to: PRRIP GC Scoring Subcommittee

from: PRRIP Executive director’s office

subject: score analyses for Cpnrd and nppd recharge projects

date: MARCH 24, 2020

1. **EXECUTIVE SUMMARY**

The original First Increment Water Objective for the Platte River Recovery Implementation Program (PRRIP or Program) called for reducing deficits to target flows at Grand Island, Nebraska by 130,000 acre-feet to 150,000 acre-feet per year (AFY). The three states that are signatories to the Program (Colorado, Nebraska, and Wyoming) contributed initial water supply projects that were credited with a score[[1]](#footnote-1) of 80,000 AFY. Program Milestone #4 called for a Water Action Plan (WAP) consisting of additional water supply and water conservation projects to be implemented during the First Increment to fulfill the remaining 50,000 AFY to 70,000 AFY.

The Program was unable to meet the full First Increment Water Objective by the end of 2019, and a 13-year First Increment Extension began on January 1, 2020. Terms of the Extension require the Program to first achieve a cumulative score of 120,000 AFY then carry out testing to determine whether the benefits of acquiring an additional 10,000 AFY justify what is assumed to be a much greater cost.

This document reports on the score analyses for two existing WAP projects involving groundwater recharge through three irrigation canals affiliated with the Central Platte Natural Resources District (CPNRD) and two canals owned and operated by the Nebraska Public Power District (NPPD). These are retiming projects in which water can be diverted into the canals at times during the non-irrigation season when streamflows are above the designated targets at Grand Island, i.e., there are excess flows. The diverted water seeps into or recharges the underlying alluvial aquifer and slowly migrates back to the Platte River over time. Associated return flows (accretions) to the river at times when there are shortages (deficits) to target flows at Grand Island are credited towards the reduction of those shortages.

All five CPNRD and NPPD canals divert from the Platte River reach between Brady and Cozad, and thus rely on a common source of excess flows. While most existing WAP projects have been scored individually as stand-alone projects, these commonalities prompted to EDO to develop a model to score both canal recharge projects simultaneously. As validation of this approach, score model results indicate that whether the CPNRD and NPPD recharge projects are modeled individually or together, the results are the same.

For each project, 16 different model runs were completed as variations on four basic scenarios**. For the CPNRD recharge project, the individual model run scores ranged from 1,073 AFY to 2,755 AFY, with a mathematical average of about 1,800 AFY. Scores for the NPPD recharge project ranged from 718 AFY to 1,689 AFY, with an average of 1,150 AFY.**

This memorandum was prepared by the EDO for the Scoring Subcommittee to document the histories of the CPNRD and NPPD recharge projects, the technical aspects of the score model inputs and assumptions, and the results of the score analyses. The memo will be reviewed, and the analyses will be vetted by the Scoring Subcommittee with the objective of recommending project scores for approval by the Program’s Governance Committee.

1. **INTRODUCTION**

Methods and key assumptions for WAP project score analyses were originally developed and approved by the Program’s Governance Committee (GC) in 2010. The same basic methodology was used consistently across all score analyses completed during the Program’s First Increment that ended in 2019, with project-specific modifications as needed. To maintain this continuity, the EDO used the previously approved scoring methodology to complete preliminary scoring analyses for the CPNRD and NPPD groundwater recharge projects. Given the geographic proximity of the three CPNRD canals and two NPPD canals (all five divert from the Platte River in the reach between Brady and Cozad) and a common source of water (excess flows available at the Brady Gage), the EDO elected to develop a score model that could be used to evaluate both projects simultaneously. The purpose of this memorandum is to provide the Scoring Subcommittee with detailed information regarding the projects and analyses, including project operational histories, project-specific inputs and assumptions developed for the score model, alternative scenarios evaluated, and estimated project scores based on modeling of those various scenarios.

1. **Approved WAP Project Scores**

Through the end of the Program’s First Increment in 2019, the GC accepted scores for six[[2]](#footnote-2) active WAP projects totaling 14,170 AFY, with the Cook Recapture Well considered to be a part of the Phelps County Canal Groundwater Recharge Project. The individual project scores are shown in **Table 1** below.

**Table 1. WAP Project Scores Accepted 2016-2019**

|  |  |  |
| --- | --- | --- |
| **Project** | **Score**  **[AFY]** | **Date Accepted** |
| No-Cost Net Controllable Conserved Water (NCCW) | 260 | March 2016 |
| Phelps County Canal Groundwater Recharge + Cook Recapture Well | 2,860 | September 2016 |
| Pathfinder Municipal Account Lease | 6,350 | September 2018 |
| CNPPID Irrigator Lease | 1,900 | June 2019 |
| Elwood Reservoir Groundwater Recharge | 2,800 | September 2019 |
| **TOTAL** | **14,170** |  |

Following the completion of the present score analyses for the CPNRD and NPPD groundwater recharge projects, there will be three more currently active WAP projects that the EDO anticipates scoring in 2021 or 2022. These include the Cottonwood Ranch broad-scale recharge project, which will begin operations in late summer 2020, and the CPNRD and NPPD surface water leases, which were operated as “pilot exchange projects” in 2018 and 2019. Other projects in various states of conceptual analysis or pilot design will likely be needed to reach a combined score of 40,000 AFY from WAP projects and the modified Water Objective of 120,000 AFY in combination with 80,000 AFY from the three initial state projects (Lake McConaughy EA, Pathfinder EA, Tamarack I).

1. **Evolution of the Nebraska Groundwater Recharge WAP Project**

Groundwater recharge in Nebraska was identified as a potential Program water project in the 1999 Water Conservation/Supply Reconnaissance Study.[[3]](#footnote-3) In that document and the 2000 Reconnaissance-Level Water Action Plan,[[4]](#footnote-4) the recharge concept in the Platte River reaches between Brady and Overton was limited to diversions of surface water into the Gothenburg and Dawson County canals during the non-irrigation season.[[5]](#footnote-5) The 2009 Water Action Plan Update[[6]](#footnote-6) expanded the project concept to include potential recharge through the Phelps County Canal. In addition to recharge opportunities involving the Gothenburg, Dawson County, and Phelps County canals, the 2009-2010 Nebraska Groundwater Recharge Pre-Feasibility Study[[7]](#footnote-7) evaluated a concept involving constructed recharge basins on fallowed lands under the Thirty Mile Canal, but not through the canal itself. That same study included the first evaluation of potential reservoir recharge for Program purposes, including at B-1 Reservoir,[[8]](#footnote-8) as well as management concepts to increase the yield and efficiency of recharge projects.

Independently, the CPNRD initiated a pilot project to recharge groundwater through the Thirty Mile, Cozad, and Orchard-Alfalfa canals in 2011. The Program selected the Phelps County Canal for a groundwater recharge feasibility study[[9]](#footnote-9) and began recharge operations there in September 2011. By the time of the 2014 Water Action Plan Update,[[10]](#footnote-10) recharge through Elwood Reservoir was being considered, and the three CPNRD canals were part of a Nebraska Water Leasing project concept that included both surface water transfers and groundwater recharge. Since 2015, active WAP projects for the Program have included groundwater recharge at all of the following existing facilities:

* CNPPID: Phelps County Canal and Elwood Reservoir[[11]](#footnote-11)
* CPNRD: Thirty Mile, Cozad, and Orchard-Alfalfa canals
* NPPD: Gothenburg and Dawson County canals.

Operations of these projects are subject to availability of excess flows, and diversions occur primarily during the non-irrigation season months.

1. **Project Descriptions and Operations History**

The CPNRD canals were first used for recharge in 2011, and the use of NPPD canals for recharge as a Program WAP project began in 2015. The following sections provide a qualitative discussion of the operations history of both projects during the Program’s First Increment, including permitting and the agreements between the Program and the districts. A more quantitative discussion of actual diversion rates and the timing of those diversions is included in a subsequent section addressing the development of key inputs to the score models.

1. **CPNRD Recharge Operations History**

The CPNRD began pilot-scale recharge operations using the Thirty Mile, Cozad, and Orchard-Alfalfa canals in 2011 (April-May and September-early October), mostly pre-dating the Program’s own recharge pilot project at the Phelps County Canal that first diverted on September 28, 2011. For various reasons, including a lack of divertible excesses and construction projects at the canals’ headgates, CPNRD recharge diversions were infrequent during the period 2012-2014, with diversions at Orchard-Alfalfa in early spring 2012, Thirty Mile in fall 2013, and Cozad for five days in fall 2014. In June 2012, CPNRD filed applications for permits to appropriate water for groundwater recharge at all three canals. These applications were eventually approved by the Nebraska DNR in March 2015 (see **Appendix A**), contingent on beneficial use of water for the stated purpose prior to September 1, 2019. All three canals met this requirement by diverting for recharge in May 2015.

In December 2013, the Program and CPNRD entered into a Water Use Lease Agreement[[12]](#footnote-12) (see **Appendix A**) for up to 20,500 AFY from combined surface water transfers and accretions (return flows) from groundwater recharge through the end of the Program’s First Increment. That same month, the Program was first invoiced by CPNRD for calculated return flows from recharge that occurred up to that point, mostly from 2011 operations. Excess flows were diverted for recharge each fall and spring from 2015 through 2017. CPNRD recharge diversions in 2018 and 2019 were minimal due to high groundwater levels, flood damage to canals, and other factors.

A new Water Service Agreement (WSA) dated September 25, 2019 provides for net recharge[[13]](#footnote-13) of up to 5,000 AFY[[14]](#footnote-14) through December 31, 2024. By changing billed volumes from calculated accretions[[15]](#footnote-15) to measured net recharge, the CPNRD recharge project is now on consistent terms with the Program’s CNPPID and NPPD groundwater recharge WAP projects.

1. **NPPD Recharge Operations History**

Beginning in March 2015, the Program and NPPD entered into a succession of WSAs (see **Appendix B**) for groundwater recharge from excess flows that carried the project through the end of the First Increment in 2019. A new WSA effective January 1, 2020 extends through the fifth year of the First Increment Extension and expires on December 31, 2025. The agreements provide for non-irrigation season (spring and fall) diversions into the Gothenburg and Dawson County canals; the Program is billed for net recharge[[16]](#footnote-16) with no specified annual volumetric limit, but the terms of the WSA allow the Program to set a limit if desired.

In addition to the series of WSAs, the NPPD was also required to secure temporary annual permits to appropriate water for recharge. The current permits are included in **Appendix B** along with recharge reports that NPPD has submitted to the Nebraska DNR each year (through spring 2019 operations).

The NPPD canals first diverted for Program recharge in September 2015. Dawson County Canal diverted in all possible seasons except spring 2017 and spring 2018. The Gothenburg Canal does not divert for Program recharge during the spring due to contractual obligations to deliver water to the B-1 Reservoir, but the canal diverted for Program recharge each fall except for 2017. Seasonal recharge diversions into the NPPD canals are expected to continue during the Program’s First Increment Extension as conditions allow (i.e., divertible excess flows are available, icing is not a concern, groundwater levels are not too high to allow effective recharge).

1. **Score Analysis Inputs and Assumptions**

The ultimate objective of a score analysis is to assess the potential for a WAP project to reduce deficits to target flows at Grand Island. To accomplish that task, a model must be developed to simulate project operations and route water downstream from a point of return on the river. Canal recharge projects are retiming projects that divert from the river during periods when streamflows are in excess of target flows and return a portion of that water to the river when there are deficits to target flows.

In the case of a canal recharge project, the model must be able to simulate the diversion of available excess flows—based on outputs from the OPSTUDY model—into the canal and seepage of that water into the underlying alluvial aquifer. The model must then be capable of calculating the timing and volume of lagged return flows to the river as well as transit losses from the point of return to Grand Island. Once the volume of water reaching Grand Island in a given time step (e.g., month or day) is known, that volume is compared to the volume of shortage—based on OPSTUDY streamflows and flow targets specified in the Program Document—to determine the amount of deficit reduction. Monthly deficit reductions are summed to annual and then averaged over the 48-year model simulation period to get a score value.

**Table 2** defines the general methods and key assumptions that form the basis of the score analysis in a manner consistent across all WAP projects. The sections that follow describe project-specific inputs and assumptions, including recharge rates and timing of diversions for the CPNRD and NPPD recharge projects; diversions by the Program recharge projects that are supplied through the CNPPID system (Phelps County Canal recharge, Elwood Reservoir recharge, and Cottonwood Ranch broad-scale recharge); estimation of divertible excess flows at the Brady gage; and the various model scenarios that were evaluated.

**Table 2. Key Scoring Assumptions**

| **Component** | **Data** |
| --- | --- |
| Hydrology (A) | OPSTUDY Adjusted Present Condition with Three State Projects (without pulse flows). EA flows included at Grand Island to reduce deficits, but not available for project diversions. |
| Model Analysis Period (B) | 1947-1994 |
| Model Time Step (C) | Monthly |
| Excesses/Shortages Calculation | Calculated at Grand Island, NE |
| Target Flows (D) | Appendix A-5, Column 4 or 8, depending on daily/monthly time step |
| Routing (E) | WMC Loss Model |
| Accretion Modeling Method (F) | Unit Response Functions (URF) developed using IDS-AWAS |

(A) OPSTUDY output files StElmnts.pul (daily) and/or StElmnts.tab (monthly) are used.

(B) The 1947-1994 analysis period is dictated by OPSTUDY.

(C) A monthly time step was used for all aspects of the modeling, including analysis of diversions and recharge, accretions to the river, and deficit reductions at Grand Island.

(D) Based on Column 4 or 8 of Appendix A-5 in the Program Document, Attachment 5 Water Plan, Section 11 Water Plan Reference Materials. Column 4 = target flows in “cfs” are used for the daily analysis. Column 8 = target flows in “average cfs” were summed on a monthly basis and converted to acre-feet as a monthly target flow volume in the scoring model.

(E) The WMC Loss Model was first developed by the Water Management Committee as part of the Water Conservation/Supply Reconnaissance Study (Chapter 7 and Appendix E), covering the period 1975-1994. The model period was updated to include 1995-2006 as part of the Water Management Study, Phase I.[[17]](#footnote-17) Use of the WMC Loss Model for routing in WAP project score analyses was included as part of the scoring methodology approved by the GC in 2010.[[18]](#footnote-18)

(F) IDS-AWAS is the Alluvial Water Accounting System developed by the Integrated Decision Support Group at Colorado State University.

1. **Inputs for CPNRD Canals**

The rates of recharge and the timing of diversions into the canals for recharge are critical inputs to the score models. The following sections describe the development of these inputs using actual recharge operations data provided by CPNRD during the First Increment.

* 1. ***Recharge Rates***

For the sake of simplicity, the recharge analysis assumed that diversion, infiltration, and recharge rates were equal. This means that modeled diversions were assumed to be limited to the amount that could infiltrate in a given time step. Seasonal recharge operations data provided by CPNRD for the period 2011-2017 was used to estimate net recharge rates based on measured diversions minus any spills or other surface returns. The specific files were a set of three spreadsheets provided to the EDO by CPNRD at the end of 2017. CPNRD also submitted an invoice in late 2017 for transferred surface water and calculated accretions from groundwater. The invoice included figures that showed the volumes of diversions, recharge, and river returns for each year or recharge season. The EDO cross-checked the diversion data in the spreadsheets against the volumes reported in those figures to ensure that the correct data sets were being used for this analysis. The CPNRD canals made minimal diversions for recharge in 2018-2019, so no data from those years was factored into the recharge rate calculations. **Table 3** shows the calculated average net recharge rate and diversion dates for each season of Thirty Mile Canal recharge operations from spring 2011 through fall 2017. **Table 4** and **Table 5** show the same information for the Cozad Canal and Orchard-Alfalfa Canal, respectively.

**Table 3. Thirty Mile Canal Net Recharge Rate and Recharge Dates**

|  |  |  |
| --- | --- | --- |
| **Recharge Season** | **Average Net Recharge Rate**  **[cfs]** | **Recharge Dates** |
| Spring 2011 | 47.0 | 4/18; 4/22-5/31 |
| Fall 2011 | 47.1 | 9/1-10/3 |
| Spring 2012 | Did Not Divert | |
| Fall 2012 | Did Not Divert | |
| Spring 2013 | Did Not Divert | |
| Fall 2013 | 53.9 | 10/22-11/10 |
| Spring 2014 | Did Not Divert | |
| Fall 2014 | Did Not Divert | |
| Spring 2015 | 57.1 | 5/11-5/31 |
| Fall 2015 | 41.6 | 9/8-9/30 |
| Spring 2016 | 39.0 | 4/6-4/12; 4/17-5/15 |
| Fall 2016 | 43.1 | 9/1-9/3; 9/5-9/30; 10/9-10/13; 11/16-12/6 |
| Spring 2017 | 57.7 | 3/31-4/3; 5/11-5/17 |
| Fall 2017 | 10.7 | 9/11; 10/4; 10/7-10/11 |
| **Average =** | **44** |  |

**Table 4. Cozad Canal Net Recharge Rate**

|  |  |  |
| --- | --- | --- |
| **Recharge Season** | **Average Net Recharge Rate**  **[cfs]** | **Recharge Dates** |
| Spring 2011 | 19.1 | 4/18-5/17 |
| Fall 2011 | 26.3 | 9/1-10/10 |
| Spring 2012 | Did Not Divert | |
| Fall 2012 | Did Not Divert | |
| Spring 2013 | Did Not Divert | |
| Fall 2013 | Did Not Divert | |
| Spring 2014 | Did Not Divert | |
| Fall 2014 | 30.6 | 9/26-9/30 |
| Spring 2015 | 43.8 | 5/11-5/31 |
| Fall 2015 | 30.4 | 9/8-9/30 |
| Spring 2016 | 21.9 | 3/16-4/6 |
| Fall 2016 | 50.3 | 9/1-9/13; 9/16-9/23 |
| Spring 2017 | 26.9 | 4/3; 5/11-5/17 |
| Fall 2017 | Did Not Divert | |
| **Average =** | **31** |  |

**Table 5. Orchard-Alfalfa Canal Net Recharge Rate**

|  |  |  |
| --- | --- | --- |
| **Recharge Season** | **Average Net Recharge Rate**  **[cfs]** | **Recharge Dates** |
| Spring 2011 | 10.5 | 4/18-5/17 |
| Fall 2011 | 22.2 | 9/1-10/12 |
| Spring 2012 | 13.4 | 3/18-4/18 |
| Fall 2012 | Did Not Divert | |
| Spring 2013 | Did Not Divert | |
| Fall 2013 | Did Not Divert | |
| Spring 2014 | Did Not Divert | |
| Fall 2014 | Did Not Divert | |
| Spring 2015 | 41.7 | 5/13-5/31 |
| Fall 2015 | 2.3 | 9/8-9/26 |
| Spring 2016 | 5.4 | 3/18-5/15 |
| Fall 2016 | 3.9 | 9/1-10/3; 11/15-12/4 |
| Spring 2017 | 6.5 | 5/11-5/13; 5/16-5/17 |
| Fall 2017 | 7.6 | 9/12-10/2; 10/4; 10/7-10/10 |
| **Average =** | **13** |  |

CPNRD[[19]](#footnote-19) explained that the widely fluctuating net recharge rates for the Orchard-Alfalfa Canal—as high as 41.7 cfs and as low as 2.3, in back-to-back seasons—are significantly impacted by groundwater levels, timing of diversions, and whether Thirty Mile has been operating for recharge, and are thus not unreasonable results that should be excluded.

* 1. ***Timing of Diversions***

Two scenarios for the timing of CPNRD recharge diversions were modeled in the score analysis. For the first scenario, the EDO also evaluated the timing of diversions based on the 2011-2017 recharge dates shown in the tables in the previous section. For a given month, any day that recharge diversions for the Program had ever occurred was assumed to be a possibility for recharge, even if all of those dates did not occur in the same year. The number of potential diversion days in a month was then rounded to the closest 5 (or the end of the month for those with 31 days); for example, 19 days of recharge was rounded to 20 days or 23 days was rounded to 25. **Table 6** shows the results of this analysis for the CPRND canals. The variability in timing between canals is a function of when actual CPNRD recharge operations occurred for the Program. For example, Cozad Canal has never diverted for Program recharge later than October 10 in the fall, but both Thirty Mile and Orchard-Alfalfa had at least one year in which recharge diversions resumed following the mid-November target flow change and continued into the first week of December.

**Table 6. Potential Recharge Diversion Days per Month at CPNRD Canals (Scenario 1)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Thirty Mile** | **Cozad** | **Orchard-Alfalfa** |
| Jan | 0 | 0 | 0 |
| Feb | 0 | 0 | 0 |
| Mar | 0 | 15 | 15 |
| Apr | 25 | 20 | 30 |
| May | 31 | 31 | 31 |
| Jun | 0 | 0 | 0 |
| Jul | 0 | 0 | 0 |
| Aug | 0 | 0 | 0 |
| Sep | 30 | 30 | 30 |
| Oct | 20 | 10 | 10 |
| Nov | 25 | 0 | 15 |
| Dec | 5 | 0 | 5 |

Since the score modeling was done on a monthly time step, the results do not apply to specific dates within the month, just that experience shows recharge diversions could occur on as many as 25 days in April or 10 days in October. In the score model, the recharge rates from the tables above were multiplied by the days per month in Table 6 and converted to acre-feet to get a monthly volumetric limit on recharge diversions for each canal.

The second timing scenario represents wider spring and fall windows for recharge diversions based on dates specified in Attachment A of the December 2013 Water Use Lease Agreement, which stated “The excess flow diversions will be made during the non-irrigation season March, April, first half of May, last half of September, October, and November.” **Table 7** shows the model inputs for this scenario.

**Table 7. Potential Recharge Diversion Days per Month at CPNRD Canals (Scenario 2)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Month** | **Thirty Mile** | **Cozad** | **Orchard-Alfalfa** |
| Jan | 0 | 0 | 0 |
| Feb | 0 | 0 | 0 |
| Mar | 31 | 31 | 31 |
| Apr | 30 | 30 | 30 |
| May | 15 | 15 | 15 |
| Jun | 0 | 0 | 0 |
| Jul | 0 | 0 | 0 |
| Aug | 0 | 0 | 0 |
| Sep | 15 | 15 | 15 |
| Oct | 31 | 31 | 31 |
| Nov | 30 | 30 | 30 |
| Dec | 0 | 0 | 0 |

Monthly volumetric limits on recharge diversions for this scenario were calculated by multiplying the average net recharge rates from Tables 3, 4, and 5 by the corresponding diversion days per month columns in Table 7.

1. **Inputs for NPPD Canals**

Data sources and analysis of recharge rates and timing of diversions for the NPPD canals are described in the following sections. The analytical approach was the same as for the CPNRD canals described above.

* 1. ***Recharge Rates***

Recharge rates for the NPPD canals were derived from operations data for the period (fall) 2015-2019. For recharge seasons in 2018 and 2019, NPPD provided this data directly to the EDO in spreadsheets prepared to calculate billings for net recharge diversions. For earlier recharge, the EDO extracted the data from the annual recharge reports prepared by NPPD and submitted to the Nebraska DNR. **Table 8** shows the calculated net recharge rates and recharge diversion dates for the Gothenburg Canal; **Table 9** shows the same for the Dawson County Canal.

**Table 8. Gothenburg Canal Net Recharge Rate**

|  |  |  |
| --- | --- | --- |
| **Recharge Season** | **Average Net Recharge Rate**  **[cfs]** | **Recharge Dates** |
| Fall 2015 | 38.4 | 9/11-9/30 |
| Spring 2016 | Did Not Divert | |
| Fall 2016 | 58.6 | 9/15-9/30; 10/11-10/14; 11/16-12/5 |
| Spring 2017 | Did Not Divert | |
| Fall 2017 | Did Not Divert | |
| Spring 2018 | Did Not Divert | |
| Fall 2018 | 34.6 | 9/8-9/11; 9/13-9/17 |
| Spring 2019 | Did Not Divert | |
| Fall 2019 | 37.9 | 9/13-10/14 |
| **Average =** | **42** |  |

**Table 9. Dawson County Canal Net Recharge Rate**

|  |  |  |
| --- | --- | --- |
| **Recharge Season** | **Average Net Recharge Rate**  **[cfs]** | **Recharge Dates** |
| Fall 2015 | 71.7 | 9/11-9/30 |
| Spring 2016 | 44.0 | 4/6-4/13; 4/18-4/24 |
| Fall 2016 | 48.6 | 9/15-9/30; 11/16-12/5 |
| Spring 2017 | Did Not Divert | |
| Fall 2017 | 60.4 | 10/4-10/5; 10/7-10/11; 11/27-12/19 |
| Spring 2018 | Did Not Divert | |
| Fall 2018 | 47.8 | 9/8-9/17; 9/20-10/1 |
| Spring 2019 | 22.0 | 4/8-4/9; 4/14/-4/22 |
| Fall 2019 | 41.8 | 9/10-9/18; 9/26-10/28 |
| **Average =** | **48** |  |

* 1. ***Timing of Diversions***

As with the CPNRD canals, two scenarios were developed for the timing of recharge diversions into the NPPD canals. Monthly diversion days for the first scenario based on 2015-2019 operations are shown in **Table 10** below.

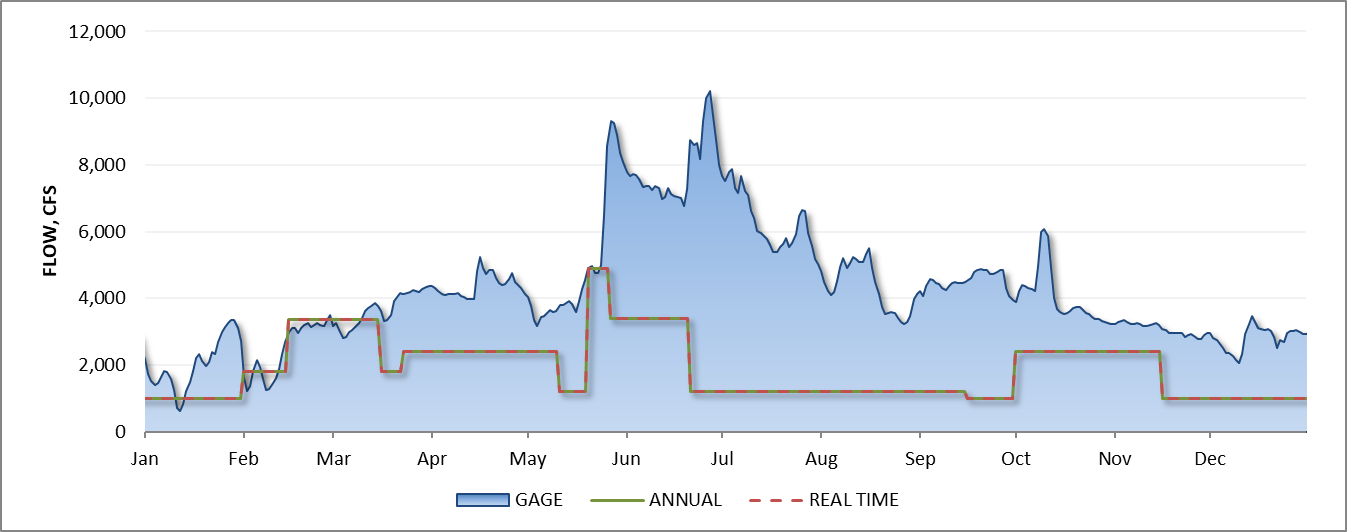
**Table 10. Potential Recharge Diversion Days per Month at NPPD Canals (Scenario 1)**

|  |  |  |
| --- | --- | --- |
| **Month** | **Gothenburg** | **Dawson County** |
| Jan | 0 | 0 |
| Feb | 0 | 0 |
| Mar | 0 | 0 |
| Apr | 0 | 20 |
| May | 0 | 0 |
| Jun | 0 | 0 |
| Jul | 0 | 0 |
| Aug | 0 | 0 |
| Sep | 25 | 25 |
| Oct | 15 | 31 |
| Nov | 15 | 15 |
| Dec | 5 | 20 |

As discussed previously, Gothenburg Canal does not divert for Program recharge in the spring due to contractual obligations to deliver water to B-1 Reservoir. In October, Gothenburg has not diverted for Program recharge past the 14th, but Dawson County has diverted until the 28th, hence the difference of half the month for Gothenburg versus the full month for Dawson County. Neither canal has ever diverted for Program recharge between November 1 and November 15, after which target flows drop and recharge operations occasionally resume if hydrologic and icing conditions allow. In December, both canals diverted through the 5th of the month in fall 2016; in fall 2017, when Dawson County diverted as late as December 19, Gothenburg did not divert at all for Program recharge.

A second scenario with an expanded window of time for fall recharge diversions was developed based on reasonable assumptions for NPPD’s system operations and the availability of excess flows. The 2011 Canal Winter Operations Feasibility Study[[20]](#footnote-20) recommended using the NPPD canals for recharge during “shoulder seasons” in order to avoid risking damage to the canal infrastructure due to ice. Specific date ranges were noted in the appendices of that report but were generally inconsistent with the actual timing of NPPD recharge diversions during the First Increment, particularly in the spring, and were therefore not used for the present analysis.

Instead, fall diversions were assumed to be possible at both canals between September 15 and December 15. Operations during the First Increment show that irrigation operations have typically ended by mid-September. Recharge has continued well into December when conditions permit, but past mid-December there is increased risk of ice formation that could damage the canal infrastructure. While divertible excess flows may not be available in every year, **Figure 1** demonstrates that in certain years during the First Increment such as the wet year of 2011 it was possible to have excesses for the entire period between September 15 and December 15. Spring diversions were kept at 20 days in April for Dawson County and zero days at Gothenburg.



**Figure 1. 2011 Grand Island Gage Hydrograph and USFWS Target Flows**

**Table 11** shows the diversion days input to the score model for the second NPPD diversion timing scenario.

**Table 11. Potential Recharge Diversion Days per Month at NPPD Canals (Scenario 2)**

|  |  |  |
| --- | --- | --- |
| **Month** | **Gothenburg** | **Dawson County** |
| Jan | 0 | 0 |
| Feb | 0 | 0 |
| Mar | 0 | 0 |
| Apr | 0 | 20 |
| May | 0 | 0 |
| Jun | 0 | 0 |
| Jul | 0 | 0 |
| Aug | 0 | 0 |
| Sep | 15 | 15 |
| Oct | 31 | 31 |
| Nov | 30 | 30 |
| Dec | 15 | 15 |

Consistent with the analysis for the CPNRD canals, monthly volumetric diversion limits were calculated by multiplying the average net recharge rates from Tables 8 and 9 by the corresponding days per month in Tables 10 and 11.

1. **Assumptions for Other Projects**

Some of the model scenarios include diversions of excess flows for WAP projects in the CNPPID system. For those scenarios it was necessary to make assumptions about diversions into the Phelps County Canal and Elwood Reservoir recharge projects as well as the Cottonwood Ranch broad-scale recharge project.

The first configuration for CNPPID recharge diversions is regarded as “limited” and includes the following assumptions:

* Phelps County Canal recharge diversions limited to 30 cfs between September 15 and February 15. The diversion rate is consistent with assumptions made in the recent Elwood Reservoir recharge score analysis, and the timing is reflective of operations during the First Increment.
* Cottonwood Ranch recharge diversions are limited to 600 AF in any month. This is based on the EDO’s reasonable expectation for operations that have not yet started.
* For Elwood Reservoir recharge, modeled diversions from the Elwood score analysis were used, based on a 12,000 AF annual diversion cap. The EDO ran sensitivity analyses for Elwood annual diversion caps also including 8,000 AF and 15,000 AF. Regardless of which Elwood diversions were input to the current score model, the score estimates for CPNRD and NPPD recharge were within +/-5 AF.

The Elwood Reservoir recharge score analysis conservatively assumed higher diversions by Phelps and Cottonwood Ranch. Those are used here in combination with the same Elwood diversions based on a 12,000 AF annual cap for a “CNPPID maximum” configuration. Specifically, the Elwood score analysis prioritized excess flow diversions within the CNPPID system based on rules defined in Exhibit F of the Cottonwood Ranch WSA dated August 2018. The Elwood score analysis started from total excess flows available within the CNPPID system, then estimated an aggregate prioritized diversion for Phelps and Cottonwood Ranch to determine how much excess was left for Elwood recharge. This aggregate prioritized diversion—the difference between total CNPPID system excesses and excesses available to Elwood—is the volume used for Phelps and Cottonwood Ranch in the “CNPPID maximum” configuration.

1. **Excess Flows Availability and Diversion Priority**

Having defined critical input parameters for the CPNRD and NPPD canals, the next step was to determine the amount of excess flows available for diversion by the canals between Brady and Cozad. It was also necessary to establish diversion priorities for the CPNRD and NPPD canals and other projects potentially competing for the same supply of excess flows, in particular those Program WAP projects filled through the CNPPID’s Tri-County Supply Canal.

* 1. ***Net Available Flow at Brady***

An important input dataset for the CPNRD and NPPD recharge score analysis is the net available flow at the Brady gage. This was calculated using OPSTUDY data and a method that was developed by the EDO in 2010 to estimate divertible flows available at the Gothenburg Canal, presumably as part of the Nebraska Ground Water Recharge Pre-Feasibility Study. The EDO at that time recognized an oddity in the OPSTUDY data, in that the modeled flows showed higher volumes of Lake McConaughy EA water at the Brady gage, reduced EA water at the Cozad gage, and then a rebound in the EA volume at the Overton gage. This implied that EA water was diverted for irrigation between Brady and Cozad, then replenished by EA water returning to the river from the CNPPID system at the Johnson #2 (J-2) Return.

Water released from the Lake McConaughy EA should not be available for diversion for recharge or otherwise, so the EDO made simplifying assumptions that EA water at Cozad was the same as EA water at Brady, and that the difference between volumes of EA water at Cozad and Overton was the volume of EA water in the CNPPID system. The resulting equation for calculating net available flow at Brady for recharge is as follows:

[Net Available at Brady] = [Brady Gage] + [Jeffrey Return] – [Brady to Cozad Irrigation Diversions] – [EA at Cozad]

where [Brady Gage] = Table 48 from StElmnts.tab

[Jeffrey Return] = Table 46

[Brady to Cozad Irrigation Diversions] = Table 120

[EA at Cozad] = Table 98

Net available flow at Brady was calculated on a monthly basis for the period 1947-1994.

In the score models, the divertible excess flows at Brady are the lesser of the net available flow at Brady or excesses at Grand Island[[21]](#footnote-21) as determined from OPSTUDY modeled streamflows[[22]](#footnote-22) greater than target flows. Consistent with previous score analyses, EA flows were included when calculating excesses and shortages to target flows at Grand Island because EA water can influence the volume of shortage that needs to be met by other Program water projects. However, as indicated above, that EA water is not available to divert for recharge.

* 1. ***Excess Flow Diversion Priorities***

**Table 12** shows the priority dates of the current excess flow diversion permits for CPRND, NPPD, and CNPPID recharge projects. Regardless of the specific priority date and relative seniority of one project over another, the recent CNPPID and NPPD permits include a provision granting the Nebraska DNR authority to adjust diversions to maximize beneficial use:

The [Nebraska DNR] may reduce or deny diversion under this appropriation if there is not enough available unappropriated water to satisfy all appropriations and the [Nebraska DNR] determines that there are more beneficial uses for the limited water supply under other appropriations, and that doing so is in the public interest. An adaptive management approach to determining which potentially complimentary or competing temporary excess water recharge projects receive a portion of a limited water supply will be applied consistently to best serve the stated goals while continuing to meet the public interest. This same determination will be made for each Project Facility that is a component of this appropriation in order to best meet the public interest as determined by the [Nebraska DNR].

At this time, CPNRD remains the only entity to have permanently approved excess flow diversion permits for groundwater recharge, which were granted nearly three years after the applications were submitted. Nebraska DNR continues to require NPPD and CNPPID to submit applications each year for temporary annual diversion permits.

**Table 12. Recharge Diversion Permits for CPNRD Canals**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Canal** | **Permit** | **Permitted Diversion Rate**  **[cfs]** | **Priority Date** | **Approval Date** |
| CPNRD Cozad | A-18922 | 100 | June 5, 2012 | March 19, 2015 |
| CPNRD Orchard-Alfalfa | A-18923 | 75 | June 5, 2012 | March 19, 2015 |
| CPNRD Thirty Mile | A-18924 | 100 | June 5, 2012 | March 13, 2015 |
| CNPPID (A) | A-19679 | 950 | November 14, 2019 | November 21, 2019 |
| NPPD Dawson County | A-19682 | 100 | January 21, 2020 | February 14, 2020 |
| NPPD Gothenburg | A-19683 | 100 | January 21, 2020 | February 14, 2020 |

(A) The CNPPID permit encompasses recharge diversions to the following Project Facilities: E65 Canal, **Phelps Canal**, **Elwood Reservoir**, **Cottonwood Ranch Complex**, Cottonwood WPA, Funk Lagoon WPA, Johnson WPA, Linder WPA, and Victor Lakes WPA. (Program WAP Projects bold and underlined).

During First Increment recharge operations, there tended to be limited overlap between the timing of diversions by the CNPPID and the CPNRD and NPPD recharge projects. In general, CPNRD and NPPD would divert in the early fall immediately following the end of the irrigation season and continue until early October, when there is typically an increase in target flows and a reduction in divertible excesses. During that time and into October, NPPD and CNPPID often stop diversions into their hydropower systems to perform maintenance, which precludes deliveries to Phelps and Elwood. Once target flows drop in mid-November, CNPPID often starts diverting to Phelps and/or Elwood and continues such diversions into February if conditions permit. CPNRD and NPPD sometimes resume canal recharge diversions in the spring before irrigation diversions begin, but it is critical that they not wet the canals for recharge but then stop before irrigation, which would allow for the proliferation of unwanted vegetation in the canals.

The original unfinished CPNRD leasing project score analysis[[23]](#footnote-23) assumed that CPNRD recharge diversions were third in priority behind the J-2 Regulating Reservoirs and Phelps County Canal groundwater recharge; this may have been simply because score analyses for those two projects were already complete. Given the actual priority dates shown in Table 12 and uncertainty as to exactly how the Nebraska DNR may allocate excess flows across multiple potentially competing recharge projects, the EDO included scenarios in the present score analysis with CNPPID recharge given top priority and with CPNRD and/or NPPD recharge given top priority.

The volume of excess flows at Brady is assumed to be split proportionally amongst the three CPNRD canals and two NPPD canals. Based on the permitted diversion rates shown in Table 12, Orchard-Alfalfa is allocated 16 percent of available excesses and the other four canals each get 21 percent. Actual modeled diversions are the lesser of that proportional share of excesses at Brady or the monthly volumetric limit calculated by multiplying net recharge rates by diversion days per month.

1. **Model Scenarios Matrix**

Pulling together the variable parameters described in the preceding sections, the EDO developed four basic model scenarios, as follows:

* Scenario 1: Recharge in CPNRD canals *or* NPPD canals only, as top priority for excess flow diversions (CNPPID excess diversions for recharge not modeled).
* Scenario 2: Recharge in CPNRD canals *and* NPPD canals, as top priority for excess flow diversions (CNPPID excess for recharge not modeled).
* Scenario 3: Recharge in CPNRD canals and NPPD canals; “limited” CNPPID given top priority for excess flow diversions.
* Scenario 4: Recharge in CPNRD canals and NPPD canals; “maximum” CNPPID given top priority for excess flow diversions.

Each of these scenarios was modeled with two options for CPNRD annual diversions:

* Unlimited volume.
* 5,000 AF maximum volume.

Finally, each of the resulting eight scenarios were modeled with two options for the timing of recharge diversions:

* Based on First Increment operations (from Tables 6 and 10).
* Longer, seasonal diversion periods (from Tables 7 and 11).

In total, 16 scenarios each were run through the score model for the CPNRD and NPPD recharge projects.

1. **AWAS ANALYSIS**

Once water has been recharged in a given canal, it flows through the aquifer and towards the river to eventually increase river flows. The primary methods used to calculate the timing and magnitude of the increased river flows resulting from recharged water include analytical equations and numerical groundwater modeling. The analytical equations or numerical models can be used to directly calculate returns or unit response functions can be developed from the results of these methods. The unit response functions can be integrated into spreadsheets and used to reduce the time and computational effort needed to determine river response to recharge events. To maintain consistency with other WAP recharge scoring analysis as well as Program accounting and operations, the EDO developed unit response functions for each canal.

1. **UNIT RESPONSE FUNCTION DEVELOPMENT**

To develop unit response functions the EDO considered three approaches: developing localized groundwater models for each canal or a group of canals, using the COHYST groundwater model, and using analytical solutions originally developed by Glover and computed in the IDS AWAS software program.[[24]](#footnote-24) Developing individual groundwater models was ruled out due to the complexity of this approach as it would require significant time and effort and would not necessarily provide significantly improved results. The lack of clear or obvious groundwater boundary conditions and the complexity of the canals, canal laterals, and drains deterred the EDO from pursuing this approach.

* 1. ***COHYST Groundwater Model***

The COHYST groundwater model is a regional numerical groundwater model that extends roughly from Lake McConaughy and the Julesburg gage on the North Platte and South Platte Rivers, respectively, through the Duncan gage on the central Platte River. The model focuses on regional calibration and performs well on a regional level but may not represent local conditions as well when canal specific results are desired. Developing unit response functions for the five canals would require several hundred model runs and significant post processing. The Nebraska DNR conducted a cycle well analysis on the COHYST groundwater model which in theory would provide the underlying data needed to develop unit response functions. The EDO attempted to develop unit response functions from the cycle well results but found the analysis could not be applied to a unit response on a monthly basis. More information on the process the EDO undertook and the resulting issues with the cycle well results can be found in the EDO’s memo to the Nebraska DNR in **Appendix C**.

* 1. ***AWAS Analytical Solution***

The EDO decided to develop unit response functions from the results of the IDS AWAS software based on the Glover[[25]](#footnote-25) analytical solution of groundwater flow. This approach is commonly used to account for return flows resulting from groundwater recharge. While the analytical solution relies on several assumptions to be made that often do not directly align with reality, such as the assumption of an infinite aquifer, the solution still provides reasonable approximations of the physical reality.

The Glover equation solved by AWAS requires distance to the river, transmissivity, storage coefficient, and recharge/pumping rate as inputs. The same inputs were used for each canal with the exception of distance to the river as this varies for each location. The hydraulic conductivity value of 200 ft/day was determined from the Hydrostratographic Unit Report[[26]](#footnote-26) used to develop the hydraulic conductivity zones for the COHYST model. An average aquifer thickness of 80 ft was determined from evaluating well logs to identify at what depth the alluvial aquifer terminated and the underlying Ogallala formation began. The transmissivity is the product of the hydraulic conductivity and the aquifer thickness. The storage coefficient of the unconfined alluvial aquifer was determined to be 0.18 in accordance with the values used in the COHYST groundwater model and the generally accepted value for the alluvial aquifer in this area. These values are also shown in **Table 13** below.

**Table 13. Inputs for AWAS**

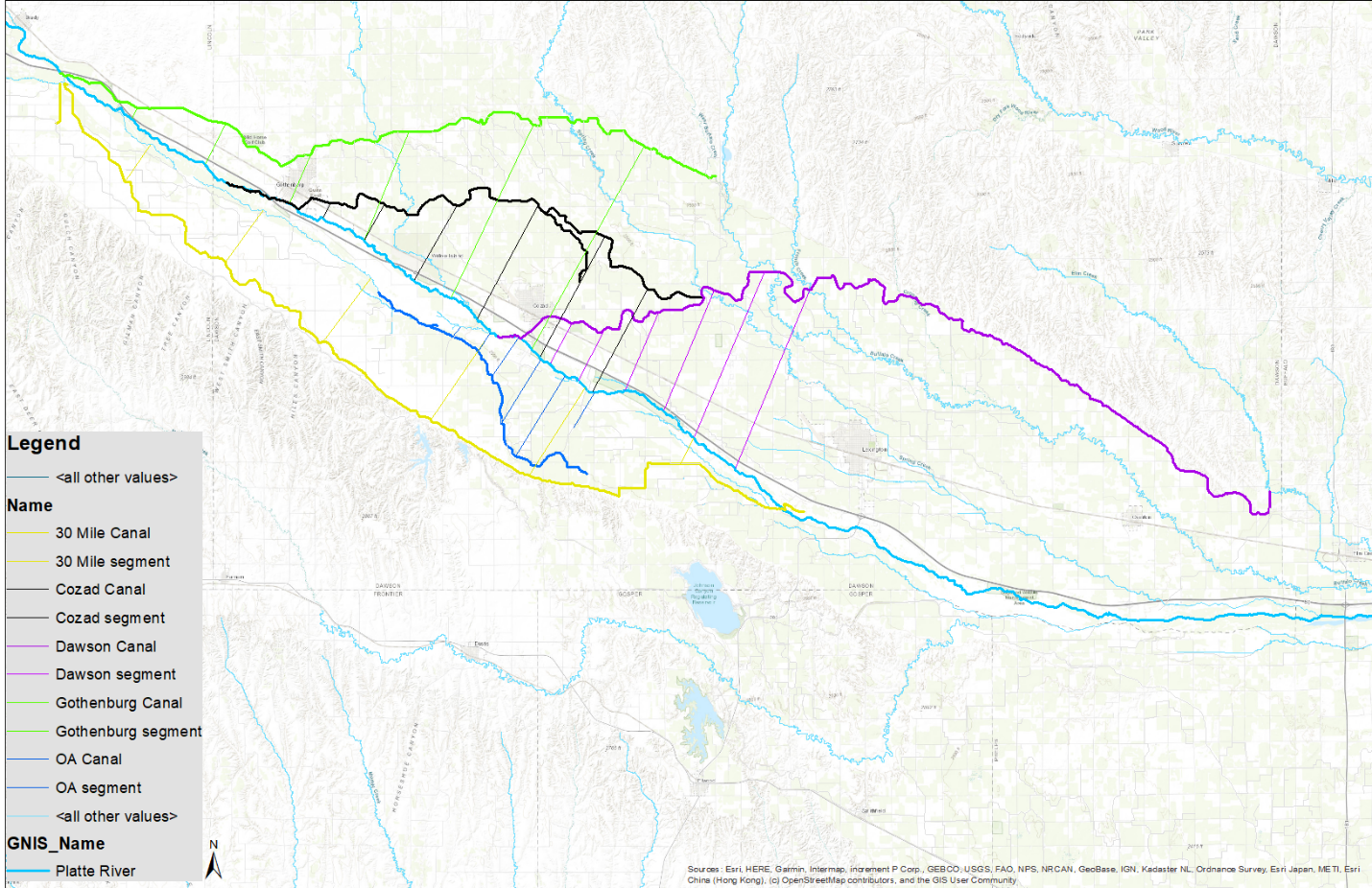
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Canal** | **Hydraulic Conductivity, k (ft/day)** | **Aquifer thickness, b (ft)** | **Transmissivity, T (ft2/day)** | **Transmissivity, T (GPD/ft)** | **Storage Coefficient, Sy (unitless)** |
| 30 Mile Canal | 200 | 80 | 16,000 | 120,000 | 0.18 |
| Cozad Canal | 200 | 80 | 16,000 | 120,000 | 0.18 |
| Orchard Alfalfa Canal | 200 | 80 | 16,000 | 120,000 | 0.18 |
| Dawson County Canal | 200 | 80 | 16,000 | 120,000 | 0.18 |
| Gothenburg Canal | 200 | 80 | 16,000 | 120,000 | 0.18 |

The “New Modified” version of AWAS was used in the URF development. The “alluvial aquifer” boundary condition was selected and a distance between the river and the edge of aquifer was set to 25,000 ft for the canals to the south of the river and 50,000 ft for the canals to the north of the river. These distances roughly correspond to the distance between the river and the valley terrace.

The AWAS software was run on a monthly time step for 48 years to coincide with the scoring time period. The “recharge” type of scenario was run with “Infinite Aquifer” boundary conditions. A unit recharge pulse was added in September to correlate to the typical start of the recharge season. The software produced the stream response on a monthly basis for the 48-year period.

* 1. ***AWAS Unit Response Functions***

Separate response functions were developed for each of the five canals. The canals were divided into segments, shown in **Figure 2** to account for the different return patterns from locations closer to and further from the river.



**Figure 2. Maps of canal segments used**

The responses from each canal segment were averaged to develop a composite response functions for the entire canal. Averaging the response from each segment is assumed to provide a reasonable estimate of the recharge response as recharge in the portions of a canal near the river will return more quickly than portions of the canal further from the river. This approach does not directly account for recharge water that is sent down canal laterals as is done for the Dawson and Gothenburg canals. The unit response function for the Dawson canal was based on the portion of the canal between the canal head gate and the French Creek return as water is not commonly recharged beyond the French Creek return. The use of canal laterals for recharge has not been consistent or predictable enough to merit their inclusion in the unit response function at this point in time. It is also assumed that the response functions from the main canal channels provide a reasonable estimation of recharge from the canal laterals.

1. **UNIT RESPONSE FUNCTIONS**

The unit response functions for each canal are shown in **Figure 3** below. Each response shows an initial rise in stream response follow by a declining response that asymptotically approaches zero. Because the stream response is a unit response, each month’s response can be understood as a percentage of the recharged water that returns to the river in that month. For example, the Gothenburg canal’s peak response is just over 0.04, or approximately 4 percent of the recharged water. The peak response occurs within the first few months after the recharge event, with the Orchard Alfalfa canal having the largest monthly response and the Dawson County canal having the lowest monthly responses.

**Figure 3. Unit response functions from the five canals (for the first 10 years of returns)**

The cumulative response from each canal is shown in **Figure 4** and the cumulative response at various times during the 48-year period are shown in **Table 14**. The cumulative responses of the canals to the south of the river are distinctive from the canals to the north of the river. The cumulative response curves of the southern canals (Thirty Mile and Orchard Alfalfa) rise more quickly and both show 100% of the recharged water returning to the river by the end of the 48-year period. For the northern canals, water returns to the river more slowly and only 83-86% of the recharged water has arrived at the river by the end of the 48-year period. The difference in response curves between the southern and northern canals are a result of two factors: the distance between the river and the edge of the aquifer and the average distance between the canal and the river. The edge of the aquifer is closer to the river to the south (approximately 25,000 ft) and further from the river to the north (approximately 50,000 ft). The closer aquifer boundary to the south results in recharged water returning to the river more quickly. The average distance between the canal and the river for the Thirty Mile and Orchard Alfalfa canals is 15,000 ft and 10,000 ft, respectively. The average distances for the Cozad, Gothenburg, and Dawson County canals are 22,500 ft, 18,000 ft, and 24,000 ft, respectively. The larger distances between the northern canals and the river results in recharged water taking longer to arrive at the river compared to the southern canals.

**Figure 4. Cumulative response from the five canals**

**Table 14. Canal recharge responses**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Canal** | **Percent returns after:** | | | | | |
| **1 year** | **2 years** | **5 years** | **10 years** | **20 years** | **48 years** |
| 30 Mile Canal | 0.14 | 0.25 | 0.50 | 0.73 | 0.93 | 1.00 |
| Orchard Alfalfa Canal | 0.31 | 0.43 | 0.63 | 0.80 | 0.95 | 1.00 |
| Gothenburg Canal | 0.19 | 0.26 | 0.37 | 0.48 | 0.63 | 0.85 |
| Cozad Canal | 0.16 | 0.23 | 0.37 | 0.51 | 0.65 | 0.86 |
| Dawson County Canal | 0.06 | 0.14 | 0.27 | 0.40 | 0.57 | 0.83 |

1. **ROUTING ACCRETIONS TO GRAND ISLAND**

Consistent with all prior score analyses, accretions at the river from the CPNRD and NPPD recharge projects were routed down the Platte River to Grand Island using transit loss factors developed using the WMC Loss Model. By the very nature of the projects, accretions from recharge projects are non-point return flows, but the WMC Loss Model requires routing from a point location. The EDO used an approach such that the point location was approximately in the middle of the stretch of the Platte River to which return flows from a particular canal accrue. Using GIS, the EDO identified the approximate midpoint of each main canal (excluding laterals) and drew a line perpendicular to the river. The location at which the perpendicular line hit the Platte River, as a distance downstream from the nearest upstream gage (Brady or Cozad), was used as the starting point for the WMC Loss Model analysis.

**Figure 5** illustrates this point return location analysis for the NPPD canals. NPPD suggested[[27]](#footnote-27) using the French Creek Return as the end of the Dawson County main canal, since recharge operations for the Program rarely extend past that location. The French Creek Return was used as the end point in the AWAS analysis described in the previous section, but for river routing purposes, using the full length of the main canal better reflects the influence of the laterals used for recharge that extend southeastward from the main canal and appropriately places the point return location a few miles farther downstream.

A close up of a map

Description automatically generated

**Figure 5. Point Return Location Analysis for the NPPD Canals**

As shown in Figure 5, the point return location for the Gothenburg Canal was assumed to be 15.77 miles downstream of the Brady gage. For the Dawson County Canal, the location was 11.32 miles downstream of the Cozad gage.

A two-step process was required for the WMC Loss Model, which is set up on a monthly time step for water years 1975-2006. In the first run, a unit volume of accretions is routed from the point return location to the next downstream gage, i.e., the top of the next downstream river reach. In the second run, the volume of water reaching the top of that next downstream reach was routed the rest of the way downstream to Grand Island. The output from the second WMC Loss Model run represents the percentage of the upstream accretions that reach Grand Island after transit losses from the river.

The WMC Loss Model output data was reorganized from water years to calendar years, and then monthly averages were calculated across the years in the 1975-2006 period with wet, normal, or dry hydrologic conditions. **Table 15** shows the routing factors for the CPNRD canals that were used in the score models, and **Table 16** shows the same for the NPPD canals.

**Table 15. Average Percent of Accretions from the CPNRD Canals Reaching Grand Island.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Month | Thirty Mile Canal | | | Cozad Canal | | | Orchard-Alfalfa Canal | | |
| Wet | Normal | Dry | Wet | Normal | Dry | Wet | Normal | Dry |
| Jan | 88% | 87% | 85% | 88% | 87% | 85% | 88% | 87% | 85% |
| Feb | 91% | 91% | 90% | 92% | 91% | 90% | 92% | 92% | 91% |
| Mar | 96% | 97% | 94% | 96% | 97% | 94% | 97% | 97% | 95% |
| Apr | 94% | 95% | 93% | 95% | 96% | 94% | 95% | 96% | 94% |
| May | 95% | 93% | 92% | 95% | 93% | 92% | 96% | 93% | 93% |
| Jun | 93% | 89% | 66% | 94% | 90% | 67% | 95% | 90% | 67% |
| Jul | 94% | 77% | 40% | 95% | 77% | 40% | 95% | 77% | 40% |
| Aug | 86% | 74% | 27% | 87% | 74% | 27% | 87% | 74% | 27% |
| Sep | 82% | 72% | 36% | 83% | 72% | 36% | 83% | 72% | 36% |
| Oct | 90% | 83% | 53% | 90% | 84% | 54% | 90% | 84% | 54% |
| Nov | 91% | 86% | 74% | 91% | 87% | 74% | 91% | 87% | 74% |
| Dec | 91% | 87% | 85% | 91% | 87% | 85% | 91% | 87% | 85% |

**Table 16. Average Percent of Accretions from the NPPD Canals Reaching Grand Island.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Month | Gothenburg Canal | | | Dawson County Canal | | |
| Wet | Normal | Dry | Wet | Normal | Dry |
| Jan | 88% | 87% | 85% | 89% | 88% | 85% |
| Feb | 92% | 91% | 90% | 92% | 92% | 91% |
| Mar | 96% | 97% | 94% | 97% | 97% | 95% |
| Apr | 94% | 96% | 94% | 96% | 96% | 94% |
| May | 95% | 93% | 92% | 97% | 94% | 93% |
| Jun | 93% | 90% | 67% | 96% | 91% | 67% |
| Jul | 94% | 77% | 40% | 96% | 78% | 41% |
| Aug | 87% | 74% | 27% | 88% | 75% | 27% |
| Sep | 82% | 72% | 36% | 84% | 73% | 36% |
| Oct | 90% | 83% | 53% | 91% | 84% | 54% |
| Nov | 91% | 87% | 74% | 92% | 87% | 74% |
| Dec | 91% | 87% | 85% | 91% | 88% | 85% |

1. **SCORE ANALYSIS RESULTS**

All of the parameters described in the preceding sections were incorporated into a series of score models developed in Microsoft Excel. The score models simulate project operations on a monthly time step over the 48-year period 1947-1994 that corresponds to the OPSTUDY modeled hydrology. The calculated monthly shortage reductions are summed to annual and averaged over 48 years to get the project score estimates. **Table 17** shows score estimates for all model runs for the CPNRD recharge project, and **Table 18** shows results for the NPPD recharge Project. The tables are organized according to the four main project operations scenarios, then the four individual model runs for each scenario reflect the variable diversion limits and the variable recharge timing.

**Table 17. Score Analysis Results for the CPNRD Recharge Project**

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario Run** | **Annual Diversion Limit** | **Recharge Timing** | **Score Estimate [AFY]** |
| Scenario 1 | CPNRD Only | | |
| Run 1a | Unlimited | First Increment Operations | 2,183 |
| Run 1b | 5,000 AF | First Increment Operations | 1,171 |
| Run 1c | Unlimited | Expanded (2013 WSA, Attachment A) | 2,755 |
| Run 1d | 5,000 AF | Expanded (2013 WSA, Attachment A) | 1,279 |
| Scenario 2 | CPNRD + NPPD | | |
| Run 2a | Unlimited | First Increment Operations | 2,183 |
| Run 2b | 5,000 AF | First Increment Operations | 1,171 |
| Run 2c | Unlimited | Expanded (2013 WSA, Attachment A) | 2,755 |
| Run 2d | 5,000 AF | Expanded (2013 WSA, Attachment A) | 1,279 |
| Scenario 3 | CPNRD + NPPD + limited CNPPID | | |
| Run 3a | Unlimited | First Increment Operations | 2,119 |
| Run 3b | 5,000 AF | First Increment Operations | 1,140 |
| Run 3c | Unlimited | Expanded (2013 WSA, Attachment A) | 2,694 |
| Run 3d | 5,000 AF | Expanded (2013 WSA, Attachment A) | 1,250 |
| Scenario 4 | CPNRD + NPPD + maximum CNPPID | | |
| Run 4a | Unlimited | First Increment Operations | 1,972 |
| Run 4b | 5,000 AF | First Increment Operations | 1,073 |
| Run 4c | Unlimited | Expanded (2013 WSA, Attachment A) | 2,501 |
| Run 4d | 5,000 AF | Expanded (2013 WSA, Attachment A) | 1,190 |
| **Average =** | | | **1,795** |

The individual model runs for the CPNRD recharge project exhibit a range of scores from 1,073 AFY to 2,755 AFY, with an average of about 1,800 AFY.

**Table 18. Score Analysis Results for the NPPD Recharge Project**

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario Run** | **Annual Diversion Limit** | **Recharge Timing** | **Score Estimate [AFY]** |
| Scenario 1 | NPPD Only | | |
| Run 1a | Unlimited | First Increment Operations | 1,339 |
| Run 1b | 5,000 AF | First Increment Operations | 860 |
| Run 1c | Unlimited | Expanded (“shoulder season”) | 1,689 |
| Run 1d | 5,000 AF | Expanded (“shoulder season”) | 959 |
| Scenario 2 | CPNRD + NPPD | | |
| Run 2a | Unlimited | First Increment Operations | 1,339 |
| Run 2b | 5,000 AF | First Increment Operations | 860 |
| Run 2c | Unlimited | Expanded (“shoulder season”) | 1,689 |
| Run 2d | 5,000 AF | Expanded (“shoulder season”) | 959 |
| Scenario 3 | CPNRD + NPPD + limited CNPPID | | |
| Run 3a | Unlimited | First Increment Operations | 1,256 |
| Run 3b | 5,000 AF | First Increment Operations | 796 |
| Run 3c | Unlimited | Expanded (“shoulder season”) | 1,592 |
| Run 3d | 5,000 AF | Expanded (“shoulder season”) | 882 |
| Scenario 4 | CPNRD + NPPD + maximum CNPPID | | |
| Run 4a | Unlimited | First Increment Operations | 1,148 |
| Run 4b | 5,000 AF | First Increment Operations | 718 |
| Run 4c | Unlimited | Expanded (“shoulder season”) | 1,466 |
| Run 4d | 5,000 AF | Expanded (“shoulder season”) | 795 |
| **Average =** | | | **1,147** |

The individual model runs for the NPPD recharge project exhibit a range of scores from 718 AFY to 1,689 AFY, with an average of about 1,150 AFY

Additionally, the model results show that giving the WAP projects in the CNPPID system a higher priority reduces the volume of excess flows available to CPNRD and NPPD, thereby reducing the estimated scores. Whether these scenarios are appropriate to consider is a matter of debate given that CPNRD technically has the higher priority (earliest) excess flow diversion permits and lingering uncertainty about Nebraska DNR’s intentions for allocating excess flows should there be competing projects or interests. Furthermore, when the EDO began this analysis, NPPD held diversion permits with an August 2019 priority that was senior to CNPPID. It was only recently that NPPD acquired new permits to better align their temporary annual permits with the calendar year rather than having a temporary permitting cycle that renewed in the late summer each year. Nonetheless, previous score analyses have attempted to evaluate Program WAP projects in combination with others, and the EDO deemed such an approach to be reasonable in the present context with multiple recharge projects currently operating.

On the other hand, whether the CPNRD and NPPD recharge projects are modeled together or individually, the results are exactly the same. This implies that there is no interference between the projects and that the availability of excess flows at Brady is more likely the limiting factor. Given these identical results, the EDO requests feedback from the Scoring Subcommittee about whether to discard the results from Scenario 1. With the other variable aspects—annual diversion volume and timing of diversions—it is difficult to assert that one option is more realistic than the other; these are probably better viewed as bookends with operational reality falling somewhere in the middle.

**Appendix A – CPNRD Supporting Documentation**

Water Use Lease Agreement (December 2013)

Amendment #1 to Water Use Lease Agreement (December 2016)

Amendment #2 to Water Use Lease Agreement (October 2018)

Water Service Agreement – Recharge from Excess Flows (September 2019)

A-18922 Cozad Canal Application Approval (March 2015)

A-18923 Orchard-Alfalfa Canal Application Approval (March 2015)

A-18924 Thirty Mile Canal Application Approval (March 2015)

**Appendix B – NPPD Supporting Documentation**

Water Service Agreement – Recharge from Excess Flows (March 2015)

Water Service Agreement – Recharge from Excess Flows (May 2016)

Water Service Agreement – Recharge from Excess Flows (Nov. 2016, effective Jan. 2017)

Water Service Agreement – Recharge from Excess Flows (October 2019, effective Jan. 2020)

A-19682 Dawson County Canal Temporary Recharge Approval (February 2020)

A-19683 Gothenburg Canal Temporary Recharge Approval (February 2020)

Recharge Analysis for Temporary Appropriations A-19385 and A-19386 (2015-2016)

Recharge Analysis for Temporary Appropriations A-19459 and A-19458 (2016-2017)

Recharge Analysis for Temporary Appropriations A-19552 and A-19553 (2017-2018)

Recharge Analysis for Temporary Appropriations A-19607 and A-19608 (2018-2019)

**Appendix C – EDO Cycle Well Data Analysis Memo**

1. A Program water project’s score is its contribution toward the required deficit reductions at Grand Island. [↑](#footnote-ref-1)
2. A score of 30,600 AFY for the J-2 Regulating Reservoirs Project was accepted by the GC in March 2012, but that score was effectively retracted when the project was placed on an indefinite hold by the GC in November 2016. [↑](#footnote-ref-2)
3. Boyle Engineering Corporation, BBC Research & Consulting, and Anderson Consulting Engineers. 1999. *Water Conservation/Supply Reconnaissance Study*. Final Report. Prepared for the Governance Committee of the Cooperative Agreement for Platte River Research. [↑](#footnote-ref-3)
4. Boyle Engineering Corporation, BBC Research & Consulting, and Anderson Consulting Engineers. 2000. *Reconnaissance-Level Water Action Plan*. Prepared for Governance Committee of the Cooperative Agreement for Platte River Research. [↑](#footnote-ref-4)
5. The 1999 reconnaissance study also evaluated recharge potential in upstream reaches on the North Platte and South Platte rivers in Nebraska, Wyoming, and Colorado, but no other specific sites were considered below the confluence at North Platte, NE. [↑](#footnote-ref-5)
6. Office of the Executive Director and the Water Advisory Committee. 2010. Platte River Recovery Implementation Program *2009 Water Action Plan Update*. Final. [↑](#footnote-ref-6)
7. Office of the Executive Director, Water Advisory Committee, Hahn Water Resources LLC, and Ann Bleed and Associates. 2010. Platte River Recovery Implementation Program *Nebraska Ground Water Recharge Pre-Feasibility Study*. [↑](#footnote-ref-7)
8. The B-1 Reservoir is owned by CPNRD but filled through the NPPD’s Gothenburg Canal. [↑](#footnote-ref-8)
9. EA Engineering, Science, and Technology, Inc., and Daniel B. Stephens & Associates, Inc. 2012. *Pilot-Scale Recharge Report for Nebraska Groundwater Recharge Feasibility Study*, Platte River Recovery Implementation Program. [↑](#footnote-ref-9)
10. PRRIP Executive Director’s Office. 2015. *2014 Water Action Plan Project Update: Active, Future & Inactive WAP Projects*. [↑](#footnote-ref-10)
11. The Cottonwood Ranch broad-scale recharge project will be filled via a pipeline from the Phelps County Canal. Project construction was completed in 2019 and operations are expected to begin in late summer 2020. [↑](#footnote-ref-11)
12. Specific terms of the original agreement related to cost and transferred surface water were amended in January 2017 and October 2018, respectively. [↑](#footnote-ref-12)
13. Net recharge = diversions minus surface returns or spills. The specific language of the WSA states “The Total Amount Diverted shall be measured by CPNRD using automated measuring and recording gates…The Total Amount Diverted will be adjusted by subtracting any deliveries or releases made and recorded by the irrigation district.” [↑](#footnote-ref-13)
14. This volume can be exceeded with written authorization from the Program. [↑](#footnote-ref-14)
15. From a Program accounting perspective, the diminishing future accretions from CPNRD recharge during the First Increment (mostly during the period 2011-2017) will not be considered moving forward. The accretions billed during the First Increment were calculated based on a now-obsolete version of the COHYST groundwater model. To go back now and recalculate those accretions using the new unit response functions developed for this scoring analysis would only create inconsistencies and confusion. [↑](#footnote-ref-15)
16. The NPPD WSA states “The Net Amount Diverted shall be defined as the flow measured by NPPD using the Gothenburg Canal and Dawson County Canal measuring flumes located near the river headgates on the Gothenburg Canal and Dawson County Canal and subtracting each canal’s river returns as measured by NPPD. The measurement will be adjusted, as appropriate, for any deliveries made by NPPD from the Gothenburg Canal to the B-1 Reservoir.” [↑](#footnote-ref-16)
17. Boyle Engineering Corporation, Ecological Resource Consultants, Inc., BBC Research & Consulting, and Lytle Water Solutions, LLC. 2008. Water Management Study *Phase I Evaluation of Pulse Flows for the Platte River Recovery Implementation Program*. Final. [↑](#footnote-ref-17)
18. Platte River Recovery Implementation Program Governance Committee meeting minutes, June 2010. [↑](#footnote-ref-18)
19. Brandi Flyr, CPNRD District Hydrology, personal communication, February 25, 2020. [↑](#footnote-ref-19)
20. Applegate Group, Inc. 2011. *Canal Winter Operations Feasibility Study*. Nebraska Public Power District. [↑](#footnote-ref-20)
21. Or the portion remaining after CNPPID excess diversions in applicable scenarios. [↑](#footnote-ref-21)
22. StElmnts.tab Table 55 Platte River near Grand Island, with EA flows (pulse flows not included). [↑](#footnote-ref-22)
23. Between 2014 and 2016, the EDO worked with the CPNRD on a combined score analysis for the surface water transfer and accretions from groundwater recharge. Once the surface water component was modified to credit the water to the Lake McConaughy EA (the “pilot exchange project” that started in 2018) rather than return it directly to the river during the irrigation season (as was done from 2015-2017), this combined score analysis effort was abandoned. [↑](#footnote-ref-23)
24. Integrated Support System <http://www.ids.colostate.edu/projects.php?project=awas&breadcrumb=IDS+AWAS+-+Alluvial+Water+Accounting+System> [↑](#footnote-ref-24)
25. Glover, R.E. 1977. *Transient ground water hydraulics*. Water Resources Publications. [↑](#footnote-ref-25)
26. Cannia, J., Woodward, D., and Cast, L. 2006. Cooperative Hydrology Study *COHYST Hydrostratigraphic Units and Aquifer Characterization Report*. [↑](#footnote-ref-26)
27. Jeff Shafer, NPPD Water Resource Advisor, personal email communication, January 31, 2020. [↑](#footnote-ref-27)