	9400	0	15259	1948	32093
Average	0	0	0	0	0	0	374	3454	6351	6634	9678	1207	27698