Appendix E – Habitat Evaluation Procedure

Appendix E

Habitat Benefits Evaluation

Marsh Lake Ecosystem Restoration Project

Introduction

An ecosystem restoration measure is a feature or activity that addresses one or more of the planning objectives. A wide variety of alternative measures were considered for March Lake ecosystem restoration project. The Marsh Lake ecosystem restoration alternative measures are described in Section 4 of the main report. The full range of alternative measures is described in Section 4.1. In Section 4.2 of the main report, each measure was assessed and a determination was made regarding whether it should be retained for further consideration in the formulation of alternative plans.

The Corps is required to consider the option of "No Action" as one of the alternatives. With the No Action plan, which is synonymous with the "Future Without Project Condition," we assumed that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. The No Action plan forms the basis from which the other alternative plans are compared.

Estimated annualized costs of the alternative measures retained for further consideration are provided below are based on March 2010 price levels. They include costs for detailed engineering design, construction and operation and maintenance over the 50-year planning time horizon.

Table 1. Alternative measures retained for further consideration.

Measure Number	Alternative Measures	First Cost of Construction	Interest During Construction	Total Investment	Annualized Cost	Annual O+M Costs	Total Annual Costs
1	No Action	$0	$0	$0	$0	$0	$0
2	Restore Pomme de Terre River to its former channel	$3,741,500	$249,117	$3,990,617	$197,843	$5,622	$203,466
3	Modify Marsh Lake Dam to attain target water levels, construct fishway	$1,217,400	$81,057	$1,298,457	$64,374	$6,207	$70,581
4	Growing season drawdowns to restore emergent aquatic plants, modify Marsh Lake Dam with stoplog structure	$2,605,900	$173,506	$2,779,406	$137,795	$13,926	$151,721
5	Install gated culverts in Louisburg Grade Road	$414,200	$27,578	$441,778	$21,902	$952	$22,854
6	Breach dike at abandoned fish pond	$7,000	$0	$7,000	$347	$0	$347
7	Construct islands in Marsh Lake	$3,946,500	$262,766	$4,209,266	$208,683	$15,190	$223,874

Alternative Plans

Alternative plans are combinations of alternative measures that would contribute to attaining the planning objectives. A stand alone or independent measure can be implemented independently of others, resulting in some positive amount of ecosystem restoration output. Optional or dependent measures are measures that must be implemented along with other measures. Optional measures may be combined with each other as well as with the stand alone measures. Brief descriptions of the measures considered in this study are presented below. More detailed descriptions of the measures are in Section 4.1 of the main report.

Alternative Measures

Measure 1 – No Action

The No Action alternative is a stand-alone measure that could be implemented independently. The Corps is required to consider the option of “No Action” as one of the alternatives. With the No Action plan, which is synonymous with the “Without Project Future Condition,” we assume that no project would be implemented by the Federal Government or by local interests to achieve the planning objectives. The No Action plan forms the basis from which the other alternative plans are compared.

Measure 2 – Restore the Pomme de Terre River to its former channel

This is a stand-alone measure that could be implemented independently of other restoration alternatives. Earthen berms would be constructed to re-route the river into its former channel both upstream and downstream of the Marsh Lake Dam embankment. Approximately 11,500 feet and 21 acres of former river channel would be restored. This alternative would include a bridge over the river to maintain access to the Marsh Lake Dam and monitoring of the native mussel community.

Measure 3 - Modify Marsh Lake Dam to attain target water levels, construct fishway

This is a stand-alone measure that could be implemented independently of other restoration alternatives. Marsh Lake Dam would be modified with a fixed-crest weir fishway that would allow passive attainment of target water levels in most years and also allow continuous fish passage between Lac qui Parle and Marsh Lake.

Measure 4 - Growing season drawdowns to restore emergent aquatic plants, reduce carp abundance and modify Marsh Lake Dam with a stoplog structure

This is a stand-alone measure that could be implemented independently of other restoration alternatives. Marsh Lake Dam would be modified with a stop log water control structure to enable water level management. Growing season drawdowns to elevation 936.0 ft would be done to encourage reestablishment of emergent aquatic plants and to increase the extent of submersed aquatic plants. Following growing season drawdowns, winter drawdowns to elevation 935.0 ft could be done to reduce carp abundance. The drawdowns would be conducted as needed to maintain objectives for aquatic vegetation in Marsh Lake. We assume that drawdowns would be done on average once every five years.

Measure 6 – Breach dike at abandoned fish pond

This is a stand-alone measure that could be implemented independently of other restoration alternatives. Breaching the fish pond dike on the downstream side of the Marsh Lake Dam would provide connectivity between the fish pond area and the upper end of Lac qui Parle, allowing native floodplain vegetation to become established, fish access and providing seasonally variable habitat for fish and wading birds.

Measure 7 – Construct islands in Marsh Lake

This is a stand-alone measure that could be implemented independently. Constructing islands to break up wave action and reduce sediment resuspension would improve conditions for submersed aquatic plant growth. Although this is a stand-alone measure, it would be best to construct islands in Marsh Lake in conjunction with growing season and winter drawdowns (Measure 4) and modifying Marsh Lake Dam to attain target water levels (Measure 3). Growing season drawdowns would consolidate lake bed sediment, reducing sediment resuspension. Growing season drawdowns would allow germination of emergent aquatic plants, increasing their extent, reducing wave action and sediment resuspension. Winter drawdowns would reduce carp abundance, sediment resuspension and grazing on submersed aquatic plants. It may require implementation of all these measures in combination to change the ecosystem state of Marsh Lake from the current unvegetated turbid condition to clearer water with submersed aquatic plants.

Optional Measures

Measure 5 – Install gated culverts in Louisburg Grade Road

This is an optional measure because it would not need to be implemented unless Measure 4 was implemented with growing season drawdowns on Marsh Lake. Measure 5 is dependent on implementing Measure 4 and would enhance its performance. Installing stoplog control structures on the Louisburg Grade Road culverts would enable holding water in upper Marsh Lake in years when a growing season drawdown was conducted, allowing northern pike to successfully spawn in the flooded marsh vegetation and the young to grow into juveniles. This measure should be combined with Measure 4.

HEP Analyis of the Alternative Measures

The Marsh Lake project area is described in Section 2.8 of the main report. The alternative measures would affect a variety of habitats in the project area (Table 2). Representative species and guilds of organisms that occur in the Marsh Lake project area were selected for Habitat Evaluation Procedures (HEP) analyses to estimate ecosystem restoration benefits.

The HEP models applied to estimate ecosystem outputs of the Marsh Lake Project are USFWS “Blue Book” models and a waterfowl habitat model developed for use on the Upper Mississippi River System. The Diving Duck Migration Habitat Model is currently undergoing planning model certification with the Corps Ecosystem Restoration

Center of Expertise. The Diving Duck Migration Habitat Model has been used extensively since 1994 to quantify habitat benefits for habitat restoration projects on the Upper Mississippi River. It has stood the test of time and was developed consistent with USFWS's standards for HEP.

Devendorf, R.D. 2001. A migratory habitat model for diving ducks using the Upper Mississippi River. St. Paul District, U.S. Army Corps of Engineers.

Short, H.L and R.J. Cooper. 1985. Habitat suitability index models - Great blue heron FWS/OBS82-10.99.43 pp.

McMahon, T. E., J. W. Terrell, and P. C. Nelson. 1984. Habitat suitability information: Walleye. U.S. Fish and Wildlife Service. FWS/OBS-82/10.56. 43 pp.

Inskip, P.D. 1982. Habitat suitability index models: Northern pike. FWS/OBS-82/10.17. 40 pp.

Table 2. Habitat area types that would be restored by the alternative measures and representative species and guilds used in the habitat benefits analysis.

Alternative Measures	**Habitat Models**	Marsh Lake Aquatic	Pomme de Terre River Aquatic	Upper Marsh Lake Shallow Aquatic	Lac qui Parle Aquatic	Abandoned Fish Pond
1) No Action	Walleye - Lacustrine				+	
	Northern Pike - Lacustrine	+		+	+	
	Diving Ducks	+				
	Great Blue Heron					+
2) Restore Pomme de Terre River to its former channel	Walleye - Lacustrine		+		+	
3) Modify Marsh Lake Dam to attain target water levels, construct fishway	Northern Pike - Lacustrine			+	+	
4) Growing season drawdowns to restore emergent aquatic plants, modify Marsh Lake Dam	Diving Ducks	+				
5) Install gated culverts in Louisburg Grade Road	Northern Pike - Lacustrine	+		+		
6) Breach dike at abandoned fish pond	Great Blue Heron					+
7) Construct islands in Marsh Lake	Diving Ducks	+				

Areas Affected by the Alternative Measures

Each of the alternative measures would affect different areas of habitat (Table3). The habitat areas in Marsh Lake and Lac qui Parle were estimated using the land cover GIS and bathymetry data developed by the DNR. The area of Pomme de Terre River aquatic habitat was estimated by calculating the area in acres using stream length (Marsh Lake to Morris Minnesota Dam) and stream widths from DNR stream survey data. The additional area of the re-routed Pomme de Terre River was estimated using GIS. The area affected by drawdowns and island construction was estimated using GIS using the lake bathymetry map prepared from DNR survey data, and a wind-fetch / wave action / sediment resuspension model described in the Hydraulics Appendix J.

Table 3. Area (acres) of habitat types affected by alternative measures for the Marsh Lake project.

Alternative Measures	Marsh Lake Aquatic Unvegetated	Marsh Lake Aquatic Vegetated	Marsh Lake Emergent Vegetation	Pomme de Terre River Aquatic	Pomme de Terre River Delta Floodplain	Upper Marsh Lake Shallow Aquatic	Lac qui Parle Aquatic	Abandoned Fish Pond
1) No Action	6100	<610	1032	454	293	1,715	7,700	15
2) Restore Pomme de Terre River to its former channel				454	293		7,700	
3) Modify Marsh Lake Dam to attain target water levels, construct fishway	6100	>3050						
4) Growing season drawdowns to restore emergent aquatic plants, modify Marsh Lake Dam			2625					
5) Install gated culverts in Louisburg Grade Road						1,715	7,700	
6) Remove dike at abandoned fish pond								15
7) Construct islands in Marsh Lake	<3050	>3050						

1. Average WSEL of Marsh Lake during growing season: 938.6 ft
2. Area of Marsh Lake at 938.6 ft: 6100 Acres
3. Area of Marsh Lake at 936.0 ft: 3475 acres
4. Area of Marsh Lake dewatered at 936.0 ft: 2625 acres
5. Water Surface Elevation of Marsh Lake during Winter Drawdown: 935.0 ft
6. Area of Marsh Lake during Winter Drawdown 935.0 ft: 2425 acres
7. Area of Marsh Lake upstream of the Louisburg Grade Road (northern pike spawning habitat) = 1,715 acres
8. Area of Pomme de Terre River between Marsh Lake and Marshall Dam = 454 acres
9. Area of Pomme de Terre River channel proposed for restoration = 11,500 lineal feet, 21 acres
10. Area of the Pomme de Terre River delta area below Marsh Lake Dam (between RR grade and the dam) = 293 acres.
11. Area of the abandoned fish rearing pond = 15.6 acres including dike, 15.0 acres within dike

Marsh Lake covers 6100 acres when at the average growing season water level of 938.6 ft. This area is the main part of Marsh Lake between the Louisburg Grade Road and the dam. Upper Marsh Lake upstream of the Louisburg Grade Road is a complex of wetlands that covers 1715 acres.

As of 1999 there were 1032 acres of emergent aquatic vegetation within the 6100 acres in the main part of Marsh Lake. Based on recent aerial photography, the area of emergent aquatic vegetation has not changed since then. The forecasted future without-project extent of emergent aquatic vegetation in Marsh Lake is also 1032 acres.

The existing and forecasted without-project future extent of submersed aquatic vegetation is estimated to be less than 610 acres, approximately 10 percent or less of the lake area. This is based on a 2007 submersed aquatic plant survey that monitored frequency of occurrence of submersed aquatic plants. Frequency of occurrence of sago pondweed was 11 percent (n = 165) but the plants were sparse and found mainly in protected bays and shallow areas.

The following narrative and the Marsh Lake HEP analysis spreadsheets are provided to describe calculation of the habitat benefits of the alternative measures quantified as Average Annual Habitat Units (AAHUs). The AAHUs are habitat suitability indices from the HEP models x acres x years, divided by 50 years, the project planning period.

Alternative Measure 1 – No Action The No Action future condition is described in Section 2.10 in the main report. Five habitat areas were selected for the HEP analysis (Table 2).

Diving ducks were selected as the representative guild for Marsh Lake, given their significance in the project area and the potential for improving fall diving duck migration habitat through restoring aquatic vegetation in Marsh Lake. The analysis area is the main body of Marsh Lake between the dam and the Louisburg Grade Road, a total of 6100 acres.

Table 4. Diving duck migration habitat in Marsh Lake for the No Action future condition.

Diving duck migration habitat

Assume : There would be no change over time in the area of Marsh Lake = 6100 acres average growing season area
There will be no change over time in average annual extent of SAV = <10% cover
Diving duck migration feeding habitat for EAV = ~17% cover
Values of all HSI variables will remain the same over time in the without-project future condition.

Lake Migration Habitat for Diving Ducks	Existing Conditions Year 0	Future Without Project - Year 1	Future Without Project - Year 5	Future Without Project - Year 25	Future Without Project - Year 50
HSI	0.61	0.61	0.61	0.61	0.61
Acreage	6100	6100	6100	6100	6100
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	3721.0	14884.0	74420.0	93025.0
				Total	186050.0
				AAHU	3721

Diving duck habitat in Marsh Lake would be limited in the future primarily by the low abundance and diversity of submersed and emergent aquatic vegetation. The current and future habitat suitability index is 0.61. Over the 50-year planning time period, there would be 3721 average annual habitat units (AAHU) of diving duck habitat on Marsh Lake (Tables 4 and 5).

Table 5. HEP model for diving duck habitat in Marsh Lake for the future without-project condition.

DIVING DUCK MIGRATION HABITAT MODEL
MARSH LAKE MINNESOTA RIVER - **WITHOUT-PROJECT FUTURE CONDITIONS**

VARIABLE		VALUE	COMMENTS
1) Size of Water Body			
a. Less than 100 acres	1		
b. 100 to 200 acres	5	ENTER	
c. 200 to 1,000 acres	7	VALUE= 10	Marsh Lake is >1000 acres
d. Greater than 1,000 acres	10		
2) Water Depth - Percent of Area 18" to 5'			
a. Less than 10 percent	1		
b. 10 to 40 percent	3	ENTER	
c. 40 to 70 percent	5	VALUE= 10	
d. Greater than 70 percent	10		Water depth is >70% area 18" to 5'
3) Percent Submergent Vegetation Cover			
a. Less than 10 percent	1		
b. 10 to 30 percent	3	ENTER	
c. 30 to 50 percent	6	VALUE= 1	Extent of SAV cover <10%
d. Greater than 50 percent	10		
4) Species of Submergent Vegetation Present (Key species: wild celery, sago pondweed, and other pondweeds)			
a. None of the key species present or less than 10 percent of aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 10	SAV is mostly sago pondweed
c. At least one key species covers 30 to 60 percent of the aquatic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
5) Percent Emergent Vegetation Cover			
a. Less than 10 Percent or greater than 50 percent	1		Approximately 17% EAV cover
b. 10 to 20 percent or 30 to 50 percent	5	ENTER	
c. 20 to 30 percent	10	VALUE= 5	
6) Species of Emergent Vegetation Present (Key species: arrowhead (S. rigida), soft-stem bulrush, wild rice)			
a. None of the key species present or less than 10 percent fo aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 1	EAV will remain mostly cattail
c. At least one key species covers 30 to 60 percent of the aqutaic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
7) Invertebrate Populations Present (Key Species: Sphaeriidae, Gastropoda,Hexegenia spp,Chironomidae)			
a. None of the key taxonomic groups present or present but not abundant	1		
b. At least 1 key taxonomic group present and is moderately abundant	5	ENTER VALUE= 5	dominated by chironomids, oligochaetes
c. At least 1 key taxonomic group present and is very abundant	10		
8) Disturbance			
a. Access uncontrolled - Considerable human activity during migration	1		
b. No hunting activity occurs, or closed to hunting only, but considerable human activity occurs during migration (such as fishing/boating)	3	ENTER VALUE= 4	Assume continued non-motorized zone
c. No hunting activity occurs, or closed to hunting only, and human activity during migration is minimal	4		
d. No human activity occurs, or closed to human entry	5		
		TOTAL= 46	
MAXIMUM POSSIBLE TOTAL =		75	
		HSI = 0.61	

The primary sport fish species in the project area and the selected fish species for aquatic habitat analysis are walleye and northern pike. Walleye occur in Lac qui Parle and in the Pomme de Terre River. Habitat for walleye in Marsh Lake is marginal due to the shallow depth, turbid conditions and winter hypoxia. According to the DNR, walleye are recruited into Lac qui Parle from Bigstone Lake upstream on the Minnesota River and by stocking walleye fry. Walleye rarely naturally reproduce in Lac qui Parle. Walleye occur in the Pomme de Terre River and there is evidence that they naturally reproduce there by the presence of young-of-year walleye. There is good water quality and an abundance of suitable walleye habitat in the Pomme de Terre River. Walleye in Lac qui Parle will be limited in the future by their ability to repro(duce given the habitat conditions available. The future habitat suitability index is 0.2 resulting in an AAHU of 1540 over the 50-year project planning period (Tables 6 and 7).

Table 6. Walleye habitat in Lac qui Parle for the without-project future condition.

Walleye habitat - Lac qui Parle

Assume : Lac qui Parle covers 7700 acres
Walleye from Lac qui Parle cannot get into Marsh Lake and up the Pomme de Terre River in most years
Walleye rarely successfully reproduce in Lac qui Parle. Last strong recruitment was in 2001
Walleye in Lac qui Parle are stocked and recruited from Bigstone Lake
Values of all HSI variables will remain the same over time in the without-project future condition.
Walleye habitat evaluated for Lac qui Parle without-project future conditions

Habitat for Walleye in Lac qui Parle	Existing Conditions Year 0	Future Without Project - Year 1	Future Without Project - Year 5	Future Without Project - Year 25	Future Without Project - Year 50
HSI	0.2	0.2	0.2	0.2	0.2
Acreage	7700.0	7700.0	7700.0	7700.0	7700.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	1540.0	6160.0	30800.0	38500.0
				Total	77000.0
				AAHU	1540

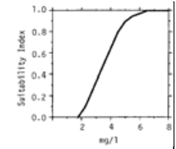
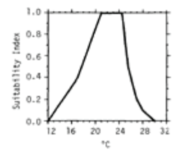
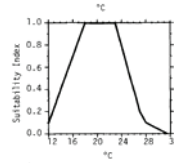
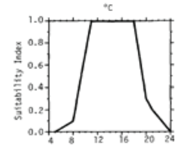
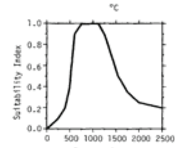
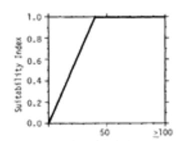
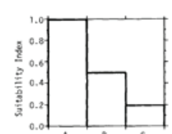
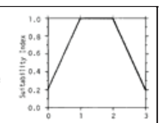
Table 7. HEP model of walleye habitat in Lac qui Parle for the without-project future condition.

Walleye Lacustrine Habitat Model
Without-Project Future Conditions

Assume : Walleye occur in Marsh Lake and in Lac qui Parle
Marsh Lake habitat is marginal for walleye due to turbidity and shallow depth
Assessed walleye habitat is in Lac qui Parle
Walleye from Lac qui Parle cannot get into Marsh Lake and up the Pomme de Terre River in most years
Walleye rarely successfully reproduce in Lac qui Parle. Last strong recruitment was in 2001
Walleye in Lac qui Parle are stocked or recruited from Marsh and Bigstone Lake

V1	Average Secchi transparency during summer Average Secchi transparency in Lac qui Parle in summer is 1.7 ft (MN DNR lake survey report) Note: Low transparency in LqP does not impose limitation on walleye, which exhibit fast growth	0.2
V2	Relative abundance of small (<12 cm) forage fish during spring and summer Assume abundant forage fish - fathead minnows, spotfin minnows, emerald shiners, white suckers	1
V3	Percent of area with cover (boulders, logs, brush, SAV) and D.O. >3 mg/l in spring and summer Some boulders, adequate D.O. Note: Cover does not impose limitation on walleye in LqP which exhibit fast growth	0.2
V4	Least suitable pH during year Lac qui Parle maximum pH is ~8.7 (Corps data)	1
V5	Minimum D.O.above thermocline in summer D.O. is adequate according to Corps data	1
V6	Minimum D.O. during summer-fall in shallow shoreline areas D.O. is adequate according to Corps data	1

Table 7 (continued). HEP model of walleye habitat in Lac qui Parle for the without-project future condition.

Variable	SI	Model variable	Suitability graph
V7 Minimum D.O. in spawning areas in spring D.O. is adequate in spring Note: Walleye reproduction rarely occurs in Lac qui Parle Probably a combination of water level and substrate limitations	1	V_7 Minimum dissolved oxygen level measured in spawning areas during spring (embryo).	
V8 Mean weekly water temperature above thermocline during summer Temperature is adequate according to Corps data	1	V_8 Mean weekly water temperature in pools (R) or above thermocline (L) during summer (adult and juvenile).	
V9 Mean weely water temperature in shallow shoreline areas during late spring, earl D.O. is adequate according to Corps data	1	V_9 Mean weekly water temperature in shallow shoreline areas during late spring-early summer (fry).	
V10 Mean weekly water temperature during spawning in spring D.O. is adequate according to Corps data Note: Walleye reproduction rarely occurs in Lac qui Parle Probably a combination of water level and substrate limitations	1	V_{10} Mean weekly water temperature during spawning in spring (embryo).	
V11 Degree days between 4 and 10C October 30 to April 16 ok according to Corps data	1	V_{11} Degree days between 4 and 10° C from October 30 to April 15. (Calculate by multiplying water temperatures in the range of 4 to 10° C by number of days that are in this temperature range. For example, 160 days of 6° C = 960 degree-days = SI of 1.0).	
V12 Spawning habitat index Highly variable depending on water level Portion of LqP littoral area >0.3m but <1.5m = 0.1 Subatrate index = 2 (5% gravel, rubble) + (3% boulders) + 0.5 (10% sand) + 0 (85% silt) = 18 Spawning habitat index = 0.1 x 18 = 1.8	0	V_{12} Spawning habitat index. Calculated by multiplying the proportion of the water body composed of riffle or littoral areas > 0.3 m but < 1.5 m deep by the substrate index where the substrate index is defined by the following equation: Substrate Index = 2(% gravel/rubble 2.5 to 15 cm in diameter) + (% boulders/bedrock) + 0.5(% sand) + 0.5(% dense vegetation) + 0(% silt/detritus).	
V13 Water level during spawning Highly variable. Often flooding during walleye spawning	0.2	V_{13} Water level during spawning and embryo development (embryo). A) Rising or normal and stable: abundance of shallow shoreline or shoal areas for spawning. B) Low: many spawning areas are exposed, and never inundated. C) Fluctuating: fluctuations sufficient to alternately expose and flood spawning areas.	
V14 Trophic status of lake Lac qui Parle is eutrophic Lac qui Parle supports a popular walleye fishery, so the eutrophic conditions (low water transparency, blue-green algae) may not limit the walleye population	1	L V_{14} Trophic status of lake or lake section. Note: The following list of parameter levels can be used to classify a water body according to trophic status (adapted from Leach et al. 1977).	

Parameter	Trophic status 0-1 (Oligotrophic)[1]	1-2 (Mesotrophic)	2-3 (Eutrophic)
Primary production rate	low	moderate	high
Organic matter in sediments	low	moderate	high
Hypolimnetic O_2 loss	low	moderate	high
Nutrient loading rates (phosphorus, nitrogen)	low	moderate	high
Morphoedaphic index (MEI) (metric)	< 5.9	6.0-7.2	> 7.3
Transparency (Secchi depth)	high (> 6 m)	moderate (1-6 m)	low (< 1m)

Component Suitability Indices Lacustrine Model	
Food = (V1+V2)/2	0.6
Cover = (3V1 + V3)/4	0.2
Water Quality = lowest of V4,V5,V6,V8,V9	1.0
Reproduction = lowest of V7, V10, V11, V12, V13	0.2
Other = V14	1.0

Lowest Component Value = Overall Habitat Suitability 0.2

Note: Food (V1, V2) and cover (V1, V3) are not limiting the walleye population in Lac qui Parle. Reproduction imposes limitation on walleye in LqP

Northern pike occur in Marsh Lake and in Lac qui Parle. Northern pike spawn in the upper end of Marsh Lake upstream of the Louisburg Grade Road. Northern pike in Marsh Lake have access to upper Marsh Lake and good flooded vegetation habitat for spawning and early life history. The habitat suitability index for northern pike in the future in Marsh Lake is 0.8, resulting in 4880 AAHUs. Northern pike in Lac qui Parle would not have access to as much suitable spawning habitat, resulting in a future habitat suitability index of 0.6 and 4620 AAHUs (Tables 8, 9 and 10).

Table 8. Northern pike habitat in Marsh Lake and Lac qui Parle for the without-project future condition.

Northern pike habitat - Marsh Lake

Assume : There would be no change in the area of upper Marsh Lake = 1715 acres
There would be no change in the area of Marsh Lake = 6100 acres
Northern pike would have unobstructed access to upper Marsh Lake for spawning
Values of all HSI variables will remain the same over time in the without-project future condition.

Northern Pike Habitat - Marsh Lake	Existing Conditions Year 0	Future Without Project - Year 1	Future Without Project - Year 5	Future Without Project - Year 25	Future Without Project - Year 50
HSI	0.8	0.8	0.8	0.8	0.8
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	4880.0	19520.0	97600.0	122000.0
				Total	244000.0
				AAHU	4880

Northern pike habitat - Lac qui Parle

Assume : There would be no change in the area of Lac qui Parle = 7700 acres
Northern pike would not access to upper Marsh Lake for spawning, would spawn in former Pomme de Terre River delta area
Values of all HSI variables will remain the same over time in the without-project future condition.

Northern Pike Habitat - Marsh Lake	Existing Conditions Year 0	Future Without Project - Year 1	Future Without Project - Year 5	Future Without Project - Year 25	Future Without Project - Year 50
HSI	0.6	0.6	0.6	0.6	0.6
Acreage	7700.0	7700.0	7700.0	7700.0	7700.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	4620.0	18480.0	92400.0	115500.0
				Total	231000.0
				AAHU	4620

Table 10. HEP model of northern pike habitat in Marsh Lake for the without-project future condition.

Northern Pike Model (Lacustrine) Marsh Lake
Without-Project Future Conditions

Assume : Northern pike occur in Marsh Lake, spawn in flooded vegetation in upper Marsh Lake

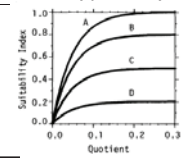
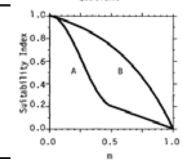
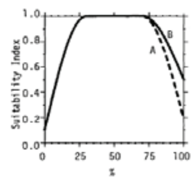
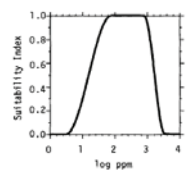
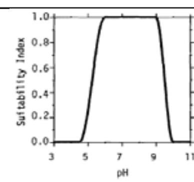
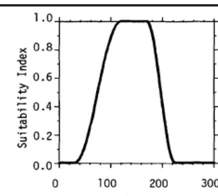
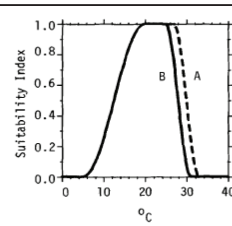
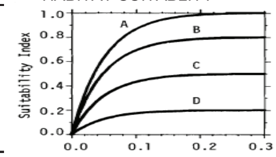
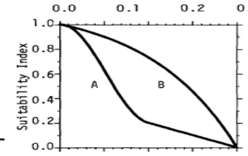
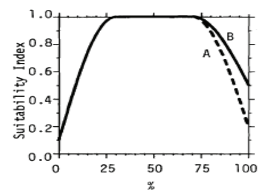
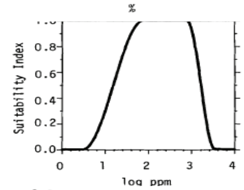
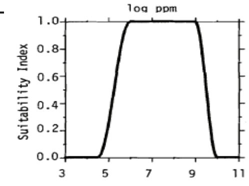
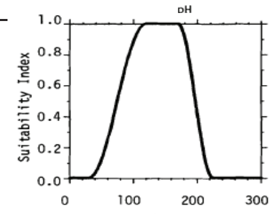
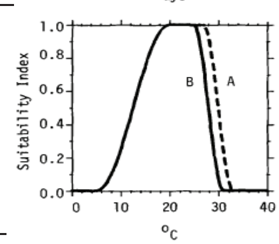
	VARIABLE	VALUE	COMMENTS
V1	Ratio of spawning habitat area to midsummer habitat area Upper Marsh Lake = 1715 acres Marsh Lake = 6100 acres Ratio = 0.28, curve A = good vegetation	1.0	
V2	Drop in water level during embryo (A) and fry (b) stage, whichever is lowest Typically, Marsh Lake water levels during northern pike spawning are high and remain high for weeks	0.8	
V3	Percent of midsummer area with SAV or EAV Marsh Lake EAV area = 1032 acres Marsh Lake SAV area = ~10% of 6100 acres = 610 26.9	1.0	
V4	Log10 summer TDS Mean Marsh Lake summer TDS = 675 mg/l Log10 of 675 = 2.829304	1.0	
V5	Least suitable pH during embyro and fry stages pH is ok - Corps data	1.0	
V6	Average length of frost-free season 135 days average at Milan MN R.H. Skaggs and D.G. Baker 1985 Fluctuations in the length of the growing season in Minnesota Climate Change http://www.springerlink.com/content/g65g3wl9k074w840/	1	
V7	Maximal weekly water temperature in summer A = unstratified lake 28C Corps data	0.8	
	Habitat Suitability Index = lowest of the habitat suitability ratings	0.8	

Table 11. HEP model for northern pike habitat in Lac qui Parle for the without-project future condition.

Northern Pike Model (Lacustrine) Lac qui Parle

Without-Project Future Conditions

Assume : Northern pike spawn in the former Pomme de Terre River delta area in upper Lac qui Parle

	VARIABLE	VALUE	HABITAT SUITABLITY
V1	Ratio of spawning habitat area to midsummer habitat area Former PdT River delta = 293 acres Lac qui Parle = 7700 acres Ratio = 0.038, curve A = good vegetation	0.6	
V2	Drop in water level during embryo (A) and fry (b) stage, whichever is lowest Typically, Lac qui Parle water levels during northern pike spawning are high and remain high for weeks	0.8	
V3	Percent of midsummer area with SAV or EAV Lac qui Parle EAV area assumed to be ~1000 acres Lac qui Parle SAV area = ~5% of 7700 acres = 385 acres 17.8 %	0.6	
V4	Log10 summer TDS Lac qui Parle summer TDS = ~ 675 mg/l Log10 of 675 = 2.829304	1.0	
V5	Least suitable pH during embyro and fry stages pH is ok - Corps data	1.0	
V6	Average length of frost-free season 135 days average at Milan MN R.H. Skaggs and D.G. Baker 1985 Fluctuations in the length of the growing season in Minnesota Climate Change http://www.springerlink.com/content/g65g3wl9k074w840/	1	
V7	Maximal weekly water temperature in summer A = unstratified lake 28C Corps data	0.8	
	Habitat Suitability Index = lowest of the habitat suitability ratings	0.6	

Great blue heron was selected as the representative species for the abandoned fish pond area downstream of the Marsh Lake Dam. The fish pond area has potential to be restored to be a connected shallow marsh and aquatic habitat more suitable for fish-eating birds like great blue heron. The abandoned fish pond area covers 15 acres. Future habitat suitability index would be 0.31, providing 5 AAHUs (Tables 12 and 13). Foraging habitat quality is the primary factor limiting great blue heron habitat in the abandoned and isolated fish pond area.

Table 12. Blue heron habitat in the abandoned fish pond area adjacent to Marsh Lake Dam for the without-project future condition.

Great Blue Heron Habitat - Abandoned Fish Pond Area

Assume: Values of all HSI variables will remain the same over time in the without-project future condition.
Area of abandoned fish pond = 15 acres

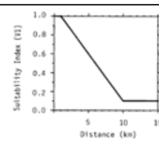
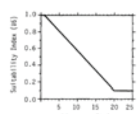
Wetland Habitat for Great blue heron in 500 ft wide band	Existing Condition Year 0	Future Without Project - Year 1	Future Without Project - Year 5	Future Without Project - Year 25	Future Without Project - Year 50
HSI	0.31	0.31	0.31	0.31	0.31
Acreage	15.0	15.0	15.0	15.0	15.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0.0	4.6	18.6	93.0	116.2
				Total	232.4
				AAHU	5

Table 13. HEP model of great blue heron habitat in the abandoned fish pond area for the without-project future condition.

Great Blue Heron Model
Without-Project Future Conditions

Assume :
Heron foraging area in abandoned fish pond
Heron nesting areas are available in wooded floodplain nearby

V1 distance between foraging and nesting areas SI = 1.0
V2 foraging areas quality SI = 0.5
V3 disturbance in foraging areas SI = 1.0
V4 nesting trees SI = 1.0
V5 disturbance during nesting SI = 0.9
V6 distance between potential and active nest sites (<2km) SI = 1.0
HSI = (V1 x V2 x V3 x V4 x V5 x V6) exp 0.5 = 0.67

VARIABLE		VALUE	HABITAT SUITABILITY
V1	Distance between foraging areas and existing or potential heronries Assumed to be close < 5 km	0.6	
V2	Foraging area quality Heron foraging area in abandonded fish pond is marginal habitat for blue herons with no flow through, limited small fish abundance	0.2	V2 = 1.0 if potential foraging habitats usually have shallow, clear water with a firm substrate and a huntable population of small fish. V2 = 0.0 if potential foraging habitats usually do not provide the desirable combination of conditions.
V3	Disturbance in foraging areas Little human disturbance	1	V3 = 1.0 if there usually is no human disturbance near the potential foraging zone during the 4 hours following sunrise or preceding sunset or the foraging zone is generally about 100 m from human activities and habitation or about 50 m from roads with occasional, slow-moving traffic. V3 = 0.0 if the above conditions are not usually met.
V4	Potential nesting areas Assume potential nesting areas are available and suitable	1	Variable 4 (V4) in the model defines a potential nest site as a grove of trees at least 0.4 ha in area located over water or within 250 m of water. These potential nest sites may be on an island within a river or lake, within a woodland dominated swamp, or in vegetation near a river or lake. Trees used as nest sites are at least 5 m high and have many branches at least 2.5 cm in diameter that are capable of supporting nests. Trees may be alive or dead but must have an "open canopy" that allows an easy access to the nest. V4 = 1.0 if potential treeland habitats usually fulfill all of these conditions. V4 = 0.0 if potential treeland habitats usually do not fulfill all of these conditions.
V5	Disturbance in nesting areas Assume nesting areas receive little human disturbance	1	V5 = 1.0 if the exclusion zone is usually free from human disturbances during the nesting season. V5 = 0.0 if the exclusion zone is usually not free from human disturbance during the nesting season.
V6	Distance between potential and active nest sites Assume distance is < 5 km	0.8	 Figure 3. Distance between a potential nest site and an active nest site modifies SI values.

HSI = (V1 x V2 x V3 x V4 x V5 x V6) exp 0.5
HSI = (0.6 x 0.2 x 1 x 1 x 1 x 0.8) exp 0.5 0.31

Alternative Measure 2 – Restoring the Pomme de Terre River to its Former Channel would provide fish in Lac qui Parle access to approximately 454 acres of high quality Pomme de Terre River habitat in the 52 miles of river between Lac qui Parle and the dam at Marshall, Minnesota. Restoring the Pomme de Terre River to its former channel would also restore 11,500 lineal feet and 21 acres of former river channel habitat between Marsh Lake Dam and the Minnesota River in the upper end of Lac qui Parle. Walleye were selected as the representative species for the habitat benefits analysis for this alternative measure. Lac qui Parle covers 7,700 acres at the average annual water level. The limitation of spawning habitat suitability would be removed in that walleye would have access to high quality spawning habitat in the Pomme de Terre River. Future average annual habitat units would be 8107, resulting in a net gain over the without project condition of 6567 AAHUs (Tables 14 and 15).

Table 14. Walleye habitat in Lac qui Parle with the Pomme de Terre River restored to its former channel.

Walleye Habitat - Lac qui Parle and Pomme de Terre River

Assume : Walleye occur in Lac qui Parle
Marsh Lake habitat is marginal for walleye due to turbidity and shallow depth
Walleye from Lac qui Parle will be able to migrate between Lac qui Parle and the Pomme de Terre River
Walleye rarely successfully reproduce in Lac qui Parle. Last strong recruitment was in 2001
Walleye successfully reproduce in the Pomme de Terre River as evidenced by presence of YOY
Walleye in Lac qui Parle are stocked and recruited from Marsh and Bigstone Lake
Restoration benefits to walleye will be in Pomme de Terre River and in Lac qui Parle
Lac qui Parle area = 7700 acres, Pomme de Terre River to Morris = 454 acres
Restored Pomme de Terre River channel = 21 acres

Habitat for Walleye	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.2	1	1	1	1
Acreage	7700	8175	8175	8175	8175
Year	0	1	5	25	50
Cumulative Annual Habitat Units	0	4794	32700	163500	204375
				Total	405369
				AAHU	**8107**

Alternative 2 Total AAHU	**8107**
Minus No Action for Walleye	**1540**
Alternative 2 Net Gain AAHU	**6567**

Table 15. HEP model of walleye habitat in Lac qui Parle with the Pomme de Terre River restored to its former channel.

Walleye Lacustrine and Riverine Habitat Model
With-Project Future Conditions - Pomme de Terre River restored to its former channel

Assume : Marsh Lake habitat is very marginal for walleye due to turbidity, winter hypoxia and shallow depth
Walleye occur in Lac qui Parle
Walleye in Lac qui Parle are stocked or recruited from Marsh and Bigstone Lake
Walleye rarely successfully reproduce in Lac qui Parle. Last strong recruitment was in 2001
Walleyes will be able to move freely between the Pomme de Terre River and Lac qui Parle
Walleye successfully reproduce in the Pomme de Terre River as evidenced by presence of YOY
Benefits to walleye will be in Pomme de Terre River and Lac qui Parle

VARIABLE	VALUE	COMMENTS
V1 Average Secchi transparency during summer Assume average 2 - 3 ft Secchi transparency, based on stream survey data	1	
V2 Relative abundance of small (<12 cm) forage fish during spring and summer Assume abundant forage fish - fathead minnows, spotfin minnows, emerald shiners, white suckers	1	
V3 Percent of area with cover (boulders, logs, brush, SAV) and D.O. >3 mg/l in spring and summer The Pomme de Terre River has good cover and D.O. based on stream survey data	1	
V4 Least suitable pH during year pH 7.9 based on stream survey data	1	
V5 Minimum D.O. in pools and runs in summer D.O. is adequate based on stream survey data	1	
V6 Minimum D.O. during summer-fall in shallow shoreline areas D.O. is adequate based on stream survey data	1	

Variable

V_1 Average transparency (Secchi depth) durin summer.

V_2 Relative abundance o small (< 12 cm) fora fishes during spring and summer (fry, juvenile, and adult)

Note: SI for this variable f predicted or future co ditions can be based o standing crop predicti models, such as those presented by Aggus and Morais (1979).

V_3 Percent of water bod with cover (boulders log piles, brush, submerged vegetation and adequate dissolv oxygen (> 3 mg/l) du the spring and summe (fry, juvenile, and

V_4 Least suitable pH during the year.

V_5 Minimum dissolved o level in pools and (R) or above thermo (L) in summer (adul juvenile).

Table 15 (continued). HEP model of walleye habitat in Lac qui Parle with the Pomme de Terre River restored to its former channel.

V7	Minimum D.O. in spawning areas in spring D.O. is adequate based on stream survey data	1
V8	Mean weekly D.O. in pools during summer D.O. is adequate based on stream survey data	1
V9	Mean weely water temperature in shallow shoreline areas during late spring, early summer Water temperature ok based on stream survey data	1
V10	Mean weekly water temperature during spawning in spring Water temperature presumed to be ok	1
V11	Degree days between 4 and 10C October 30 to April 16 Don't have data to calculate, presumed to be OK	1
V12	Spawning habitat index Abundant suitable spawning habitat	1
V13	Water level during spawning Variable but good. Upstream lakes and wetlands maintain spring flow.	1
V14	Trophic status of lake Lac qui Parle is eutrophic Lac qui Parle supports a popular walleye fishery, so the eutrophic conditions (low water transparency, blue-green algae) may not limit the walleye population	1

Component Suitability Indices Lacustrine/Riverine Model	
Food = (V1+V2)/2	1.0
Cover = (3V1 + V3)/4	1.0
Water Quality = lowest of V4,V5,V6,V8,V9	1.0
Reproduction = lowest of V7, V10, V11, V12, V13	1.0
Other = V14	1.0
Lowest Component Value = Overall Habitat Suitability	1.0

V_6 Minimum dissolved o level during summer along shallow shore areas (fry).

V_7 Minimum dissolved o level measured in spawning areas duri spring (embryo).

V_8 Mean weekly water temperature in pool (R) or above thermo cline (L) during summer (adult and juvenile).

V_9 Mean weekly water temperature in shallow shoreline areas during late spring-early summe (fry).

V_{10} Mean weekly water temperature during spawning in spring (embryo).

V_{11} Degree days between 4 and 10° C from October 30 to April (Calculate by multi- plying water tempera- tures in the range 4 to 10° C by numbe of days that are in this temperature ra For example, 160 da of 6° C = 960 degre days = SI of 1.0).

V_{12} Spawning habitat in

Calculated by multiplying th proportion of the water body composed of riffle or littor areas > 0.3 m but < 1.5 m de by the substrate index where the substrate index is defin by the following equation:

Substrate Index = 2(% gravel rubble 2.5 to 15 cm in diameter) + (% boulders/ bedrock) + 0.5(% sand) + 0.5(% dense vegetation) + 0(% silt/detritus).

V_{13} Water level during spawning and embryo development (embryo

A) Rising or norma and stable: abundance of shallow shoreli or shoal areas for spawning.
B) Low: many spawning areas are exposed, ar never inundated

Restoring the Pomme de Terre River to its former channel would provide additional benefits by restoring river channel and floodplain structure, function and processes. The restored 21 acres of river channel would positively affect 292 acres of floodplain habitat in the upper end of Lac qui Parle. Additional benefits would accrue to floodplain vegetation, wading birds like great blue heron, to resident fish, macroinvertebrates and to freshwater mussels.

Alternative Measure 3 – Modifying Marsh Lake Dam to passively attain target water levels by constructing a fishway would be primarily done to attain Objective 4a to restore a more natural hydrologic regime, in order to attain Objective 7b, increased submersed aquatic plants in Marsh Lake and Objective 8A, increased waterfowl use on Marsh Lake. Diving ducks were selected as the representative guild for the habitat analysis benefits for this alternative measure. Marsh Lake covers 6100 acres at the average annual water level. Modifying the Marsh Lake Dam with a fishway would provide passive water level management with somewhat lower water levels in late summer, but the average annual water level and lake acreage would remain the same.

This measure would increase the extent of submersed and emergent aquatic vegetation but significant inter-annual variation in the extent of submersed aquatic vegetation would occur. Sediment loading from the Pomme de Terre River, wind-driven sediment resuspension, sediment resuspension and grazing by carp would combine to limit submersed aquatic vegetation under this stand-alone alternative to an estimated three years out of ten of abundant SAV. The Alternative Measure 2 net gain would be 483 AAHUs (Tables 18 and 19).

Modifying Marsh Lake Dam spillway with a fishway would also provide benefits to fish in Lac qui Parle. Northern pike from Lac qui Parle could gain access to prime spawning habitat in the upper end of Marsh Lake.

Table 18. Diving duck habitat in Marsh Lake with dam modification with fishway to achieve target water levels.

Diving duck migration habitat

Assume : There would be no change over time in the area of Marsh Lake = 6100 acres average growing season area
Habitat value will increase by year 2

Lake Migration Habitat for Diving Ducks	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.61	0.69	0.69	0.69	0.69
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	3965.0	16836.0	84180.0	105225.0
				Total	210206.0
				AAHU	**4204**

Alternative 3 Total AAHU	**4204**
Minus No Action for diving ducks	**3721**
Alternative 3 Net Gain AAHU	**483**

Table 19. HEP model of diving duck habitat in Marsh Lake with dam modification with fishway to achieve target water levels.

DIVING DUCK MIGRATION HABITAT MODEL
MARSH LAKE MINNESOTA RIVER - **WITH-PROJECT FUTURE CONDITIONS**
ALTERNATIVE MEASURE 3 DAM MODIFICATION WITH FISHWAY TO ACHIEVE TARGET WATER LEVELS

VARIABLE		VALUE	COMMENTS
1) Size of Water Body			
a. Less than 100 acres	1		
b. 100 to 200 acres	5	ENTER	
c. 200 to 1,000 acres	7	VALUE= 10	
d. Greater than 1,000 acres	10		
2) Water Depth - Percent of Area 18" to 5'			
a. Less than 10 percent	1		
b. 10 to 40 percent	3	ENTER	
c. 40 to 70 percent	5	VALUE= 10	
d. Greater than 70 percent	10		
3) Percent Submergent Vegetation Cover			
a. Less than 10 percent	1		Target water levels would allow SAV to grow to 30 to 50% cover 3 out of 10
b. 10 to 30 percent	3	ENTER	years on average, limited by sediment
c. 30 to 50 percent	6	VALUE= 2	resuspension and carp grazing
d. Greater than 50 percent	10		
4) Species of Submergent Vegetation Present (Key species: wild celery, sago pondweed, and other pondweeds)			
a. None of the key species present or less than 10 percent of aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 10	Assume SAV is mostly sago pondweed
c. At least one key species covers 30 to 60 percent of the aquatic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
5) Percent Emergent Vegetation Cover			
a. Less than 10 Percent or greater than 50 percent	1		
b. 10 to 20 percent or 30 to 50 percent	5	ENTER	
c. 20 to 30 percent	10	VALUE= 10	Assume dam modifications will increase extent of EAV to >20%
6) Species of Emergent Vegetation Present (Key species: arrowhead (S. rigida), soft-stem bulrush, wild rice)			
a. None of the key species present or less than 10 percent fo aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 1	Assume EAV will remain mostly cattail
c. At least one key species covers 30 to 60 percent of the aqutaic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
7) Invertebrate Populations Present (Key Species: Sphaeriidae, Gastropoda,Hexegenia spp,Chironomidae)			
a. None of the key taxonomic groups present or present but not abundant	1		
b. At least 1 key taxonomic group present and is moderately abundant	5	ENTER VALUE= 5	Assume invert community will remain dominated by chironomids, oligochaetes
c. At least 1 key taxonomic group present and is very abundant	10		
8) Disturbance			
a. Access uncontrolled - Considerable human activity during migration	1		
b. No hunting activity occurs, or closed to hunting only, but considerable human activity occurs during migration (such as fishing/boating)	3	ENTER VALUE= 4	Assume continued non-motorized zone
c. No hunting activity occurs, or closed to hunting only, and human activity during migration is minimal	4		
d. No human activity occurs, or closed to human entry	5		
		TOTAL= 52	
		MAXIMUM POSSIBLE TOTAL = 75	
		HSI = 0.69	

Alternative Measure 4 - Growing season drawdowns to restore emergent aquatic plants by modifying Marsh Lake Dam with a stop log structure would enable active water level management to restore a more natural stage hydrograph on Marsh Lake. This measure would provide the Lac qui Parle Wildlife Management Area managers considerable flexibility to positively affect the ecosystem conditions in Marsh Lake. Growing season drawdowns could be conducted to reestablish emergent aquatic plants, followed by winter drawdown to kill carp that feed on submersed aquatic plants. This measure would result in increased extent of emergent aquatic plants by exposing lake bottom and consolidating sediment, allowing EAV to germinate from seed and persist for a number of years before another drawdown is needed.

This stand-alone measure would increase the extent of submersed aquatic vegetation but significant inter-annual variation in the extent of submersed aquatic vegetation would occur. Sediment loading from the Pomme de Terre River and wind-driven sediment resuspension would combine to limit submersed aquatic vegetation under this stand-alone alternative to an estimated three years out of ten of abundant SAV. This measure would result in a net gain of 725 AAHUs for diving ducks (Tables 20 and 21).

In addition to improving habitat for diving ducks, drawdowns would contribute to maintaining a vegetated and clear-water ecosystem state. Drawdowns would improve habitat conditions for dabbling ducks and marsh birds like yellow-headed blackbird and wading birds like herons and bitterns. Increased emergent vegetation would benefit furbearers like muskrat and mink. The winter drawdowns would suppress carp abundance, reducing sediment resuspension and grazing by carp.

Table 20. Diving duck habitat in Marsh Lake with drawdowns to restore aquatic vegetation.

Diving duck migration habitat

Assume : There would be no change in the area of Marsh Lake = 6100 acres average growing season area
Growing season drawdowns would dewater up to 2625 acres, increase extent of EAV and SAV
SAV would increase after first year of drawdown
Additional future drawdowns would be conducted to maintain the extent of SAV
Average annual extent of SAV will increase to >50% cover by year 2

Lake Migration Habitat for Diving Ducks	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.61	0.73	0.73	0.73	0.73
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	4087.0	17812.0	89060.0	111325.0
				Total	222284.0
				AAHU	4446

Alternative 4 Total AAHU	4446
Minus No Action for Diving Ducks	3721
Alternative 4 Net Gain AAHU	725

Table 21. HEP model of diving duck habitat in Marsh Lake with drawdowns to restore aquatic vegetation.

DIVING DUCK MIGRATION HABITAT MODEL
MARSH LAKE MINNESOTA RIVER - MEASURE 4 **WITH-DRAWDOWNS FUTURE CONDITIONS**

VARIABLE		VALUE	COMMENTS
1) Size of Water Body			
a. Less than 100 acres	1		
b. 100 to 200 acres	5	ENTER	
c. 200 to 1,000 acres	7	VALUE= 10	Marsh Lake is >1000 acres
d. Greater than 1,000 acres	10		
2) Water Depth - Percent of Area 18" to 5'			
a. Less than 10 percent	1		
b. 10 to 40 percent	3	ENTER	
c. 40 to 70 percent	5	VALUE= 10	Water depth is >70% area 18" to 5'
d. Greater than 70 percent	10		
3) Percent Submergent Vegetation Cover			Drawdowns would allow SAV
a. Less than 10 percent	1		to grow to 30 to 50% cover 3 out of 10
b. 10 to 30 percent	3	ENTER	years on average, limited by PdT River
c. 30 to 50 percent	6	VALUE= 2	sediment loading, wind driven sediment
d. Greater than 50 percent	10		resuspension
4) Species of Submergent Vegetation Present (Key species: wild celery, sago pondweed, and other pondweeds)			
a. None of the key species present or less than 10 percent of aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 10	SAV is mostly sago pondweed
c. At least one key species covers 30 to 60 percent of the aquatic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
5) Percent Emergent Vegetation Cover			
a. Less than 10 Percent or greater than 50 percent	1		
b. 10 to 20 percent or 30 to 50 percent	5	ENTER	
c. 20 to 30 percent	10	VALUE= 10	Drawdowns will increase EAV to >20%
6) Species of Emergent Vegetation Present (Key species: arrowhead (S. rigida), soft-stem bulrush, wild rice)			
a. None of the key species present or less than 10 percent fo aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aquatic bed (add one point if more than one key species is present)	3	ENTER VALUE= 4	Drawdowns will increase EAV diversity EAV will remain dominated by cattail
c. At least one key species covers 30 to 60 percent of the aqutaic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
7) Invertebrate Populations Present (Key Species: Sphaeriidae, Gastropoda,Hexegenia spp,Chironomidae)			
a. None of the key taxonomic groups present or present but not abundant	1		
b. At least 1 key taxonomic group present and is moderately abundant	5	ENTER VALUE= 5	Macroinvertebrate community will remain dominated by chironomids, oligochaetes
c. At least 1 key taxonomic group present and is very abundant	10		
8) Disturbance			
a. Access uncontrolled - Considerable human activity during migration	1		
b. No hunting activity occurs, or closed to hunting only, but considerable human activity occurs during migration (such as fishing/boating)	3	ENTER VALUE= 4	Assume continued non-motorized zone
c. No hunting activity occurs, or closed to hunting only, and human activity during migration is minimal	4		
d. No human activity occurs, or closed to human entry	5		
		TOTAL= 55	
MAXIMUM POSSIBLE TOTAL =		75	
		HSI = 0.73	

Alternative Measure 5 - Northern pike in Marsh Lake migrate into the flooded marsh area in upper Marsh Lake to spawn. Installing gated culverts in the Louisburg Grade Road would allow northern pike from Marsh Lake to successfully spawn during years when Marsh Lake is drawn down. Assuming that Marsh Lake would be drawn down once every five years to restore aquatic vegetation, the net gain in habitat units would be 610 AAHUs (Tables 22 and 23).

Table 22. Northern pike habitat in Marsh Lake with gated culverts in the Louisburg Grade Road, allowing successful northern pike reproduction in years when Marsh Lake is drawn down.

Northern pike habitat - Marsh Lake

Assume : There would be no change in the area of upper Marsh Lake = 1715 acres
There would be no change in the area of Marsh Lake = 6100 acres
Northern pike would have unobstructed access to upper Marsh Lake for spawning in all years except drawdown years
Increased SAV and EAV with Marsh Lake Dam modifications and drawdowns would improve habitat, but not the HS model value
No stoplog structures would be installed in the culverts under Louisburg Grade Road
Marsh Lake would be drawn down 10 times in 50 years

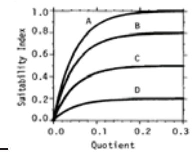
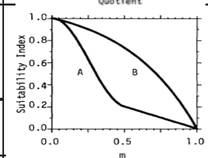
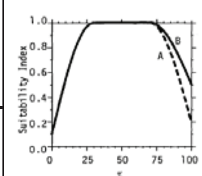
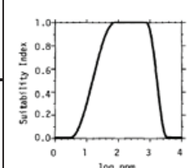
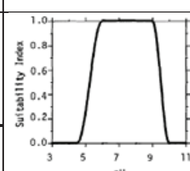
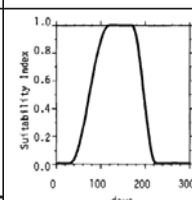
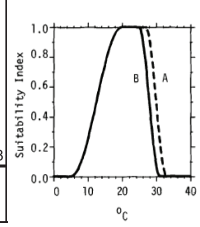
Northern Pike Habitat - Marsh Lake	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.8	0.8	0.8	0.8	0.8
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	4880.0	19520.0	97600.0	122000.0
				Total	244000.0
	No Action for Northern Pike			**AAHU**	4880
SI for years with drawdowns w/o gated culverts = 0.3, resulting in 1830 AHUs in drawdown years AAHU with drawdowns and without gated culverts = ((244000 - (4880 x 10) + (1830 x 10))/50					4270
			Alternative 5 Net Gain AAHU		610

Table 23. HEP model of northern pike habitat in Marsh Lake without gated culverts in the Louisburg Grade Road in years when Marsh Lake is drawn down.

Northern Pike Model (Lacustrine) Marsh Lake

With drawdowns future condition, without gated culverts in the Louisburg Grade Road

Assume : Northern pike occur in Marsh Lake, spawn in flooded vegetation in upper Marsh Lake
Northern pike would not successfully reproduce in Marsh Lake in drawdown years

	VARIABLE	VALUE	COMMENTS
V1	Ratio of spawning habitat area to midsummer habitat area Upper Marsh Lake = 1715 acres Marsh Lake = 6100 acres Ratio = 0.28, curve A = good vegetation	1.0	
V2	Drop in water level during embryo (A) and fry (b) stage, whichever is lowest Typically, Marsh Lake water levels during northern pike spawning are high and remain high for weeks During a drawdown, water levels during the fry stage would fall by approximately 0.75 m	0.3	
V3	Percent of midsummer area with SAV or EAV Marsh Lake EAV area = 1032 acres Marsh Lake SAV area = ~10% of 6100 acres = 610 26.9	1.0	
V4	Log10 summer TDS Mean Marsh Lake summer TDS = 675 mg/l Log10 of 675 = 2.829304	1.0	
V5	Least suitable pH during embyro and fry stages pH is ok - Corps data	1.0	
V6	Average length of frost-free season 135 days average at Milan MN R.H. Skaggs and D.G. Baker 1985 Fluctuations in the length of the growing season in Minnesota Climate Change http://www.springerlink.com/content/g65g3wl9k074w840/	1	
V7	Maximal weekly water temperature in summer A = unstratified lake 28C Corps data	0.8	

Habitat Suitability Index = lowest of the habitat suitability ratings — 0.3

<u>Alternative Measure 6</u> – Breaching the embankment enclosing the abandoned fish pond would provide aquatic habitat connectivity between the fish pond area and upper Lac qui Parle. Water levels in the fish pond area would fluctuate in concert with water levels in Lac qui Parle. Fish would gain access to the shallow aquatic habitat in the fish pond, improving foraging habitat for fish-eating birds like great blue herons. Great blue heron was selected as the representative species for habitat benefits analysis of this alternative measure. Breaching the abandoned fish pond would provide 5 additional AAHUs of blue heron habitat (Tables 24 and 25).

Table 24. Great blue heron habitat in the abandoned fish pond area with breached embankment.

Great Blue Heron Habitat

Assume : Heron nesting areas are available in wooded floodplain nearby
Habitat in abandoned fish pond area would improve (more forage fish) within one year after breaching dike
Area of abandonded fish pond = 15 acres

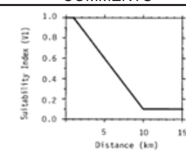
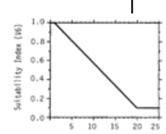
Wetland Habitat for Great blue heron in 500 ft wide band	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.31	0.69	0.69	0.69	0.69
Acreage	15.0	15.0	15.0	15.0	15.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0.0	7.5	41.4	207.0	258.8
				Total	514.6
				AAHU	10
			Minus No Action for Herons		5
		Alternative 6 Net Gain AAHUs			5

Table 25. HEP model of great blue heron habitat in the reconnected abandoned fish pond area.

Great Blue Heron Model
With-Project Future Conditions

Assume : Heron foraging area in abandoned fish pond
Heron nesting areas are available in wooded floodplain nearby

V1 distance between foraging and nesting areas SI = 1.0
V2 foraging areas quality SI = 0.5
V3 disturbance in foraging areas SI = 1.0
V4 nesting trees SI = 1.0
V5 disturbance during nesting SI = 0.9
V6 distance between potential and active nest sites <2km SI = 1.0
HSI = (V1 x V2 x V3 x V4 x V5 x V6) exp 0.5 = 0.69

	VARIABLE	VALUE	COMMENTS
V1	Distance between foraging areas and existing or potential heronries < 5 km	0.6	
V2	Foraging area quality Heron foraging area in abandoned fish pond improved by connection to upper Lac qui Parle, forage fish gain access	1	V2 = 1.0 if potential foraging habitats usually have shallow, clear water with a firm substrate and a huntable population of small fish. V2 = 0.0 if potential foraging habitats usually do not provide the desirable combination of conditions.
V3	Disturbance in foraging areas Little human disturbance in these areas	1	V3 = 1.0 if there usually is no human disturbance near the potential foraging zone during the 4 hours following sunrise or preceding sunset or the foraging zone is generally about 100 m from human activities and habitation or about 50 m from roads with occasional, slow-moving traffic. V3 = 0.0 if the above conditions are not usually met.
V4	Potential nesting areas Assume potential nesting areas are available and suitable	1	Variable 4 (V4) in the model defines a potential nest site as a grove of trees at least 0.4 ha in area located over water or within 250 m of water. These potential nest sites may be on an island within a river or lake, within a woodland dominated swamp, or in vegetation near a river or lake. Trees used as nest sites are at least 5 m high and have many branches at least 2.5 cm in diameter that are capable of supporting nests. Trees may be alive or dead but must have an "open canopy" that allows an easy access to the nest. V4 = 1.0 if potential treeland habitats usually fulfill all of these conditions. V4 = 0.0 if potential treeland habitats usually do not fulfill all of these conditions.
V5	Disturbance in nesting areas Assume nesting areas receive little human disturbance	1	V5 = 1.0 if the exclusion zone is usually free from human disturbances during the nesting season. V5 = 0.0 if the exclusion zone is usually not free from human disturbance during the nesting season.
V6	Distance between potential and active nest sites Assume distance is < 5 km	0.8	 Figure 3. Distance between a potential nest site and an active nest site modifies SI values.

HSI = (V1 x V2 x V3 x V4 x V5 x V6) exp 0.5
HSI = (0.6 x 1.0 x 1 x 1 x 1 x 0.8) exp 0.5 — 0.69

Alternative Measure 7 – Constructing islands in Marsh Lake would reduce wind fetch, sediment resuspension, and increase submersed aquatic vegetation that provides food for migrating diving ducks.

This stand-alone measure would increase submersed aquatic vegetation but significant inter-annual variation in the extent of submersed aquatic vegetation would occur. Sediment loading from the Pomme de Terre River and sediment resuspension and grazing by carp would combine to limit submersed aquatic vegetation under this stand-alone alternative to an estimated three years out of ten of abundant SAV. This stand-alone alternative measure would provide a net gain of 239 AAHUs of diving duck migration habitat (Tables 26 and 27).

Table 26. Diving duck habitat in Marsh Lake with islands.

Diving duck migration habitat

Assume : There would be no change over time in the area of Marsh Lake = 6100 acres average growing season area
Islands would protect against sediment resuspension and increase extent of SAV in the first year following construction

Lake Migration Habitat for Diving Ducks	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.56	0.65	0.65	0.65	0.65
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	3690.5	15860.0	79300.0	99125.0
				Total	197975.5
				AAHU	3960

Alternative 7 Total AAHU	3960
No Action Total AAHU	3721
Alternative 7 Net Gain AAHU	239

Table 27. HEP model of diving duck habitat in Marsh Lake with islands.

DIVING DUCK MIGRATION HABITAT MODEL
MARSH LAKE MINNESOTA RIVER - **WITH ISLANDS FUTURE PROJECT CONDITION**

VARIABLE		VALUE		COMMENTS
1) Size of Water Body				
a. Less than 100 acres	1			
b. 100 to 200 acres	5	ENTER		
c. 200 to 1,000 acres	7	VALUE=	10	Marsh Lake is >1000 acres
d. Greater than 1,000 acres	10			
2) Water Depth - Percent of Area 18" to 5'				
a. Less than 10 percent	1			
b. 10 to 40 percent	3	ENTER		
c. 40 to 70 percent	5	VALUE=	10	Water depth is >70% area 18" to 5'
d. Greater than 70 percent	10			
3) Percent Submergent Vegetation Cover				
a. Less than 10 percent	1			Islands would allow SAV to grow to 30 to 50% cover 3 out of 10 years on average, limited by PdT River
b. 10 to 30 percent	3	ENTER		
c. 30 to 50 percent	6	VALUE=	2	sediment loading, sediment resuspension by carp and carp grazing
d. Greater than 50 percent	10			
4) Species of Submergent Vegetation Present (Key species: wild celery, sago pondweed, and other pondweeds)				
a. None of the key species present or less than 10 percent of aquatic bed	1			
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE=	10	SAV is mostly sago pondweed
c. At least one key species covers 30 to 60 percent of the aquatic bed (add one point if more than one key species is present)	6			
d. Greater than 60 percent of aquatic bed is comprised of key food species	10			
5) Percent Emergent Vegetation Cover				
a. Less than 10 Percent or greater than 50 percent	1			
b. 10 to 20 percent or 30 to 50 percent	5	ENTER		Islands will shelter EAV,
c. 20 to 30 percent	10	VALUE=	5	increase to >10%
6) Species of Emergent Vegetation Present (Key species: arrowhead (S. rigida), soft-stem bulrush, wild rice)				
a. None of the key species present or less than 10 percent fo aquatic bed	1			
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE=	3	Assume EAV will increase in diversity
c. At least one key species covers 30 to 60 percent of the aqutaic bed (add one point if more than one key species is present)	6			
d. Greater than 60 percent of aquatic bed is comprised of key food species	10			
7) Invertebrate Populations Present (Key Species: Sphaeriidae, Gastropoda,Hexegenia spp,Chironomidae)				
a. None of the key taxonomic groups present or present but not abundant	1			
b. At least 1 key taxonomic group present and is moderately abundant	5	ENTER VALUE=	5	Invertebrate community will remain dominated by chironomids, oligochaetes
c. At least 1 key taxonomic group present and is very abundant	10			
8) Disturbance				
a. Access uncontrolled - Considerable human activity during migration	1			
b. No hunting activity occurs, or closed to hunting only, but considerable human activity occurs during migration (such as fishing/boating)	3	ENTER VALUE=	4	Assume continued non-motorized zone
c. No hunting activity occurs, or closed to hunting only, and human activity during migration is minimal	4			
d. No human activity occurs, or closed to human entry	5			
		TOTAL=	49	
MAXIMUM POSSIBLE TOTAL =			75	
		HSI =	0.65	

Combinations of Alternative Measures

<u>Alternative Measures 2, 3, 4, and 7</u>

These measures implemented together would have synergistic effects. Given the difficulty in restoring shallow lakes it would be best to implement these measures together. These measures would in combination, contribute to restoring a vegetated clearer water ecosystem state in Marsh Lake, improving habitat conditions for migrating diving ducks, other waterfowl and shorebirds. Measure 4 implemented along with the others would provide water level management flexibility to adaptively respond to conditions in Marsh Lake, reducing the inter-annual variation in the abundance of aquatic vegetation and habitat conditions for waterfowl.

Restoring the Pomme de Terre River to its former channel would reduce sediment loading to Marsh Lake and reduce carp abundance, This would improve water clarity allowing increased growth of submersed aquatic vegetation and would reduce the abundance of carp that resuspend sediment and graze on aquatic vegetation by denying them winter dissolved oxygen refuge in the Pomme de Terre River.

Modifying Marsh Lake Dam with a fishway to attain target water levels would reduce the duration of high water events on Marsh Lake and provide more consistent water depth, allowing increased growth of submersed aquatic plants.

Conducting growing season drawdowns on Marsh Lake using a stop log water control structure would restore both emergent and submersed aquatic plants. Increased extent of emergent aquatic plants would reduce wind fetch and sediment resuspension. Winter drawdowns of Marsh Lake would reduce carp abundance, sediment resuspension and grazing by carp on submersed aquatic plants.

Constructing islands in Marsh Lake would increase submersed aquatic plants by significantly reducing wind fetch and sediment resuspension.

Considering the future ecosystem conditions in Marsh Lake with the combination of Alternative Measures 2, 3, 4, and 7, diving duck migration habitat conditions would be better than with the stand-alone alternative measures. Implementing these alternative measures together would result in 1326 AAHUs for diving duck migration habitat (Tables 28, 29).

Table 28. Diving duck migration habitat on Marsh Lake with combination of Alternative measures 2, 3, 4, and 7.

Diving duck migration habitat

Assume : There would be no change over time in the area of Marsh Lake = 6100 acres average growing season area
Alt 2 Re-routing PdT River to former channel will reduce sediment loading to Marsh Lake, increase water clarity, SAV growth
reduce over-winter survival of carp
Alt 3 Modify Marsh Lake Dam to attain target water levels, construct fishway will increase SAV growth
Alt 4 Drawdowns of Marsh Lake with stop log water control structure will increase EAV and SAV growth
Winter drawdowns of Marsh Lake will reduce carp abundance
Alt 7 Islands would protect against sediment resuspension and increase extent of SAV
If implemented together, these alternative measures would improve habitat condtiions in the first year following construction

Lake Migration Habitat for Diving Ducks	Existing Conditions Year 0	Future With Project - Year 1	Future With Project - Year 5	Future With Project - Year 25	Future With Project - Year 50
HSI	0.56	0.83	0.83	0.83	0.83
Acreage	6100.0	6100.0	6100.0	6100.0	6100.0
Year	0.0	1.0	5.0	25.0	50.0
Cumulative Annual Habitat Units	0	4239.5	20252.0	101260.0	126575.0
				Total	252326.5
				AAHU	5047

Combination Alternatives 2,3,4,7 Total AAHU	5047
No Action Total AAHU	3721
Alternative 7 Net Gain AAHU	1326

Table 29. HEP model of diving duck habitat in Marsh Lake with combination of alternative measures 2, 3, 4, and 7.

DIVING DUCK MIGRATION HABITAT MODEL

Marsh Lake with Pomme de Terre River restored to its former channel, attaining target water levels with a fishway, growing season and winter drawdowns using stoplog control structure, and with constructed islands

VARIABLE		VALUE	COMMENTS
1) Size of Water Body			
a. Less than 100 acres	1		
b. 100 to 200 acres	5	ENTER	
c. 200 to 1,000 acres	7	VALUE= 10	Marsh Lake is >1000 acres
d. Greater than 1,000 acres	10		
2) Water Depth - Percent of Area 18" to 5'			
a. Less than 10 percent	1		
b. 10 to 40 percent	3	ENTER	
c. 40 to 70 percent	5	VALUE= 10	Water depth is >70% area 18" to 5'
d. Greater than 70 percent	10		
3) Percent Submergent Vegetation Cover			Islands and drawdowns would allow SAV to grow to >50% cover most years
a. Less than 10 percent	1		
b. 10 to 30 percent	3	ENTER	
c. 30 to 50 percent	6	VALUE= 10	
d. Greater than 50 percent	10		
4) Species of Submergent Vegetation Present (Key species: wild celery, sago pondweed, and other pondweeds)			
a. None of the key species present or less than 10 percent of aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 10	SAV is mostly sago pondweed
c. At least one key species covers 30 to 60 percent of the aquatic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
5) Percent Emergent Vegetation Cover			
a. Less than 10 Percent or greater than 50 percent	1		
b. 10 to 20 percent or 30 to 50 percent	5	ENTER	Drawdowns will allow germination of EAV,
c. 20 to 30 percent	10	VALUE= 10	islands will shelter EAV, increase cover to >20%
6) Species of Emergent Vegetation Present (Key species: arrowhead (S. rigida), soft-stem bulrush, wild rice)			
a. None of the key species present or less than 10 percent fo aquatic bed	1		
b. At least one key species covers 10 to 30 percent of the aqutaic bed (add one point if more than one key species is present)	3	ENTER VALUE= 3	EAV will increase in diversity
c. At least one key species covers 30 to 60 percent of the aqutaic bed (add one point if more than one key species is present)	6		
d. Greater than 60 percent of aquatic bed is comprised of key food species	10		
7) Invertebrate Populations Present (Key Species: Sphaeriidae, Gastropoda,Hexegenia spp,Chironomidae)			
a. None of the key taxonomic groups present or present but not abundant	1		
b. At least 1 key taxonomic group present and is moderately abundant	5	ENTER VALUE= 5	Invertebrate community will remain dominated by chironomids, oligochaetes
c. At least 1 key taxonomic group present and is very abundant	10		
8) Disturbance			
a. Access uncontrolled - Considerable human activity during migration	1		
b. No hunting activity occurs, or closed to hunting only, but considerable human activity occurs during migration (such as fishing/boating)	3	ENTER VALUE= 4	Assume continued non-motorized zone
c. No hunting activity occurs, or closed to hunting only, and human activity during migration is minimal	4		
d. No human activity occurs, or closed to human entry	5		
		TOTAL= 62	
MAXIMUM POSSIBLE TOTAL =		75	
		HSI = 0.83	

Net Habitat Benefits of the Alternative Measures

Table 32 provides the net habitat benefits of the alternative measures and combinations of alternative meausures expressed as AAHUs, based on the selected representative species, models, acres affected and timing of habitat improvements.

Table 32. Net habitat benefit of the alternative measures for the Marsh Lake project.

Measure Number	Alternative Measures	Net Benefit (AAHU)
1	No Action	0
2	Restore Pomme de Terre River to its former channel	6567
3	Modify Marsh Lake Dam to attain target water levels, construct fishway	483
4	Growing season drawdowns to restore emergent aquatic plants, modify Marsh Lake Dam with stoplog structure	725
5	Install gated culverts in Louisburg Grade Road	610
6	Breach dike at abandoned fish pond	5
7	Construct islands in Marsh Lake	239
	Combinations of Measures	
2,3,4,7	PdT River to former channel	1326
	Modify Marsh Lake Dam with fishway	
	Modify Marsh Lake Dam with stop log structure, drawdowns	
	Construct islands in Marsh Lake	
3,4,5	Modify Marsh Lake Dam to attain target water levels, construct fishway	1372
	Growing season drawdowns to restore emergent aquatic plants, modify Marsh Lake Dam with stoplog structure	
	Install gated culverts in Louisburg Grade Road	