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Programmatic Environmental Impact Statement
Technical Appendix

Analysis of Impacts to Riverine Fish Communities in the Central Platte River

U.S. DEPARTMENT OF THE INTERIOR
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Bureau of Reclamation
Platte River Office

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INTRODUCTION

The objectives of this technical report are to describe the fishery in the central Platte River and to provide detailed descriptions of the methods and results of analyzing the impacts of the various alternatives on the central Platte River fish community. The primary quantitative approaches used in this analysis include modeling the physical habitat, evaluating temporal trends in physical habitat, and assessing impacts on turbidity and summer water temperatures. The general outline for this assessment is presented in Figure 1.

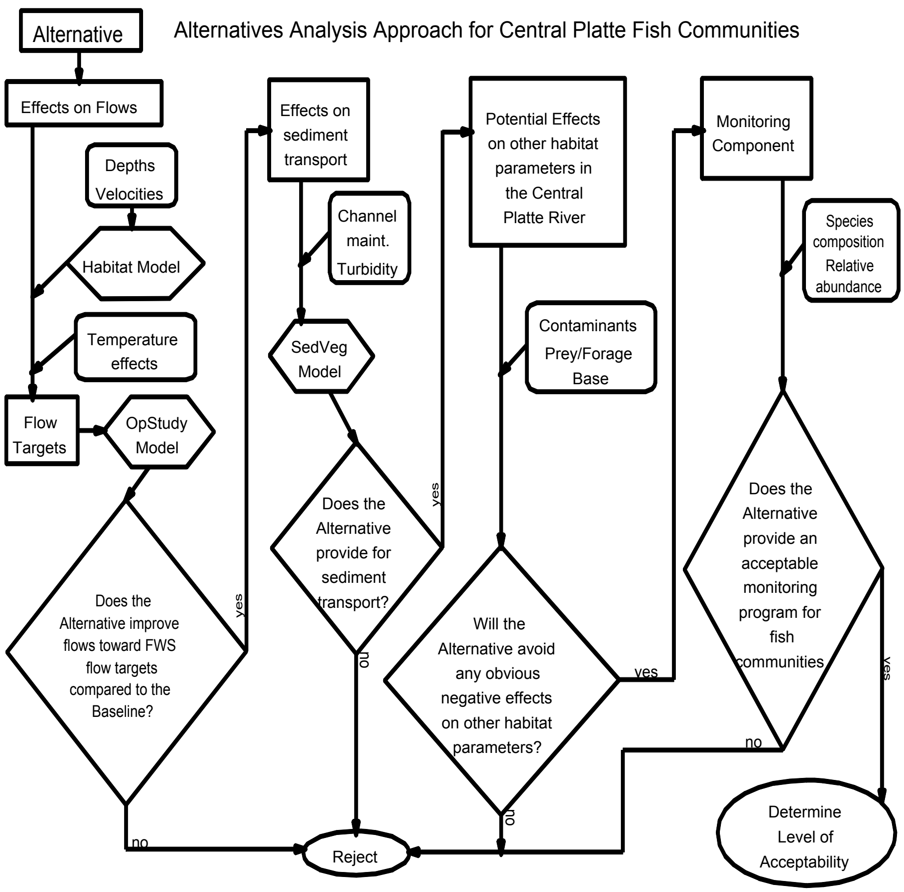

Figure 1. Flow chart of various approaches to analyzing alternatives on central Platte River fish community.

BACKGROUND

Fish Community

One of the most important fish resources affected by the proposed program is located in the central Platte River between Lexington and Grand Island, Nebraska; also known as the Big Bend Reach. Of particular importance are small fishes that provide forage for the endangered interior least tern, and larger fish that supply forage for bald eagles.

Fish surveys conducted on the central Platte River since the late 1930s have documented a fish community dominated by minnows (Johnson 1942; Morris 1960; Bliss and Schainost 1973; Chadwick et al. 1997). Fish communities dominated by minnows are common in prairie streams where available aquatic habitat is primarily shallow, open water (Cross and Collins 1975; Pflieger 1975). From 1990 through 1995, the fish community of the Big Bend Reach was monitored twice annually by Chadwick and Associates, Inc. (1992, 1993, 1994) and Chadwick Ecological Consultants (1995, 1996). During the 6-year period, 41 fish species were collected in the central Platte River, including 15 species of the minnow family (Cyprinidae) (excluding carp (*Cyprinus carpio*)). One minnow species, silver chub (*Macrhybopsis storeriana*), was collected on one occasion and a second species, flathead chub (*Platygobio gracilis*), was collected on only three occasions. The most abundant small fish collected were sand shiner (*Notropis stramineus*), the non-native mosquitofish (*Gambusia affinis*), plains killifish (*Fundulus zebrinus*), red shiner (*Cyprinella lutrensis*), and bigmouth shiner (*Notropis dorsalis*) (Chadwick Ecological Consultants 1996). Other common fish include fathead minnow (*Pimephales promelas*), river carpsucker (*Carpiodes carpio*), white sucker (*Catostomus commersoni*), channel catfish (*Ictalurus punctatus*), carp , largemouth bass (*Micropterus salmoides*), and quillback (*Carpiodes cyprinus*) (Chadwick Ecological Consultants 1996). Species composition of the minnows was quite consistent over the 6-year period and they represented between 33.3 to 57.9 percent of the species collected during a sampling period.

Physical Habitat

Habitat in the central Platte River is typical of many other Great Plains streams. Low gradient, sandy silt bottoms, highly variable flows, high summer water temperatures, high turbidity, and high chloride and total dissolved solids make such streams harsh environments for fish (Matthews 1987, 1988; Cross and Moss 1986). Fish living in plains streams, including those common in the Platte, are generally well adapted to the variable and harsh habitat.

Important fish habitat in the central Platte River includes deeper pools and shallow areas, side channels, backwaters, and shoreline cover (Morris 1960; Peters et al. 1989). Of five main channel habitat types (open channel, bank, snag, backwater, and isolated backwater) characterized by Chadwick Ecological Consultants (1996), open channel accounted for more than 95 percent of all water surface area in the central Platte River. Pool habitat is most abundant in the central Platte River below Grand Island.

Water Temperature

Droughts are a major feature of the central Platte River. Low water limits fish habitat and allows water temperatures to reach high summer ambient air temperatures. Summer water temperatures of typical plains streams range from 36° to 37° C in the main stems and 32° to 35° C in thermal refugia (Matthews and Zimmerman 1990). These temperatures are typical of the Platte River.

Elevated water temperatures affect fish in a variety of ways. Fish physiology can be altered during high water temperature conditions influencing survival rates, growth rates, embryonic development, and susceptibility to parasites and diseases. Elevated temperatures can also affect metabolism, fluid-electrolyte balance, and the acid-base relationship within fish (Lantz 1970; Islam and Strawn 1975). Fish behavior can also be altered with respect to habitat utilization activities, distribution, and species interactions (Crawshaw 1977; Matthews and Hill 1979; Adams et al. 1982; Stauffer et al. 1984). Changes in water temperature can also affect timing of spawning, duration of incubation, and timing of gonadal maturation (Fry 1971; Matthews and Maness 1979; Armour 1991). Water quality of a stream is influenced by changes in water temperature which affect solubility of dissolved gases, deoxygenation rates, and synergistic toxicity (Theurer et al. 1984).

Periodic low summer flows coupled with high temperatures are believed to be a critical factor in determining the abundance and diversity of the central Platte River forage fish community. Between 1974 and 1996, there were 23 reported fish kills occurring between May and September in the central Platte River (Nebraska Game and Parks Commission (NGPC), unpublished data). Nine of these reports occurred in 1991. Fish kills occurred in 57% of the 23 years. Goldowitz (1996) demonstrated that fish kills were highly likely in other years, but not documented. Most of the reported fish kills (92%) occurred in the central Platte River between Cozad and Columbus. A dewatered channel was responsible for one fish kill in 1975 and toxic chemicals resulted in fish kills in 1983 and 1989. A wide range of fish species were affected by these kills, including channel catfish, walleye, sunfish, suckers, and minnows. High water temperatures (>32°C) and low flows were observed for many of the kills.

For the central Platte River, Dinan (1992), Zander (1995 and 1996) and Sinokrot et al. (1996) demonstrated a relationship between river water temperature and instream flows. Study results indicate that to reduce the frequency and duration of potential lethal maximum water temperatures, flows of sufficient quantity must be provided; and reductions in flow during summer months could increase frequency and duration of high water temperatures that adversely impact fish populations (Dinan 1992). As flow increases, the wetted width and water depth increase. Heat supplied to the water surface by the sun or warm air is absorbed by a larger volume of water. In general, higher flows are associated with lower maximum water temperature and less fluctuation around the mean temperature.

Results from Dinan's (1992) effort indicate a relationship exists between daily maximum water temperature and discharge. Increased flows during summer months can reduce the frequency and duration of daily maximum water temperatures in excess of 35°C throughout the central Platte River. Flows of 400 cfs at Grand Island provided little or no protection to the central Platte River fish community from high water temperatures. A flow of 800 cfs reduced the average daily maximum water temperatures and the number of days when temperatures were in excess of 35°C throughout the central Platte River. A flow of 1,200 cfs further reduced average daily maximum water temperature at all sites and reduced the number of days when maximum water temperatures were in excess of 35°C. Sinokrot et al. (1996) found that a 1,200 cfs minimum flow is required to significantly reduce violations of the Nebraska water temperature standard of 32.0°C during the summer and findings of a peer review panel (McCutcheon et al. 1996) found that Sinokrot et al. (1996) had reached credible and scientifically valid conclusions. The critical months identified in the Kingsley Biological Opinion are June, July, and August (U.S. Fish and Wildlife Service (USFWS) 1997).

Data from NGPC (1985) on species composition and relative abundance of 13 fish species sampled near the Jeffrey Island least tern nest colony on the Platte River in 1985 showed that the sand shiner represented over 50% of total fish collected. Fessell (1996) found that the more common Platte River fish species could only tolerate temperatures in excess of 36°C for brief periods. He reported an average field tolerance temperature for sand shiners of 33.5°C. Dinan (1992) assumed that 35°C represented the lethal temperature for the forage fish community. This was based primarily on thermal tolerances for various common fish species in the Platte River (Matthews 1986;1987).

METHODS

Physical Habitat

Availability and quality of aquatic habitat has a direct and indirect effect on the abundance and diversity of fish within the central Platte River. In the Kingsley Project Biological Opinion (USFWS 1997), the Fish and Wildlife Service used river channel hydraulic analysis for the central Platte River developed by Hardy and Associates (1992) and habitat suitability indices developed by Peters and Holland (1994) to model the relationship between available fish habitat and discharge for various fish "guilds"in the central Platte River. This "Habitat Model" used the Physical Habitat Simulation System (PHABSIM) component of the Instream Flow Incremental Methodology (IFIM) developed by the Fish and Wildlife Service (Bovee et al. 1998) to combine hydraulic analysis with habitat suitability indices for water depth, velocity, and cover. A guild is a "group of species which exploit the same class of environmental resources in a similar way" (Root 1967, <u>in</u> Leonard and Orth 1988). The primary assumption with this analysis is that a diverse assemblage of fish species is needed to maintain the integrity of the fishery and to provide an adequate forage base for both the interior least tern and bald eagle. Twenty four different native fish species/life stages were grouped into five guilds based on similarities in the shape of their Habitat Area Curves (Tables 1 and 2). In the Kingsley Biological Opinion, a final discharge/habitat relationship for the five guild fish community was developed by comparing individual guild curves to determine the minimum percent of optimal habitat for a range of flows (Figure 2). This "optimization technique" showed that a flow of 1,200 cfs provided the maximum percent of optimal habitat among the minimum habitat values. The PHABSIM analysis assumed that the stream channel was in equilibrium (i.e., no aggradation or degradation) for each alternative.

Table 1. Fish species/life stages within each guild for the central Platte River.

Species	Life Stage	Abundance[1]
Guild A		
Red shiner	Young-of-the-year	High
River shiner	Juvenile	Moderate
Sand shiner	Young-of-the-year	High
Sand shiner	Juvenile	High
Guild B		
Western silvery minnow	Adult	Moderate
Flathead chub	Juvenile	Rare
Red shiner	Juvenile	High
Red shiner	Adult	High
Sand shiner	Adult	High
Plains minnow	Adult	Rare
Fathead minnow	Adult	High
Quillback carpsucker	Juvenile	Low
River carpsucker	Juvenile	Low
Plains killifish	Adult	High
Guild C		
Emerald shiner	Adult	Low
River shiner	Adult	Moderate
Bigmouth shiner	Adult	High
Freshwater drum	Juvenile	Low
Guild D		
Common carp	Adult	Moderate
Speckled chub	Adult	Rare
Silver chub	Adult	Rare
Guild E		
Gizzard shad	Adult	Low
Channel catfish	Juvenile	Low
Channel catfish	Adult	Low

[1] Source: Chadwick and Associates, Inc. (1992-1996)

Table 2. Normalized habitat area (HA) values (0-100%) for five fish guilds at various flows in the central Platte River. Source: Kingsley Project Biological Opinion (USFWS 1997)

	Guilds				
Discharge (cfs)	A	B	C	D	E
0	0	0	0	0	0
50	35.78	25.72	24.44	11.23	5.84
100	54.70	44.19	39.56	23.06	12.31
125	59.90	49.31	44.13	26.77	14.42
150	66.88	55.14	49.22	30.82	16.49
175	71.93	60.31	53.75	35.69	18.77
200	77.54	65.60	58.55	39.20	20.95
225	82.42	70.16	63.04	42.37	23.02
250	84.27	72.58	65.57	45.17	24.47
275	84.50	74.23	67.66	47.36	26.11
300	92.54	80.99	74.50	51.37	28.80
350	99.14	88.50	81.08	57.48	31.98
400	100.0	93.77	86.83	63.04	35.45
450	97.77	95.49	89.80	66.85	38.25
500	94.73	97.19	92.58	70.48	41.09
550	89.99	96.48	93.23	73.33	43.57
600	92.82	100.0	97.25	76.58	46.52
650	90.83	98.87	97.60	78.08	48.53
700	87.09	96.87	96.50	80.64	51.35
750	85.58	97.29	97.63	82.74	52.90
800	83.74	96.69	98.06	84.24	54.77
900	80.22	95.34	98.70	87.26	58.63
1000	76.57	94.06	99.17	89.92	61.57
1100	73.83	92.98	100.0	91.46	64.93
1200	70.23	91.68	99.99	93.17	67.27
1300	66.41	88.70	97.48	94.33	71.06
1400	63.90	87.28	97.26	95.52	73.09
1500	60.51	85.13	96.73	96.15	75.78
1600	56.56	81.48	93.88	97.86	79.58
1700	53.43	79.47	92.77	98.16	81.37
1800	50.84	76.72	90.61	100.0	86.25
1900	48.57	74.85	89.84	99.49	87.42
2000	46.75	73.77	89.62	99.19	88.99
2500	38.84	64.95	84.05	94.50	93.62
3000	35.97	59.13	79.92	89.25	96.93
3500	34.52	55.58	76.89	84.58	98.32
4000	34.72	53.60	76.09	81.31	100.0

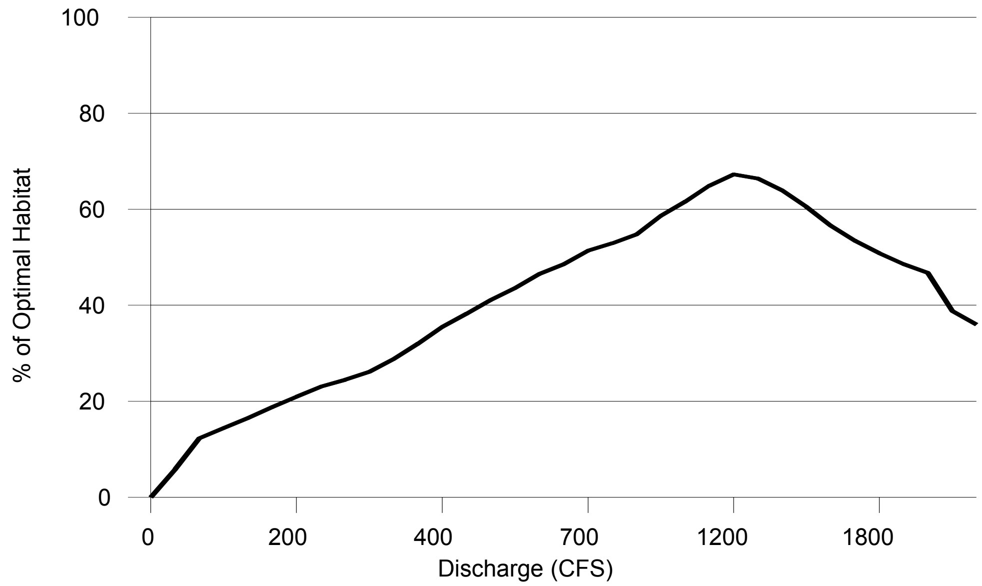

Figure 2. Relationship of habitat and discharge for 5 fish guilds in central Platte River.

The effects of alternative flow regimes on physical habitat were determined using the relationships between available fish habitat and discharge (Habitat Area Curves). The OpStudy Model was used to simulate average monthly discharge over a 52 year period of record for each alternative at two locations in the central Platte River. Using the habitat time series computer programs within PHABSIM, discharge data from Overton and Grand Island, Nebraska were converted to percent of optimal habitat using the final habitat/discharge relationships discussed above for the five fish guilds. Monthly habitat duration curves for each alternative were then compared to the present condition to determine percentage change in fish habitat. Positive and negative percent differences were interpreted as minor (<10%) (- or +), moderate (10-20%) (-- or ++), or major (>20%) (--- or +++), depending on the magnitude of change. The final step was a tally of each positive and negative category to determine which alternative provided the most benefit to the fish community. Monthly flow duration curves were also generated for comparative purposes.

Water Temperature

Water temperature impacts were assessed based on the knowledge that elevated summer water temperatures can have a detrimental effect on the central Platte River fish community. For this analysis, we used daily summer flow and air temperature data from the Mormon Island thermograph for the period of June 1988 through September 1995. There were no data collected in 1989 at this site. This data set differs from the data of 1988-1990 used in the Kingsley Biological Opinion (USFWS 1997).

One approach used to assess summer water temperature impacts was a hydrologic analysis that involved calculating the percent of time 1,200 cfs was met or exceeded at Grand Island during June, July, and August for each alternative using monthly flows provided by the OpStudy Model. Adopting a summer flow recommendation of 1,200 cfs reduces the frequency and duration of high water temperature events. A flow of 1,200 cfs provides the most "cost effective" improvement toward meeting this goal. The alternative with the highest percentage of summer months with flows greater than or equal to 1,200 cfs would provide the most benefit to the fish community. This approach was used in the Kingsley Biological Opinion (USFWS 1997).

Another approach used to assess temperature impacts was to look at how often, based on probabilities, the state standard, the thermal maximum for sand shiners, and the lethal temperature for the fish community would be met with each alternative. A probability distribution based on flow was developed. The analysis was based on historical daily flow data from the Grand Island gage and the temperature data for the Mormon Island thermograph site. The maximum water temperature data were subset into flow intervals. The intervals were based on 100 CFS increments at lower flows. As flows increased, increments were increased to insure that each interval included at least 25 temperature measurements. Once the increment size was increased, that became the minimum size for higher flow intervals.

The water temperature data within each flow interval were sorted from low to high and a cumulative frequency distribution was developed. The probabilities of exceeding the 32°C temperature standard, 33.5°C, and 35°C thermal maximums were calculated as the complement of the frequency from the cumulative frequency distribution associated with the last occurrence of 32°C, 33.5°C, or 35°C or the last temperature that did not exceed 32°C, 33.5°C, or 35°C. The probability of exceeding these temperatures was then aligned with the flow intervals and plotted (Tables 4, 5, 6; Figures 3, 4, 5). Quadratic regression was developed by regressing the probabilities against the interval number and its square root. The maximum flow used in the regression was 6,497 cfs. The probabilities of exceeding 32°C, 33.5°C, and 35°C with the highest flow interval were 0.02, 0.03, and 0.00, respectively (Tables 4, 5, 6). None of the observed maximum temperature observations exceeded 33.5°C or 35°C in the high flow interval (> 3,100 ft^3/s). The minimum flow used in deriving each of the curves was 50 CFS.

The number of days during the summer that 32°C, 33.5°C, and 35°C would be exceeded at various flows is plotted in Figure 6.

Table 4. Estimated Probability of Exceeding 32.0°C at the Mormon Island Thermograph Site as a Function of Flow as Measured at the USGS Grand Island gage.

Flow	Fraction > 32.0°	# of Obs.	Prob. > 32.0°C
0-99	0.66	53	0.53
100-199	0.53	49	0.51
200-299	0.37	46	0.49
300-399	0.51	35	0.47
400-499	0.50	28	0.45
500-699	0.29	45	0.42
700-899	0.30	50	0.38
900-1099	0.35	48	0.34
1100-1499	0.31	45	0.29
1500-1999	0.23	26	0.21
2000-3099	0.14	36	0.11
≥ 3100	0.02	55	0.02

Table 5. Estimated Probability of Exceeding 33.5°C at the Mormon Island Thermograph Site as a Function of Flow as Measured at the USGS Grand Island gage.

Flow	Fraction > 33.5°	# of Obs.	Prob. > 33.5°C
0-99	0.49	53	0.50
100-199	0.45	49	0.43
200-299	0.28	46	0.37
300-399	0.43	35	0.32
400-499	0.39	28	0.28
500-699	0.11	45	0.23
700-899	0.12	50	0.19
900-1099	0.15	48	0.15
1100-1499	0.18	45	0.11
1500-1999	0.00	26	0.07
2000-3099	0.06	36	0.03
≥ 3100	0.00	55	< 0.03

Table 6. Estimated Probability of Exceeding 35°C at the Mormon Island Thermograph Site as a Function of Flow as Measured at the USGS Grand Island gage.

Flow	Fraction > 35°	# of Obs.	Prob. > 35°C
0-99	0.26	53	0.21
100-199	0.24	49	0.20
200-299	0.15	46	0.18
300-399	0.29	35	0.17
400-499	0.14	28	0.15
500-699	0.02	45	0.13
700-899	0.00	50	0.10
900-1099	0.02	48	0.08
1100-1499	0.07	45	0.04
1500-1999	0.00	26	0.00
2000-3099	0.00	36	0.00
=> 3100	0.00	55	0.

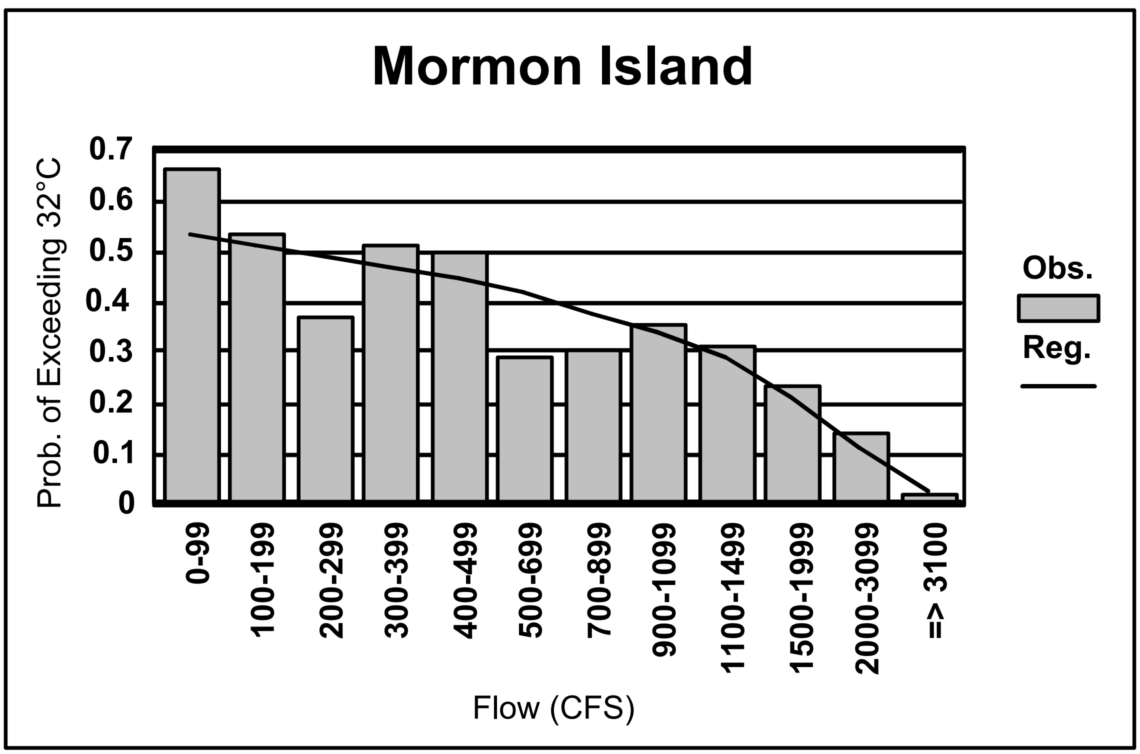

Figure 3. Fraction of observed maximum temperatures exceeding 32°C at Mormon Island thermograph site and number of temperature observations per flow interval.

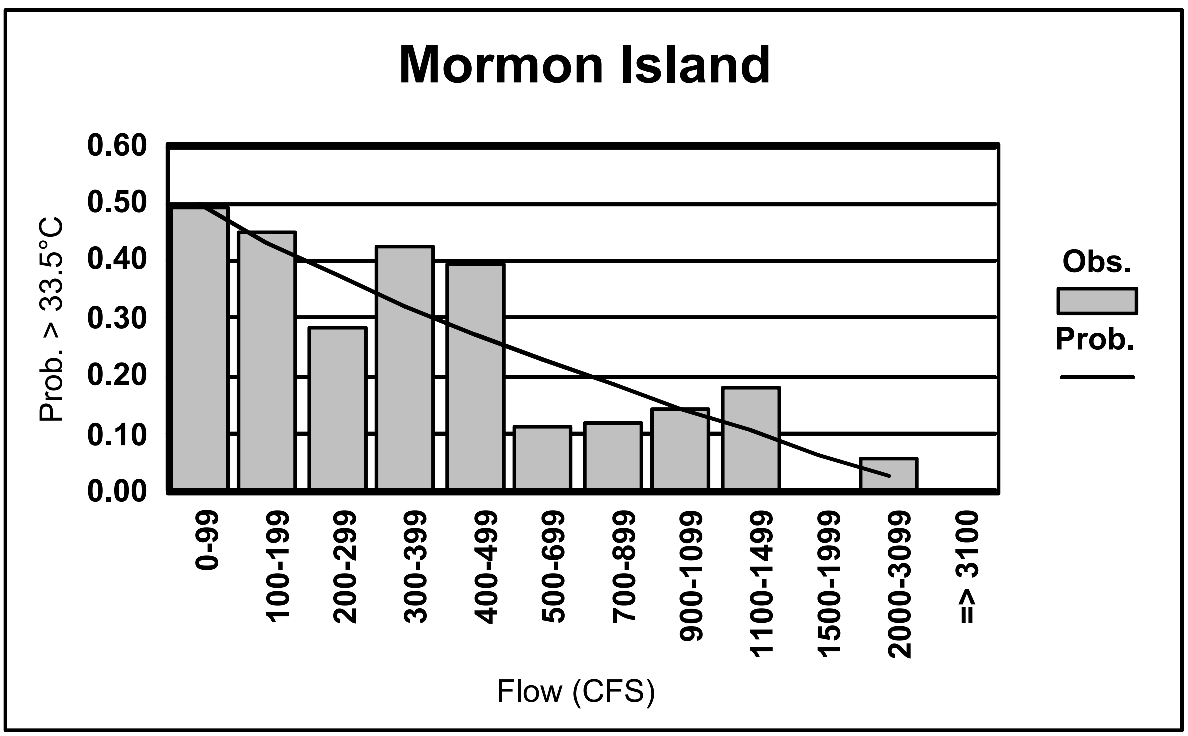

Figure 4. Fraction of observed maximum temperatures exceeding 33.5°C at Mormon Island thermograph site and number of temperature observations per flow interval.

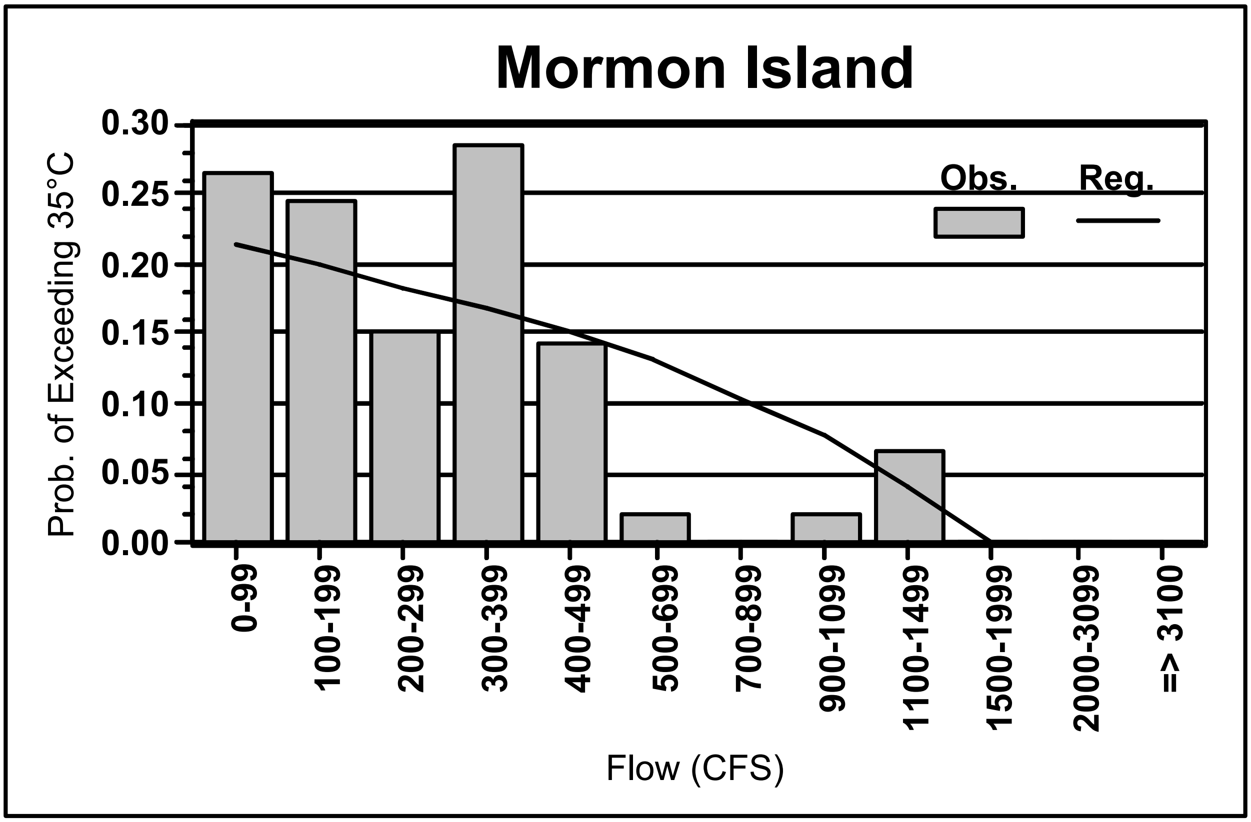

Figure 5. Fraction of observed maximum temperatures exceeding 35°C at Mormon Island thermograph site and number of temperature observations per flow interval.

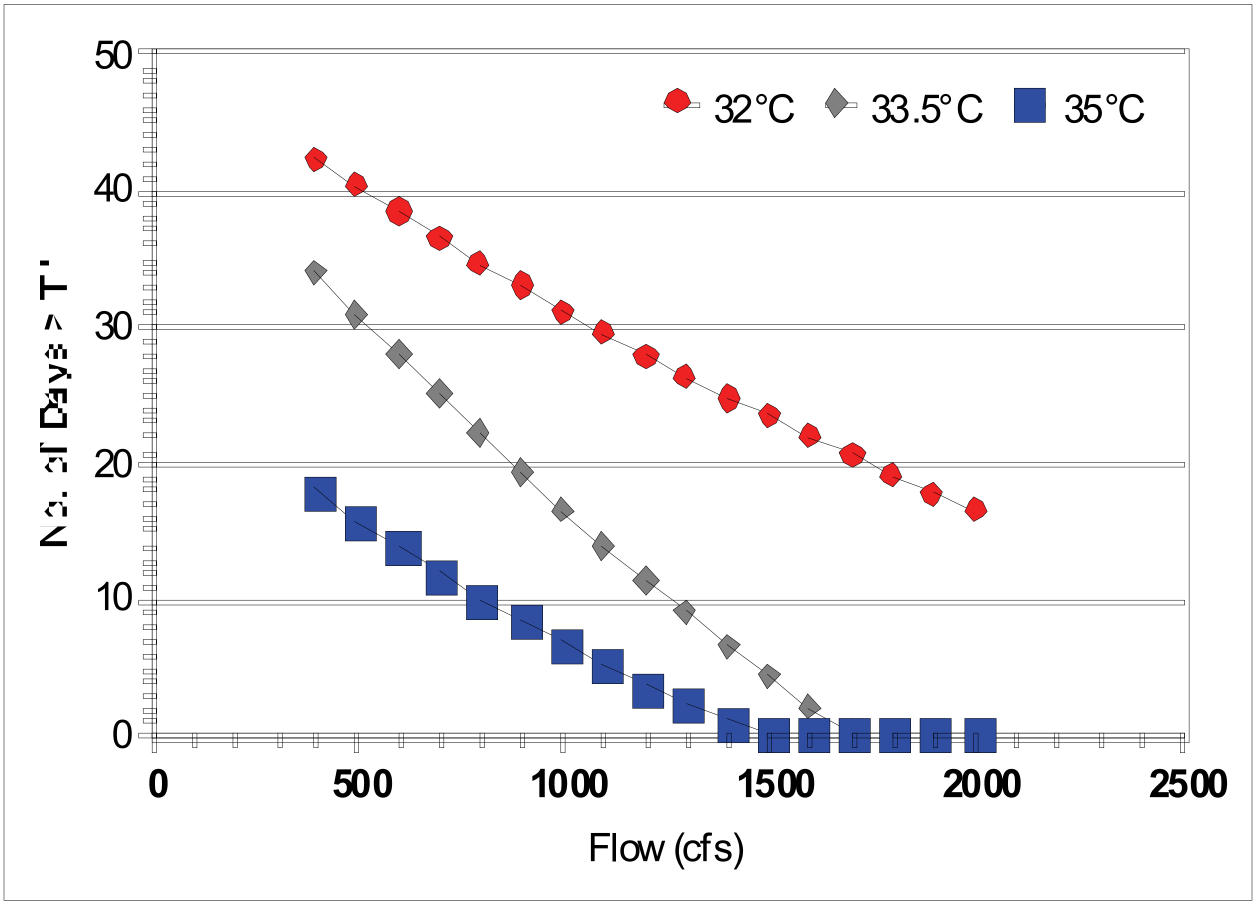

Figure 6: Number of days per summer (June through August) that indicated temperature would be exceeded at constant flow at level shown

Other Impacts

A qualitative assessment was used to determine the potential effects of each alternative on other water quality parameters important to the fish community in the central Platte River. These parameters included selenium and turbidity. The potential toxicity of Platte River sediments to fish is addressed in the Water Quality Technical Appendix.

As discussed above, the PHABSIM analysis was only appropriate where river channels were in equilibrium and not aggrading or degrading. In areas of the Platte River where alternatives resulted in aggradation or degradation, another analysis was necessary. Thus, the SedVeg Model was used to assess effects of stream channel changes on forage fish habitat. Sand shiners were used to represent forage fish for least terns. Sand shiner habitat suitability criteria for depth were used to assess impacts on fish habitat using SedVeg. Based on information in Peters et al. (1989) and Conklin et al. (1995), the following optimum depth criteria were used for sand shiners:

Juvenile and Adult life stages -
Summer (June 22 to Sept 2) - 3 - 20 cm
Fall, Winter, Spring (Sept 3 - June 21) - 3 - 10 cm

The analysis involved quantifying total channel widths with these optimum depths (i.e., summing wetted widths with these depths across the river channel) between years 30 and 78 under each alternative. This provided a gross estimate of channel changes and subsequent effects on forage fish habitat in the Platte River.

ALTERNATIVES ANALYSIS

Physical Habitat

Overton

The results of the physical fish habitat analysis at Overton using PHABSIM are summarized in Tables A-1 to A-5 in Appendix A - Habitat Duration Results for each alternative. Table 7 summarizes the relative comparisons of each alternative with present condition with respect to habitat changes. Table 8 summarizes the total positive and negative habitat impacts for each alternative and ranks the alternatives in order of benefit to the fishery resources.

Based on this habitat analysis, all alternatives are similar and generally better than present conditions for the fishery resource. Program Water Emphasis alternative ranked highest among alternatives for most positive benefits. All alternatives had similar major habitat gains (+++). October and March had the most negative habitat losses for all alternatives. September had the only major positive habitat gains for all alternatives. Given this analysis, all alternatives resulted in similar and generally better impacts compared to present conditions, but the Program Water Emphasis alternative would provide slightly more benefit for the fish community among alternatives at Overton.

Table 7. Fish habitat alternative comparisons to Present Conditions at Overton, Nebraska.

JANUARY	% OF OPTIMAL HABITAT CONDITIONS				% DIFFERENCES COMPARED TO PRESENT CONDITIONS				RELATIVE BENEFITS COMPARED TO PRESENT CONDITIONS			
PERCENT EXCEEDANCE	10	20	80	90	10	20	80	90	10	20	80	90
PRESENT CONDITIONS	65.1	63.4	40.6	37.7								
GOVERNANCE	66.4	65.5	44.6	40.2	2.0	3.3	10.0	6.7	+	+	++	+
WATER EMPHASIS	66.3	64.4	42.7	39.9	1.8	1.5	5.1	5.9	+	+	+	+
WET MEADOW	66.7	61.4	42.0	38.8	2.4	-3.1	3.6	3.0	+	-	+	+
WATER LEASING	66.4	62.6	38.5	36.5	1.9	-1.3	-5.2	-3.0	+	-	-	-
FEBRUARY												
PRESENT CONDITIONS	66.5	65.2	35.9	35.3								
GOVERNANCE	63.2	56.7	36.3	36.1	-5.0	-13.0	1.0	2.1	-	--	+	+
WATER EMPHASIS	55.3	43.1	36.2	35.8	-16.8	-33.9	0.8	1.3	--	---	+	+
WET MEADOW	65.0	60.0	36.3	35.7	-2.2	-8.0	0.9	1.1	-	-	+	+
WATER LEASING	57.2	48.8	35.5	34.7	-13.9	-25.2	-1.3	-1.7	--	---	-	-
MARCH												
PRESENT CONDITIONS	65.8	64.8	38.6	36.6								
GOVERNANCE	64.6	60.6	37.3	36.4	-1.8	-6.4	-3.5	-0.5	-	-	-	-
WATER EMPHASIS	64.0	59.3	37.1	35.6	-2.7	-8.5	-3.9	-2.6	-	-	-	-
WET MEADOW	65.5	64.1	37.5	35.7	-0.5	-1.0	-2.9	-2.5	-	-	-	-
WATER LEASING	65.9	59.7	36.8	35.5	0.2	-7.8	-4.8	-3.1	+	-	-	-
APRIL												
PRESENT CONDITIONS	64.9	62.7	44.7	37.9								
GOVERNANCE	66.0	61.9	43.5	38.1	1.7	-1.3	-2.7	0.5	+	-	-	+
WATER EMPHASIS	66.2	63.5	44.2	38.1	2.1	1.4	-1.3	0.6	+	+	-	+

WET MEADOW	66.8	62.8	44.3	36.7	2.9	0.2	-1.0	-3.2	+	+	-	-
WATER LEASING	65.3	62.9	44.7	37.0	0.6	0.4	-0.2	-2.3	+	+	-	-
MAY												
PRESENT CONDITIONS	66.0	63.3	42.3	37.1								
GOVERNANCE	66.4	64.8	40.1	38.1	0.6	2.4	-5.2	2.8	+	+	-	+
WATER EMPHASIS	66.8	65.5	38.7	37.1	1.2	3.5	-8.5	0.0	+	+	-	-
WET MEADOW	66.4	64.7	40.5	37.1	0.5	2.3	-4.4	0.1	+	+	-	+
WATER LEASING	66.5	65.0	43.2	36.7	0.6	2.7	2.2	-1.2	+	+	+	-
JUNE												
PRESENT CONDITIONS	63.7	56.6	35.5	34.6								
GOVERNANCE	66.5	65.8	39.2	37.7	4.4	16.3	10.3	9.1	+	++	++	+
WATER EMPHASIS	66.8	65.5	38.1	36.5	4.8	15.8	7.2	5.6	+	++	+	+
WET MEADOW	66.7	65.9	38.8	36.1	4.7	16.4	9.2	4.5	+	++	+	+
WATER LEASING	67.0	65.8	40.2	36.3	5.1	16.4	13.3	4.9	+	++	++	+
JULY												
PRESENT CONDITIONS	65.4	62.4	39.8	38.1								
GOVERNANCE	66.0	64.8	43.8	41.9	0.9	3.9	10.1	9.9	+	+	++	+
WATER EMPHASIS	65.5	64.6	46.5	43.2	0.2	3.6	16.8	13.5	+	+	++	++
WET MEADOW	65.5	63.5	45.0	41.8	0.1	1.8	13.1	9.6	+	+	++	+
WATER LEASING	65.1	62.5	42.2	38.6	-0.6	0.2	5.8	1.3	-	+	+	+
AUGUST												
PRESENT CONDITIONS	59.1	56.0	38.8	36.9								
GOVERNANCE	63.0	60.0	44.8	42.3	6.6	7.2	15.6	14.7	+	+	++	++
WATER EMPHASIS	61.0	59.5	45.5	41.2	3.1	6.4	17.4	11.8	+	+	++	++
WET MEADOW	60.4	57.9	44.2	39.7	2.2	3.4	13.9	7.5	+	+	++	+
WATER LEASING	58.0	54.7	39.1	32.6	-1.8	-2.3	0.8	-11.6	-	-	+	--
SEPTEMBER												

PRESENT CONDITIONS	60.5	57.9	35.7	23.8								
GOVERNANCE	60.1	56.8	37.0	28.1	-0.7	-1.8	3.5	18.0	-	-	+	++
WATER EMPHASIS	61.8	58.2	35.9	28.8	2.2	0.6	0.4	20.9	+	+	+	+++
WET MEADOW	61.4	58.2	38.1	29.5	1.5	0.5	6.8	23.6	+	+	+	+++
WATER LEASING	60.6	58.4	35.1	28.5	0.1	1.0	-1.7	19.7	+	+	-	++
OCTOBER												
PRESENT CONDITIONS	67.0	66.4	50.6	40.3								
GOVERNANCE	67.0	66.6	46.7	38.5	-0.1	0.3	-7.7	-4.4	-	+	-	-
WATER EMPHASIS	66.8	66.2	45.5	39.0	-0.3	-0.2	-10.0	-3.4	-	-	--	-
WET MEADOW	66.9	66.3	43.8	39.2	-0.2	-0.1	-13.3	-2.9	-	-	--	-
WATER LEASING	66.7	65.0	46.1	39.8	-0.4	-2.1	-8.9	-1.4	-	-	-	-
NOVEMBER												
PRESENT CONDITIONS	66.3	64.1	44.0	38.6								
GOVERNANCE	65.9	64.0	50.8	41.8	-0.5	0.0	15.4	8.4	-	-	++	+
WATER EMPHASIS	66.2	64.7	46.1	41.3	-0.1	1.1	4.8	7.0	-	+	+	+
WET MEADOW	65.8	63.9	45.7	38.7	-0.7	-0.2	3.8	0.3	-	-	+	+
WATER LEASING	66.3	65.3	40.4	38.0	0.1	2.0	-8.3	-1.4	+	+	-	-
DECEMBER												
PRESENT CONDITIONS	67.0	65.9	44.9	39.3								
GOVERNANCE	66.4	65.6	47.8	44.9	-0.8	-0.4	6.5	14.4	-	-	+	++
WATER EMPHASIS	66.1	65.4	46.4	42.4	-1.3	-0.7	3.2	8.0	-	-	+	+
WET MEADOW	66.4	65.3	44.7	39.3	-0.8	-0.9	-0.5	0.0	-	-	-	-
WATER LEASING	66.4	63.8	40.2	37.6	-0.9	-3.1	-10.5	-4.3	-	-	--	-

Table 8. Summary of impacts for fish habitat at Overton (sum of each value for all months and all exceedance levels)

VALUE	GOVERNANCE	WATER EMPHASIS	WET MEADOW	WATER LEASING
MINOR LOSS -	17	13	19	24
MODERATE LOSS --	1	2	1	3
MAJOR LOSS ---	0	1	0	1
NO CHANGE	0	0	0	0
MINOR GAIN +	21	26	24	17
MODERATE GAIN ++	9	5	3	3
MAJOR GAIN +++	0	1	1	0

Alternative rankings for most positive benefits:
Water Emphasis - 32
Governance - 30
Wet Meadows - 28
Water Leasing - 20

Alternative rankings for most major habitat gains:
Water Emphasis - 1
Wet Meadows - 1
Governance - 0
Water Leasing - 0

Grand Island

The results of the physical fish habitat analysis at Grand Island using PHABSIM are summarized in Tables A-6 to A-10 in Appendix A - Habitat Duration Results for each alternative. Table 9 summarizes the relative comparisons of each alternative with present condition with respect to habitat changes. Table 10 summarizes the total positive and negative habitat impacts for each alternative and ranks the alternatives in order of benefit to the fishery resources.

Based on the above habitat analysis, all alternatives were similar and generally better than present conditions for the fishery resource at Grand Island except for Water Leasing. September had the most major increases in habitat for all exceedances compared to present conditions. June had positive habitat gains for all alternatives at all exceedance levels. March had the most negative impacts on fish habitat for all alternatives. Given this analysis, all alternatives had similar and generally beneficial impacts compared to present conditions except Water Emphasis and Governance alternatives would provide slightly more benefit for the fish community among alternatives.

Table 9. Fish habitat alternative comparisons to Present Conditions at Grand Island, Nebraska.

JANUARY	% OF OPTIMAL HABITAT CONDITIONS				% DIFFERENCES COMPARED TO PRESENT CONDITIONS				RELATIVE BENEFITS COMPARED TO PRESENT CONDITIONS			
PERCENT EXCEEDANCE	10	20	80	90	10	20	80	90	10	20	80	90
PRESENT CONDITIONS	66.4	64.6	43.1	39.2								
GOVERNANCE	66.7	65.7	47.1	43.2	0.5	1.7	9.5	10.2	+	+	+	++
WATER EMPHASIS	66.5	65.0	46.3	42.7	0.1	0.6	7.6	9.0	+	+	+	+
WET MEADOW	65.7	64.1	45.3	37.0	-1.1	-0.8	5.1	-5.5	-	-	+	-
WATER LEASING	66.2	63.4	42.3	39.1	-0.3	-1.9	-1.8	-0.1	-	-	-	-
FEBRUARY												
PRESENT CONDITIONS	66.7	63.5	35.5	34.7								
GOVERNANCE	65.1	54.3	36.6	35.5	-2.5	-14.5	2.9	2.3	-	--	+	+
WATER EMPHASIS	57.4	40.3	36.2	34.9	-14.0	-36.6	2.0	0.5	--	---	+	+
WET MEADOW	64.6	55.6	35.9	35.2	-3.1	-12.5	0.9	1.4	-	--	+	+
WATER LEASING	57.5	50.5	34.9	34.6	-13.8	-20.6	-1.8	-0.4	--	---	-	-
MARCH												
PRESENT CONDITIONS	64.4	62.0	36.2	35.3								
GOVERNANCE	61.5	56.8	36.9	35.2	-4.6	-8.3	2.1	-0.3	-	-	+	-
WATER EMPHASIS	63.1	51.7	36.0	35.2	-2.0	-16.6	-0.6	-0.3	-	--	-	-
WET MEADOW	64.6	57.4	35.8	35.3	0.3	-7.3	-0.9	-0.1	+	-	-	-
WATER LEASING	63.0	54.1	35.4	35.0	-2.3	-12.7	-2.1	-1.0	-	--	-	-
APRIL												
PRESENT CONDITIONS	65.2	61.9	40.0	36.2								
GOVERNANCE	63.9	60.7	40.4	37.9	-2.0	-2.0	1.0	4.7	-	-	+	+
WATER EMPHASIS	62.8	59.0	40.7	37.9	-3.7	-4.7	1.6	4.6	-	-	+	+

WET MEADOW	64.9	60.6	40.7	36.7	-0.5	-2.0	1.8	1.4	-	-	+	+
WATER LEASING	64.4	60.7	41.8	36.3	-1.2	-1.9	4.4	0.3	-	-	+	+
MAY												
PRESENT CONDITIONS	66.7	63.6	38.9	36.0								
GOVERNANCE	66.3	63.8	39.3	37.0	-0.6	0.3	0.8	2.9	-	+	+	+
WATER EMPHASIS	66.2	60.3	37.0	36.9	-0.9	-5.2	-4.9	2.6	-	-	-	+
WET MEADOW	66.5	64.6	39.1	37.0	-0.3	1.5	0.5	2.9	-	+	+	+
WATER LEASING	65.3	64.5	39.3	37.1	-2.1	1.5	0.9	3.1	-	+	+	+
JUNE												
PRESENT CONDITIONS	64.8	55.0	34.8	34.5								
GOVERNANCE	67.2	66.0	37.4	35.2	3.6	20.1	7.6	1.9	+	+++	+	+
WATER EMPHASIS	67.2	66.3	37.3	35.1	3.7	20.6	7.3	1.6	+	+++	+	+
WET MEADOW	66.9	64.9	37.6	35.3	3.2	18.1	8.1	2.2	+	++	+	+
WATER LEASING	67.3	65.9	41.0	35.7	3.7	19.9	18.0	3.3	+	++	++	+
JULY												
PRESENT CONDITIONS	65.5	58.1	36.1	31.2								
GOVERNANCE	65.0	60.9	39.3	35.7	-0.9	4.9	8.8	14.4	-	+	+	++
WATER EMPHASIS	65.0	60.2	39.4	37.3	-0.8	3.6	9.1	19.7	-	+	+	++
WET MEADOW	64.9	59.5	38.3	36.9	-0.9	2.4	5.9	18.5	-	+	+	++
WATER LEASING	65.7	56.5	37.4	31.7	0.2	-2.7	3.6	1.7	+	-	+	+
AUGUST												
PRESENT CONDITIONS	60.3	53.2	35.0	29.8								
GOVERNANCE	60.0	55.6	41.5	37.2	-0.4	4.6	18.6	24.6	-	+	++	+++
WATER EMPHASIS	59.9	55.5	41.1	36.2	-0.6	4.3	17.5	21.5	-	+	++	+++
WET MEADOW	58.8	55.1	40.3	34.1	-2.4	3.5	15.0	14.2	-	+	++	++
WATER LEASING	55.6	54.8	35.0	28.6	-7.8	3.0	0.1	-4.1	-	+	+	-
SEPTEMBER												

PRESENT CONDITIONS	58.7	53.2	22.5	17.1								
GOVERNANCE	62.1	59.2	28.9	25.8	5.8	11.3	28.4	50.9	+	++	+++	+++
WATER EMPHASIS	60.0	49.0	30.7	28.9	2.2	-7.8	36.7	68.9	+	-	+++	+++
WET MEADOW	58.4	48.0	28.0	24.6	-0.5	-9.7	24.8	43.6	-	-	+++	+++
WATER LEASING	56.1	53.0	27.0	23.2	-4.3	-0.3	20.2	35.6	-	-	+++	+++
OCTOBER												
PRESENT CONDITIONS	65.1	64.2	44.1	35.2								
GOVERNANCE	66.2	65.0	45.9	38.5	1.6	1.3	3.9	9.4	+	+	+	+
WATER EMPHASIS	66.6	66.2	47.4	39.3	2.2	3.0	7.3	11.6	+	+	+	++
WET MEADOW	66.2	65.9	43.8	36.9	1.6	2.6	-0.8	4.9	+	+	-	+
WATER LEASING	67.1	66.2	49.1	42.1	2.9	3.1	11.2	19.8	+	+	++	++
NOVEMBER												
PRESENT CONDITIONS	66.2	64.1	40.9	38.4								
GOVERNANCE	66.8	64.2	45.9	42.9	0.9	0.2	12.3	11.9	+	+	++	++
WATER EMPHASIS	66.6	63.9	45.7	42.3	0.5	-0.3	11.7	10.2	+	-	++	++
WET MEADOW	66.7	63.0	41.5	39.0	0.7	-1.7	1.5	1.6	+	-	+	+
WATER LEASING	66.2	63.3	39.9	38.2	0.0	-1.3	-2.3	-0.5	-	-	-	-
DECEMBER												
PRESENT CONDITIONS	66.8	66.5	47.3	39.2								
GOVERNANCE	65.7	64.2	48.3	46.7	-1.6	-3.5	2.1	19.1	-	-	+	++
WATER EMPHASIS	65.0	63.7	46.4	42.8	-2.7	-4.2	-1.8	9.3	-	-	-	+
WET MEADOW	66.8	65.8	46.1	43.7	-0.1	-1.0	-2.4	11.4	-	-	-	++
WATER LEASING	65.4	64.7	42.2	37.5	-2.1	-2.7	-10.7	-4.4	-	-	--	-

Table 10. Summary of impacts for fish habitat at Grand Island (sum of each value for all months and all exceedance levels)

VALUE	GOVERNANCE	WATER EMPHASIS	WET MEADOW	WATER LEASING
MINOR LOSS -	11	15	19	24
MODERATE LOSS --	1	2	1	3
MAJOR LOSS ---	0	1	0	1
NO CHANGE	0	0	0	0
MINOR GAIN +	25	21	21	14
MODERATE GAIN ++	7	5	5	4
MAJOR GAIN +++	4	4	2	2

Alternative rankings for most positive benefits:
Governance - 36
Water Emphasis - 30
Wet Meadows - 28
Water Leasing - 20

Alternative rankings for most major habitat gains:
Governance - 4
Water Emphasis - 4
Wet Meadows - 2
Water Leasing - 2

Water Temperature

A comparison of alternatives relative to water temperature at Grand Island during the months of June, July, and August is presented in Table 11. This table shows the tabulation of months with flow greater than 1,200 ft^3/s for each of the alternatives. Each of the implementation scenarios of the Governance Committee gave the same result. In general, this analysis showed that all alternatives had similar percentage of flows greater than or equal to 1,200 cfs during these months.

Table 11. Comparison of alternatives relative to various target flows and temperatures at Grand Island gage.

Alternative	Number of years Q > 1,200 ft3/s		Mean probability of exceeding 32 °C	33.5 °C	35 °C
Present Conditions	June	25	0.22	0.15	0.07
	July	20	0.30	0.20	0.09
	August	1	0.38	0.31	0.13
GC Alternative	June	33	0.20	0.10	0.05
	July	21	0.29	0.18	0.08
	August	1	0.37	0.27	0.12
Water Emphasis	June	36	0.19	0.08	0.04
	July	21	0.29	0.18	0.08
	August	1	0.36	0.28	0.12
Wet Meadow	June	32	0.21	0.10	0.05
	July	21	0.29	0.18	0.08
	August	1	0.37	0.29	0.12
Water Leasing	June	33	0.18	0.08	0.04
	July	18	0.30	0.20	0.09
	August	2	0.38	0.50	0.22

Compared to Present Conditions, there were generally more months with flows greater than or equal to 1,200 cfs for all alternatives, particularly in June. All alternatives also had similar low probabilities of exceeding the various temperature levels among alternatives. There was an increase in the number of months with an average flow exceeding 1,200 ft^3/s in June and July, but not in August when the temperature standard was exceeded most often. These results indicated that when the conditions were the poorest in terms of the temperature standard, the Governance Committee made conditions very slightly better. The Wet Meadow and the Water Leasing alternatives gave similar results as the Governance Committee in June and July (Table 11). In August, the only difference among alternatives was an increase of one year >1,200 cfs comparison to Present Condition. The Water Emphasis alternative showed an increase of 11 years in which the target flow was exceeded in June over the total of the present condition, highest among alternatives. The Water Emphasis alternative also showed same effects in July and August as Governance Committee and Wet Meadow.

It should be noted that the results in Table 11 are based on monthly data. Comparisons of the results to the 1,200 ft^3/s benchmark (target flow) and the probability of exceeding the water quality standard (32 °C) based on daily flows are shown in Table 12 for the Present Condition and the other alternatives. The daily flow analysis was run on the same 48-year period as the monthly flow analysis. Total number of days in the analysis for June in the 48-year study period amounted to 1,440; there were 1,488 total days in the flow analysis for each of July and August.

Table 12. Comparison of the number of days in June, July, and August in the 48-year daily (total days = 4418) study that the flow at Grand Island exceeded 1,200 ft³/s and a comparison of the probability of exceeding the temperature standard (32 °C) between Present Condition and each alternative.

Month	Alternative	Total days with flow > 1,200 ft^3/s	Mean probability of exceeding standard	Standard Deviation of the mean probability	Paired t-Test on the mean probabilities of exceeding the standard	Probability of > t
June	Present Conditions	744	0.262	0.186	—	—
	Governance Committee	799	0.242	0.160	11.45	4.12E-29
	Full Water Leasing	906	0.214	0.161	26.98	4.69E-130
	Wet Meadow	809	0.245	0.154	8.60	2.07E-17
	Water Emphasis	876	0.228	0.151	18.75	2.39E-70
July	Present Conditions	486	0.329	0.154	—	—
	Governance Committee	461	0.325	0.141	2.96	3.10E-03
	Full Water Leasing	474	0.339	0.159	-9.30	4.65E-20
	Wet Meadow	481	0.329	0.142	-0.08	9.39E-01
	Water Emphasis	462	0.329	0.143	-0.10	9.24E-01
August	Present Conditions	106	0.425	0.076	—	—
	Governance Committee	115	0.409	0.077	13.90	2.24E-41
	Full Water Leasing	115	0.431	0.098	-3.70	2.21E-04
	Wet Meadow	115	0.418	0.078	6.39	2.24E-10
	Water Emphasis	119	0.411	0.078	14.36	7.24E-44

Table 12 indicates that about ½ the days in June (744 of 1440 or about 15 days in June per year) had a flow greater than 1,200 ft^3/s under existing conditions. The Governance Committee would increase this to 799 days out of the period of record (or the equivalent of about 17 days in June per year), least among alternatives. Full Water Leasing had the greatest number of days >1,200 cfs in June among alternatives. The July comparison showed a decrease from 486 days among the 1488 in the record in the present condition to between 461 days with the Governance Committee (from 33 percent to 31 percent of the days in the record for July). Wet Meadow had the greatest number of days >1,200 cfs in July among alternatives. The number of days in August with the Governance Committee alternative at or above 1,200 ft^3/s increased from 106 to 115, which was similar to the other alternatives. In summary, on the basis of daily flows, there was a small difference in the number of times that the 1,200 flow was exceeded among alternatives during the summer (Table 12).

The daily comparison to the 1,200 ft^3/s flow gave radically different results from the monthly comparison. The monthly comparison indicated that the Governance Committee made matters better only in June and July in terms of meeting the 1,200 ft^3/s target flow; the daily comparison indicated that the situation improved in June and August and were worse than Present Conditions in July (tables 11 and 12). Because of the increased sensitivity of the daily analysis, the results are considered to be a better evaluation of the potential impacts of the program alternatives on the capability of meeting the target flow for meeting the Platte River temperature standard.

Table 12 also summarizes the probabilities of exceeding the temperature standard of 32 °C during the months of June through August. Table 12 also presents a statistical comparison of the probabilities of exceeding the temperature standard with each of the alternatives, including each of the Governance Committee Implementation scenarios, to the Present Condition. These results would be expected to show a decrease if conditions were improved by an alternative, and they did. In all cases the test statistic was statistically significant and indicated that the probability of exceeding the standard decreased. On the basis of the t-values, the greatest improvement in June and July occurred with the adoption of the Water Leasing alternative (Table 24). In August, the greatest improvement over the present condition occurred with adoption of the Water Emphasis alternative. The poorest showing of any of the alternatives in meeting the standard in each of the 3 months was the Governance Committee alternative, but even that alternative showed an improvement over Present Condition.

Water quality

Other impacts to forage fish in the central Platte River are water quality related. Recently, high selenium levels have been found in fish tissues (see Water Quality Appendix). The source of these high levels is suspected to be from ground water sources through the food chain (Jim Yahnke, personal communication). The Water Emphasis alternative incorporates the ground water mound as an element at this time. There is an optional element within this alternative that would drain water directly to the Platte River and lower the water table under irrigated lands. Thus, there is the potential impact on forage fish from selenium contamination from construction of any drains from the ground water mound south of the river (see Water Quality Appendix). Impacts on water quality standards of each alternative are discussed in the Water Quality Technical Report.

Monthly turbidity for each alternative in the Central Platte River near Grand Island is compared to Present Condition in Figure 7. Slight increases in turbidity would occur with all alternatives compared to Present Condition. This may result in a reduced ability of fish to capture prey or escape predators because of vision impairment caused by increased turbidity (Waters, 1995).

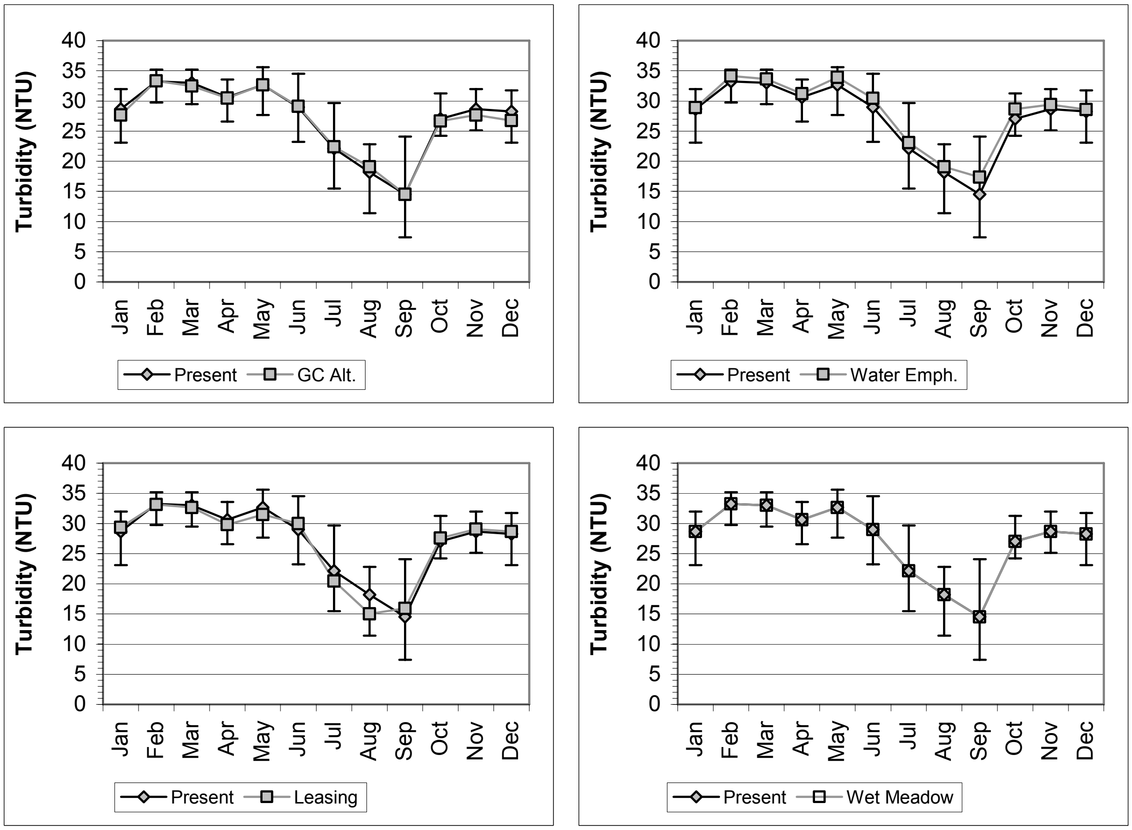

Figure 7. Monthly turbidity of each alternative compared to Present Condition in the Central Platte River. (Note: error bars on the Present Condition represent the inter-quartile range (equivalent to ±1 std. dev))

SedVeg

The SedVeg Users Guide for FEIS Runs (July 25, 2005) lists cross sections used in the SedVeg analysis. Table 13 is the output data from the Sed Veg modeling for least tern forage fish habitat. The data were generated from averaging channel widths for all cross sections modeled after years 30 and 78 (see SedVeg Users Guide for details on modeling). Channel widths within optimum depth criteria identified for forage fish in summer and non-summer periods are displayed in this table for Present Condition and each alternative.

The results indicated most channel width increases occurred during summer after each increment. All alternatives showed minimal change in summer channel widths over Present Condition after 78 years. More impact occurred during non-summer. Among alternatives, Wet

Meadow Alternative had the largest summer channel widths (461.5 ft) after 30 years and after 78 years (795.1 ft) (Table 13).

Table 13. SedVeg summary of channel widths for each alternative that meet forage fish depth criteria[1]

	Average Transect Widths (ft)				Percent Difference From Present Condition			
Alternative	After 30 Years		After 78 Years		After 30 Years		After 78 Years	
	Non-summer	Summer	Non-summer	Summer	Non-summer	Summer	Non-summer	Summer
Present Condition	72.3	467.4	115.8	749.5				
Governance Committee	52.9	457.4	112.6	755.3	-26.9	-2.1	-2.8	0.8
Water Emphasis	48.9	456.2	105.4	745.5	-32.5	-2.4	-8.9	-0.5
Wet Meadow	51.3	461.5	97.9	795.1	-29.0	-1.2	-15.4	6.1
Water Leasing	82.7	457.5	89.8	768.5	14.4	-2.1	-22.5	2.5

[1] Depth criteria: Non-summer = 3-10 cm
Summer = 3-20 cm

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Appendix A - Habitat Duration Results

Table A-1. Fish habitat analysis at Overton for Present Conditions.

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	65.1	63.4	40.6	37.7
FEBRUARY	66.5	65.2	35.9	35.3
MARCH	65.8	64.8	38.6	36.6
APRIL	64.9	62.7	44.7	37.9
MAY	66.0	63.3	42.3	37.1
JUNE	63.7	56.6	35.5	34.6
JULY	65.4	62.4	39.8	38.1
AUGUST	59.1	56.0	38.8	36.9
SEPTEMBER	60.5	57.9	35.7	23.8
OCTOBER	67.0	66.4	50.6	40.3
NOVEMBER	66.3	64.1	44.0	38.6
DECEMBER	67.0	65.9	44.9	39.3

Table A-2. Fish habitat analysis at Overton for Governance

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.4	65.5	44.6	40.2
FEBRUARY	63.2	56.7	36.3	36.1
MARCH	64.6	60.6	37.3	36.4
APRIL	66.0	61.9	43.5	38.1
MAY	66.4	64.8	40.1	38.1
JUNE	66.5	65.8	39.2	37.7
JULY	66.0	64.8	43.8	41.9
AUGUST	63.0	60.0	44.8	42.3
SEPTEMBER	60.1	56.8	37.0	28.1
OCTOBER	67.0	66.6	46.7	38.5
NOVEMBER	65.9	64.0	50.8	41.8
DECEMBER	66.4	65.6	47.8	44.9

Table A-3. Fish habitat analysis at Overton for Program Water

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.3	64.4	42.7	39.9
FEBRUARY	55.3	43.1	36.2	35.8
MARCH	64.0	59.3	37.1	35.6
APRIL	66.2	63.5	44.2	38.1
MAY	66.8	65.5	38.7	37.1
JUNE	66.8	65.5	38.1	36.5
JULY	65.5	64.6	46.5	43.2
AUGUST	61.0	59.5	45.5	41.2
SEPTEMBER	61.8	58.2	35.9	28.8
OCTOBER	66.8	66.2	45.5	39.0

NOVEMBER	66.2	64.7	46.1	41.3
DECEMBER	66.1	65.4	46.4	42.4

Table A-4. Fish habitat analysis at Overton for Wet Meadow

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.7	61.4	42.0	38.8
FEBRUARY	65.0	60.0	36.3	35.7
MARCH	65.5	64.1	37.5	35.7
APRIL	66.8	62.8	44.3	36.7
MAY	66.4	64.7	40.5	37.1
JUNE	66.7	65.9	38.8	36.1
JULY	65.5	63.5	45.0	41.8
AUGUST	60.4	57.9	44.2	39.7
SEPTEMBER	61.4	58.2	38.1	29.5
OCTOBER	66.9	66.3	43.8	39.2
NOVEMBER	65.8	63.9	45.7	38.7
DECEMBER	66.4	65.3	44.7	39.3

Table A-5. Fish habitat analysis at Overton for Water Leasing

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.4	62.6	38.5	36.5
FEBRUARY	57.2	48.8	35.5	34.7
MARCH	65.9	59.7	36.8	35.5
APRIL	65.3	62.9	44.7	37.0
MAY	66.5	65.0	43.2	36.7
JUNE	67.0	65.8	40.2	36.3
JULY	65.1	62.5	42.2	38.6
AUGUST	58.0	54.7	39.1	32.6
SEPTEMBER	60.6	58.4	35.1	28.5
OCTOBER	66.7	65.0	46.1	39.8
NOVEMBER	66.3	65.3	40.4	38.0
DECEMBER	66.4	63.8	40.2	37.6

Table A-6. Fish habitat analysis at Grand Island for Present

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.4	64.6	43.1	39.2
FEBRUARY	66.7	63.5	35.5	34.7
MARCH	64.4	62.0	36.2	35.3
APRIL	65.2	61.9	40.0	36.2
MAY	66.7	63.6	38.9	36.0
JUNE	64.8	55.0	34.8	34.5
JULY	65.5	58.1	36.1	31.2
AUGUST	60.3	53.2	35.0	29.8
SEPTEMBER	58.7	53.2	22.5	17.1
OCTOBER	65.1	64.2	44.1	35.2
NOVEMBER	66.2	64.1	40.9	38.4
DECEMBER	66.8	66.5	47.3	39.2

Table A-7. Fish habitat analysis at Grand Island for Governance

Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.7	65.7	47.1	43.2
FEBRUARY	65.1	54.3	36.6	35.5
MARCH	61.5	56.8	36.9	35.2
APRIL	63.9	60.7	40.4	37.9
MAY	66.3	63.8	39.3	37.0
JUNE	67.2	66.0	37.4	35.2
JULY	65.0	60.9	39.3	35.7
AUGUST	60.0	55.6	41.5	37.2
SEPTEMBER	62.1	59.2	28.9	25.8
OCTOBER	66.2	65.0	45.9	38.5
NOVEMBER	66.8	64.2	45.9	42.9
DECEMBER	65.7	64.2	48.3	46.7

Table A-8. Fish habitat analysis at Grand Island for Program

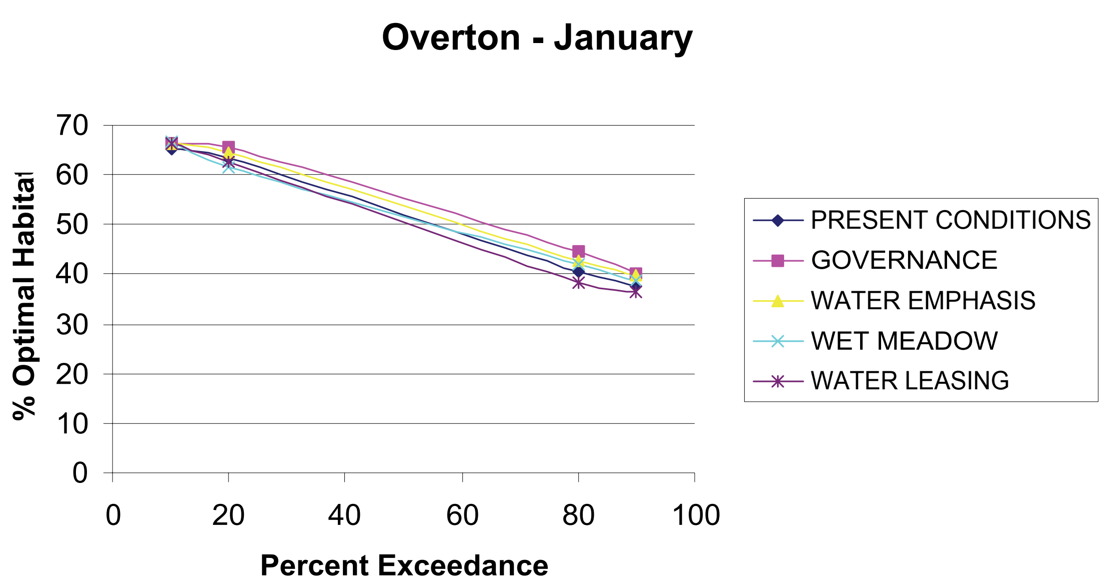
Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.5	65.0	46.3	42.7
FEBRUARY	57.4	40.3	36.2	34.9
MARCH	63.1	51.7	36.0	35.2
APRIL	62.8	59.0	40.7	37.9
MAY	66.2	60.3	37.0	36.9
JUNE	67.2	66.3	37.3	35.1
JULY	65.0	60.2	39.4	37.3
AUGUST	59.9	55.5	41.1	36.2
SEPTEMBER	60.0	49.0	30.7	28.9
OCTOBER	66.6	66.2	47.4	39.3
NOVEMBER	66.6	63.9	45.7	42.3
DECEMBER	65.0	63.7	46.4	42.8

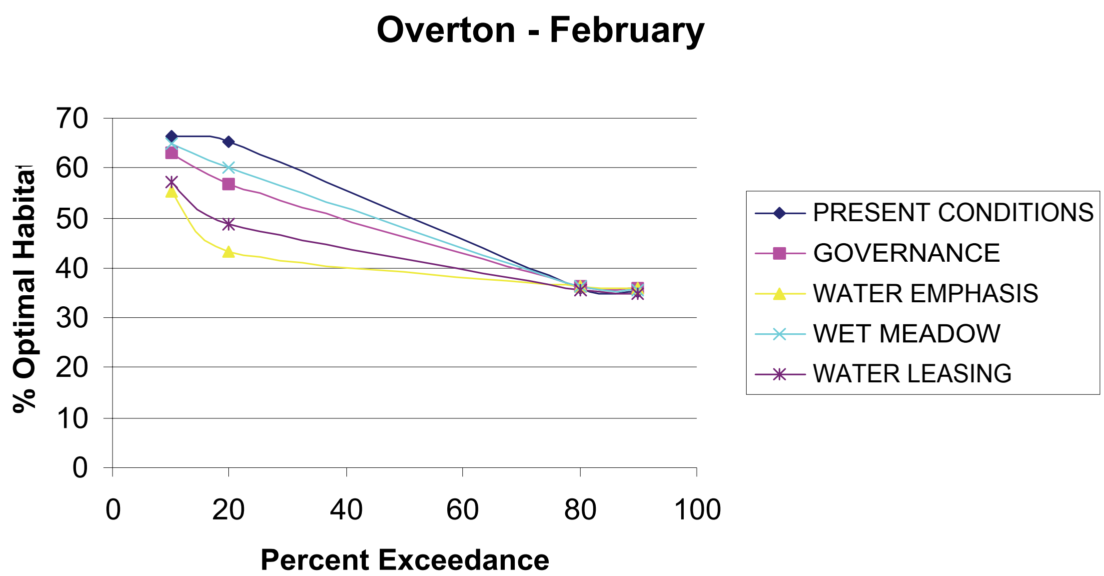
Table A-9. Fish habitat analysis at Grand Island for Wet Meadow

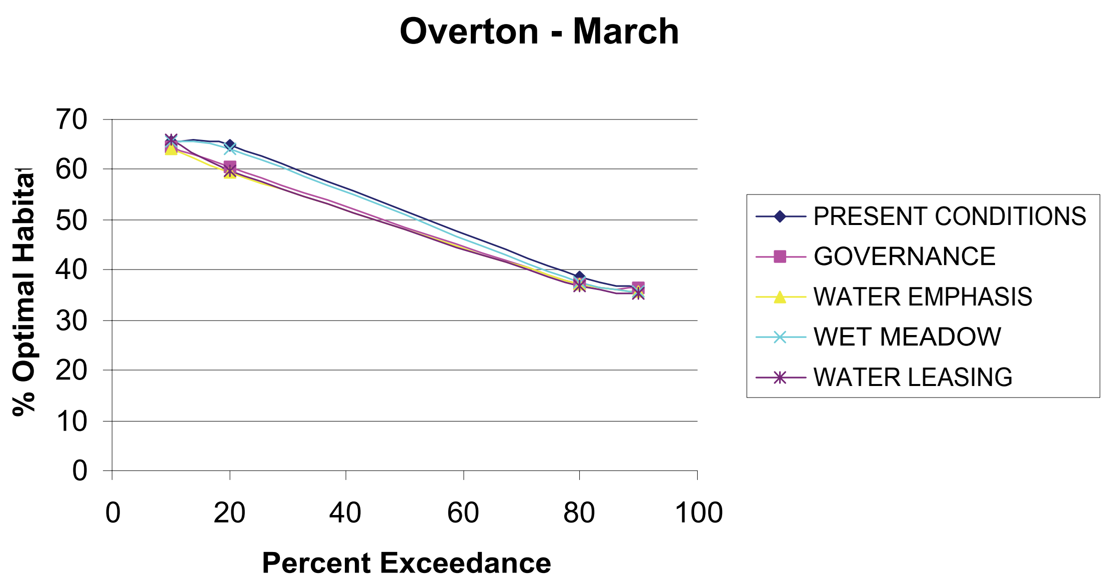
Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	65.7	64.1	45.3	37.0
FEBRUARY	64.6	55.6	35.9	35.2
MARCH	64.6	57.4	35.8	35.3
APRIL	64.9	60.6	40.7	36.7
MAY	66.5	64.6	39.1	37.0
JUNE	66.9	64.9	37.6	35.3
JULY	64.9	59.5	38.3	36.9
AUGUST	58.8	55.1	40.3	34.1
SEPTEMBER	58.4	48.0	28.0	24.6
OCTOBER	66.2	65.9	43.8	36.9
NOVEMBER	66.7	63.0	41.5	39.0
DECEMBER	66.8	65.8	46.1	43.7

Table A-10. Fish habitat analysis at Grand Island for Water

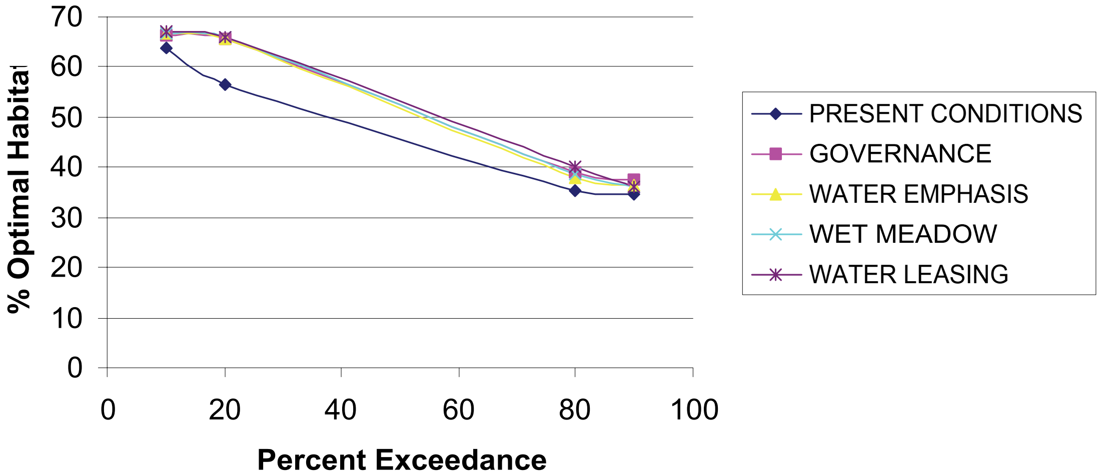
Month	% of optimal habitat at various exceedance			
	10%	20%	80%	90%
JANUARY	66.2	63.4	42.3	39.1
FEBRUARY	57.5	50.5	34.9	34.6
MARCH	63.0	54.1	35.4	35.0
APRIL	64.4	60.7	41.8	36.3
MAY	65.3	64.5	39.3	37.1
JUNE	67.3	65.9	41.0	35.7
JULY	65.7	56.5	37.4	31.7
AUGUST	55.6	54.8	35.0	28.6
SEPTEMBER	56.1	53.0	27.0	23.2
OCTOBER	67.1	66.2	49.1	42.1
NOVEMBER	66.2	63.3	39.9	38.2
DECEMBER	65.4	64.7	42.2	37.5



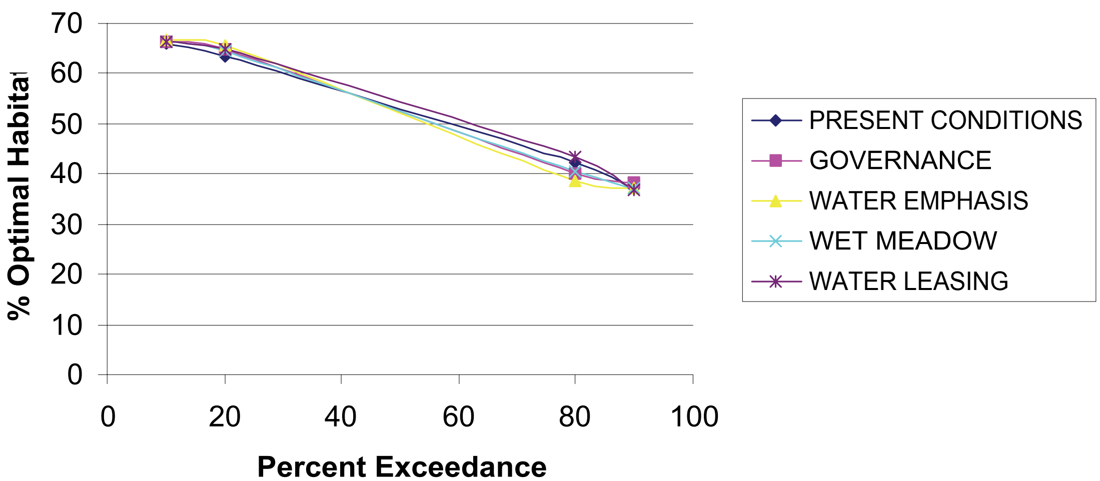

Overton - February
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING

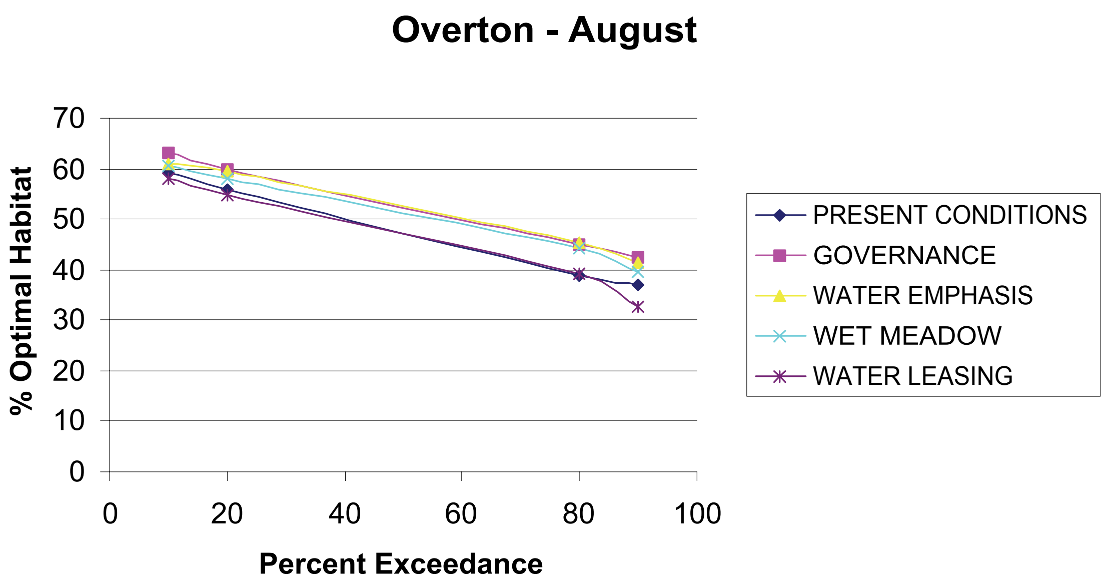

Overton - March
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING

Overton - June



Overton - May





Overton - August
% Optimal Habitat
70
60
50
40
30
20
10
0
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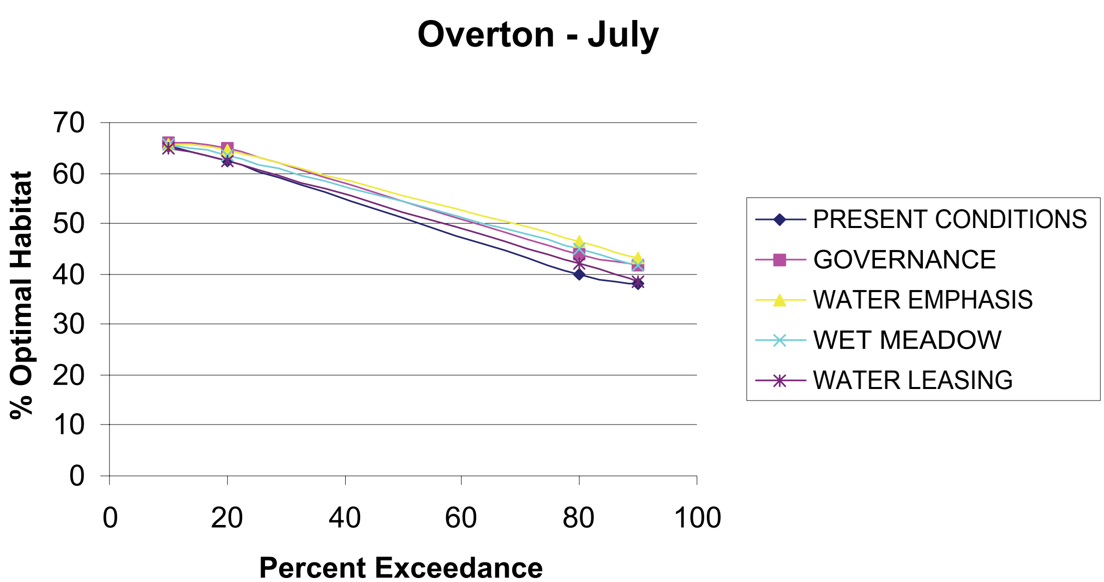
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING



Overton - July
% Optimal Habitat
70
60
50
40
30
20
10
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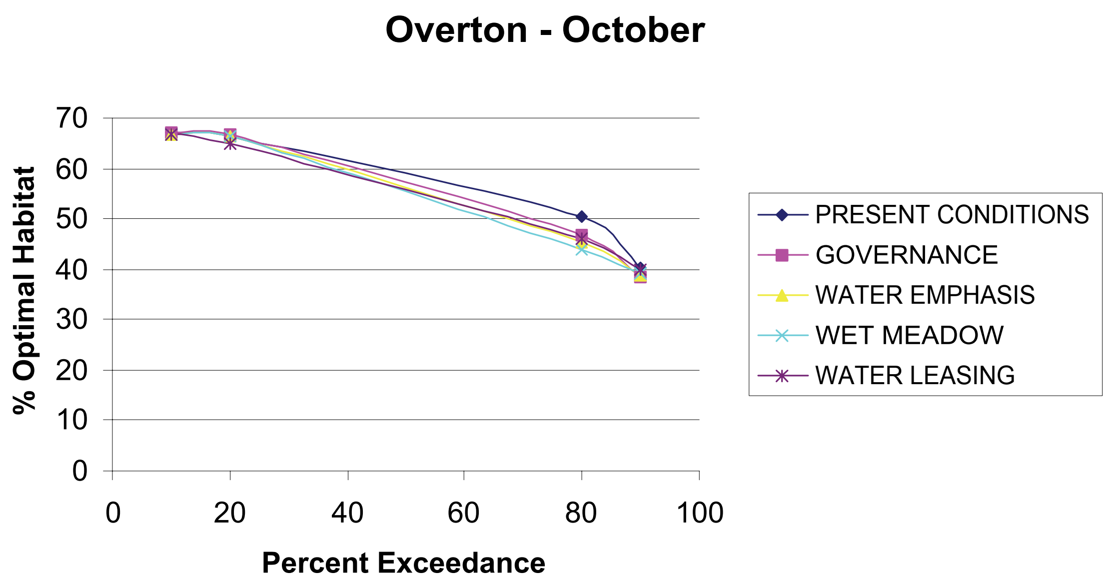
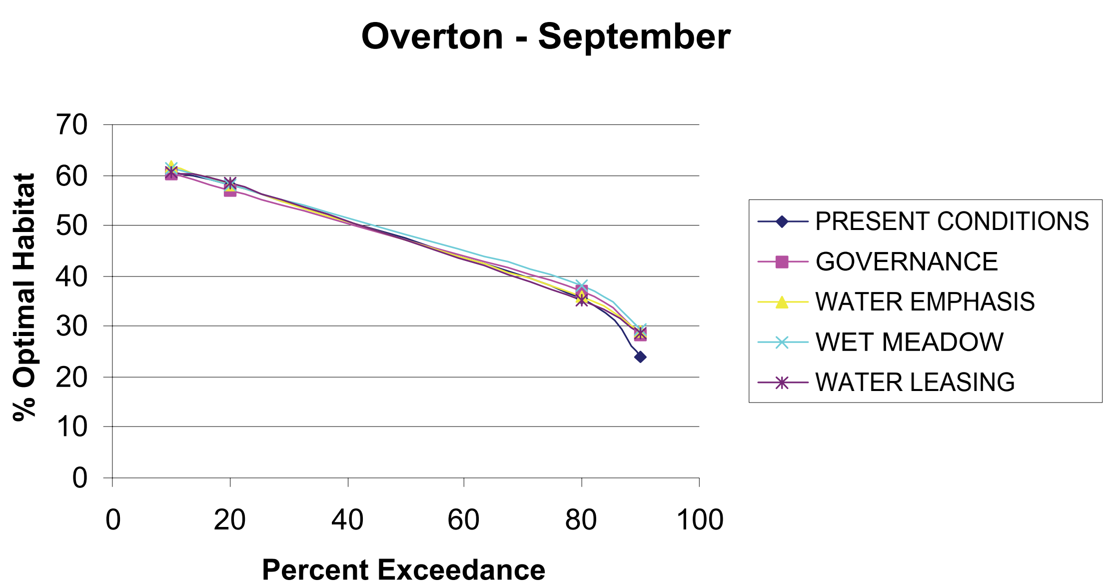
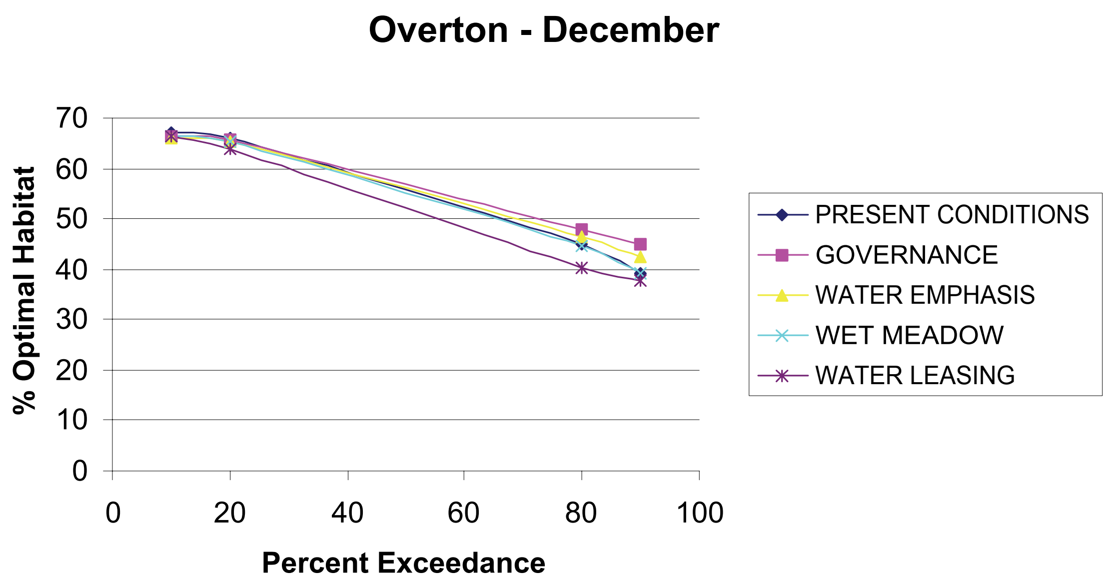
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING



Overton - October
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING



Overton - September
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Overton - December
% Optimal Habitat
70
60
50
40
30
20
10
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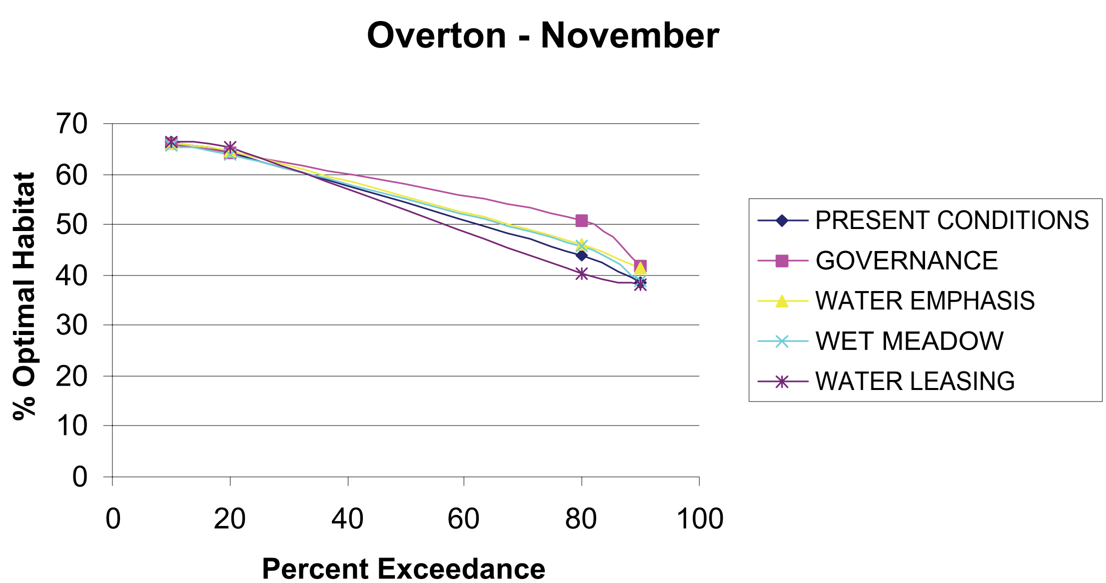
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Overton - November
% Optimal Habitat
70
60
50
40
30
20
10
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20
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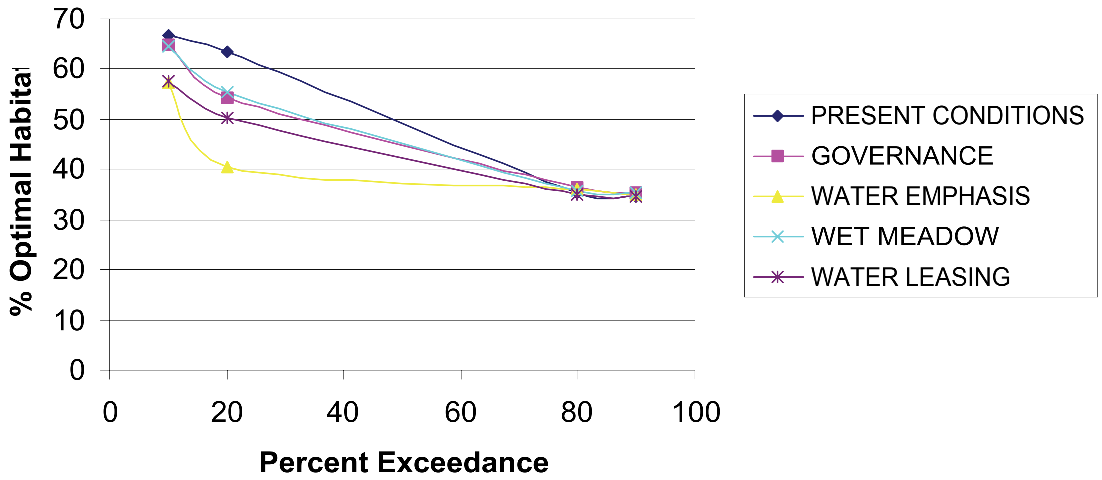
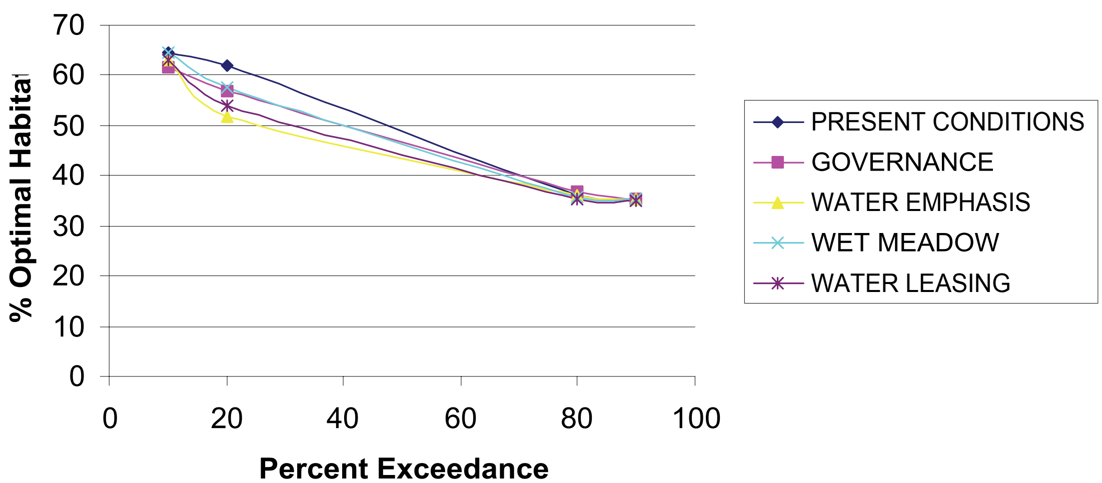
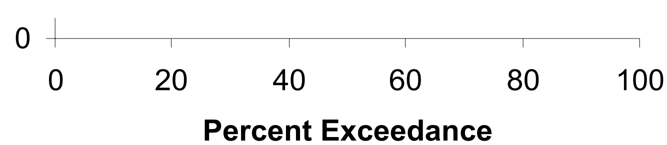
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING

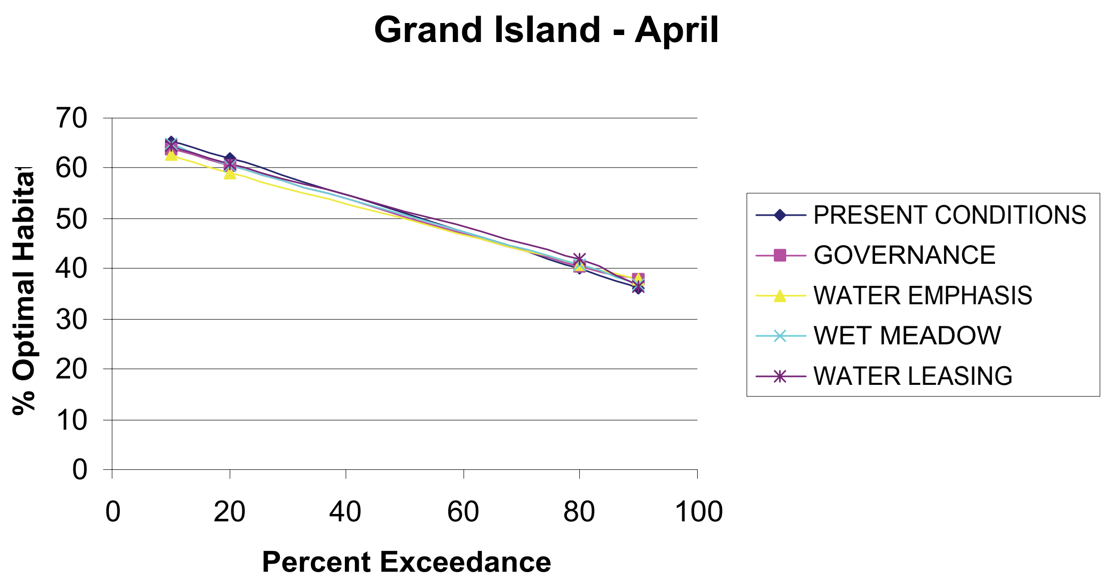
Grand Island - February



Grand Island - March






Grand Island - April
% Optimal Habitat
70
60
50
40
30
20
10
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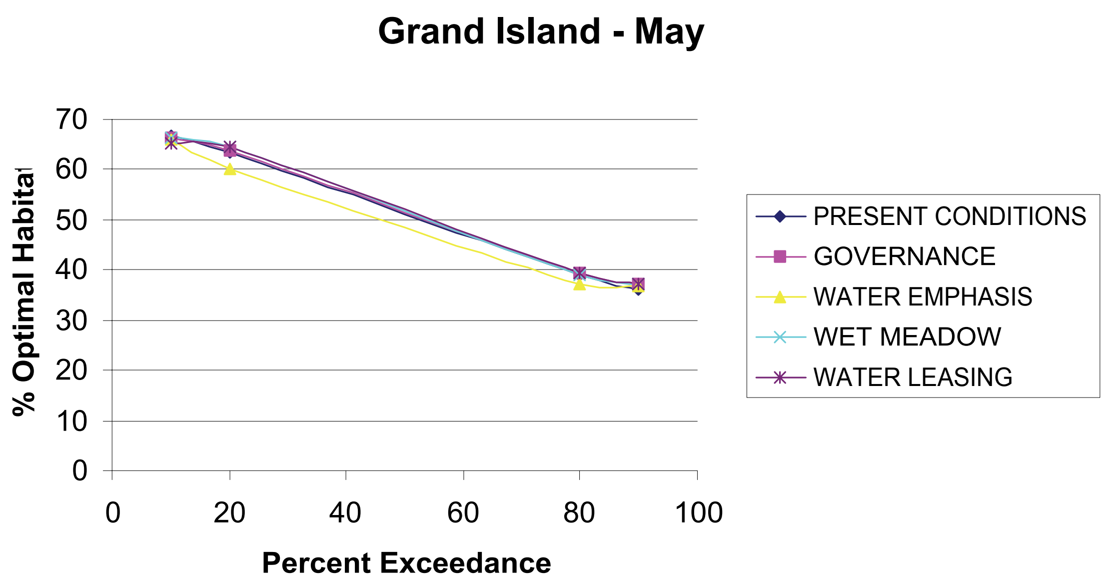
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - May
% Optimal Habitat
70
60
50
40
30
20
10
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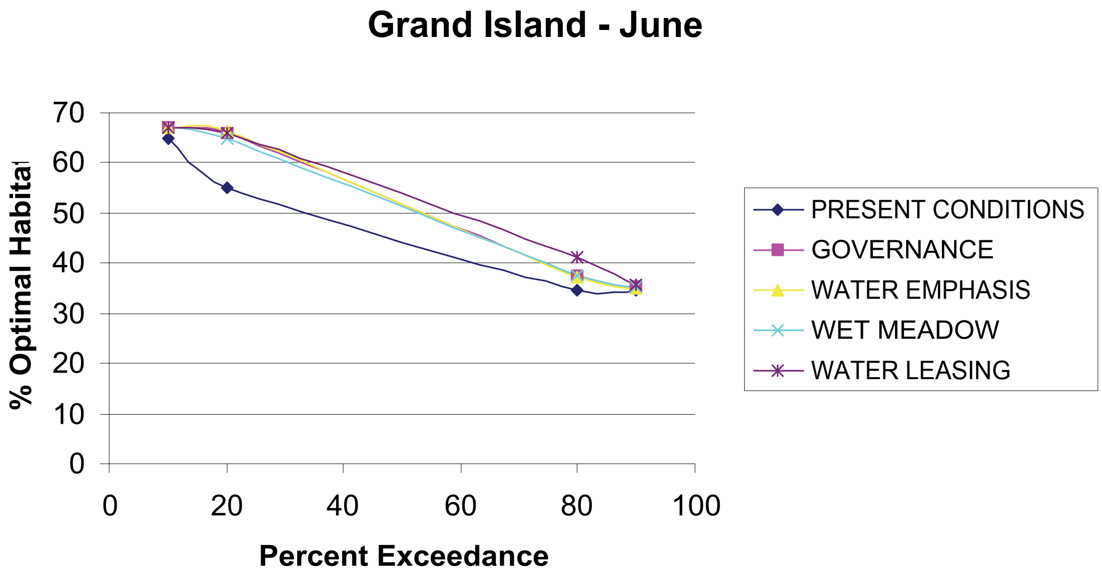
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - June
70
60
50
40
30
20
10
0
% Optimal Habitat
0
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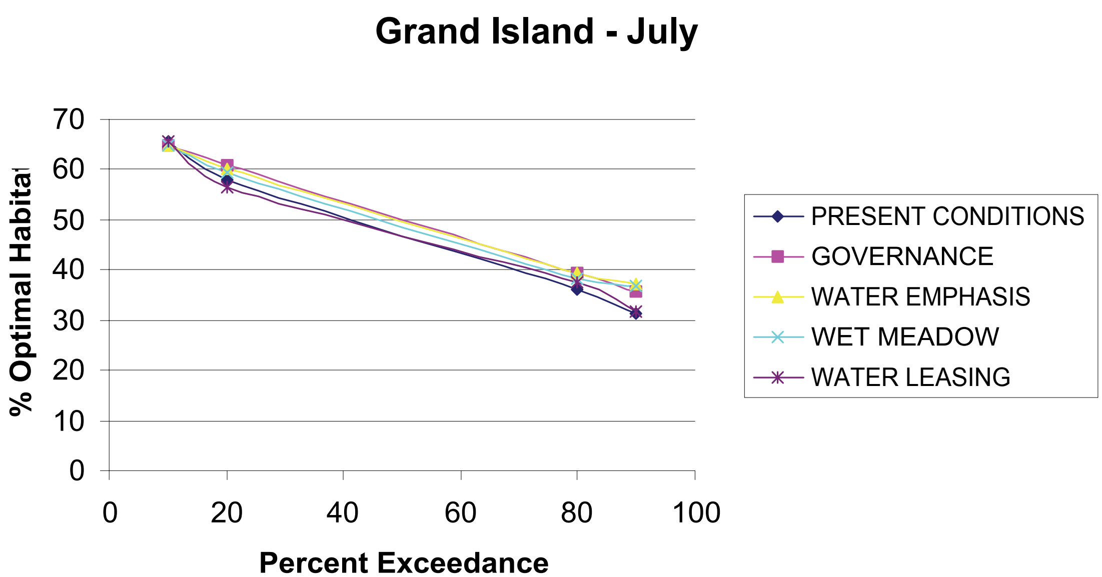
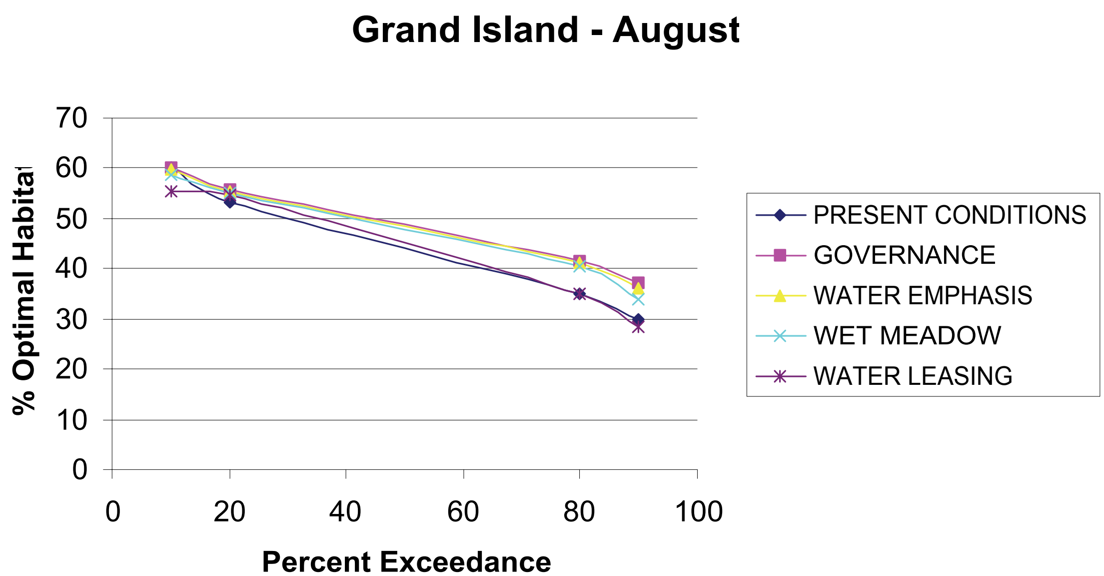
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - July
70
60
50
40
30
20
10
0
% Optimal Habitat
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - August
% Optimal Habitat
0
10
20
30
40
50
60
70
0
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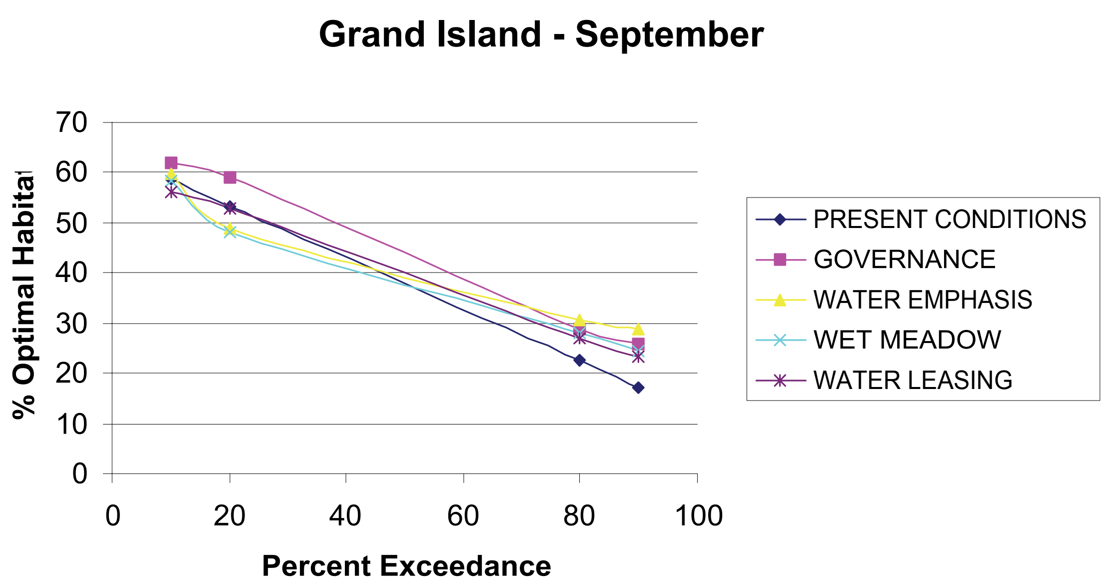
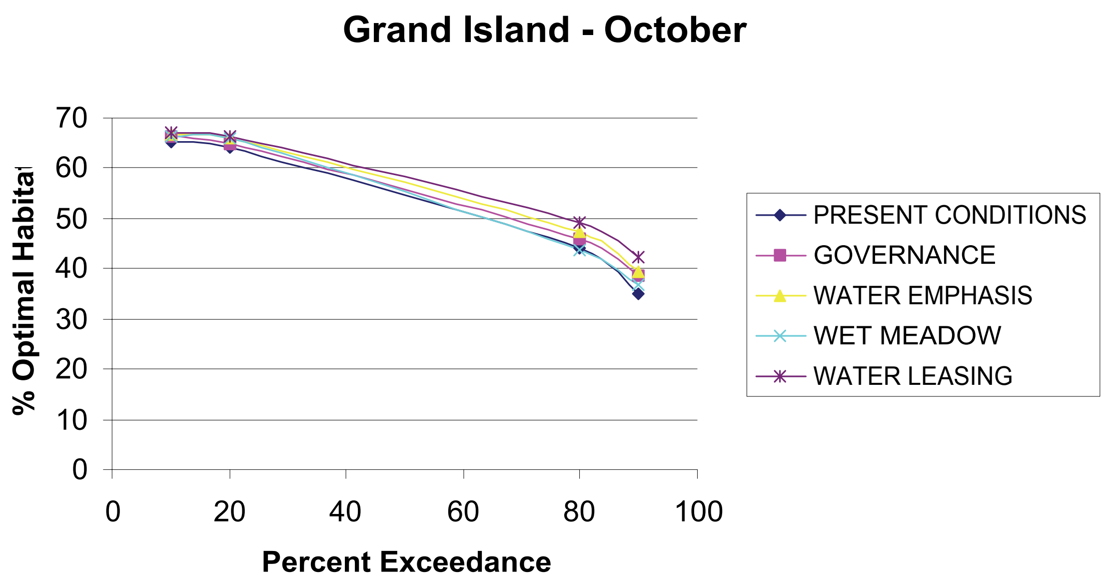
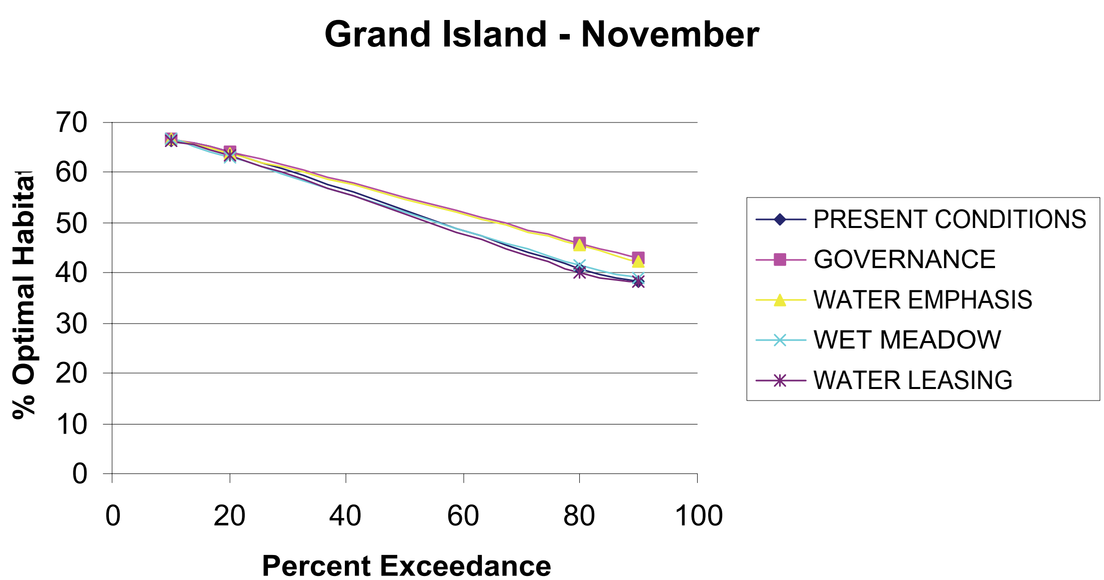
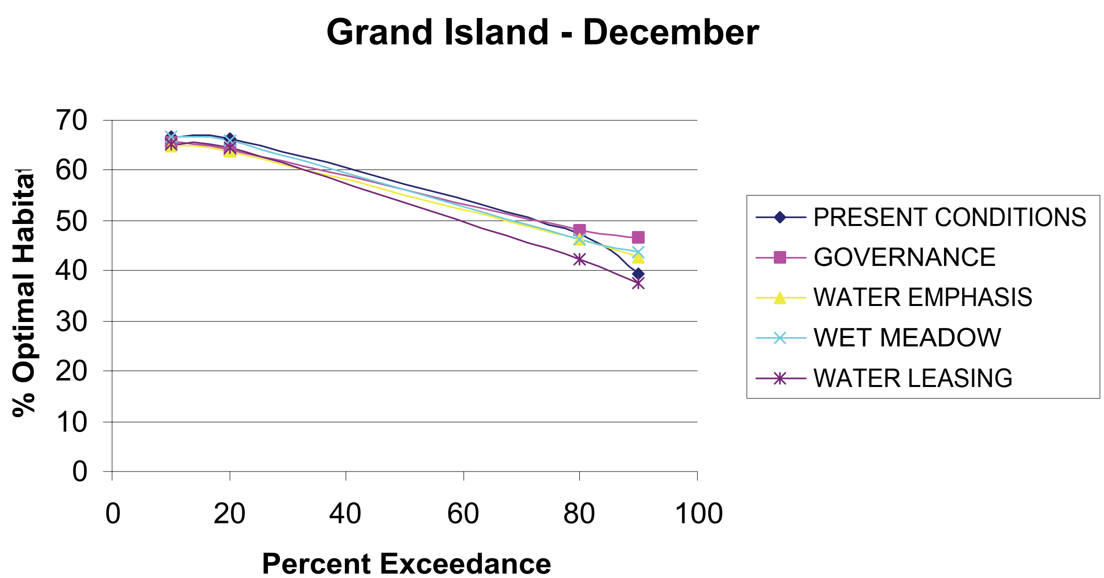
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - September
% Optimal Habitat
0
10
20
30
40
50
60
70
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - October
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - November
% Optimal Habitat
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING


Grand Island - December
70
60
50
40
30
20
10
0
% Optimal Habitat
0
20
40
60
80
100
Percent Exceedance
PRESENT CONDITIONS
GOVERNANCE
WATER EMPHASIS
WET MEADOW
WATER LEASING