APPENDIX C

Devils Lake, North Dakota

Final
Integrated Planning Report
and
Environmental Impact Statement

Environmental Resources

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Introduction

This appendix is supporting documentation for Volume 1 and describes in more detail the baseline conditions and anticipated environmental effects associated with the various alternatives for flood damage reduction at Devils Lake. The information in this appendix contains information developed to date. A number of studies are presently being conducted on aquatic resources, biota transfer, soil salinity, groundwater, cultural resources, and terrestrial resources. The information in this appendix may need to be revised when these studies are completed.

The appendix is divided into 4 main sections:

1. Base Conditions.
2. Environmental Effects.
3. NEPA Process and Scoping.
4. Mitigation of Environmental Effects.

Studies conducted for this analysis have identified data deficiencies and gaps that could be filled in order to provide a baseline for resources and develop a more detailed analysis of any particular resource. While the Corps may agree that these gaps exist and it would be worthwhile to collect additional information, there are other factors, which influence what can be conducted for the study. The Corps has taken the information and based on, among other things, availability of funds, schedules, study authorization, significance of the issue, availability of existing information, potential effect on final decision, and consultation with other agencies, has made decisions on which studies to conduct. The existing information and the studies being conducted are adequate to draw conclusions and make recommendations related to the study. The results of these studies would be considered in developing the long-term monitoring plan and identifying possible mitigation measures.

The existing conditions are discussed by geographic region; upper basin, Devils Lake, Sheyenne River, and Red River. The environmental effects are presented by alternatives, with further breakdown into geographic regions. The results of the scoping process conducted in 1998 and 2001 are also summarized in this appendix. A Supplemental Scoping Document was prepared in July 2001.

Further coordination is required with the U.S. Fish and Wildlife Service in accordance with the Fish and Wildlife Coordination Act. Coordination accomplished to date in summarized in this appendix. A Coordination Act Report will be included with the EIS.

Potential mitigation costs are also estimated. This was used for the economic evaluation of the alternatives. These were preliminary estimates based on existing information. As studies are completed, mitigation needs may be revised.

1. Base Condition - Devils Lake Basin

Natural Resources

The discussion of natural resources is confined primarily to the study area and area of potential impact as defined in the geographic scope of analysis in the Scoping Document. The general discussion is presented to establish the overall setting.

The Devils Lake basin is the result of the last advance of continental ice sheets in North Dakota. Glacial Devils Lake was maintained at about elevation 1450 ft msl by glacial meltwater flowing from the retreating ice sheet to the north, by precipitation, and by snowmelt water. Several coulees provide drainage for the basin, delivering water to the Devils Lake chain. Mauvais Coulee, the largest drainage channel in the Devils Lake system, is a tributary to Lakes Alice and Irvine. Water flows in it intermittently, largely in response to precipitation and wetland drainage. Big Coulee flows through Pelican Lake and into West Bay Devils Lake.

Devils Lake itself supports a valuable sport fishery, which greatly improved during the 1980s and 1990s with rising water levels. Devils Lake is a brackish lake, developed through lake level fluctuations, which are beneficial to the support of the current fishery. Primary species pursued by anglers are walleye, northern pike, yellow perch, and white bass. White suckers and black bullheads are also present but not at population levels sufficient to degrade the quality of the sport fishery. At lower lake levels, virtually all game fish populations were maintained through stocking, due to low natural reproduction from brackish water quality. With current high lake levels freshening the lake, many species are experiencing successful natural reproduction. Forage species such as fathead minnows have increased dramatically with the high lake levels.

In the past, game fish reproduction in East Bay has been lower than western bays, due to high salinity levels. Reproductive success of fish other than fathead minnows and brook sticklebacks in East Bay has been low. Only adult fathead minnows and brook sticklebacks were caught in West Stump Lake in 1987 and 1988. With recent high lake levels, game fish reproduction has expanded in the lakes and in 1997 perch have been successfully stocked in Stump Lake.

Prior to 1965, no game fishery existed in Devils Lake. Routine stocking of game fish was initiated in 1965. During the 1980s and 1990s the fishery improved, which resulted in a dramatic increase in recreational use of the lake. Most fishing activity occurs in Devils Lake west of Highway 57.

Long-term maintenance of the fishery in Devils Lake is dependent on the balanced relationship of nutrients, salinity, water levels, and total dissolved solids (TDS) concentrations. Fluctuating lake levels provide excellent habitat and TDS concentrations around 1000 ppm influence natural reproduction. This balance of water quality constituents helps to prevent oxygen depletion from occurring, has limited fish reproduction, and regulates algae blooms. The result has been a simple but highly productive and valued fishery.

Fish species identified in various portions of the Devils Lake study area are identified in Table C-1 below.

Table C-1. COMPARISON OF FISH SPECIES OF THE PROJECT AREA

		LOCATION						
Scientific Name	**Common Name**	Upper Sheyenne	Lake Ashtabula	Lower Sheyenne	Devils Lake	Upstream Lakes	Red River of the North	Lake Winnipeg
Acipenser fulvescens	lake sturgeon						X	X
Ambloplites rupestris	rock bass			X			X	X
Ameiurus melas	black bullhead	X	X	X			X	X
Ameiurus natalis	yellow bullhead						X	
Ameiurus nebulosus	brown bullhead	X	X					X
Aplodinotus grunniens	freshwater drum			X			X	X
Carassius auratus	goldfish			X			X	
Carpiodes carpio	river carpsucker			X			X	X
Carpoides cyprinus	quillback			X			X	
Catostomus catostomus	longnose sucker							X
Catostomus commersoni	white sucker	X	X	X	X		X	X
Coregonus artedi	lake cisco							X
Coregonus clupeaformis	lake whitefish							X
Cottus bairdi	mottled sculpin							X
Cottus cognatus	slimy sculpin							X
Cottus ricei	spoonhead sculpin							X
Couesius plumbeus	lake chub							X
Culaea inconstans	brook stickleback	X	X	X	X	X	X	X
Cyprinella spiloptera	spotfin shinner			X			X	
Cyprinus carpio	carp			X			X	X
Esox lucius	northern pike	X	X	X	X	X	X	X
Esox masquinongy	muskellunge			X	X		X	
Esoxlucius SE. masquinongy	tiger muskie				X			
Etheostoma exile	Iowa darter	X	X	X				X
Etheostoma nigrum	Johnny darter	X	X	X				X
Hiodon alosoides	goldeye						X	X
Hiodon tergisus	moneye			X			X	X
Hybognathus hankinsoni	brassy shinner			X				
Ichthyomyzon castaneus	chestnut lamprey						X	X
Ichthyomyzon unicuspis	silver lamprey						X	X
Ictalurus melas	black bullhead	X	X	X	X		X	
Ictalurus punctatus	channel catfish			X			X	X
Ictiobus cyprinellus	bigmouth buffalo			X			X	X
Lepomis cyanellus	green sunfish	X	X	X			X	
Lepomis gibbosus	pumpkinseed	X	X	X			X	
Lepomis humilis	orange spotted sunfish	X	X	X			X	
Lepomis macrochirus	bluegill	X	X	X			X	
Lota lota	burbot						X	X
Macrhybopsis storeriana	silver chub			X			X	X
Micropterus dolomieu	smallmouth bass	X	X	X			X	X
Micropterus salmoides	largemouth bass	X	X				X	
Mocomis biguttatus	hornyhead chub			X				
Morone chrysops	white bass	X	X	X	X		X	X
Moxostoma anisurum	silver redhorse			X			X	X
Moxostoma erythrurum	golden redhorse			X			X	X
Moxostoma macrolepidotum	shorthead redhorse			X			X	X
Moxostoma valenciennesi	greater redhorse			X			X	
Notemigonus crysoleucas	golden shinner	X	X	X			X	
Notropis anogenus	pugnose shinner			X				
Notropis atherinoides	emerald shinner			X			X	X
Notropis blennius	river shinner			X			X	

Notropis cornutus	common shinner	X	X	X			X	
Notropis dorsalis	bigmouth shinner			X			X	
Notropis heterodon	blackchin shinner			X				X
Notropis heterolepis	blacknose shinner			X				X
Notropis hudsonius	spottail shinner	X	X	X			X	X
Notropis rubellus	rosyface shinner			X				
Notropis stramineus	sand shinner	X	X	X			X	
Notropis texanus	weed shinner							X
Notropis volucellus	mimic shinner							X
Noturus flavus	stonecat			X			X	
Noturus gyrinus	tadpole madtom	X	X	X			X	X
Oncorhynchus mykiss	rainbow trout	X						
Osmerus mordax	rainbow smelt						X	X
Perca flavescens	yellow perch	X	X	X	X	X	X	X
Percina carprodes	logperch						X	X
Percina maculata	blackside darter	X	X	X			X	X
Percina shumardi	river darter			X			X	X
Percopsis omiscomaycus	trout-perch	X	X	X			X	X
Phaxinus eos	northern redbelly dace			X				
Pimephales notatus	bluntnose minnow			X				
Pimephales promelas	fathead minnow	X	X	X	X	X	X	X
Platygobio gracilis	flathead chub						X	X
Pomoxis annularis	white crappie	X	X	X			X	
Pomoxis nigromaculatus	black crappie	X	X	X	X		X	X
Pungitlus pungitius	ninespine stickleback							X
Rhinichthys atratulus	blacknose dace	X	X	X			X	
Rhinichthys cataractae	longnose dace	X	X	X			X	X
Salvelinus namaycush	lake trout	X						X
Semotilus atromaculatus	creek chub	X	X	X			X	
Stizostedion canadense	sauger			X			X	X
Stizostedion vitreum	walleye	X	X	X	X		X	X
Umbra limi	central mudminow			X			X	X

Tiger muskie have been introduced into the Red River drainage. Striped bass were introduced into Devils Lake in the past, but their continued presence there is doubtful.

Sources:

Peterka, J.J. 1978. Fishes and Fisheries of the Sheyenne River, North Dakota. Ann. Proc. N.D. Acad. Sci. Vol.32, Pt. II, Dec. 1978, p29-44.

Goldstein, R.M. 1995. Aquaticer Communities and Contaminants in Fish from Streams of the Red River of the North Basin, Minnesota and North Dakota. USGS Water Res Inv. Rpt. 95-4047.

Garrison Joint Technical Committee. 1996. Preliminary Assessment of the Environmental Effects with International Implications of a Transfer of Water from Devils Lake to the Hudson Bay Drainage.

Fish parasites recorded in various portions of the basin are identified in Table C-2 below.

Table C-2. Fish Parasites

Scientific Name (Parasite)	Location: Upper Sheyenne (US); Ashtabula (A); Lower Sheyenne (LS) Devils Lake (DL); Lake Winnipeg (LW)
Monogenea	
Cleidodiscus adspectus	A,LS
C. pricei	A,LS
Dactylogyrus acicularis	LS
D. extensus	LS
Dactylogyrus spp.	US
Gyrodactylus hoffmani	DL
Tetraonchus monenteron	US
Digenea	
Allocreadium ictaluri	LS
Alloglossidium corti	LS
Bucephaloides pusillus	LS
Bucephaloides sp.	LS
Clinostomum marginatum	US, A
Crepidostomum cooperi	A
C. ictaluri	LS, A
C. illinoiense	A, LS
Diplostomulum spathaceum	US, A, LS,DL
Hysteromorpha triloba	US, A, LS
Neascus spp.	US, DL,A, LS
Neochasmus umbellus	LS
Phyllodistomum lysteri	A
Phyllodistomum staffordi	US,A,LS
Tetracotyle diminuta	A
T. intermedia	A,LS
Triganodistomum attenuatum	A
Cestoda	
Biacetabulum macrocephalum	A
Bothriocephalus cuspidatus	A,LS
Caryophyllid	LS
Cestode	A,LS
Coroallotaenia minutia	A,LS
Corallobothriin	US, A,LS
Ligula intestinalis	DL
Proteocephalus pearsi	A
Proteocephalus pinguis	US;A, DL, LS
Proteocephalus spp.	US; DL, A, LS
Triaenophorus nodulosus	LS
Nematoda	
Camallanus lacustris	A,LS
C. oxycephalus	A,LS
Camallanus sp.	A,LS
Contracaecum spiculigerum	US,A,LS, DL
Contracaeum spp.	US,A,LS
Metabronema salvelini	LS
Rhabdochona cascadilla	US,LS
R. ovifilamenta	LS
Spinitectus gracilis	US,A,LS
Spinitectus sp.	A
Spiroxys sp.	US
Acanthocephala	
Leptorhychoides thecatum	LS

Neoechinorhynchus prolixum	LS
Octospinifer macilentus	US, LS
Pomphorhynchus bulbocolli	US, A
Rhadinorhynchus sp.	DL
Hirudinea	
Actinobdella triannulata	A
Myzobdella moorei	US, LS
Placobdella montifera	US
Crustacea	
Achtheres ambloplitis	LS
Argulus appendiculosus	US
A. catostomi	US, A
Ergasilus centrarchidarum	A,LS
Ergasilus cyprinaceus	US
E. versicolor	US,A,LS
Ergasilus spp.	US
Lernaea cyprinacaea	US
Lernaea sp.	US

Screening studies for fish parasites and viruses conducted in 2001 by the U.S. Fish and Wildlife Service did not identify any organisms in Devils Lake that are not already present in the Red River drainage or considered to be the result of widespread distribution.

Wildlife in the Devils Lake basin is closely associated with water and wetlands. Shallow-water wetland habitats are clearly the most valuable habitat types for waterfowl. Many wildlife and waterfowl species utilize lakes in the Devils Lake chain and surrounding habitats. Stump Lake has long been known as an excellent staging and breeding area for waterfowl and shorebirds. In 1905, President Theodore Roosevelt declared the west bay of Stump Lake as a National Reservation, making it one of the oldest refuges in the nation.

The Devils Lake basin and downstream rivers also provide breeding or migratory habitat for a number of Federally listed threatened or endangered species. Table C-3 provides a list of these species and North Dakota and Minnesota counties in which they are listed.

Table C-3. Threatened and Endangered Species

Species and Status	Ramsey	Benson	Towner	Cavalier	Nelson	Walsh	Sheridan	Wells	Eddy	Griggs	Barnes	Ransom	Richland	Cass	Grand Forks	Pembina	Traill	Clay	Norman	Polk	Marshall	Kittson
	COUNTIES																					
	North Dakota Counties																	**Minnesota Counties**				
	Devils Lake Counties																					
Bald Eagle - T	X	X	X	X	X	X																
Whooping Crane - E		X	X	X																		
Gray Wolf - E			X	X																		
Piping Plover - T		X				X																
	Sheyenne River Counties																					
Bald Eagle - T		X			X		X	X	X	X	X	X	X	X								
Whooping Crane - E		X					X	X	X	X	X											
Piping Plover - T		X					X	X	X													
Western Prairie Fringed Orchid - T												X	X									
	Red River Counties																	**Red River Counties**				
Bald Eagle - T						X							X	X	X	X	X			X	X	X
Western Prairie Fringed Orchid - T													X					X	X	X		X
Gray Wolf - E						X									X	X				X	X	X
Canada Lynx - T																						X

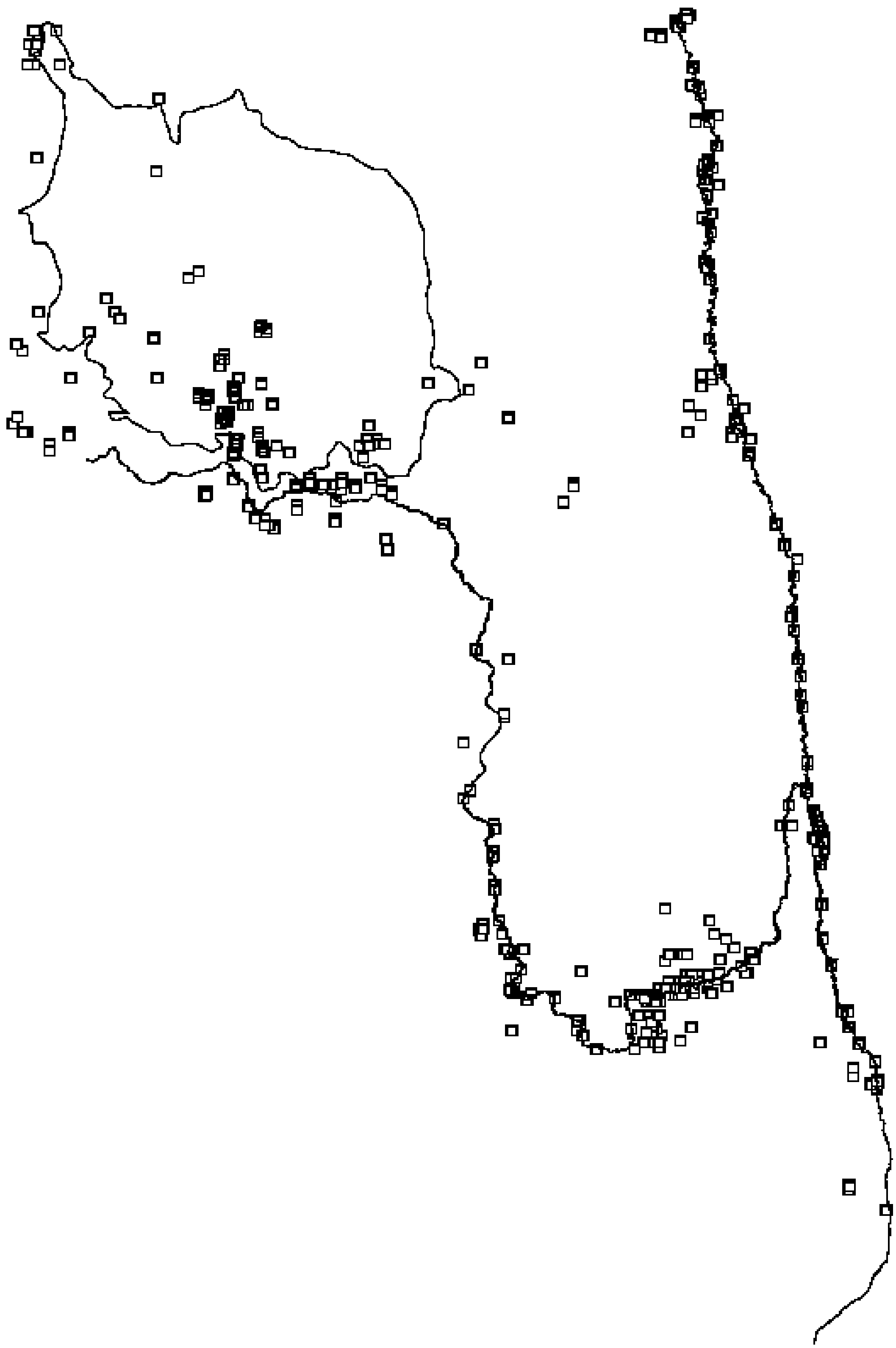
Source: U.S. Fish and Wildlife Service.

The States of North Dakota and Minnesota have developed lists of natural heritage sites, which exhibit significant natural or cultural values (Table C-4). These include wildlife and vegetation species, vegetation types, and aquatic resources. There are 70 natural heritage sites listed in the Devils Lake basin.

Table C-4. NATIONAL HERITAGE SITES IN THE DEVILS LAKE STUDY AREA

Location	Number of Sites by Type									
	Stream	Plant	Mussel	Vegetation	Fish	Reptile/ Amphibian	Insect	Animal	Bird	**TOTAL**
West End Outlet Route	0	0	0	0	0	0	0	0	0	0
Sheyenne River (within 1/4 mi.)										
Above Baldhill Dam	2	1	2	1	0	0	0	0	0	6
Below Baldhill Dam	3	76	31	62	19	3	9	0	10	213
Sheyenne River Total	5	77	33	63	19	3	9	0	10	219
Sheyenne River (flooded area)										
Above Baldhill Dam	1	0	1	0	0	0	0	0	0	2
Below Baldhill Dam	0	6	11	3	0	0	2	0	1	23
Sheyenne River Total	1	6	12	3	0	0	2	0	1	25
Red River (within 1/4 mile)										
North of Grand Forks	3	2	34	5	4	0	0	4	3	55
South of Grand Forks	0	0	16	7	3	0	0	0	1	27
Red River Total	3	2	50	12	7	0	0	4	4	82
Devils Lake										
1447 to 1459	3	2	0	6	0	0	0	0	9	20
1449 to 1463	0	0	0	1	0	0	0	0	2	3
Devils Lake Total	3	2	0	7	0	0	0	0	11	23
Upper Basin Depressions	1	0	0	1	0	0	0	0	5	7

Figure C-1. Natural heritage sites located within the Devils Lake basin and along the Sheyenne and Red Rivers in North Dakota and Minnesota.



The following Figures (C-2 and C-3) show the locations of rare fish and mussel species based on the Natural Heritage Inventory.

Figure C-2. Rare fish species.

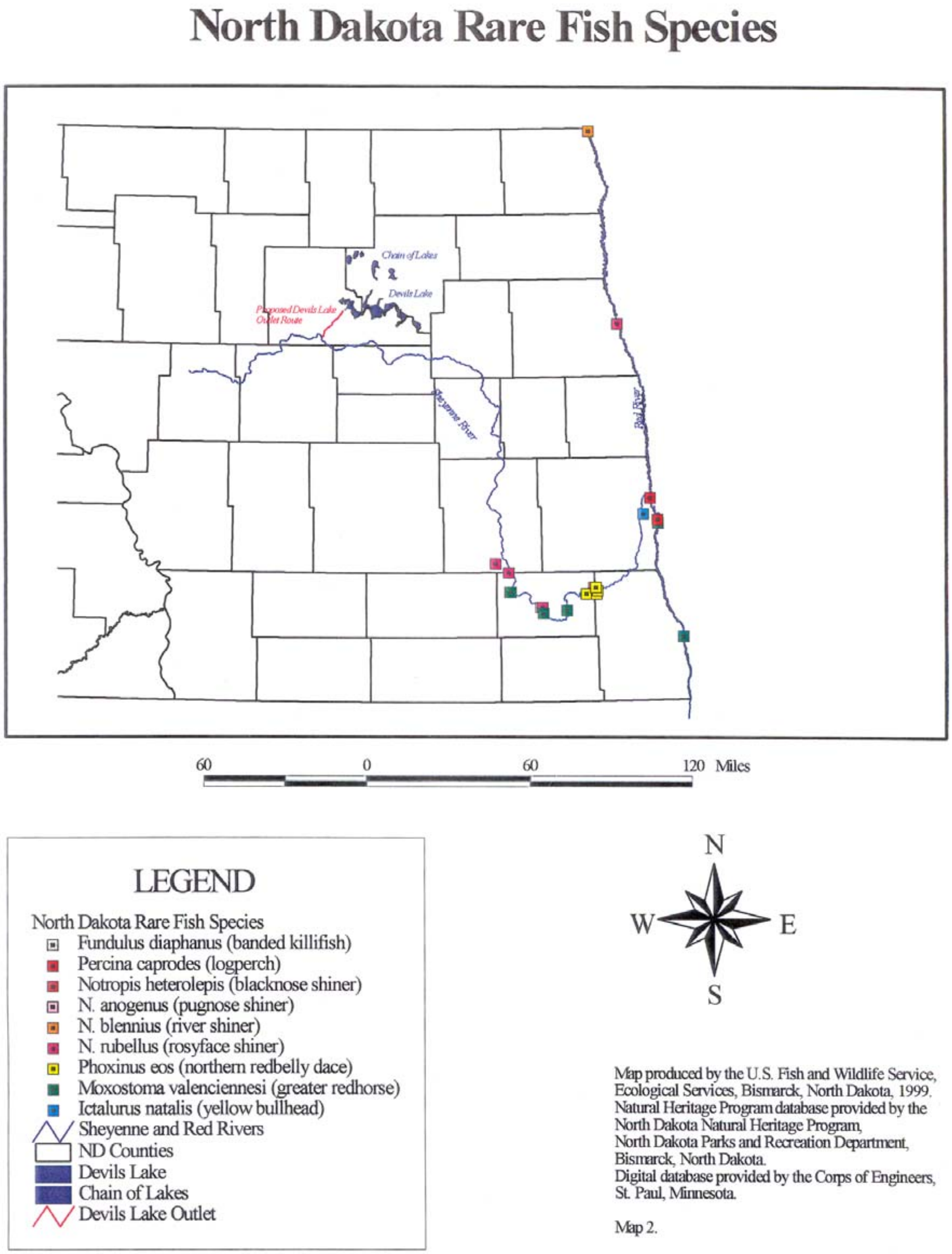
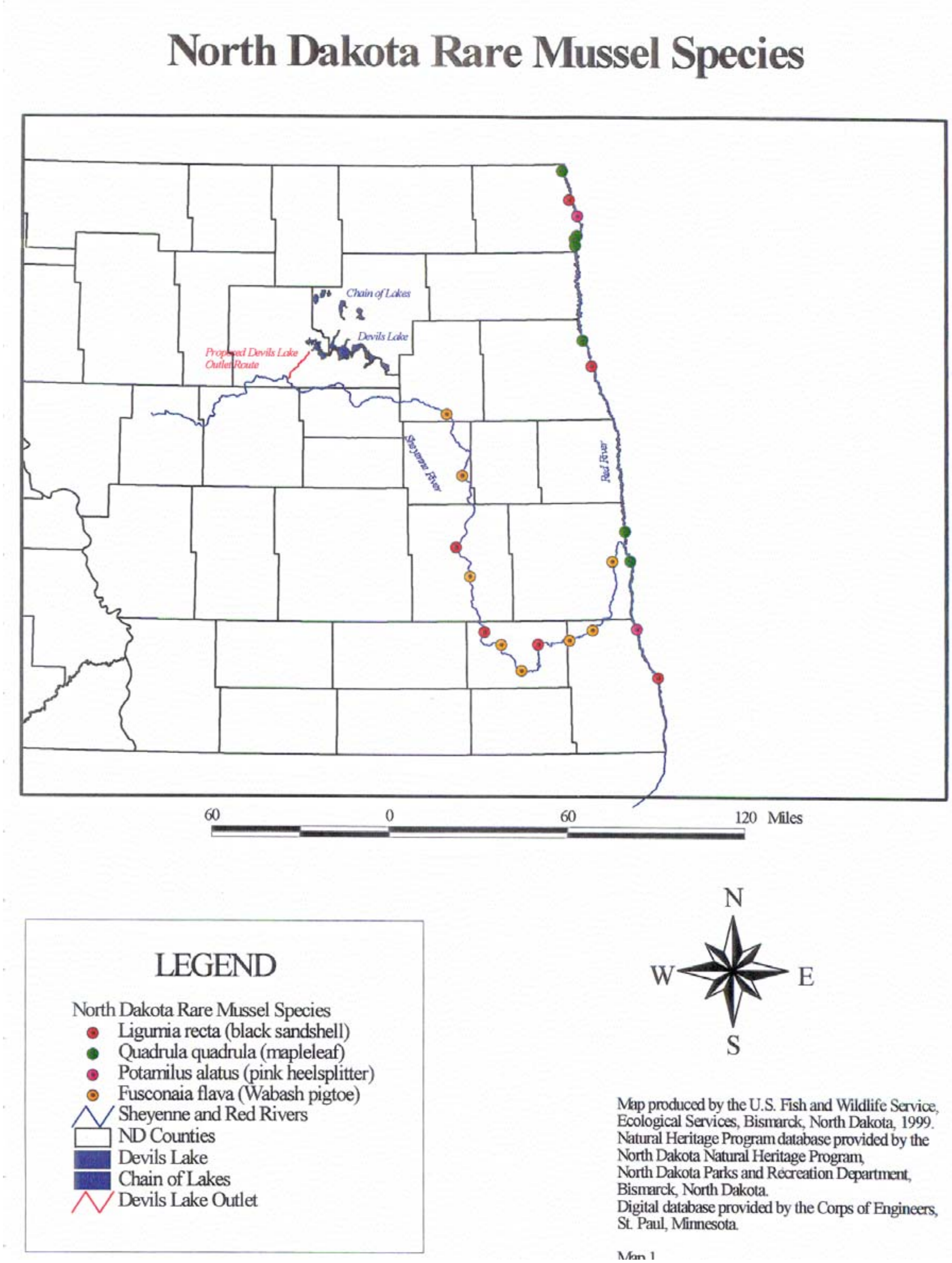


Figure C-3. Rare Mussel Species.



Land use around Devils Lake is presented in Table C-5. The dominant land use is agricultural.

Table C-5. Land Use by Elevation Around Devils Lake

Land Use	Elevation Zone				TOTAL
	1447-1450	1450-1455	1455-1461	1461-1463	
Cropland	11,158	17,957	47,621	14,587	91,323
Woodland	3,047	2,030	3,425	1,120	9,622
Grassland	7,739	6,940	17,854	5,665	38,198
Grass-Shrub	48	22	20	5	95
Wetland (NWI)	10,445	3,696	18,148	2,333	34,622
Wetland (LTM)	1,765	2,366	5,102	1,089	10,322
Urban	296	326	833	269	1,724
TOTAL	34,498	33,337	93,003	25,068	185,906

Source: 30 meter Landsat Thematic Mapper (LTM) 1987 through 1994
Wetland information from U.S. Fish and Wildlife Service National Wetlands Inventory (NWI)
Total wetland acreage includes areas classified as river.

Table C-6 below shows the distribution of Conservation Reserve Program (CRP) lands within the basin based on the percent of the county within the basin (see table below). Approximately 200,000 acres of land is currently under the CRP program in the basin.

Table C-6.

Estimate of Conservation Reserve Program (CRP) Acreage in the Devils Lake Basin

County	CRP Acreage by County	Percent of County in the Basin	Estimated CRP Acreage in the Basin *
Benson	43,621	50	21,811
Cavalier	29,848	22	6,567
Nelson	108,756	32	34,802
Pierce	87,367	11	9,610
Ramsey	69,288	100	69,288
Rolette	68,323	22	15,031
Towner	54,336	67	36,405
Walsh	88,348	9	7,951
Total	**549,887**		**201,465**

Source: U.S. Fish and Wildlife Service 1997 Planning Aid Letter and Substantiating Report Devils Lake Feasibility Study.

* Based on percent of county within the basin

Land use in the entire Devils Lake basin is distributed as follows: cropland, 64 percent; grassland, 22 percent; urban 0.4 percent; wetland, 11 percent; and woodland, 3 percent (Figure C-4).

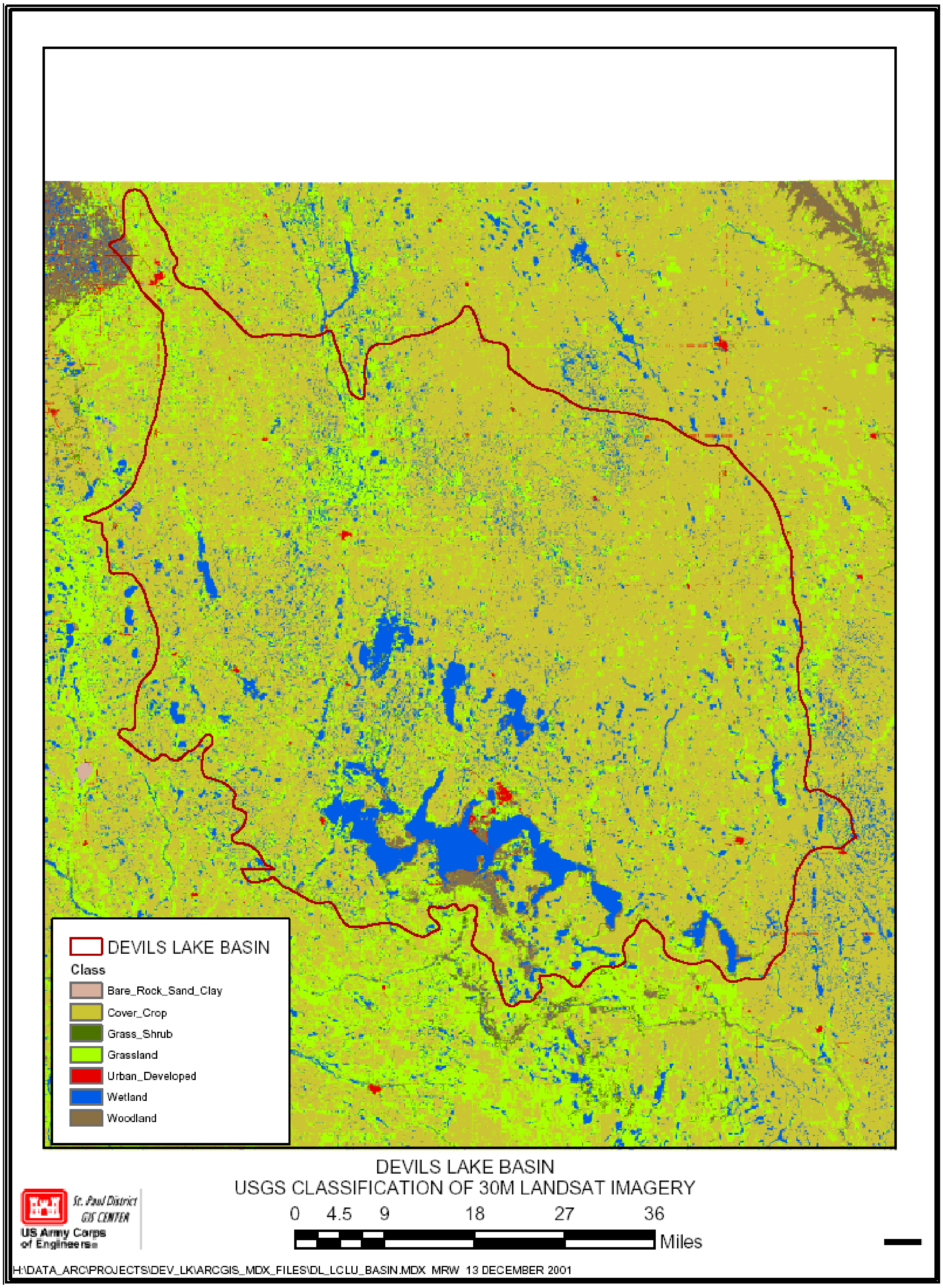


Figure C-4. Land use in the Devils Lake Basin

There are a number of programs available in the Devils Lake basin to assist landowners in land management practices and restoration activities. The U.S. Environmental Protection Agency reviewed these programs in a report prepared in 1999. The following summarizes these programs.

Table C-6A summarizes the applicable wetland restoration and upper basin storage programs. As shown, there are many programs that provide financial incentive to landowners to store water or restore wetland and upland habitats.

Table C-6A
Summary of Watershed Management Programs

Federal				
Natural Resources Conservation Service	Conservation Reserve Program	The CRP provides incentive payments to farmers to convert highly erodible cropland or other sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers.	Farmers receive an annual payment up to 50 percent of the owners costs for the term of the multiyear contract. The rates are based on the soils in the county and the average of the last 3 years cash rent. Further, wetland restoration is encouraged by payment of up to 25 percent of the costs. Contracts last 10 to 15 years.	NRCS P.O. Box 1458 Bismarck, ND 58501 (701) 250-4441
	Emergency Watershed Protection Program	The EWP program provides property owners with agricultural lands prone to frequent flooding with an opportunity to minimize flood risks and losses to their property. Three options are associated with this program: (1) retire the land completely from production and return it to a natural state; (2) restrict the production of agricultural crops, but allow haying, grazing, or silviculture; or, (3) retain the right to cropping, haying, grazing, or silviculture, while ceding all other land uses to the United States, including development and future federal disaster payments.	NRCS provides 100 percent of the funds for emergency measures. Funding for this program is appropriated year to year as deemed necessary.	

Natural Resources Conservation Service	Wetland Reserve Program	The WRP is a voluntary program designed to protect and restore wetlands on private property. The WRP provides three options to landowners: (1) permanent easements; (2) 30-year easements; and (3) 10-year restoration cost-share agreements. The WRP could be applied to land that is already under water. Eligible lands for WRP include: wetlands farmed under natural conditions, farmland that has become a wetland as a result of flooding; rangeland, pasture, production forests; riparian zones, lands adjacent to protected wetlands and previously restored wetlands.	If the landowner selects a permanent easement, the NRCS covers the restoration and legal costs and compensates the landowner with the lesser of an area rate cap, the appraised agricultural value, or an amount proposed by the landowner. For the 30-year easement option, the NRCS pays all legal costs and 75 percent of what would be paid for a permanent easement. For the 10-year restoration cost-share, 50 to 75 percent is reimbursed.	NRCS P.O. Box 1458 Bismarck, ND 58501 (701) 250-4441
	Environmental Quality Incentives Program	All EQIP activities must be carried out according to a conservation plan. EQIP seeks to seed land back to grass for haying, pasture or range. EQIP also offers property owners incentive payments to substantially reduce erosion rates through residue management.	Up to 75 percent of costs are reimbursed. Cost-share and incentive payments are limited to $10,000 per person per year and $50,000 for the life of the contract. Agreements last for 5 to 10 years. Residue management incentive payments up to $12 per acre, maximum of 160 acres over a 3-year period are available.	
Natural Resources Conservation Service	Wildlife Habitat Incentives Program	WHIP provides financial incentives to develop habitat for fish and wildlife on private lands. Participants agree to implement a wildlife habitat development plan and NRCS agrees to provide cost-share assistance for the initial implementation of wildlife habitat development practices.	NRCS and program participants enter into a cost-share agreement for wildlife habitat development. If the participant agrees, cooperating state or private organizations may provide expertise or additional funding. These agreements generally last a minimum of 10 years.	NRCS P.O. Box 1458 Bismarck, ND 58501 (701) 250-4441

U.S. Fish and Wildlife Service	Partners for Fish and Wildlife	This program provides financial aid to private landowners to restore or create wetlands and to plant uplands to grass. Cost-sharing is secured from federal, state, local, and private agencies.	Up to 100 percent of costs are reimbursed for restoring (10 year agreements) or creating wetlands (20-30 year agreements). For planting crops to tame or native grasses, 80 percent of costs are reimbursed (10-20 year terms).	Kevin Willis USFWS 1500 Capitol Avenue Bismarck, ND 58501 (701) 250-4418 kevin_willis@fws.gov
	Wetland Easement Program	This wetland preservation program perpetually protects against draining, filling, leveling or burning. When wetlands naturally dry, landowner can hay, graze or farm area. Eligible properties must have wetlands of value to waterfowl.	Payment to landowner is based on total wetland acreage and the wetland complex on property. Cost-sharing for restoration work may be available.	
U.S. Bureau of Reclamation	Wetland Development Program	This program is designed to restore, create, and enhance wetlands and riparian habitats. First priority is given to projects on lands managed directly by USBR followed by projects on lands managed by other DOI agencies. To date, USBR has worked with USFWS and Ducks Unlimited to develop multipurpose wetlands on public lands managed by the USFWS.	The Wetland Development Program has not been implemented on private properties to date.	Dr. Rick Nelson USBR Dakotas Area Office P.O. Box 1017 Bismarck, ND 58502
State				
North Dakota State Water Commission	Available Storage Acreage Program	ASAP provides temporary storage of water that would otherwise contribute to Devils Lake. This program is largely implemented through creating water storage on agricultural or other lands through lease agreements on a yearly basis.	Landowners receive compensation for temporary storage of water on land in the upper basin. Reimbursements are based on bids and have ranged from $30 to $100 per acre.	NDSWC 900 E. Boulevard Ave. Bismarck, ND 58505-0850 (701) 328-4968

North Dakota Department of Agriculture	Waterbank Program	The Waterbank Program makes annual payments to farmers for setting aside wetlands and creating adjacent wildlife habitat. All leased tracts must be open to public walking access and have a ratio of one to three wetlands to uplands.	The compensation ranges from $8 to $30 per acre per year, based on soil types and county (up to 160 acres per participant). Agreements are made for 5- or 10- year increments.	Judy Carlson NDDA 600 E. Boulevard Ave. Department 602 Bismarck, ND 587505-0020 (701) 328-4997
North Dakota Game and Fish	Private Lands Initiative	This program provides rental agreements and cost-sharing to develop or protect wildlife habitat. The agreements typically last 3 to 6 years and are renewable. Participants must agree to open their land to public walking access.	Payments are based on the soil classification or are cost-share agreements for the habitat development or wetland restoration.	Greg Link NDGFD 100 N. Bismarck Expwy Bismarck, ND 58501-5095 phone: (701) 328-6331 fax: (701) 328-6532
North Dakota Department of Health	Nonpoint Source Pollution Control Projects (CWA Section 319 Projects)	Section 319 funding is available to local or state project sponsors through a competitive grant process. All projects submitted from North Dakota compete against other proposals submitted within EPA Region 8. After all proposals have been reviewed, the states are notified of the projects to receive funding and the funds are allocated.	Through a competitive grant process, EPA provides 60 percent of the funding for selected projects. The remaining 40 percent must come from state or local sources. The state or local match may be in the form of in-kind services. The funds are available for expenditure for up to 5 years after they are allocated.	NDDH Division of Water Quality 1200 Missouri Avenue P.O. Box 5520 Bismarck, ND 58506-5520 phone: (701) 328-5214
	Clean Water State Revolving Fund	The CWSRF provides grants to states and Puerto Rico. CWSRF has most commonly been used to finance municipal wastewater treatment projects, but is available to fund a broad range of watershed-based activities.	Assistance is typically in the form of low-interest loans; financing is also available for loan guarantees, bond insurance or refinancing of existing debt. Loans cover 100 percent of eligible costs and can be up to 20 years in length.	

Private				
North Dakota Wetlands Trust	Conservation Reserve Program Piggy-Back Program	CRP provides a one-time incentive payment to restore the wetland hydrology on drained wetlands. The restoration lasts the life of the associated CRP contract.	The NRCS, USFWS, Ducks Unlimited and NDWT are sharing the costs of plugging ditches.	Sharon Clancy NDWT 502 Highway 2 West Devils Lake, ND 58301 (701) 662-4088
	Efficiency Incentive Program	EIP provides annual payments to landowners for restoring wetlands and planting surrounding uplands to grass. To qualify for the program, the tracts should include restorable wetlands and the owner should set aside uplands around the wetlands at a 3 uplands acre to 1 wetlands acre ratio. Tracts should be 40 to 160 acres in size.	All costs of restoring the wetlands are paid for by the NDWT. In addition, an annual payment of $20 per acre for 15 years is paid to the landowner. Uplands that are planted in grass or dense cover are reimbursed at a rate of $35 per acre per year.	
	Create-A-Wetland	This program provides annual temporary storage of water.	The landowner is compensated at a rate of $10 per acre for water held until April 15 and $40 per acre for water held until July 15. The commitment must be for a minimum of 3 years.	
Delta Waterfowl Foundation	Adopt-A-Pothole	Agreements with landowners last 10 years. Landowners agree not to alter uplands and wetlands in the contract. The program also restores drained wetlands that have been used for crop production.	Delta Waterfowl may provide remuneration for inconvenience and associated costs. Landowners sign a 10-year contract to grow duck nesting habitat.	Lloyd Jones Delta Waterfowl P.O. Box 3128 Bismarck, ND 58502 (701) 222-8857

Ducks Unlimited, Inc.	Conservation Easement Program	The program sets up perpetual conservation easements with private landowners allowing the landowner to protect key natural habitats while continuing to use the area for economic gain or recreation. Interested donors contact Ducks Unlimited, which then conducts an assessment of the property to determine if it has resources and values pertinent to Duck's Unlimited's mission. Each conservation easement is tailored to the participant.	The donating landowners receive assistance from Ducks Unlimited in land management and yearly monitoring to ensure continued protection of the natural resources. The landowners receive a tax allowance of up to 30 percent of adjusted gross income for their donation which can be spread over 5 years. In addition, reductions in estate taxes and local taxes may result due to the easement.	Ducks Unlimited, Inc. 3502 Franklin Avenue Bismarck, ND 58501 phone: (701) 258-5599
	Grasslands for Tomorrow	Grasslands for Tomorrow was developed from concern that the CRP successes to return cropland to grassland would disappear once the short-term contracts expire. This initiative focuses on employing approved grassland management techniques, conservation tillage practices, conservation easements, and wetland developments on private property to provide habitat for waterfowl.	Ducks Unlimited contributes funds to groups and agencies whose work is consistent with Ducks Unlimited's mission.	
	Matching Aid to Restore Habitat Program	Ducks Unlimited works with state fish and game agencies to provide funding for habitat restoration.	Ducks Unlimited makes matching grants at the 50 percent funding level.	

In summary, the main Devils Lake chain consists of an excellent sport fishery and provides habitat for a wide range of aquatic, wildlife, and avian species. The recreational opportunities provided by the lake result in tremendous economic value to the area.

Cultural Resources

Only portions of the Devils Lake shoreline (e.g., recreation areas, Grahams Island State Park, City of Devils Lake levee alignments) between elevations 1444' and 1465' have been surveyed for cultural resources. Known cultural resource sites along the Devils Lake shoreline between elevations 1444' and 1447' include four prehistoric archeological sites, six historic archeological sites, and ten architectural/standing structure sites. Three of these sites have been determined to be eligible to the National Register of Historic Places.

Known cultural resource sites along the Devils Lake shoreline between elevations 1447' and 1465' include nine prehistoric archeological sites, six historic archeological sites, and sixteen architectural/standing structure sites. This group of sites contains one National Register eligible site and two National Register listed sites (Benson County Courthouse and Grace Episcopal Church in Minnewaukan). There are also unverified leads to four prehistoric archeological sites, eight historic archeological sites, and twelve architectural sites in the Devils Lake area between elevations 1444' and 1465'.

Less than 10 percent of the Stump Lakes vicinity and the channel connecting East Devils Lake with Stump Lakes between elevations 1407' and 1465' has been surveyed for cultural resources. Three small areas have been surveyed along Tolna Coulee. One prehistoric archeological sites and one historic archeological site are recorded for the Stump Lakes area between elevations 1407' and 1447'. One additional prehistoric archeological sites and one architectural/standing structure site are recorded from elevation 1447' to 1465'. One prehistoric archeological site is recorded for Tolna Coulee. There are no sites recorded for the connecting channel below 1460'. There are no National Register eligible or listed sites for these areas. There is one unverified lead to a prehistoric archeological site between 1460' and 1465' at Stump Lakes and an unverified lead to a historic archeological site near the mouth of Tolna Coulee.

Base Condition - Upper Basin

Natural Resources

The Devils Lake basin is located within the transitional zone between the tall grass and mixed grass prairies. Historically, nearly 2 million acres of the Devils Lake basin was native grasslands, interspersed with wetlands, woodland, and shrub lands. By the mid-1970s, only 127,875 acres of native grassland remained, comprising 8 percent of the basin's cover type.

Land use in the upper basin is dominated by cropland, with about 65 percent of the sites identified as potential depression storage sites classified as such.

Grassland in association with wetlands is vital to upland nesting waterfowl and other migratory birds. Native grasslands are also important habitat for resident species such as sharp-tailed grouse, pheasant, partridge, deer, rabbit, skunk, and many nongame bird species.

Woodlands cover about 3 percent of the basin. The native forest surrounding the Devils Lake chain ranks as one of the three largest blocks of contiguous forest remaining in the state. Because North Dakota has such limited woodlands, prairie woodland habitat in the basin is valuable to a wide variety of wildlife. The rising lake levels have resulted in the inundation of thousands of acres of woodlands and the loss of over 1 million trees.

Wetland habitats of Devils Lake and its watershed can be grouped into broad categories which provide several functions and values unique to wetlands such as flood water storage, habitat for wildlife, filtering of polluted water, and groundwater recharge. Most of the wetlands in the basin can be classified as palustrine, emergent, temporarily, seasonally and semipermanently flooded wetlands. The upper basin chain of lakes can be described as lacustrine.

Base Condition - Sheyenne River

Natural Resources

The Sheyenne River is one of four major North Dakota tributaries to the Red River, with a watershed of 6,910 square miles. The upper reach of the river is a narrow and relatively small river with intermittent flows ranging from flood, usually in the spring, to occasional no flow in the summer. The channel capacity is estimated at about 600-cfs. The average flows and stages for various portions of the Sheyenne and Red Rivers are shown in Table C-7.

Table C-7. STAGE AT VARIOUS CONTROL POINTS							
	LOWEST FLOW ON USGS RATING		MEAN MAY FLOW		MEAN AUG FLOW		NWS
GAGE	Q	STAGE	Q	STAGE	Q	STAGE	FLOOD STAGE
Insertion Point	0	1423.3	64	1423.7	4	1423.3	
Sheyenne	0	3.5	64	3.9	4	3.6	
Warwick	3	2.1	108	2.8	29	2.4	
Cooperstown	0	9.5	235	10.5	69	9.9	19.0(Old)
Valley City	0	2.9	391	4.6	61	3.3	13.0
Lisbon	2	1.8	383	4.2	160	3.1	11.0
Kindred	20	2.2	522	5.0	160	2.9	16.0
Horace	74	11.0	540	15.3	165	11.9	
West Fargo	17	3.0	557	9.3	170	5.7	16.5
Halstad	158	2.6	3681	10.0	1124	5.3	24.0
Grand Forks	510	14.9	6808	18.2	2298	16.1	28.0
Drayton	430	10.3	9268	16.8	2637	11.9	32.0
Emerson	52	744.0	12539	763.0	2951	751.0	781.5
Winnipeg			15293		2564		

1. Some of the USGS gauges are located upstream of small dams. Stations with dams d/s are Sheyenne, Warwick, and Cooperstown; RRN gauges at Drayton and Grand Forks are upstream of dams.

2. Insertion point mean May and Aug flows are for the town of Sheyenne gage. Gauge discontinued after 1951.

Lake Ashtabula is a popular recreation area located about midway along the river's length. Boating, swimming, and fishing are popular activities in the 5,430-acre reservoir.

The river from Lake Ashtabula to just below Lisbon flows through a valley ½ to 1 mile wide and as deep as 200 ft, through glacial till and Cretaceous Niobrara and Pierre Formations. The river segment from Lisbon to the confluence with the Red River crosses the Sheyenne Delta, through an extensive sandhills areas and the floor of glacial Lake Agassiz, forming the Red River Valley.

Land use in the riparian zone of the Sheyenne River is predominantly woodland, grassland, and cropland, depending on the location. The lower reach of the Sheyenne River flows through the Sheyenne Delta, which is one of the more heavily forested areas of the state. The Delta area also contains a number of state-listed species of concern.

Figure C-5 shows an example of the 4-m multi-spectral Ikonos imagery obtained to develop baseline information. The example shown is of the upper Sheyenne River and is false infrared.

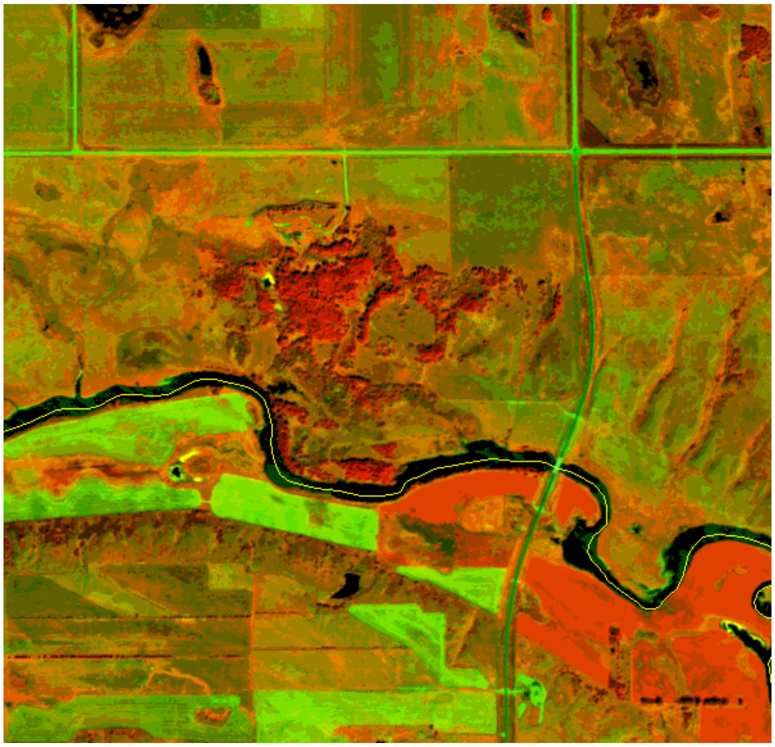


Figure C-5. Four-meter multi-spectral image of the upper Sheyenne River

The Sheyenne National Grasslands, managed by the U.S. Forest Service, is also located in the Delta area. The Sheyenne River flows through a unique natural area in southeastern North Dakota known as the Sheyenne Sandhills. The Sandhills are home to 17 different state-listed species. The Mirror Pool Wildlife Management Area, located in the Delta, is the largest fen or peatland on the Sheyenne River.

The Sheyenne National Grasslands area provides habitat for many rare plants. The U.S. Forest Service conducted a study identifying the locations of these rare plants in 2001. Of the 31 target plant species, 16 were located during field surveys in 2001. For these 16 different species, 62 separate populations were documented and mapped. At each population, habitat and population data were collected. For 34 of the populations, frequency or census data were collected. A summary of how many populations were found and how many plots were established for each species is found in Table C-8.

Of the 33 target plant species, 17 were located during field surveys in 2001 or 2002. For these 17 different species, 72 separate populations were documented and mapped. At each population, habitat data were collected. For 39 of the populations, frequency, density, or census data were collected. A summary of how many populations were found and how many plots were established for each species is found in Table C-8.

The most frequently encountered species was *Dryopteris carthusiana*, which had 10 populations mapped in the project area. *Athyrium filix-femina* and *Dryopteris cristata* were also commonly encountered, with 9 populations of each species found in 2001 or 2002.

There were seven species that were very uncommon, with only one population of each found and mapped in 2001 or 2002. These include: *Apios americana*, *Cypripedium pubescens var. pubescens*, *Euonymus atropurpurea, Galium labradoricum, Gymnocarpium dryopteris, Onoclea sensibilis*, and *Solidago flexicaulis*. The single population of *Apios americana* represents the rediscovery of a species not found since 1926 in North Dakota and is a very significant find.

Table C-8. Plant Species Located During 2001 or 2002 Surveys With Number Of Populations Found And Number Of Frequency Or Census Plots.

Latin Name	Common Name	Number of Populations Mapped	Number of Populations with Frequency, Density, or Census Plot Data Collected
Apios americana	Ground nut	1	1
Athyrium filix-femina	Northern lady-fern	9	3
Campanula aparinoides	Marsh bellflower	8	6
Carex formosa	Handsome sedge	4	2
Cypripedium parviflorum	Small yellow lady's slipper	8	3
Cypripedium pubescens var. pubescens	Large yellow lady's slipper	1	1
Cypripedium reginae	Showy lady's slipper	5	3
Dryopteris carthusiana	Spinulose woodfern	10	4
Dryopteris cristata	Crested woodfern	9	3
Equisetum palustre	Marsh horsetail	5	3
Euonymus atropurpurea	Wahoo	1	1
Galium labridoricum	Bog bedstraw	1	1
Gymnocarpium dryopteris	Oakfern	1	1
Menyanthes trifoliata	Buckbean	2	2
Onoclea sensibilis	Sensitive fern	1	1
Solidago flexicaulis	Zigzag goldenrod	1	1
Thelypteris palustris	Marsh fern	5	3
Totals		72	39

Abundance measurements (either frequency or census data) were completed for 17 different plant species. Table C-9 provides a summary of the species name, plot ID code, measurement type, and the frequency or census measurement data for each plot.

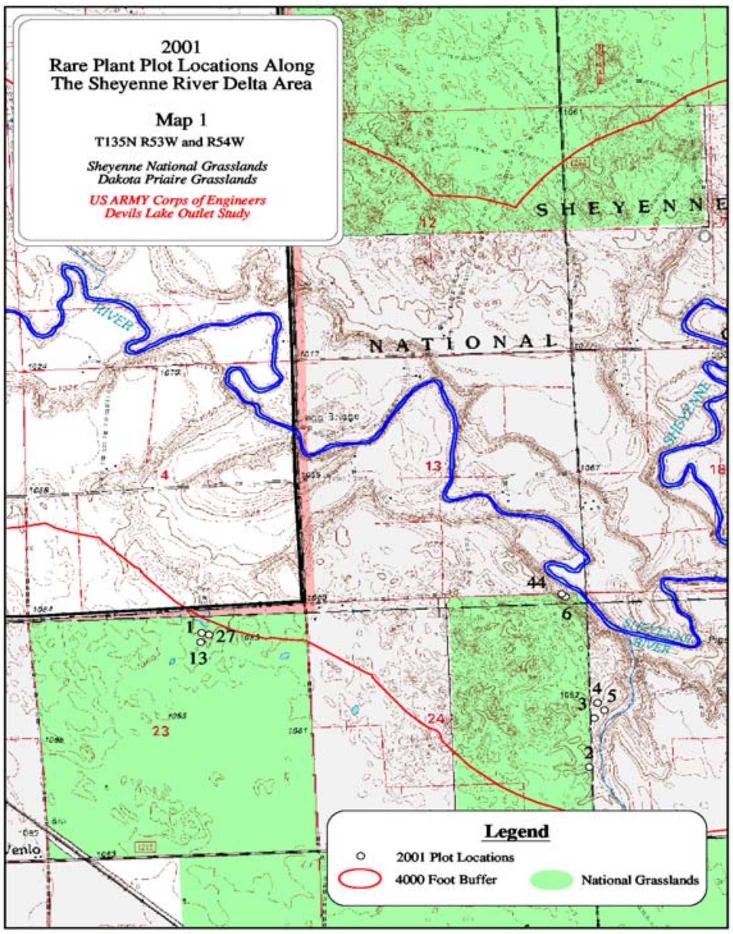
Frequency data shown in the table represent the percentage of quadrats that the species occurred in a plot established within a population. Census data shown in the table represent the number of individual plants found in a plot established within a population.

Table C-9. Summary of Frequency or Census Data for each Plot

Species name	Population ID Code	Measurement type	Plot Measurement (Frequency % or Census Count)
Apios americana	APIAME001	Density	5 stems/.25 M²
Athyrium filix-femina	ATHFIL001	Frequency	30.00%
Athyrium filix-femina	ATHFIL002	Frequency	17.78%
Athyrium filix-femina	ATHFIL007	Frequency	57.50%
Campanula aparinoides	CAMAPA001	Frequency	97.50%
Campanula aparinoides	CAMAPA003	Frequency	20.00%
Campanula aparinoides	CAMAPA004	Frequency	24.44%
Campanula aparinoides	CAMAPA005	Frequency	42.86%
Campanula aparinoides	CAMAPA007	Frequency	51.28%
Campanula aparinoides	CAMAPA008	Frequency	43.33%
Carex formosa	CARFOR001	Frequency	43.75%
Carex formosa	CARFOR004	Frequency	46.67%
Cypripedium parviflorum	CYPPAR001	Census	41
Cypripedium parviflorum	CYPPAR002	Census	5
Cypripedium parviflorum	CYPPAR003	Census	22
Cypripedium pubescens var. pubescens	CYPPLA001	Census	1
Cypripedium reginae	CYPREG001	Census	1
Cypripedium reginae	CYPREG002	Census	3
Cypripedium reginae	CYPREG003	Census	1
Dryopteris carthusiana	DRYCAR001	Frequency	31.67%
Dryopteris carthusiana	DRYCAR002	Census	6
Dryopteris carthusiana	DRYCAR005	Frequency	10.00%
Dryopteris carthusiana	DRYCAR007	Frequency	12.82%
Dryopteris cristata	DRYCRI001	Frequency	16.67%
Dryopteris cristata	DRYCRI002	Census	11
Dryopteris cristata	DRYCRI006	Frequency	30.00%
Equisetum palustre	EQUPAL001	Frequency	92.50%
Equisetum palustre	EQUPAL002	Frequency	73.81%
Equisetum palustre	EQUPAL003	Frequency	83.33%
Euonymus atropurpurea	EUOATR001	Frequency	69.05%
Galium labradoricum	GALLAB001	Frequency	40.00%
Gymnocarpium dryopteris	GYMDRY001	Frequency	37.50%
Menyanthes trifoliata	MENTRI001	Frequency	35.00%
Menyanthes trifoliata	MENTRI002	Frequency	32.00%
Onoclea sensibilis	ONOSEN001	Frequency	75.56%
Solidago flexicaulis	SOLFLE001	Frequency	33.33%
Thelypteris palustris	THEPAL001	Frequency	85.00%
Thelypteris palustris	THEPAL002	Frequency	35.56%
Thelypteris palustris	THEPAL005	Frequency	60.00%

The species documented during 2001 and 2002 field surveys range from wetland dependent species such as *Menyanthes trifoliata* to upland species, such as *Euyonmous atropurpurea.* Upland species may be located well above the probable zone of influence from the Sheyenne River. However, because the exact zone of influence has not absolutely been determined, data was collected on all target species within a 4,000 foot corridor on each side of the river.

Figure C-6. Map showing the location of some of the sample plot and plant locations



The State of North Dakota has also developed a list of natural heritage sites, which exhibit significant natural or cultural values. These include wildlife and vegetation species, vegetation types, and aquatic resources. There are 857 natural heritage sites listed in the Sheyenne River basin.

The Sheyenne River provides spawning habitat and nursery areas for forage fish, as well as a migrational avenue for sport fish, including channel catfish, northern pike, walleye, bass, and crappie. The Sheyenne River contains more species of fish than any other North Dakota tributary with over 50 species identified. There are nine species of freshwater mussels inhabiting the Sheyenne River.

The riparian areas along the Sheyenne River provide valuable habitat for a variety of wildlife species. Game species found along the river's riparian corridor and adjacent uplands include white-tailed deer, moose, wood duck, dabbling duck, pheasant, greater prairie chicken, turkey, squirrels, and rabbits. Furbearing species and migratory non-game birds use the river corridor for breeding, feeding, and migration.

In summary, the Sheyenne River Valley provides significant and unique aquatic and terrestrial resources. It is one of the most heavily wooded areas of the State and contains one of the most diverse and largest fisheries.

Cultural Resources

Less than 25 percent of the area along the banks of the Sheyenne River has been previously surveyed for cultural resources, with most work concentrating in Ransom (Fort Ransom-Lisbon areas), Barnes (Lake Ashtabula), and Griggs (Lake Ashtabula and upstream to Highway 200) Counties. There are 161 prehistoric archeological sites, 34 historic archeological sites, and 57 architectural/standing structure sites recorded within one-quarter mile from the Sheyenne River channel between the proposed Devils Lake outlet at Peterson Coulee in Benson County and its mouth north of Fargo in Cass County.

Included in the above site totals are one historic district determined eligible to the National Register, as well as two historic districts (Biesterfeldt and T.J. Walker) and eight individual sites (seven bridges, Lisbon Opera House) listed on the National Register. In addition, there are unverified leads to 77 prehistoric archeological sites, 65 historic archeological sites, and 5 architectural sites for this same stretch of river banks.

A canoe-based reconnaissance of the cutbanks of the Sheyenne River (minus the Lake Ashtabula shoreline) in the fall of 2000 and the spring of 2001 recorded 46 prehistoric archeological sites and relocated eight previously recorded archeological sites, all 54 of which are visibly eroding out of the river's cutbanks. In addition, 14 architectural/standing structure sites (three dams, eight bridges, three structures) were also recorded along this stretch of river. No human burials, graves, or mounds were observed in or at the river's banks. Natural erosion along the Sheyenne River's banks is no doubt affecting additional archeological sites than those where eroding artifacts were observed during this reconnaissance survey.

Base Condition - Red River of the North

Natural Resources

The Red River of the North is a part of the Hudson Bay drainage system in parts of North Dakota, South Dakota, and Minnesota. The entire drainage area consists of about 39,200 miles. The Red River flows north into Canada across the floor of the glacial lake bed for 394 river miles. The lake bed is nearly flat, with an average slope of about 0.4 ft/mile. The river has a high sediment load of silts and clays and is characterized by a low gradient and high sinuosity (see the flow and stage table under Sheyenne River for average flows at various points along the Red River).

The Red River provides spawning habitat and nursery areas for forage fish, as well as a migrational avenue for sport fish. The Red River has been identified as one of the highest quality channel catfish fisheries in the nation. Eight species of freshwater mussels more found in the Red River.

Although the habitats supporting fish and wildlife resources along the Red River have been substantially altered, the remaining areas provide several important functions. Shelterbelts and riparian woodlands provide denning and nesting sites, food, escape and winter cover, and travel lanes for many wildlife and waterfowl species.

The Red River is characterized as a riverine, lower perennial, unconsolidated bottom, permanently flooded wetland. Unlike the Sheyenne River, the Red River floodplain is largely void of palustrine emergent wetland types. Red River floodplain wetlands are typically old river scars and oxbows.

The percent land use within the subbasins in each geographic unit are compared in Table C-10.

Table C-10. Percent of Geographic Unit in Land Use Category

Land Use	Basin			
	Upper Basin depressions	Devils Lake to elev. 1463	Sheyenne River within ¼ mi.	Red River within ¼ mi.
Cropland	64	48	33	62
Woodland	1	5	18	19
Grassland	9	21	36	5
Grass-Shrub	0	0	1	0
Wetland	19	25	10	11
Urban	7	1	2	3

Cultural Resources

Cultural resource surveys along the Red River have been conducted primarily in Norman and Polk Counties in Minnesota and in Grand Forks County in North Dakota. Previous surveys along the Red River have located archeological sites both on the surface and buried up to 3 m (10 ft) below the present ground surface. Sites tend to be concentrated on the terraces and lake plain uplands within one-quarter mile of the river, but are also located along old river oxbows and secondary channels.

2. Environmental Effects – Stochastic/Scenario Based - Screening of Alternatives

Introduction

The stochastic analysis identifies that there is about a 9.4-percent probability that the lake will overflow in the next 50 years. This probability is small and therefore the environmental analysis based on the stochastic future assumes that it is unlikely that the lake will overflow naturally. The downstream conditions would be determined by forecasting the existing conditions and determining the effects of project alternatives by themselves.

Figure C-7 describes the stochastic-based probability of the lake reaching various elevations over the next 50 years.

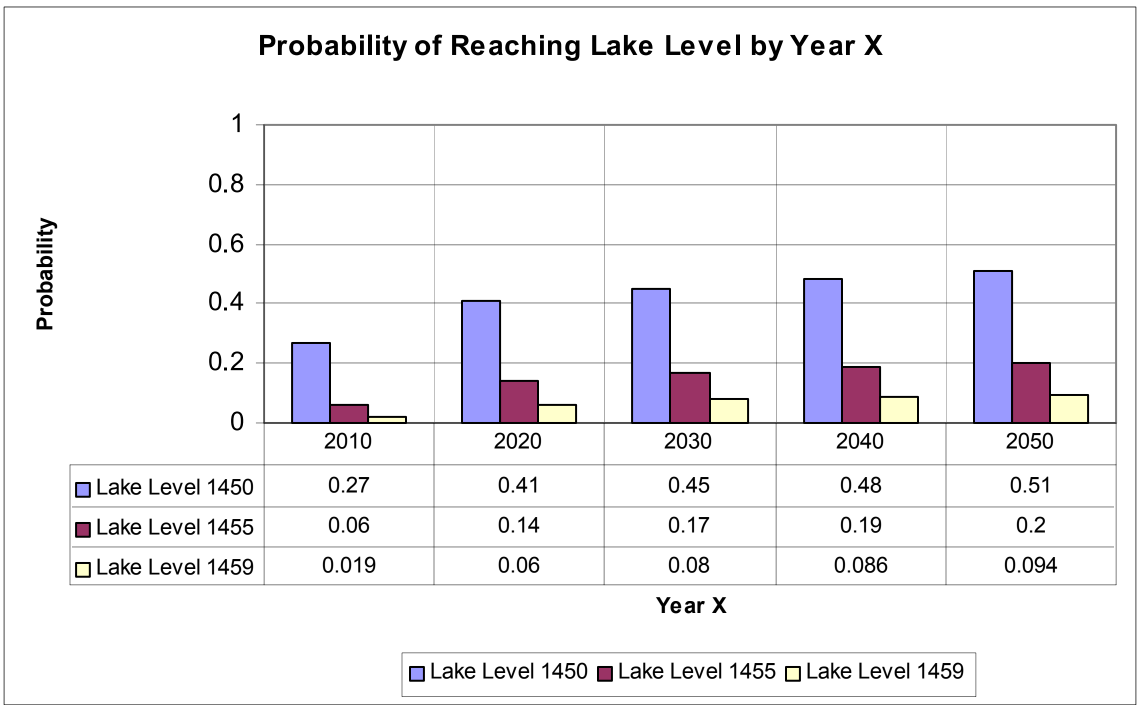


Figure C-7. Probability of Devils Lake reaching a particular lake level by year

The alternatives were evaluated using an alternate future without conditions, which assumes a continued wet climate scenario based on the climate sequence from 1993 through 1999 repeated until a natural overflow to the Sheyenne River occurred. The scenario-based future is an alternate future to the stochastic-(probability-) based future. The probability of a natural overflow ranges from 2 to 9.4 percent depending on the period of record used in the analysis. In either case the probability of a continued wet future is low; therefore, the likelihood of the impacts that were identified for the natural overflow event, the erosion of natural outlet, and the dam on Tolna Coulee to actually occur are small. Likewise the possibility of realizing the benefits of preventing a natural overflow is also small. In contrast, the probability of the impacts resulting from the operation of a constructed outlet to occur would be very high. An analysis developed by the State Water Commission and the U.S. Geological Survey indicated an outlet would reduce the likelihood of a natural overflow event from about 2 percent to 1 percent.

The potential area of impact has been determined from various hydrologic, water quality, and groundwater studies associated with the construction and operation of the various alternatives. The potential impact area is based on identified changes in the flow regime, water quality, and groundwater levels. The operation of an outlet could affect the frequency and duration of inundation. Three groundwater studies have been conducted along the Sheyenne River. One consisted of a model study in the area of the Sheyenne National Grasslands between Lisbon and Kindred, North Dakota. This analysis showed that the effects of the increased river stage on groundwater would not extend further than about 1,500 ft (approximately ¼ mile) from the river. However, up to about a 1.5-ft increase in groundwater levels could occur within 300 ft of the river. In another study, which included the installation of groundwater monitoring wells, up to a 2.5-ft increase in groundwater levels were found within 25 ft of the river and about a 1.5-ft increase at 150 ft from the river due to changes in river stage. Another groundwater model study along the Sheyenne River showed that other areas would experience less of an affect, possibly in the order of 0.5 ft up to 300 ft from the river. Effects on land use activities would depend on the current depth to groundwater.

The impact area in the upper basin is defined as the depression areas identified for restoration. The impact area around Devils Lake is separated by contour zones up to elevation 1463, which is the highest lake level attained if the lake is kept from overflowing naturally to the Sheyenne River under the wet scenario. The impact area on the Sheyenne River is defined by the flooded area outline, area of water quality and flow effects, and area of groundwater influence (¼ mile from the river). The impact area on the Red River is defined by the area of water quality and flow effects and area of groundwater influence. Flows and changes in stage would be less on the Red River, where the geographic study area of potential groundwater influence was assumed to be less than ¼ mile.

The environmental effects of the alternatives occur in the upper basin, around Devils Lake, downstream in the Red River basin, or at a combination of sites depending on the alternative.

The effects of the various alternatives on the major resource areas are compared in the following Impact Matrix Table (Table C-11). Both the stochastic and scenario futures are presented in the same table for ease of comparison, as many of the effects are similar differing primarily in magnitude and duration.

Table C-11. Impact Matrix.

IMPACT MATRIX FOR DEVILS LAKE STUDY ALTERNATIVES

Alternative	**Resource**				
	Devils Lake Aquatic Resources	**Devils Lake Basin Terrestrial Resources**	**Downstream Terrestrial Resources**	**Downstream Aquatic Resources**	**Biota Transfer**
Existing Conditions	Rise of Devils Lake has benefited fishery. Wetlands have been lost and gained. Significant fishery in Lake.	The current lake level has resulted in the loss of over 1 million trees (over 3,000 acres). Terrestrial habitat has been lost and converted to aquatic habitat. 70 Natural Heritage sites located in the basin.	Downstream riparian system and habitat provides good wildlife and natural area values. Riparian land use is predominantly agriculture and natural habitat. Grazing and other water users utilize the Sheyenne and Red Rivers. 857 Natural Heritage sites located in the Sheyenne Basin. 72 in the Red Basin.	Sheyenne River and Lake Ashtabula significant aquatic resource. Red River catfish.	Risk of biota transfer due to recreational users and natural causes. Potential for introduction or spread of known and unknown organisms.
Future Without - Stochastic Future	Fishery in lake will continue to improve to a point. Eventually lake will recede and fishery will decline. Continued construction of levees and roads could impact resources. Infrastructure protection would have little effect probability of natural overflow and resultant effects. Construction activities would have temporary affect on aquatic habitat such as turbidity. Little long-term effect on fishery.	Wetlands, woodlands, grasslands, and other habitats will be adversely affected as lake fluctuates. Relocation would impact natural resources of area. Previously developed areas would be reclaimed. Little change from No Action condition, which includes relocations.	No effect downstream if lake does not overflow naturally. Less than 10% chance of natural overflow. Therefore no appreciable change from existing conditions. Infrastructure protection would have no effect on downstream areas.	Not much change expected from current conditions. Less than 10% chance of natural overflow. Fishery would maintain itself. Infrastructure protection would have no effect on downstream areas.	Unknown. Similar to existing conditions. Less than 10% chance of natural overflow.
Future Without - Wet Scenario Future	Fishery in lake will continue to improve to a point. Eventually lake will recede and fishery will decline. Continued construction of levees and roads could impact resources. Infrastructure protection would have little effect probability of natural overflow and resultant effects. Construction activities would have temporary affect on aquatic habitat such as turbidity. Little long-term effect on fishery.	Wetlands, woodlands, grasslands, and other habitats would be lost as lake rises to overflow elevation. Relocation would impact natural resources of area. Previously developed areas would be reclaimed. Succesional recovery of habitat types as lake recedes. Little change from No Action condition, which includes relocations.	Natural overflow would have significant adverse effect on downstream resources due to increased inundation, erosion, and flows. Infrastructure protection would have no effect on downstream areas.	Significant adverse effect on aquatic resources due to increased flows, water quality changes, and erosion. Some recovery expected once overflow event ends, but recovery could take many decades. Infrastructure protection would have no effect on downstream areas.	Natural overflow would increase potential for transfer of any new or introduced organisms to downstream areas.

West Bay Outlet - 300-cfs	Fresh water removed from lake and lake level lowered, which could impact fishery. Lower lake levels reached sooner than without outlet	Outlet would lower lake levels about 3 ft. Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	6, 212, and 72 Natural Heritage sites located within 1/4 mile, potential groundwater influence, of Upper Sheyenne, Lower Sheyenne, and Red River respectively. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities.	Release constrained by water quality standards although increase in levels of constituents. Most effect on aquatic resources in upper Sheyenne due to increase flows. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities. Most effect on aquatic resources in upper Sheyenne due to increase flows.	Unknown. Potential for transfer and introduction of new species would increase due to outlet operation. Similar to future without conditions. Potential for spread of Eurasian water milfoil due to increased flows.
West Bay Outlet - 480-cfs	Outlet would reduce the potential for inundation of new aquatic habitat with resultant effect on fish resource. Outlet would not totally stabilize lake, therefore, some fluctuation in lake levels would continue. Fishery would decline sooner than future without conditions due to lower lake levels and increased water quality constituent levels. More effect than 300-cfs outlet.	Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat. Greater effect than 300-cfs outlet.	Similar to West Bay 300-cfs outlet. Significant downstream effects on community structure due to degraded water quality, increased flows, and increased shoreline erosion. 25 natural heritage sites located within flooded area of Sheyenne River. Over 600 landowners potentially affected within flooded area outline. Overbank flooding could inundate almost 16,000 acres. Potential loss of riparian vegetation and shoreline vegetation due to inundation and erosion.	Degraded water quality, increased flows, increased erosion, and loss of riparian vegetation. Dramatic change in aquatic communities such as decline in invertebrate, fish, and mussel species abundance and diversity.	Similar effects as West Bay outlet.
Pelican Lake Outlet - 300-cfs	Fresher and more water is removed from lake than with West Bay outlet, which could impact fishery. Lower lake levels reached sooner than without outlet.	Fresher and more water is removed from lake than with West Bay outlet, which could impact fishery. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	Similar effects as West Bay 300 outlet.	Similar effects as West Bay 300 outlet.	Similar effects as West Bay outlet.
Pelican Lake Outlet - 480-cfs	Fresher and more water is removed from lake than with West Bay outlet, which could impact fishery. Lower lake levels reached sooner than without outlet. In lake water quality declines due to removing fresh water. Greater effects than with 300-cfs Pelican outlet.	Similar to West Bay 480 outlet. Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat. Greater effects than with 300-cfs Pelican outlet	Similar effects as West Bay 480 outlet. Higher flows on Sheyenne River effects riparian vegetation and erosion. More impact than with 300-cfs outlet.	Similar effects as West Bay 480 outlet. Initial flows better water quality but later outlet flows worse due to degraded Devils Lake quality.	Similar effects as West Bay outlet.

Pelican Lake Outlet Only - 300-cfs - No West Bay Flow	Most of the fresh inflow is removed before it enters Devils Lake. Freshening of Devils Lake is decreased. Fishery could be adversely effected. Lake reaches lower levels sooner and increases in TDS and sulfates over without project conditions or any other outlet. Upper basin lakes used for storage and subject to increased fluctuation resulting in decreased aquatic habitat values. Lake Alice National Wildlife Refuge effected requiring compatibility statement.	Similar to other outlets. Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker succerssional recovery of terrestrial habitat. Upper basin lakes subject to more fluctuation and resulting effects to habitat and wildlife resources. National Wildlife Refuge effected.	6, 212, and 72 Natural Heritage sites located within 1/4 mile, potential groundwater influence, of Upper Sheyenne, Lower Sheyenne, and Red River respectively. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities.	Release constrained by water quality standards. Only the freshest water removed from Devils Lake and is similar to Sheyenne base condition. Most effect on aquatic resources in upper Sheyenne due to increase flows. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities. Most effect on aquatic resources in upper Sheyenne due to increase flows.	Similar effects as West Bay outlet.
East Devils Lake Outlet - 480-cfs	Water quality in Devils Lake improved. Effect on fishery depends on amount of natural reproduction. Could affect population dynamics in the lakes. For example, may result in fewer big fish and more small fish.	Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	Similar impacts to West End 480 outlet.	Increased water quality effects over West end outlets. Upper Sheyenne most impacted. Mussels impacted by increased chloride levels. Loss of streambank cover and increased erosion has adverse effect on habitat and fishery.	Similar effects as West Bay outlet.
Raise Natural Outlet	Fishery in lake will continue to improve to a point. Eventually lake will recede and fishery will decline. Continued construction of levees and roads could impact resources.	Wetlands, woodlands, grasslands, and other habitats adversely affected as lake fluctuates. Greater effects than with future without project conditions due to additional lands inundated. Greater effects than the future without project conditions due to additional lands inundated.	No effect downstream. Not much change from existing conditions.	Not much change expected from current conditions. Fishery will maintain itself.	Similar to future without conditions.
Upper Basin Storage	Upper basin storage would reduce runoff to lake resulting in lake levels about 1 ft lower. Some fresher water would be retained in upper basin. Probably minimal effect on fishery.	Upper basin storage would reduce runoff to lake resulting in lake levels about 1 ft lower. Some fresher water would be retained in upper basin. Would prevent inundation of some land areas and loss of habitat. Would modify land uses at storage sites.	Similar to future without conditions.	Similar to future without conditions.	Similar to future without conditions.
Expanded Infrastructure Protection	Would not effect probability of natural overflow and resultant effects. Construction activities would have temporary affect on aquatic habitat such as turbidity. Little long-term effect on fishery.	Relocation would impact natural resources of area. Previously developed areas would be reclaimed. Little change from No Action condition, which includes relocations.	Similar to future without conditions.	Similar to future without conditions.	Similar to future without conditions.

Natural Resources

Outlet Alternatives

Devils Lake

In some cases the outlets would have an effect on the eventual lake level, which in turn would affect the aquatic and terrestrial resources. The 300-cfs constrained outlets would have little effect on the lake levels, the lake could continue to rise and possibly overflow to the Sheyenne River. The 480-cfs unconstrained outlets would have more effect on the lake levels; however, a natural overflow could still occur.

To varying degrees, the outlets would reduce the amount of terrestrial habitat inundated. The outlets would also hasten succession by lowering lake levels. The amount of habitat affected is summarized by elevation in the land use table in the base conditions section of this report.

Likewise to varying degrees, the outlets would have an effect on aquatic habitat through their influence on lake levels. The 300-cfs constrained outlets would have little effect on lake levels and therefore, little effect on aquatic resources. The 480-cfs unconstrained outlets would have more effect on aquatic resources. As the lake rises, fisheries have improved through increased spawning habitat and natural reproduction. An outlet would accelerate the rate at which the lake recedes and could result in a lower lake level sooner than under natural conditions. This, combined with the changes in lake water quality, could result in a quicker decline of the lake fishery than under natural conditions. A natural overflow would have similar results as an outlet but with different magnitude, duration, and timing. Most of the effects described for outlet operation would also occur with a natural overflow but to a different degree.

The buried pipeline would have minimal effects along the outlet route. Temporary construction impacts to wetlands and habitat would occur. There would be no long-term impacts.

Upper Basin

The outlets would have no effect on the upper basin.

Sheyenne River

For the outlet alternatives, the downstream effects are generally similar in water quality effects and differ primarily in the discharge. The operation of an outlet would result in significant effects to cultural and natural resources, increased erosion/sedimentation, effects on aquatic and terrestrial habitat, degraded water quality, increased inundation, impacts to water users, and changes in land uses for areas along the Sheyenne River and the Red River of the North. The 300-cfs constrained outlets are intended to minimize overbank flooding. Therefore, the flow effects are confined to the channel and any induced changes in groundwater levels. The 480-cfs outlet is not constrained by water quality; therefore, water quality impacts would be greater than with the 300-cfs outlet.

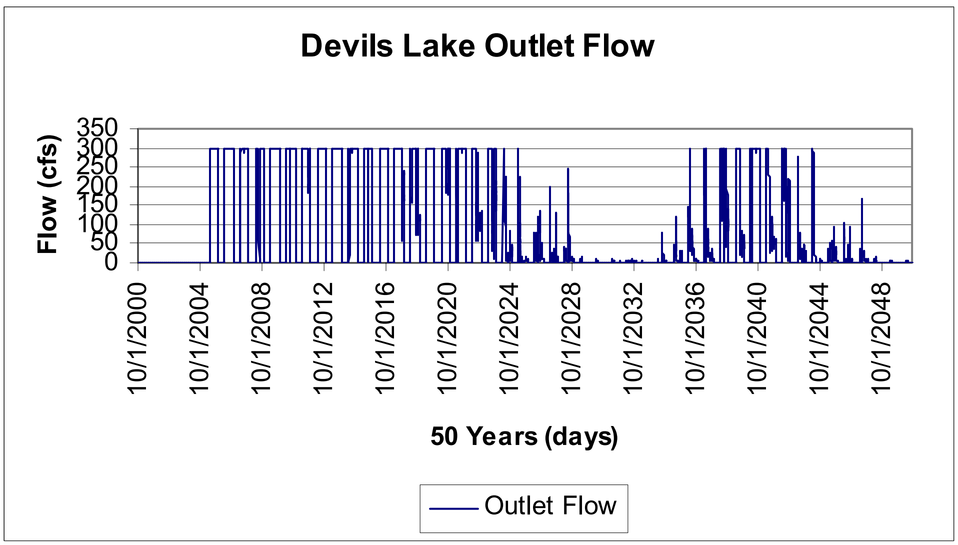
Based on modeling, the groundwater effects are assumed to be limited to within ¼ mile of the river.

Aquatic Resources

Aquatic resources would be potentially affected by changes in flow, water quality, erosion, and changes in streambank vegetation. A general discussion of the changes in flow, river stage, and duration is presented below.

An example of the amount, duration, and timing of flow for a Pelican Lake outlet is presented in Figure C-8 below (shown for Cooperstown area along the Sheyenne River). This indicates when an outlet would be operating. It shows that the outlet could result in up-and-down flows with sudden and extreme fluctuations in flow. These are the types of situations which make it difficult for species to adapt to habitat conditions.

Figure C-8. Example of outlet flow quantities over 50-year operation period.



The flow from Devils Lake for the Pelican Lake outlet over a 3-year period is shown in Figure C-9. See Appendix A for more information on water quality and flow at various control points along the Sheyenne and Red Rivers.

Figure C-9. Outlet flow quantity over a 3-year period

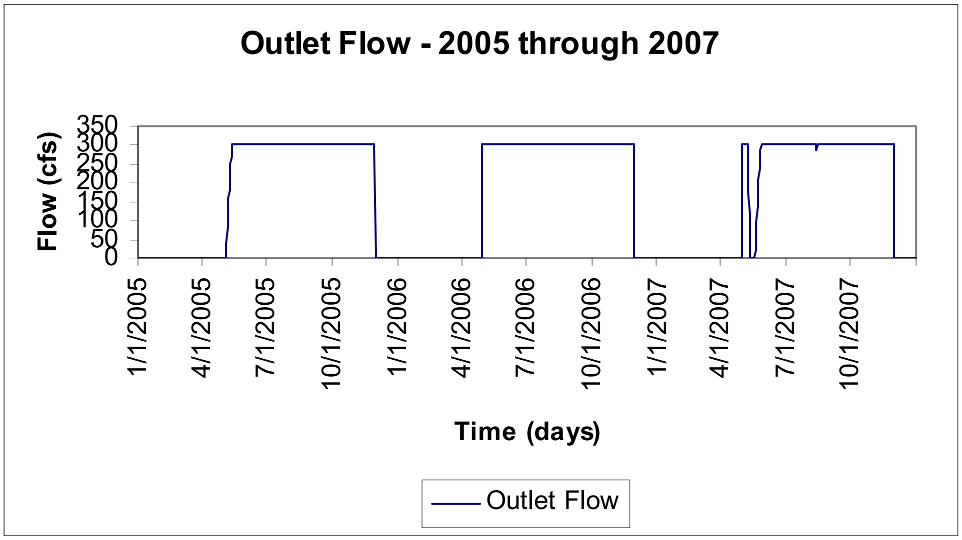
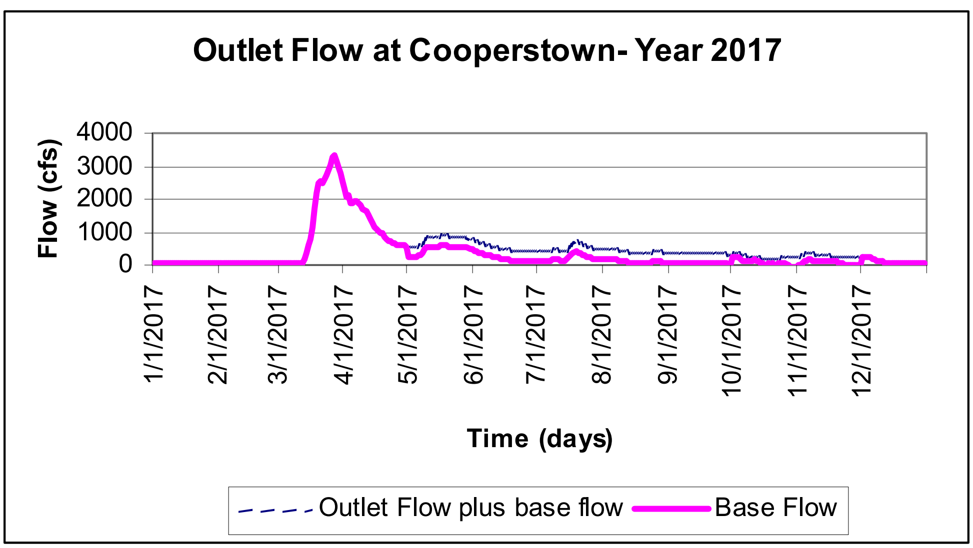


Figure C-10 shows a typical operation year with a wet scenario (year 2017). The base flow shows a peak in the spring with lower flows in the summer, fall, and winter. The outlet flow initiates on 1 May and flows at or very near capacity through most of the summer when the Pelican Lake water is fresh and flows in the Sheyenne River can be used for dilution. During the fall and winter, flows decline. Outlet operation ceases on 30 November.

Figure C-10. Outlet flow during a typical year of operation



The river stage would also change with the operation of an outlet. The approximate change in river stage is shown in Table C-12 below. River stage affects the availability of aquatic habitat and would influence the amount of erosion and vegetation growing on the banks. On the Sheyenne River, depending on the location, the stage could increase from about 1 to 3 ft and the exceedence frequency could double (see Figure C-11 for examples of profile sections below). Stage increases are expected to be lower on the Red River and would remain in the channel.

Table C-12. River stage increases due to 300-cfs and 480-cfs operation

STAGE IMPACTS OF ADDING 480 CFS

	LOW FLOW		LOW FLOW+ 480 CFS			MEAN MAY FLOW		MEAN MAY + 480 CFS			MEAN AUG FLOW		MEAN AUG + 480 CFS			NWS
GAGE	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**FLOOD STAGE**
Insertion Point	0	1423.3	480			64	1423.7	544			4	1423.3	484			
Sheyenne	0	3.5	480			64	3.9	544			4	3.6	484			
Warwick	3	2.1	483	3.7	**1.6**	108	2.8	588	3.9	**1.1**	29	2.4	509	3.8	**1.4**	
Cooperstown	0	9.5	480	11.2	**1.7**	235	10.5	715	11.8	**1.3**	69	9.9	549	11.4	**1.5**	19.0(Old)
Valley City	0	2.9	480	5.0	**2.1**	391	4.6	871	6.6	**2.0**	61	3.3	541	5.2	**1.9**	13.0
Lisbon	2	2.0	482	4.9	**2.9**	383	4.4	863	6.3	**1.9**	160	3.3	640	5.5	**2.2**	11.0
Kindred	20	2.1	500	5.0	**2.9**	522	5.1	1002	7.8	**2.7**	160	3.0	640	5.8	**2.8**	16.0
Horace	74	11.0	554	15.4	**4.4**	540	15.3	1020	18.8	**3.5**	165	11.9	645	16.2	**4.3**	
West Fargo	17	3.0	497	8.8	**5.8**	557	9.3	1037	12.3	**3.0**	170	5.7	650	9.9	**4.2**	16.5
Halstad	158	2.6	638	4.1	**1.5**	3681	9.0	4161	9.6	**0.6**	1124	5.0	1604	5.9	**0.9**	24.0
Grand Forks	510	14.9	990	15.3	**0.4**	6808	18.2	7288	18.4	**0.2**	2298	16.1	2778	16.3	**0.2**	28.0
Drayton	430	10.3	910	10.7	**0.4**	9268	16.7	9748	17.0	**0.3**	2637	11.9	3117	12.3	**0.4**	32.0
Emerson	52	744.0	532			12539	763.0	13019			2951	751.0	3431			781.5
Winnipeg						15293		15773			2564		3044			

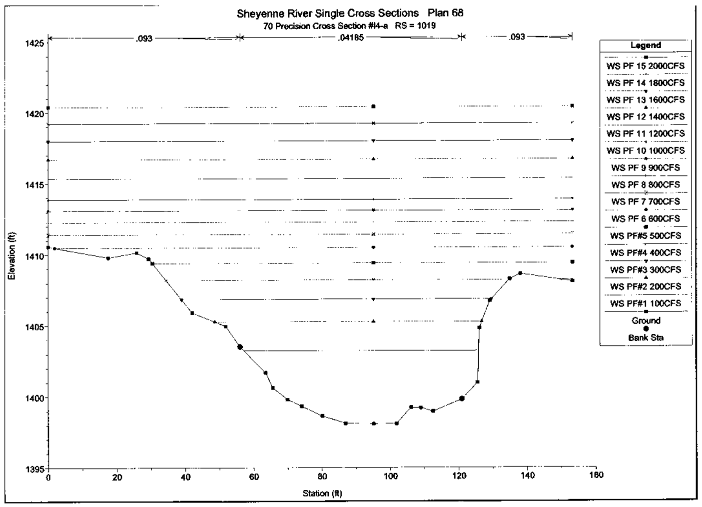
STAGE IMPACTS OF ADDING 300 CFS

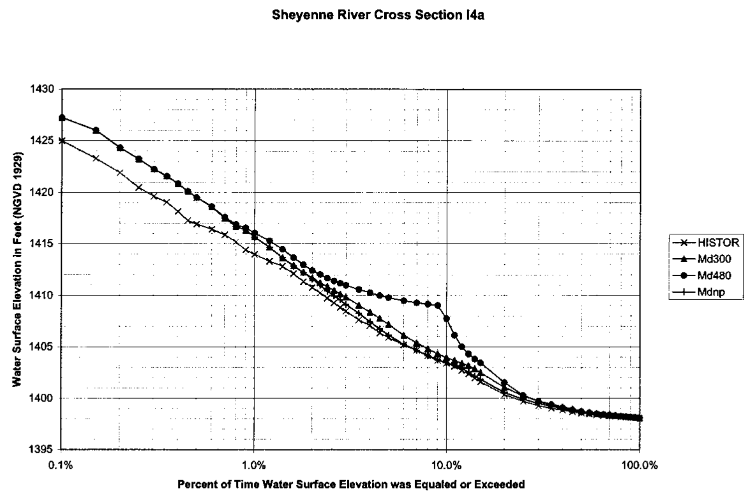
	LOW FLOW		LOW FLOW+ 300 CFS			MEAN MAY FLOW		MEAN MAY + 300 CFS			MEAN AUG FLOW		MEAN AUG + 300 CFS			NWS
GAGE	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**Q**	**STAGE**	**Q**	**STAGE**	**DIFF**	**FLOOD STAGE**
Insertion Point	0	1423.3	300	1425.7	**2.4**	64	1423.7	364	1426.3	**2.6**	4	1423.3	304	1425.7	**2.4**	
Sheyenne	0	3.5	300	4.4	**0.9**	64	3.9	364	4.5	**0.6**	4	3.6	304	4.4	**0.8**	
Warwick	3	2.1	303	3.4	**1.3**	108	2.8	408	3.6	**0.8**	29	2.4	329	3.4	**1.0**	
Cooperstown	0	9.5	300	10.7	**1.2**	235	10.5	535	11.4	**0.9**	69	9.9	369	10.9	**1.0**	19.0(Old)
Valley City	0	2.9	300	4.2	**1.3**	391	4.6	691	5.9	**1.3**	61	3.3	361	4.5	**1.2**	13.0
Lisbon	2	1.8	302	3.8	**2.0**	383	4.2	683	5.6	**1.4**	160	3.1	460	4.6	**1.5**	11.0
Kindred	20	2.2	320	3.8	**1.6**	522	5.0	822	6.8	**1.8**	160	2.9	460	4.6	**1.7**	16.0
Horace	74	11.0	374	13.9	**2.9**	540	15.3	840	17.6	**2.3**	165	11.9	465	14.7	**2.8**	
West Fargo	17	3.0	317	7.3	**4.3**	557	9.3	857	11.3	**2**	170	5.7	470	8.6	**2.9**	16.5
Halstad	158	2.6	458	3.4	**0.8**	3681	10.0	3981	10.5	**0.5**	1124	5.3	1424	6.1	**0.8**	24.0
Grand Forks	510	14.9	810	15.2	**0.3**	6808	18.2	7108	18.3	**0.1**	2298	16.1	2598	16.2	**0.1**	28.0
Drayton	430	10.3	730	10.5	**0.2**	9268	16.8	9568	17.1	**0.3**	2637	11.9	2937	12.1	**0.2**	32.0
Emerson	52	744.0	352	745.7	**1.7**	12539	763.0	12839	763.3	**0.3**	2951	751.0	3251	751.5	**0.5**	781.5
Winnipeg						15293		15593			2564		2864			

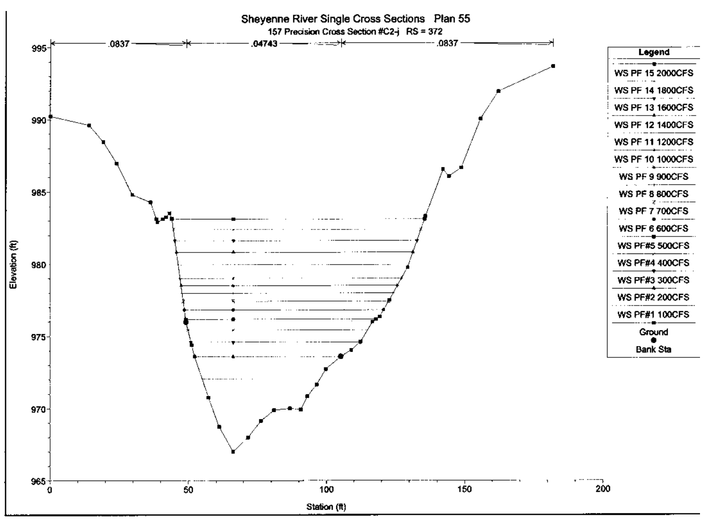
NOTES:

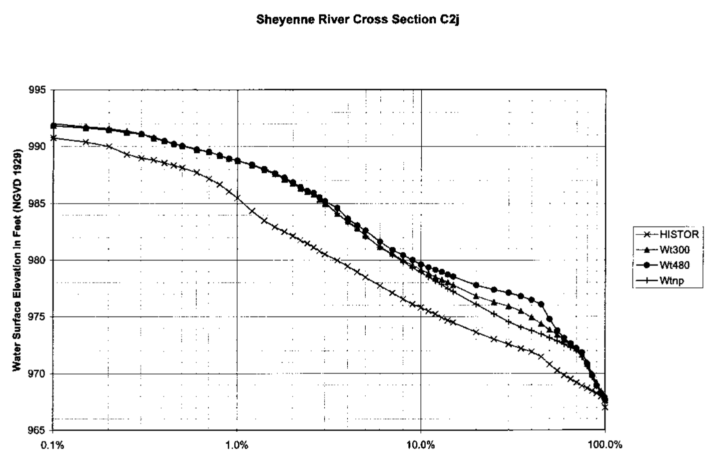
1. Some of the USGS gages are located upstream of small dams. This flattens the lower end of the rating curve so that the stage impacts of adding 300 cfs are less than would be expected for open river reaches. Stations with dams d/s are Sheye Warwick, and Cooperstown; RRN gages at Drayton and Grand Forks are upstream of dams.
2. Insertion point mean May and Aug flows are for the town of Sheyenne gage. Gage discontinued after 1951.

Figure C-11. Example of profile and exceedence frequency curves for Sheyenne River.









Stream flow alteration can adversely alter the structure, function, and composition of stream communities by altering the availability of various habitat types on both spatial and temporal scales. Substantial to significant adverse impacts on aquatic habitat availability and suitability can be expected under most, if not all, of the Devils Lake outlet options. The most flow-sensitive habitat types, such as riffles where shallow, fast habitats predominate, would be almost entirely eliminated for a majority of the year. The largest adverse impacts on habitat would likely occur in the Sheyenne River above Lake Ashtabula, where stages are projected to increase up to 3 ft.

Impacts to aquatic resources were evaluated by Earth Tech, Incorporated for a 300-cfs constrained and a 480-cfs unconstrained outlet from West Bay and the effects of a natural overflow from Stump Lake. The effects of outlets from other locations, such as Pelican Lake, would have to be interpreted from these findings. It is possible that a Pelican Lake outlet would approximate the water quality effects of a 300-cfs West Bay outlet and the flow effects of a 480-cfs West Bay outlet. For clarity and consistency, the effects of a natural overflow are presented here also and should be referred to under the sensitivity discussion.

Figure C-12 shows the locations of the habitat cross-sections for the Sheyenne and Red Rivers.

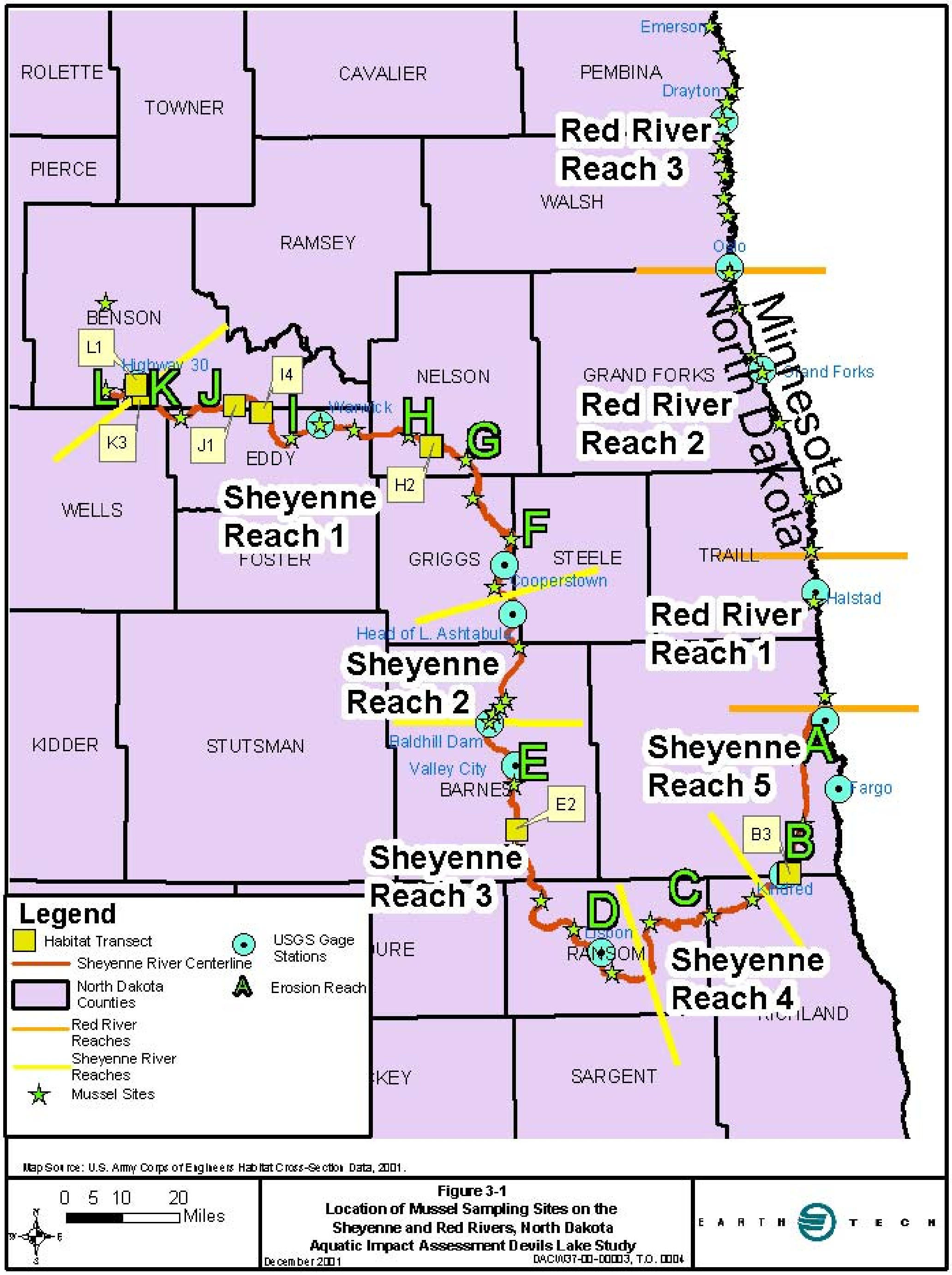


Figure C-12. Location of habitat cross-sections and reaches on the Sheyenne and Red Rivers used in the analysis

The analysis showed that the amount of any particular habitat may increase or decrease depending on operational scenario and season, and it is not uncommon for one or more habitat types in a given habitat reach to increase, while other habitat types in that same reach simultaneously decrease. This makes interpretation of these changes difficult, as the preferred habitat of some species will increase while the preferred habitat of other species simultaneously decreases. The habitat preferences of many Sheyenne and Red River fishes were identified (Table C-13). An examination reveals several facts about each habitat guild.

Shallow Pool (Sensitive habitat guild)

This guild is inhabited primarily by young of the year (YOY) and juvenile fishes. Thus, this habitat serves as an important nursery area and is considered to be one of the most important habitat guilds.

Medium Pool (Moderately sensitive habitat guild)

This habitat is preferred by the largest combination of species/life stages. Although it includes a large number of species/life stages, many of those identified are either habitat generalists (e.g., channel catfish, largemouth bass, and orangespotted sunfish) or are primarily lentic species (e.g., crappies, yellow perch) whose abundance in the river is probably low naturally. Given their more adaptable nature and the fact that they show less fidelity to lotic conditions, members of this guild are viewed as less sensitive than those in the shallow pool guild. However, several of the species listed as special concern in North Dakota require the macrophyte beds that occur in shallow and medium pools (blacknose shiner, pugnose shiner, banded killifish) or use medium pools during part of their life (trout-perch, hornyhead chub, rosyface shiner).

Deep Pool (Least sensitive habitat guild)

This guild contains the fewest species. The deep pool guild is dominated by habitat generalists (e.g., white sucker and largemouth bass) or lentic species (e.g., black crappie). Because it is used by the fewest species and most of those that use it are not particularly sensitive, this is viewed as the least sensitive guild.

Slow Riffle (Sensitive habitat guild)

This guild contains the second highest number of species/lifestages and the greatest number of spawning species. Given the number of species in this guild and the number of those that spawn in this habitat, slow riffle is considered a sensitive habitat. Since spring is the period when this habitat would be most used for spawning, spring is an especially critical period for this guild. However, it is likely that species displaced from the shallow pool guild will find the edges of shallow riffles to be a suitable alternative to their preferred habitat.

Fast Riffle (Sensitive habitat guild)

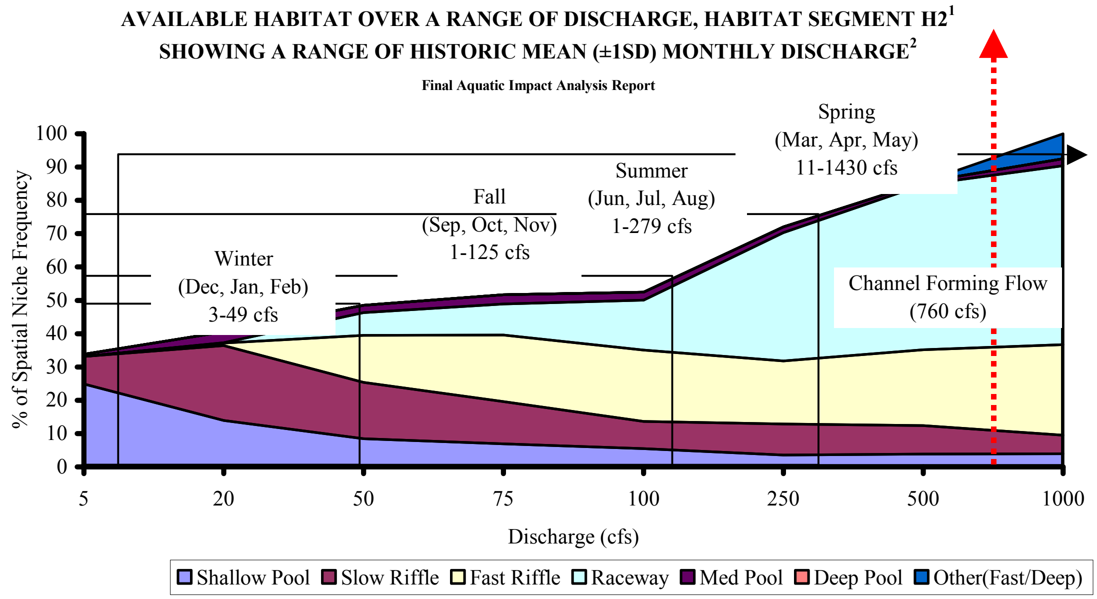
Because few obligate riffle species are present in the Red and Sheyenne Rivers, this habitat is preferred by only a few species. However, for any obligate riffle dwellers, this habitat is critical. Longnose dace and stonecat (*Noturus flavus*) would be such species. Although Aadland (1993) has assigned adult and juvenile logperch to the fast riffle guild, its habitat requirements are quite broad and, as a result, is not at as much risk as the other species in this guild. Furthermore, logperch occur only in the Red River, so the risks to this species under any of the project alternatives are negligible. Fast riffle is also used by redhorse species in the spring for spawning. Because of its rarity in the Sheyenne River and its use for spawning and for obligate riffle species, fast riffle is considered a sensitive habitat.

Raceway (Moderately sensitive habitat guild)

This guild is dominated by adult species, especially among the suckers. It is likely that some species preferring fast riffles can successfully use raceway habitat as an alternative and vice versa.

Given the overlap between the shallow pool and slow riffle guilds, between the medium and deep pool guilds, and between the fast riffle and raceway guilds, at least one member of each of these three habitat pairs should be present in reasonable amounts to support a diverse fish community. Lastly, it should be noted that the Sheyenne River is dominated by species relatively tolerant to a variety of water quality and habitat conditions (Peterka 1978; Ohio EPA 1987; Goldstein *et al.* 1996, Table 4-4). Given this, it is reasonable to expect that the fish assemblage, as a whole, will be less sensitive to habitat alterations than if it was dominated by habitat specialists.

Figure C-13 shows how the percent of available habitat type changes as the-cfs flow changes. Reach H2 is upstream of Lake Ashtabula and Reach E2 is downstream of Baldhill Dam. Upstream, raceway increases with increasing flow at the expense of slow riffle and shallow pool. Downstream, raceway and deep pool increase at the expense of all other habitats. Species that require slow, shallow pools and riffles for nursery or spawning would be adversely affected.



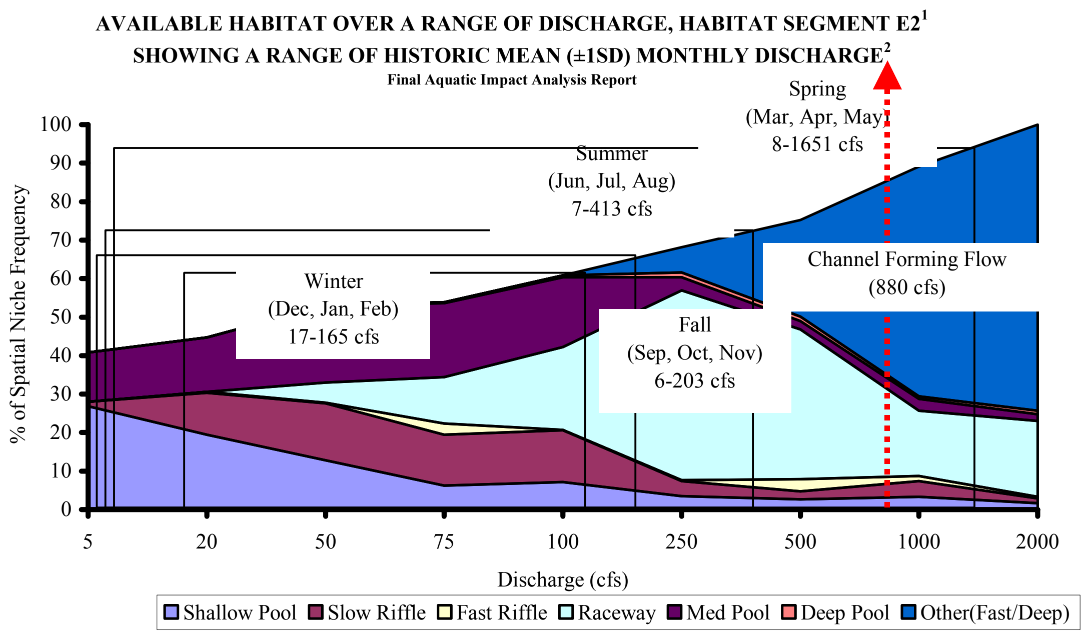


Figure C-13. Change in percent of available habitat for two reaches along the Upper and Lower Sheyenne River.

Earth Tech, Inc. conducted an evaluation of the effects of the 300-cfs constrained and 480-cfs unconstrained outlet operation. The results of this evaluation are summarized below.

The USACE modeled water quality using HEC-5Q and discharge using HEC-RAS for each baseline and future. Daily data for October 1, 2000, to September 30, 2050, at USGS gauge station points were provided. Since pumping and/or overflow were predicted to occur during only a portion of the time between 2000 and 2050, a ten-year period when pumping and/or overflow would occur was selected for analysis. The years 2005 to 2015 were used for 300MOD50 pumping and 480MOD55 pumping, and the years 2015 to 2025 were used for WETOF overflow. Three of the modeled water quality parameters—total dissolved solids (TDS), sulfate, and chloride—were summarized into minimum, maximum, average, and percent exceedence of water quality standards/guidelines and compared between baseline and future conditions for each alternative. Predicted hydrological changes were summarized using "Indicators of Hydrologic Alteration" (IHA). Parameters that changed between baseline and pumping/overflow and could impact aquatic biota were selected for comparison: monthly flow; variation in monthly flow; low flow magnitude, frequency, and duration; and difference in flow between fall and winter. Predicted depth and current velocity were modeled from existing channel configuration data and predicted discharge was modeled with Physical Habitat Simulation (PHABSIM). Predicted depth and velocity were compared to habitat suitability for shallow pool, slow riffle, fast riffle, raceway, medium pool, and deep pool fish guilds following Aadland (1993) and for low-gradient stream invertebrate diversity and tricopteran abundance guilds following Gore *et al.* (2001). WEST (2001) modeled geomorphology changes. However, the level of detail in the model was not sufficient for quantifying future erosion and deposition patterns that would influence biota. In particular, information on how channel morphology would change over time at the habitat transects and sedimentation rates for the alternatives were not available. Therefore, the magnitude of erosion and deposition was estimated as the difference in time that channel-forming flow is exceeded between baseline and pumping/overflow. A methyl mercury study [U.S. Geologic Survey (USGS) and USACE preliminary data] is currently assessing the background levels of methyl mercury in the Sheyenne River and Devils Lake system. However, predictions of future increases or decreases in methyl mercury were not available at the time of this report.

Comparison of alternatives

300MOD50 Pumping

All three alternatives would have a negative effect on the existing fauna. However, the effects would be least with 300MOD50 pumping. In this alternative, water quality degradation would likely decrease algal and invertebrate diversity throughout the Sheyenne River, but should not affect fish and mollusks. Aquatic biota could experience increased stress due to water quality changes which could in turn affect population levels. Changes in habitat may benefit rheophilic species in Sheyenne River Reach 3, but could be detrimental to many of the fish species in Reach 5, as spawning, nursery, and adult habitat would be affected. The Red River fauna should not be affected by this alternative. When pumping stops, the communities would probably shift again in response to the change in water quality and habitat. The time required for habitat to stabilize after pumping stops would determine the time required for recolonization. Although that time cannot be estimated from this study, channel changes should be less in this alternative than under 480MOD55 pumping or WETOF overflow, and recolonization time is expected to be shorter than for the other alternatives.

<u>Other Alternatives</u>

The overall effects of 480MOD55 pumping and WETOF overflow would be similar in magnitude. Hydrology, habitat, and geomorphology changes would be greater with 480MOD55 pumping and water quality changes would be greater with WETOF overflow.

<u>480MOD55 Pumping</u>

With 480MOD55 pumping, macrophytes would be lost throughout most of the Sheyenne River because of scouring, deposition, and increased turbidity. Periphyton and epiphyton would also be lost because of scouring, deposition, increased turbidity, and increased water depth. The invertebrate community would be reduced to those species tolerant of sulfate, chloride, and unstable substrates. Unionids would probably be extirpated by water quality. Other mollusks would be reduced by water quality and/or unstable substrate, reduced periphyton, and reduced macrophytes. Fish species richness and abundance in Reaches 1 to 4 would probably be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced.

Recolonization potential of the Sheyenne River would be limited due to the lack of permanent tributaries, upstream migration blockage of Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed, and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize; however, fish and unionid species may not recolonize within the life of the project.

Red River Reach 1 could experience an increase in emergent and wetland fringe macrophytes as new shallow water zones are inundated with the higher flow. Increased depth would also favor phytoplankton over periphyton, but this is probably already the case. Fish should not be affected in the Red River. However, a decline in abundance and richness of sensitive mollusk and invertebrate taxa could be expected throughout the Red River. Unlike the Sheyenne River, the Red River has several large tributaries that harbor similar fish species to the Red River. Thus, as water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries, and have short life spans and mobile adult stages. If unionids were not severely affected in Red River Reaches 2 and 3, unionids would probably recolonize Red River Reach 1 as fish recolonized from Reaches 2 and 3. However, if unionids were decimated throughout the river, recolonization may not occur, as few unionids have been recently found in the lower reaches of tributaries due to high chloride levels and/or fluctuating water levels.

WETOF Overflow

Although flow increases that would affect hydrology, geomorphology, and habitat would occur with WETOF overflow, water quality would be degraded more than the other alternatives. Loss of macrophytes through burial and scouring is expected throughout most of the Sheyenne River. In Sheyenne River Reach 1, sensitive algae are likely to be extirpated by high sulfate levels. Periphyton and epiphyton could be lost due to scouring and burial. Intolerant phytoplankton would also likely be affected through Sheyenne River Reach 3. These effects should dissipate some in Reaches 4 and 5, but without information on the tolerance of most species, these effects are difficult to estimate. A decrease in richness and abundance of invertebrates sensitive to chloride and sulfate is expected throughout the Sheyenne and Red Rivers. In the Sheyenne River, even taxa tolerant to these variables may not tolerate the concentrations expected. Additionally, unstable habitat conditions in Reaches 1 and 3 would also negatively affect invertebrate survival. The extirpation of unionids, sphaeriids, and prosobranchs is expected in Sheyenne River Reaches 1 through 5 due to increased chloride levels and habitat instability. Fish species richness and abundance in Reaches 1 to 4 would be reduced by water quality and changes in habitat. In Reach 5, fish may be limited to transient individuals. Habitat for rheophilic adults would be available, but most of these species are simple lithophils that require clean substrate for spawning. Additionally, nursery habitat for most of these species would be limited, weedy cover would be lost, and invertebrate abundance would be reduced.

Recolonization potential of the Sheyenne River is limited due to the lack of permanent tributaries, upstream migration blockage of Baldhill Dam, and the extent of habitat damage that may occur. Although water quality may recover to pre-pumping conditions, habitat throughout the river would have changed and substrate may be left unstable. The lower Sheyenne River could recolonize from the Rush, Maple, and Red Rivers once habitat stabilizes. The upper reaches would require time to stabilize; however, fish and unionid species may not recolonize within the life of the project.

Water quality effects from WETOF overflow would extend throughout the Red River. However, hydrology, geomorphology, and habitat in the Red River should not be affected by WETOF overflow. Water quality changes may not affect macrophytes and algae. Some decline in richness and abundance of sensitive invertebrate taxa is expected throughout the Red River due to high chloride and sulfate levels. Chloride levels may occasionally exceed levels thought to limit unionids (100 mg/l), but should be below this limit most of the year in Reach 1, and throughout the year in Reaches 2 and 3. However, chloride could reach up to 90 mg/l in Red River Reach 3. Thus, some decline in unionids and other mollusks might occur in Reach 1, and mollusks may be affected in Reaches 2 and 3. Degraded water quality in Red River Reach 1 may also result in the loss of an occasional year class of sensitive fish species, but should not affect recruitment in Reaches 2 and 3. As water quality improves, fish would probably recolonize within a few years. Invertebrates would also recolonize, as most species probably occur in tributaries, and have short life spans, and mobile adult stages. Unionids, however, may not recover. The lower reaches of most Red River tributaries do not harbor unionids due to water quality problems. If unionids were not severely affected in Red River Reaches 2 and 3, unionids would probably recolonize Red River Reach 1, as fish recolonized from Reaches 2 and 3.

Table C-13 is a summary of the habitat classifications of various fish species found in the Sheyenne and Red Rivers. It provides information on habitat requirements for fish species at different life stages.

Table C-13. Habitat Classification for Various Sheyenne and Red River Fishes.

HABITAT CLASSIFICATIONS FOR VARIOUS SHEYENNE AND RED RIVER FISHES
Final Aquatic Impact Analysis Report

Pool			Riffle		Raceway
Shallow	Medium	Deep	Slow	Fast	
Sand shiner (C4)– A[1,2]	Common shiner (C1, C3)– J	Common shiner (C1, C3)– Y	Longnose dace (W)– Sp	Longnose dace (W)– A	Golden redhorse (C3)– A
Bluntnose minnow (C3) - Y	Common shiner (C1, C3)– A	White sucker (C1,4) – A	Common shiner (C1, C3)– Sp	Silver redhorse (SC3, 4, 5)– Sp	Shorthead redhorse (C3, 4)– A
Longnose dace (W)– Y	Golden redhorse (C3)– J	Silver redhorse (SC3, 4, 5)– J	Sand shiner (C4)– Sp	Shorthead redhorse (C3, 4)– Sp	Shorthead redhorse (C3, 4)– J
Golden redhorse (C3)– Y	Channel catfish (C5)– A	Largemouth bass (W)– Y	Bluntnose minnow (C3, 4) – A	Stonecat (W)– J	Greater redhorse (SC3, 4)– A
Green sunfish (W)– Y	Channel catfish (C5)– J	Black crappie (W)– A	White sucker (C1,4) – J	Stonecat (W)– Y	Greater redhorse (SC3, 4)– J
Green sunfish (W)– A	Tadpole madtom (W)– Y	Black crappie (W)– Y	Shorthead redhorse (C3, 4) – Y	Logperch (Red)– A	Stonecat (W)– A
Orangespotted sunfish (W) –A	Northern pike (W)– A		Golden redhorse (C3)– Sp	Logperch (Red)- Y	Smallmouth bass (C3)– A
Bluegill (W)– J	Orangespotted sunfish (W)- J		Greater redhorse (SC3, 4)– Sp		Smallmouth bass (C3)– J
Bluegill (W)– Y	Largemouth bass (W)– J		Channel catfish (C5)– Y		Logperch (Red)- Sp
Smallmouth bass (C3)- Y	Black crappie (W)- J		Yellow perch (W)- A		
	White crappie (W)– A		Silver redhorse (SC3, 4, 5)– Y		
	White crappie (W)– J				
	White bass (W)– J				
	Yellow perch (W)– J				
	Walleye (W)– J				
	Walleye (W)– Y				
Black bullhead (C1)-Y[3]	Black bullhead (C1)-Sp, A	Freshwater drum (C5)-A	Spotfin shiner (C3, 4)-A	Rosyface shiner (SC3, 4, 5)-A, Sp	River darter (SC3)-A
Brook stickleback (C1)	Brook stickleback (C1)		Bigmouth shiner (C4)-A		
Creek chub (C1)-A	Creek chub (C1)-A		Creek chub (C1)-Sp		
Fathead minnow (C1)	Trout-perch (C1, SC1, 2, 3)-A	Trout-perch (C1, SC1, 2, 3)-A	Trout-perch (C1, SC1, 2, 3)-Sp		
Trout-perch (C1, SC1, 2, 3)-A	Fathead minnow (C1)		Blackside darter (C3)		
Johnny darter (C3)-A	Rosyface shiner (C3, SC3,4,5)-A, Sp		Johnny darter (C3)-A, Sp		
Hornyhead chub (SC3)-J	Hornyhead chub (SC3)-A		Hornyhead chub (SC3)-A		
Pugnose shiner (SC3)	Pugnose shiner (SC3)	Pugnose shiner (SC3)			
Blacknose shiner (SC3)	Banded killifish (SC3)				
Banded killifish (SC3)	Blacknose shiner (SC3)				

[1] Species (distribution)-life stage
Distribution-W=widely distributed, C#=common in Sheyenne River Reach #, SC#=special concern in Reach #
Life stage- A=adult, Sp=spawner, J=juvenile, Y=young of year

[2] Upper portion of table from Aadland (1993)

[3] Guilds assigned from habitat information in Plieger (1975), Becker (1983), Peterka and Koel (1996)

<u>Summary of 480-cfs Unconstrained Pumping (480MOD55) Compared to the 1455 Moderate Future Baseline (MOD55)</u>

Sheyenne River Reach 1

Water quality, hydrology, geomorphology, and habitat are expected to differ between 480MOD55 pumping and MOD55 baseline in Reach 1.

Macrophytes would be significantly impacted in Sheyenne River Reach 1. Increased turbidity may reduce abundance and habitat because of reduced light penetration and phytosynthetic potential. Submerged and emergent macrophytes may not remain established as deeper pools develop. Fast riffle habitat would also reduce macrophyte abundance because of increased scouring. Species would be reduced to areas of slow run or shallow pools where water velocity and depth are more moderate. Fringe species (typically a community of willows, sedges, and rushes) may also be affected. Increased water depth and velocity would likely remove the shallow marsh, wetland, and woody shrubs along the banks of the river. Exposure of these banks may lead to additional bank erosion and habitat changes.

Impacts would be mostly caused by changes in hydrology, including potential scouring or uprooting of macrophyte beds (i.e., submerged pondweeds), increased water depth, which may drown existing emergent vegetation, and desiccation and destruction of beds exposed in late fall and winter. Submerged species would be reduced the most. Exposing more area and expanding the wetted perimeter may create some additional habitat, but the species colonizing the new habitats would likely be more aggressive and tolerant of the increased disturbance rates and decreased water quality. Species of concern include reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), giant reed grass (*Phramites australis*) and flowering rush (*Butomus umbellatus*). All of these species have been identified in the basin and can readily inhabit disturbed areas. With the changes in hydrology, Reach 1 may begin to have communities similar to the existing communities in Reaches 3, 4, and 5. The loss of macrophytes would also affect the colonization area available for epiphytes, food and cover for invertebrates, and cover for fish.

Algal species would also likely decline in abundance and diversity in Reach 1. Changes in water quality would likely extirpate or reduce the abundance of at least some of the sensitive taxa, which would shift the overall taxa to those more tolerant of the degraded conditions. These tolerant taxa may not be as palatable to fish, invertebrates, and mollusks. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. In winter, exposed algae may be prone to desiccation. Some species are adapted to periodic desiccation and can form protective cell walls, sheaths, spores, or cysts. Annual draw-downs may ultimately favor those species capable of withstanding exposure. This would decrease algal abundance and diversity, and may have trophic consequences. Water level draw-downs can concentrate nutrients and produce algal blooms. Algal blooms in winter may cause significant reductions in dissolved oxygen and have impacts on other biota.

Many of the invertebrate taxa in this reach are sensitive to either sulfate or chloride. Concentrations of these parameters are expected to reach levels that would extirpate the sensitive fauna and possibly some of the more tolerant taxa, reducing species richness. Those not affected by water quality changes would probably be affected by unstable substrate, decreased habitat suitability, increased turbidity, declining winter water levels, and decreases in macrophytes and algae. This would reduce the invertebrate species to those very tolerant of high chloride and sulfate and able to survive in unstable substrate. Of the species found in Reach 1, these may include Nematoda and a few species of oligochaetes and chironomids. The loss of invertebrates would undoubtedly affect the fishes.

Most of the mollusks (unionids, sphaeriids, and prosobranchs) would be extirpated by the high chloride levels that are predicted with 480MOD55 pumping.

Fish would also likely decline in abundance and diversity because of the decline in reproductive success of some species due to water quality, siltation of spawning habitat, and lack of shallow pool and slow riffle nursery habitat. Lack of macrophytes would also affect northern pike and brook stickleback. Species not affected by the above factors include fathead minnow, creek chub, black and brown bullhead, tadpole madtom, trout perch, white bass, smallmouth bass, and white and black crappie. However, these species may be affected by lack of prey items and winter freezing.

After pumping stops, slower flowing, shallow habitats would return and this upper reach would be less hydrologically stable. In addition, the channel would have changed, probably becoming wider and deeper, such that the reduced water levels would result in less available wetted habitat during low-flow conditions. Unionids would probably not survive the pumping conditions. Only a few small permanent tributaries drain into Reach 1, and their suitability as unionid refugia is unlikely. Fish hosts are prevented from carrying glochidia upstream past Baldhill Dam. Unless unionid refugia occur in the small tributaries, this fauna is unlikely to recolonize. As conditions improve, the fish and invertebrate fauna would eventually invade from Lake Ashtabula. Recolonizing species would be dependent upon species remaining in Lake Ashtabula and habitat types that form once pumping stops. The length of time required for recolonization would depend on the time required for the channel to stabilize, which is not known.

Sheyenne River Reach 2

Water quality and turbidity would be the most likely factors to change in Lake Ashtabula. Changes may be severe, as water quality standards would be exceeded both upstream and downstream of the lake. The increased TDS, sulfate, and chloride levels would be well below toxic levels for the fish species present. However, changes in water quality would likely affect the algal composition, macrophyte composition, and invertebrate composition (including mollusks). Sensitive invertebrates, mollusks, algae, and macrophytes would not likely survive water quality conditions in Reaches 1 and 3, and thus would probably not likely survive in Lake Ashtabula. Water quality in Lake Ashtabula, however, may not affect fish reproduction.

Water quality should improve when pumping stops in the year 2016. However, the fauna remaining in Lake Ashtabula would be those species tolerant to the poorer water quality conditions.

Sheyenne River Reach 3

Changes in water quality, hydrology, geomorphology, and habitat in Reach 3 would be of a magnitude similar to or greater than Reach 1. Water quality degradation would be slightly less, but changes in habitat would be greater. Additionally, Reach 3 supports a more diverse fish and invertebrate community than Reach 1.

Increased flow would likely remove some of the macrophyte species through scouring or increased water depth. Turbidity may further limit macrophytes. Increased flow may allow expansion of existing vegetation into previously uncolonized areas. However, these areas would be disturbed by decrease in flow during winter. These changes may benefit aggressive species such as cattail and purple loosestrife.

Algal species would likely decline in abundance and diversity in Reach 3. Changes in water quality may shift the overall taxa to those more tolerant of the degraded conditions. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. Additionally, reduced abundance of macrophytes would reduce epiphyton. In winter, exposed algae may be prone to desiccation.

The invertebrate community would probably be reduced to those species tolerant of water quality changes and unstable substrate. The invertebrate community in Reach 3 currently consists of a fairly diverse mix of dipterans (several families rather than mainly chironomids), ephemeroptera (19 taxa), hemipterans (Corixidae), and tricopterans. Both tolerant and intolerant taxa occur in each of these groups. Habitat for rheophilic invertebrates should improve (hydropsychid caddisflies, some of the ephemeropterans, simulid dipterans); however, the scouring and deposition of substrate may negate the improvement in habitat conditions for these species. The amount of scouring and deposition may be the factor that determines which invertebrate species survive. At this point, scouring and deposition are expected to be worse than under MOD55 baseline, but the magnitude has not been determined.

Unionids, sphaeriids, and prosobranch gastropods would likely be extirpated from this reach due to increased sulfate and chloride concentrations.

Although water quality changes are not expected to affect fish species, many of the fish species in this reach, including several North Dakota special concern species, would be negatively affected by scouring and deposition, habitat changes, and possible declines in invertebrate abundance and macrophyte beds. Of the common species in this reach (common shiner, spotfin shiner, bluntnose minnow, shorthead redhorse, golden redhorse, smallmouth bass, blackside darter, and Johnny darter), common shiner, both redhorses, and blackside darter are simple lithophils that would be negatively affected by depositional substrate in spawning areas. Of the North Dakota special concern species in this reach, hornyhead chub and rosyface shiner could be negatively affected by increased turbidity; pugnose shiner, blacknose shiner, and banded killifish could be negatively affected by the loss of weed beds; and silver redhorse, greater redhorse, and river darter (simple lithophils) could be affected by depositional substrate in spawning areas. Habitat changes would reduce the community further to species that live entirely in fast water areas; however, if substrate is deposited in these areas or substrate is unstable, these habitats are of little use, particularly if invertebrates are depleted. Additionally, any fish trapped in shallow pools when discharge is reduced in the winter may freeze.

When pumping stops, the channel would have changed somewhat in configuration due to erosion and deposition. If the fish fauna are depleted during pumping, species from downstream may recolonize according to available habitat. Thus, the fish fauna could change from the diverse fish fauna that now occurs in this area to a less diverse fauna such as in Reach 5. Some of the North Dakota special concern species are primarily inhabitants of spring-fed tributary streams and may be able to reinvade after pumping stops if habitat is suitable. Invertebrates would likely drift in from Lake Ashtabula. However, only tolerant fauna would be likely to survive the lowered water quality in the lake. Invertebrates should also be able to reinvade from tributary streams. Diversity should increase with time, as habitats re-stabilize and species invade from tributaries and downstream areas. Unionids would not likely survive pumping. Most of the unionid species found in Reach 3 prior to pumping may still occur in the Red River. Recolonization of unionids would follow recolonization of fishes. As with Reach 1, the time required for recolonization would be dependent on the time required for habitat to stabilize, which is currently unknown.

Sheyenne River Reaches 4 and 5

Impacts to Reaches 4 and 5 would also be due to changes in water quality, hydrology, scouring. deposition, turbidity, and habitat, which should be similar to or slightly less than in Reach 3. However, overall impacts to Reaches 4 and 5 should be less than Reach 3 because of the lower habitat variability and species richness in Reaches 4 and 5.

Macrophytes are sparse in this reach due to high turbidity, relatively deep water, and unstable substrate. Changes in habitat do not favor the establishment of macrophytes. Increased flow in the summer and fall may improve habitat for some fringe areas and help establish wetland and emergent vegetation, but this would be a long-term process. Existing macrophyte beds would likely be removed or buried because of scouring and deposition expected with the increased flow.

The algal community would be affected similarly to Reach 3. Attached algae and epiphytes would be depleted by increased scouring, turbidity, and substrate instability.

Differences in water quality may be less between 480MOD55 pumping and MOD55 baseline in these reaches than in upstream reaches, but increased chloride and sulfate would be sufficient to reduce invertebrate species richness. Habitat for rheophilic taxa is expected to increase; however, this habitat may not be useful because of scouring and deposition.

Scouring and deposition would likely render habitat unsuitable for unionids. Sphaeriids and prosobranchs may also be reduced by habitat instability.

The fish community in Reach 5 is not particularly species rich compared to Reach 3; however, many of the species in this reach are simple lithophilic spawners (emerald shiner, sauger, and redhorse), and some need the shallow, medium, and deep pools as adults or juveniles (channel catfish, northern pike, sunfish, and minnows), which would be almost eliminated from at least the Habitat Segment B area. In addition to reduced habitat availability, food sources (algae and invertebrates) would also be depleted. The cumulative effects of these factors could severely deplete the fish fauna in Reach 5.

When pumping stops, this reach should be the first to recolonize. Since habitat is similar to the Red River, Red River fish and invertebrate species would likely be those to recolonize. The Maple River may also serve as a refuge and source of recolonizing fish and invertebrates. As with other Sheyenne River reaches, the time for recolonization would be dependent on the time required for habitat stabilization.

Red River

Both water quality and hydrology would be affected in the Red River, although the impacts would be greatest in Reach 1. Increased flow is only expected in Reach 1. Channel morphology of the Red River essentially precludes shallow-water habitat. Thus, macrophytes are not common. If shallow water areas are created, macrophytes may have an opportunity to colonize. The increased flow would also benefit phytoplankton over periphyton. However, this is probably already the case in the Red River. Changes in sulfate and chloride may be sufficient throughout the Red River to affect the abundance of invertebrates, including mollusks. A shift to tolerant species and a decline in species richness would be expected. The increased low flow magnitude, frequency, and duration may be less stressful to fish, at least in Reach 1.

Most of the species currently in the Red River would likely remain during pumping, although in different frequency depending on their tolerance to water quality and hydrology changes. As water quality and hydrology return to baseline conditions, the fauna should follow. None of the species should be extirpated, and many of the fish and probably invertebrate species occur in Red River tributaries. Unionids, however, are lacking in the lower end of most tributaries and may not be able to recolonize if decimated. However, they are not expected to be significantly affected by water quality, as chloride in Reach 1 is not expected to exceed 100 mg/l, and monthly averages would only exceed 50 mg/l in a few months.

Summary of 480-cfs Unconstrained Pumping (480MOD55) Compared to the 1455 Moderate Future Baseline (MOD55)

Sheyenne River Reach 1

Water quality, hydrology, geomorphology, and habitat are expected to differ between 480MOD55 pumping and MOD55 baseline in Reach 1.

Macrophytes would be significantly impacted in Sheyenne River Reach 1. Increased turbidity may reduce abundance and habitat because of reduced light penetration and phytosynthetic potential. Submerged and emergent macrophytes may not remain established as deeper pools develop. Fast riffle habitat would also reduce macrophyte abundance because of increased scouring. Species would be reduced to areas of slow run or shallow pools where water velocity and depth are more moderate. Fringe species (typically a community of willows, sedges, and rushes) may also be affected. Increased water depth and velocity would likely remove the shallow marsh, wetland, and woody shrubs along the banks of the river. Exposure of these banks may lead to additional bank erosion and habitat changes.

Impacts would be mostly caused by changes in hydrology, including potential scouring or uprooting of macrophyte beds (i.e., submerged pondweeds), increased water depth, which may drown existing emergent vegetation, and desiccation and destruction of beds exposed in late fall and winter. Submerged species would be reduced the most. Exposing more area and expanding the wetted perimeter may create some additional habitat, but the species colonizing the new habitats would likely be more aggressive and tolerant of the increased disturbance rates and decreased water quality. Species of concern include reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), giant reed grass (*Phramites australis*) and flowering rush (*Butomus umbellatus*). All of these species have been identified in the basin and can readily inhabit disturbed areas. With the changes in hydrology, Reach 1 may begin to have communities similar to the existing communities in Reaches 3, 4, and 5. The loss of macrophytes would also affect the colonization area available for epiphytes, food and cover for invertebrates, and cover for fish.

Algal species would also likely decline in abundance and diversity in Reach 1. Changes in water quality would likely extirpate or reduce the abundance of at least some of the sensitive taxa, which would shift the overall taxa to those more tolerant of the degraded conditions. These tolerant taxa may not be as palatable to fish, invertebrates, and mollusks. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. In winter, exposed algae may be prone to desiccation. Some species are adapted to periodic desiccation and can form protective cell walls, sheaths, spores, or cysts. Annual draw-downs may ultimately favor those species capable of withstanding exposure. This would decrease algal abundance and diversity, and may have trophic consequences. Water level draw-downs can concentrate nutrients and produce algal blooms. Algal blooms in winter may cause significant reductions in dissolved oxygen and have impacts on other biota.

Many of the invertebrate taxa in this reach are sensitive to either sulfate or chloride. Concentrations of these parameters are expected to reach levels that would extirpate the sensitive fauna and possibly some of the more tolerant taxa, reducing species richness. Those not affected by water quality changes would probably be affected by unstable substrate, decreased habitat suitability, increased turbidity, declining winter water levels, and decreases in macrophytes and algae. This would reduce the invertebrate species to those very tolerant of high chloride and sulfate and able to survive in unstable substrate. Of the species found in Reach 1, these may include Nematoda and a few species of oligochaetes and chironomids. The loss of invertebrates would undoubtedly affect the fishes.

Most of the mollusks (unionids, sphaeriids, and prosobranchs) would be extirpated by the high chloride levels that are predicted with 480MOD55 pumping.

Fish would also likely decline in abundance and diversity because of the decline in reproductive success of some species due to water quality, siltation of spawning habitat, and lack of shallow pool and slow riffle nursery habitat. Lack of macrophytes would also affect northern pike and brook stickleback. Species not affected by the above factors include fathead minnow, creek chub, black and brown bullhead, tadpole madtom, trout perch, white bass, smallmouth bass, and white and black crappie. However, these species may be affected by lack of prey items and winter freezing.

After pumping stops, slower flowing, shallow habitats would return and this upper reach would be less hydrologically stable. In addition, the channel would have changed, probably becoming wider and deeper, such that the reduced water levels would result in less available wetted habitat during low-flow conditions. Unionids would probably not survive the pumping conditions. Only a few small permanent tributaries drain into Reach 1, and their suitability as unionid refugia is unlikely. Fish hosts are prevented from carrying glochidia upstream past Baldhill Dam. Unless unionid refugia occur in the small tributaries, this fauna is unlikely to recolonize. As conditions improve, the fish and invertebrate fauna would eventually invade from Lake Ashtabula. Recolonizing species would be dependent upon species remaining in Lake Ashtabula and habitat types that form once pumping stops. The length of time required for recolonization would depend on the time required for the channel to stabilize, which is not known.

Sheyenne River Reach 2

Water quality and turbidity would be the most likely factors to change in Lake Ashtabula. Changes may be severe, as water quality standards would be exceeded both upstream and downstream of the lake. The increased TDS, sulfate, and chloride levels would be well below toxic levels for the fish species present. However, changes in water quality would likely affect the algal composition, macrophyte composition, and invertebrate composition (including mollusks). Sensitive invertebrates, mollusks, algae, and macrophytes would not likely survive water quality conditions in Reaches 1 and 3, and thus would probably not likely survive in Lake Ashtabula. Water quality in Lake Ashtabula, however, may not affect fish reproduction.

Water quality should improve when pumping stops in the year 2016. However, the fauna remaining in Lake Ashtabula would be those species tolerant to the poorer water quality conditions.

Sheyenne River Reach 3

Changes in water quality, hydrology, geomorphology, and habitat in Reach 3 would be of a magnitude similar to or greater than Reach 1. Water quality degradation would be slightly less, but changes in habitat would be greater. Additionally, Reach 3 supports a more diverse fish and invertebrate community than Reach 1.

Increased flow would likely remove some of the macrophyte species through scouring or increased water depth. Turbidity may further limit macrophytes. Increased flow may allow expansion of existing vegetation into previously uncolonized areas. However, these areas would be disturbed by decrease in flow during winter. These changes may benefit aggressive species such as cattail and purple loosestrife.

Algal species would likely decline in abundance and diversity in Reach 3. Changes in water quality may shift the overall taxa to those more tolerant of the degraded conditions. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. Additionally, reduced abundance of macrophytes would reduce epiphyton. In winter, exposed algae may be prone to desiccation.

The invertebrate community would probably be reduced to those species tolerant of water quality changes and unstable substrate. The invertebrate community in Reach 3 currently consists of a fairly diverse mix of dipterans (several families rather than mainly chironomids), ephemeroptera (19 taxa), hemipterans (Corixidae), and tricopterans. Both tolerant and intolerant taxa occur in each of these groups. Habitat for rheophilic invertebrates should improve (hydropsychid caddisflies, some of the ephemeropterans, simulid dipterans); however, the scouring and deposition of substrate may negate the improvement in habitat conditions for these species. The amount of scouring and deposition may be the factor that determines what invertebrate species survive. At this point, scouring and deposition are expected to be worse than under MOD55 baseline, but the magnitude has not been determined.

Unionids, sphaeriids, and prosobranch gastropods would likely be extirpated from this reach due to increased sulfate and chloride concentrations.

Although water quality changes are not expected to affect fish species, many of the fish species in this reach, including several North Dakota special concern species, would be negatively affected by scouring and deposition, habitat changes, and possible declines in invertebrate abundance and macrophyte beds. Of the common species in this reach (common shiner, spotfin shiner, bluntnose minnow, shorthead redhorse, golden redhorse, smallmouth bass, blackside darter, and Johnny darter), common shiner, both redhorses, and blackside darter are simple lithophils that would be negatively affected by depositional substrate in spawning areas. Of the North Dakota special concern species in this reach, hornyhead chub and rosyface shiner could be negatively affected by increased turbidity; pugnose shiner, blacknose shiner, and banded killifish could be negatively affected by the loss of weed beds; and silver redhorse, greater redhorse, and river darter (simple lithophils) could be affected by depositional substrate in spawning areas. Habitat changes would reduce the community further to species that live entirely in fast water areas; however, if substrate is deposited in these areas or substrate is unstable, these habitats are of little use, particularly if invertebrates are depleted. Additionally, any fish trapped in shallow pools when discharge is reduced in the winter may freeze.

When pumping stops, the channel would have changed somewhat in configuration due to erosion and deposition. If the fish fauna are depleted during pumping, species from downstream may recolonize according to available habitat. Thus, the fish fauna could change from the diverse fish fauna that now occurs in this area to a less diverse fauna such as in Reach 5. Some of the

North Dakota special concern species are primarily inhabitants of spring-fed tributary streams and may be able to reinvade after pumping stops if habitat is suitable. Invertebrates would likely drift in from Lake Ashtabula. However, only tolerant fauna would be likely to survive the lowered water quality in the lake. Invertebrates should also be able to reinvade from tributary streams. Diversity should increase with time, as habitats restabilize and species invade from tributaries and downstream areas. Unionids would not likely survive pumping. Most of the unionid species found in Reach 3 prior to pumping may still occur in the Red River. Recolonization of unionids would follow recolonization of fishes. As with Reach 1, the time required for recolonization would be dependent on the time required for habitat to stabilize, which is currently unknown.

Sheyenne River Reaches 4 and 5

Impacts to Reaches 4 and 5 would also be due to changes in water quality, hydrology, scouring. deposition, turbidity, and habitat, which should be similar to or slightly less than in Reach 3. However, overall impacts to Reaches 4 and 5 should be less than Reach 3 because of the lower habitat variability and species richness in Reaches 4 and 5.

Macrophytes are sparse in this reach due to high turbidity, relatively deep water, and unstable substrate. Changes in habitat do not favor the establishment of macrophytes. Increased flow in the summer and fall may improve habitat for some fringe areas and help establish wetland and emergent vegetation, but this would be a long-term process. Existing macrophyte beds would likely be removed or buried because of scouring and deposition expected with the increased flow.

The algal community would be affected similarly to Reach 3. Attached algae and epiphytes would be depleted by increased scouring, turbidity, and substrate instability.

Differences in water quality may be less between 480MOD55 pumping and MOD55 baseline in these reaches than in upstream reaches, but increased chloride and sulfate would be sufficient to reduce invertebrate species richness. Habitat for rheophilic taxa is expected to increase; however, this habitat may not be useful because of scouring and deposition.

Scouring and deposition would likely render habitat unsuitable for unionids. Sphaeriids and prosobranchs may also be reduced by habitat instability.

The fish community in Reach 5 is not particularly species rich compared to Reach 3; however, many of the species in this reach are simple lithophilic spawners (emerald shiner, sauger, and redhorse), and some need the shallow, medium, and deep pools as adults or juveniles (channel catfish, northern pike, sunfish, and minnows), which would be almost eliminated from at least the Habitat Segment B area. In addition to reduced habitat availability, food sources (algae and invertebrates) would also be depleted. The cumulative effects of these factors could severely deplete the fish fauna in Reach 5.

When pumping stops, this reach should be the first to recolonize. Since habitat is similar to the Red River, Red River fish and invertebrate species would likely be those to recolonize. The

Maple River may also serve as a refuge and source of recolonizing fish and invertebrates. As with other Sheyenne River reaches, the time for recolonization would be dependent on the time required for habitat stabilization.

Red River

Both water quality and hydrology would be affected in the Red River, although the impacts would be greatest in Reach 1. Increased flow is only expected in Reach 1. Channel morphology of the Red River essentially precludes shallow-water habitat. Thus, macrophytes are not common. If shallow-water areas are created, macrophytes may have an opportunity to colonize. The increased flow would also benefit phytoplankton over periphyton. However, this is probably already the case in the Red River. Changes in sulfate and chloride may be sufficient throughout the Red River to affect the abundance of invertebrates, including mollusks. A shift to tolerant species and a decline in species richness would be expected. The increased low flow magnitude, frequency, and duration may be less stressful to fish, at least in Reach 1.

Most of the species currently in the Red River would likely remain during pumping, although in different frequency depending on their tolerance to water quality and hydrology changes. As water quality and hydrology return to baseline conditions, the fauna should follow. None of the species should be extirpated, and many of the fish and probably invertebrate species occur in Red River tributaries. Unionids, however, are lacking in the lower end of most tributaries and may not be able to recolonize if decimated. However, they are not expected to be significantly affected by water quality, as chloride in Reach 1 is not expected to exceed 100 mg/l, and monthly averages would only exceed 50 mg/l in a few months.

Summary of Wet Future with Natural Overflow (WETOF) Compared to Wet Future Baseline (WET)

Sheyenne River Reach 1

Water quality, hydrology, geomorphology, and habitat are expected to differ between WET baseline and WETOF overflow in Reach 1. Water quality effects may be worse, as TDS, sulfate, and chloride levels would be almost double (TDS) to more than double (sulfate and chloride) the concentrations expected with 480MOD55 pumping. Flow, on the other hand, is not expected to increase as much; therefore, changes in hydrology, geomorphology, and habitat are not expected to be as great.

Macrophytes would be significantly impacted in Reach 1. Increased turbidity may reduce abundance and habitat because of reduced light penetration and photosynthetic potential. Submerged and emergent macrophytes may not remain established as deeper pools develop. Fast riffle habitat would also reduce macrophyte abundance because of increased scouring. Species would be reduced to areas of slow run or shallow pools, where water velocity and depth would be more moderate. Fringe species (typically a community of willows, sedges, and rushes) may also be affected. Increased water depth and velocity would likely remove the shallow marsh, wetland, and woody shrubs along the banks of the river. Exposure of these banks may lead to additional bank erosion and habitat changes.

Impacts would be mostly caused by changes in hydrology, including potential scouring or uprooting of macrophyte beds (i.e., submerged pondweeds) and increased water depth, which may drown existing emergent vegetation. Submerged species would be reduced the most. Exposing more area and expanding the wetted perimeter may create some additional habitat, but the species colonizing the new habitats would likely be more aggressive and tolerant of the increased disturbance rates and decreased water quality. Species of concern would include reed canary grass, purple loosestrife, giant reed grass, and flowering rush. All of these species have been identified in the basin and can readily inhabit disturbed areas. With the changes in hydrology, Reach 1 may begin to have communities similar to those existing in Reaches 3, 4, and 5. The loss of macrophytes would also affect the colonization area available for epiphytes, food and cover for invertebrates, and cover for fish.

Algal species would also likely decline in abundance and diversity in Reach 1. Changes in water quality would likely extirpate or reduce the abundance of at least some of the sensitive taxa, which would shift the overall taxa to those more tolerant of the degraded conditions. These tolerant taxa may not be as palatable to fish, invertebrates, and mollusks. The loss of algal diversity and decreased water quality may also increase the occurrence of noxious blooms. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species.

Many of the invertebrate taxa in this reach are sensitive to either sulfate or chloride. Concentrations of these parameters are expected to reach levels that would extirpate the sensitive fauna and possibly some of the more tolerant taxa, reducing species richness. Those not affected by water quality changes would probably be affected by unstable substrate, decreased habitat suitability, increased turbidity, and decreases in macrophytes and algae. This would reduce the invertebrate species to those very tolerant of high chloride and sulfate and able to survive in unstable substrate. The species found in Reach 1 may include nematode and a few species of oligochaetes and chironomids. The loss of invertebrates would undoubtedly affect the fishes.

The high chloride levels that are predicted with WETOF overflow would probably extirpate most of the mollusks (unionids, sphaeriids, and prosobranchs).

Fish would also likely decline in abundance and diversity because of the decline in reproductive success of some species due to water quality and siltation of spawning habitat. Lack of macrophytes would also affect northern pike and brook stickleback. Species not affected by the above factors would include fathead minnow, creek chub, black and brown bullhead, tadpole madtom, trout perch, white bass, smallmouth bass, and white and black crappie. However, these species may be affected by lack of prey items.

After overflow stops, water quality may improve, and slower-flowing, fast-water habitat would decline. This upper reach would be less hydrologically stable. The channel would probably have changed, becoming wider and deeper, such that the reduced water levels would result in less available wetted habitat during low-flow conditions. Unionids, many invertebrate species, algal species, and macrophyte species would probably not survive WETOF overflow. Only a few small permanent tributaries drain into Reach 1 and their suitability as unionid, fish, and invertebrate refugia is unlikely. Fish hosts are prevented from carrying glochidia upstream past

Baldhill Dam. Unless unionid refugia occur in the small tributaries, this fauna is unlikely to recolonize. As conditions improve, the fish and invertebrate fauna would eventually invade from Lake Ashtabula. Recolonizing species would be dependent upon species remaining in Lake Ashtabula and the habitat types that would form once pumping stops. The length of time required for recolonization would depend on the time required for the channel to stabilize, which is not known.

Sheyenne River Reach 2

Water quality and turbidity would be the most likely factors to change in Lake Ashtabula. Changes may be severe, as water quality standards would be exceeded both upstream and downstream of the lake. The increased TDS, sulfate, and chloride levels would be well below toxic levels for the fish species present. However, changes in water quality would likely affect the algal composition, macrophyte composition, and invertebrate composition (including mollusks). Sensitive invertebrates, mollusks, algae, and macrophytes would not likely survive water quality conditions in Reaches 1 and 3, and thus probably would not likely survive in Lake Ashtabula. Water quality in Lake Ashtabula also may affect fish reproduction. The loss of macrophytes, change in algal composition, and loss of invertebrates would also likely affect fish abundance.

Water quality should improve when overflow stops in the year 2025. However, the fauna remaining in Lake Ashtabula would be those species tolerant to the poorer water quality conditions.

Sheyenne River Reach 3

Changes in water quality, hydrology, geomorphology, and habitat in Reach 3 would be of a magnitude similar to or greater than Reach 1. Water quality degradation would be slightly less, but changes in habitat would be greater. Additionally, Reach 3 would support a more diverse fish and invertebrate community than Reach 1.

Increased flow would likely remove some of the macrophyte species through scouring or increased water depth. Turbidity may further limit macrophytes. Increased flow may allow expansion of existing vegetation into previously uncolonized areas. The effects of water quality changes are unknown, but those species intolerant of high sulfate and chloride would likely be extirpated. These changes may benefit aggressive species such as cattail and purple loosestrife.

Algal species would likely decline in abundance and diversity in Reach 3. Changes in water quality may shift the overall taxa to those more tolerant of the degraded conditions. Increased flow would favor phytoplankton species and may make conditions too deep for some periphytic species. Additionally, reduced abundance of macrophytes would reduce epiphyton.

The invertebrate community would probably be reduced to those species tolerant of water quality changes and unstable substrate. Water quality changes in this reach would only be slightly less than in Reach 1. The invertebrate community in Reach 3 currently consists of a fairly diverse mix of dipterans (several families rather than mainly chironomids), ephemeropteran (19 taxa), hemipterans (Corixidae), and tricopterans. Both tolerant and intolerant taxa occur in each of these groups. Habitat for rheophilic invertebrates and overall invertebrate diversity should not change. However, scouring and deposition of substrate would tend to reduce the usefulness of these habitats. Between water quality degradation and unstable substrate, few invertebrate species may survive.

Unionids, sphaeriids, and prosobranch gastropods would likely be extirpated from this reach due to increased sulfate and chloride concentrations.

Water quality changes would be expected to affect reproduction of sensitive fish species (northern pike, rosyface shiner, hornyhead chub, greater redhorse). Additionally, scouring and deposition, habitat changes, and possible declines in invertebrate abundance and macrophyte beds would negatively affect many of the fish species in this reach, including several North Dakota special concern species. Of the common species in this reach (common shiner, spotfin shiner, bluntnose minnow, shorthead redhorse, golden redhorse, smallmouth bass, blackside darter and Johnny darter), common shiner, both redhorses, and blackside darter are simple lithophils that would be negatively affected by depositional substrate in spawning areas. Of the North Dakota special concern species in this reach, hornyhead chub and rosyface shiner could be negatively affected by increased turbidity and water quality; pugnose shiner, blacknose shiner, and banded killifish could be negatively affected by the loss of weed beds and water quality; and silver redhorse, greater redhorse, and river darter (simple lithophils) would be affected by depositional substrate in spawning areas. Habitat changes would reduce the community further to species that live entirely in fast-water areas; however, if substrate is deposited in these areas or substrate is unstable, these habitats would be of little use, particularly if invertebrates are depleted.

When overflow stops, the channel would have changed somewhat in configuration due to erosion and deposition. If the fish fauna are depleted during overflow, species from downstream may recolonize according to available habitat. Thus, the fish fauna could change from the diverse fish fauna that now occur in this area to a less diverse fauna such as in Reach 5. Some of the North Dakota special concern species are primarily inhabitants of spring-fed tributary streams and may be able to reinvade after overflow stops if habitat is suitable. Invertebrates would likely drift in from Lake Ashtabula. However, only tolerant fauna are likely to survive the lowered water quality in the lake. Invertebrates should also be able to reinvade from tributary streams. Diversity should increase with time, as habitats restabilize and species invade from tributaries and downstream areas. Unionids would not likely survive overflow. Most of the unionid species found in Reach 3 prior to pumping may still occur in the Red River. Recolonization of unionids would follow recolonization of fishes. As with Reach 1, the time required for recolonization would be dependent on the time required for habitat to stabilize, which is currently unknown.

Sheyenne River Reaches 4 and 5

Impacts to Reaches 4 and 5 would also be due to changes in water quality, hydrology, scouring. deposition, turbidity, and habitat, which should be similar to or slightly less than in Reach 3. However, overall impacts to Reaches 4 and 5 should be less than Reach 3 due to the lower habitat variability and species richness in Reaches 4 and 5.

Macrophytes are sparse in this reach due to high turbidity, relatively deep water, and unstable substrate. Changes in habitat do not favor the establishment of macrophytes. Increased flow in the summer and fall may improve habitat for some fringe areas and help establish wetland and emergent vegetation, but this would be a long-term process. Existing macrophyte beds would likely be removed or buried due to the scouring and deposition expected with the increased flow.

The algal community would be affected similarly to Reach 3. Attached algae and epiphytes would be depleted by increased scouring, turbidity, and substrate instability. Additionally, changes in water quality could be sufficient to reduce the abundance of intolerant taxa and shift the species composition toward tolerant taxa.

Differences in water quality may be less between WET baseline and WETOF overflow in these reaches than in upstream reaches, but increased chloride and sulfate would be sufficient to extirpate sensitive species and reduce the richness of tolerant taxa. Habitat diversity would also decline. Thus, invertebrate fauna remaining in these reaches would be those tolerant of high chloride and sulfate, shifting substrate, and fast water.

Water quality should not be sufficient to extirpate unionids, sphaeriids, and prosobranchs, but occasional levels above thresholds may affect reproduction and recruitment. Thus, abundance would likely decrease. Scouring and deposition would likely render habitat unsuitable for unionids. Sphaeriids and prosobranchs may also be reduced by habitat instability.

The fish community in Reach 5 is not particularly species rich compared to Reach 3, however, many of the species in this reach are simple lithophilic spawners (e.g., emerald shiner, sauger, and redhorse), and some need the shallow, medium, and deep pools as adults or juvenile (e.g., channel catfish, northern pike, sunfish, and minnows), which will be reduced in at least the Habitat Segment B area. In addition to reduced habitat availability, food sources such as algae and invertebrates would also be depleted. Water quality would also be degraded, which would reduce reproductive success. The cumulative effects of these factors could severely deplete the fish fauna in Reach 5.

When overflow stops, Reaches 4 and 5 should be the first to recolonize. Since habitat is similar to the Red River, Red River fish and invertebrate species would likely be those to recolonize. The Maple River may also serve as a refuge and source of recolonizing fish and invertebrates. As with other Sheyenne River reaches, the time for recolonization would be dependent on the time required for habitat stabilization. Since water quality would also affect the lower Red River, recolonization may take longer than under the 480-cfs unconstrained pumping conditions.

Red River

Water quality should be the only factor analyzed in this study that would be affected in the Red River. Impacts would be greatest in Red River Reach 1, but would extend to the Canadian border. Macrophytes and algae would probably not be affected in the Red River. However, changes in sulfate and chloride may be sufficient in Reach 1 to result in the occasional loss of recruitment in sensitive fish species, decrease in abundance of sensitive mollusks, and decrease in abundance and richness of invertebrates. Sensitive invertebrates and mollusks may be affected throughout the Red River. A shift to tolerant species and a decline in species richness would be expected.

Most of the species currently in the Red River would likely remain during overflow, at least in Reaches 2 and 3, although at a different frequency depending on their tolerance to water quality. As water quality returns to baseline conditions, the fauna should follow. None of the species should be extirpated, and many of the fish and probably invertebrate species occur in Red River tributaries. Unionids, however, are lacking in the lower end of most tributaries and may not be able to recolonize if decimated. Unionids are not expected to be significantly affected by water quality, as chloride in Reach 1 is not expected to exceed 100 mg/l, and monthly averages would only exceed 50 mg/l in a few months.

Table C-14 is a summary of the potential aquatic effects of an outlet to the Sheyenne

COMPARISON BETWEEN EFFECTS OF 300MOD50, 480MOD55, AND OVERFLOW ON THE AQUATIC BIOTA OF THE SHEYENNE AND RED RIVERS.
Final Aquatic Impact Analysis Report

	Sheyenne River					Red River		
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 1	Reach 2	Reach 3
Fish								
300MOD50 vs MOD50	No effect	No effect	Increase in rheophilic species	Probably no effect	Loss of spawning, nursery and adult habitat	No effect	No effect	No effect
480MOD 55 vs MOD55	Decline in abundance and diversity of fish community	No change	Decline in abundance and diversity of fish community, possible loss of special concern species	Decline in abundance and diversity of fish community	Fish may be limited to transient individuals. Habitat for rheophilic adults is present, but most of these are simple lithophils, and nursery habitat will be limited. Weedy cover and invertebrate productivity also lost.	No effect	No effect	No effect
WETOF vs WET	Decline abundance and diversity of fish	Possible decline in some fish species	Decline in most of the fish species that occur in this reach now, including most ND special concern species, fish community will probably be limited to very tolerant taxa (carp, green sunfish, fathead minnows)	Loss of sensitive species such as blacknose shiner, rosyface shiner, silver redhorse; abundance species in this reach (spotfin shiner, sand shiner, bluntnose minnow) probably not affected. Loss of species restricted to this reach (blacknose dace, blacknose shiner, blackchin shiner)	Fish may be limited to transient individuals. Habitat for rheophilic adults is present, but most of these are simple lithophils, and nursery habitat will be limited. Weedy cover and invertebrate productivity also lost.	Potential loss of occasional year class of sensitive taxa	No effect	No effect
Mollusks								
300MOD50 vs MOD50	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
480MOD 55 vs MOD55	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Unionids may be extirpated, sphaeriids and prosobranchs may be reduced in abundance	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
WETOF vs WET	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Unionids, sphaeriids, and prosobranchs may be extirpated	Some decrease in richness and abundance of sensitive taxa	Some decline in abundance of sensitive mollusks	Some decline in abundance of sensitive mollusks
Invertebrates								
300MOD50 vs MOD50	Decrease in diversity, increase in taxa tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	Decrease in taxa sensitive to chloride and sulfate	Decrease in diversity, increase in taxa tolerant of sulfate and chloride particularly those that prefer erosional habitats (Hydropsychid caddisflies, Stenelmis)	No effect	Minor increase in diversity and rheophilic species	No effect	No effect	No effect
480MOD 55 vs MOD55	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Sensitive invertebrates may be extirpated, reduced abundance of tolerant taxa	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Reduced invertebrate community to only species tolerant of water quality changes, and unstable substrate	Decrease in abundance of sensitive taxa	Decrease in abundance of sensitive taxa	Some decrease in abundance of sensitive taxa
WETOF vs WET	Decline in overall invertebrate abundance and diversity	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Sensitive invertebrates may be extirpated, tolerant taxa may decrease in abundance or richness	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa	Some decrease in richness and abundance of sensitive taxa
Algae								
300MOD50 vs MOD50	Decline in diversity	Decline in diversity	Decline in diversity	Decline in diversity	Decline in diversity	No effect	No effect	No effect
480MOD 55 vs MOD55	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Loss of some attached algae and epiphytes through scouring or burial, decreased production due to turbidity	Favor phytoplankton, possible loss of periphyton	No effect	No effect
WETOF vs WET	Possible extirpation of sensitive species, loss of periphyton and epiphytes, possible increase in phytoplankton	Decreased production, decline in water quality sensitive taxa, possible increase in tolerant taxa	Decrease in periphyton and epiphyton, decrease in intolerant phytoplankton	Possible loss of periphyton, epiphyton, increase in tolerant phytoplankton	Favor phytoplankton, possible loss of periphyton	No effect	No effect	No effect
Macrophytes								
300MOD50 vs MOD50	No effect	No effect	No effect	No effect	No effect	No effect	No effect	No effect
480MOD 55 vs MOD55	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decline in abundance and species richness	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Emergent and wetland fringe vegetation should move up the banks into new shallow water zone	No effect	No effect
WETOF vs WET	Loss of macrophytes through scouring and burial, decreased production due to turbidity	Some decrease in richness and abundance of sensitive taxa, increase in tolerant taxa	Decrease in production, richness, and abundance of macrophytes	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	Some loss of macrophytes through scouring and burial, some decreased production due to turbidity	No effect	No effect	No effect

River Monitoring and Mitigation

These mitigation measures are identified as potential and include a discussion of one possible way to implement or sample. They have not been included in the present mitigation plan or identified as needed by agencies or through scoping. They are identified as possible mitigation measures. Monitoring may address some of the concerns. Monitoring prior to operation or post project may identify the need for some of these actions. These measures have not been coordinated with agencies or the local sponsor. Costs for these measures have not been included in the cost estimates.

PRE-OPERATION MONITORING - Sheyenne River

All of the above predictions are based on modeled hydrology and water quality, available geomorphology information, and habitat modeling. Hydrology and water quality model data should be compared to actual available data (2000-2002) to verify modeled values. Most of the biotic information is fairly recent, but was not collected at the same time and location as data for the models. For the purposes of this analysis, modeled conditions at one or two locations within a reach were assumed to occur throughout the reach. Additionally, aquatic communities and habitats naturally vary over time. Therefore, additional baseline data may be needed to define average conditions and natural variability, and to relate existing biota to available habitat.

Baseline monitoring could include resampling of habitat transects at flows that would best facilitate habitat modeling. The Sheyenne River habitat and vegetation communities should be mapped using LIDAR and infrared aerial photographs. Habitat types should be field-verified and representative sections within each reach selected for sampling and long-term monitoring, so that data from habitat transects can be extrapolated to river-wide conclusions. Erosion and deposition rates need to be defined for existing conditions, and modeled and monitored for future conditions.

Once habitat transects are established, algae, macrophytes, mollusks, invertebrates, and fish should be sampled within those transects. Sampling should be seasonal, except for unionids that do not change on a seasonal basis, and take place over a period of at least three years to define trends. Habitat characteristics (depth, substrate, and flow at cells across the channel) should also be sampled seasonally for at least three years to determine habitat stability. Water quality (at least TDS, sulfate, and chloride) and productivity (chlorophyll a) should also be sampled at a minimum of three points along each habitat transect.

Phytoplankton and Periphyton

The periphyton and phytoplankton communities are very diverse and are often difficult to identify. Algae are the most basic biotic component in the river and may be the first group to respond to changes in water quality and hydrology. Changes in the algal community will also transfer up the trophic chain with consequences on the rest of the ecosystem. Algae are also primary producers and will affect nutrient transport and spiraling in the system. Many species can also form large floating mats and create aesthetic, odor, and taste problems. Some species of cyanobacteria also produce toxins when overly abundant.

Phytoplankton and periphyton have very different community compositions over a very small geographic scale. Compositions in pools, runs, riffles, and stable water (i.e. Lake Ashtabula) are often very different. For this reason, it is difficult to identify any one species that is a useful monitor for all locations. Furthermore, species composition can change seasonally, making the timing of monitoring potentially important. The following is a list of possible monitoring parameters. These could be followed for both the phytoplanktonic and periphytic components of the algal community.

1. Chlorophyll a: Before looking at individual groups of species, a broad, comparable, quantifiable measurement should be considered as a surrogate for algal abundance. Chlorophyll a is a good way to compare algal response to nutrients, water chemistry, turbidity, and geomorphology.

2. Chlorophyta (green algae): This is a large group of algae with a wide range of habitats. Under eutrophic conditions, this group can reproduce rapidly and form large algal mats. Some of the species with the widest range include *Kirchneriella* sp., *Monoraphidium* sp., *Raphidonema* sp., and *Aestrococcus* sp.

3. Bacillariophyta (diatoms): This is also a very large group with a wide range of habitats. Diatoms are present in all reaches of the project, but have distinct community shifts in different flow and water quality conditions.

4. Cyanobacteria (blue-green algae): This group of algae is usually not common in undisturbed systems. It is generally considered a nuisance, as it can affect water quality and is not consumed by wildlife. When eutrophication occurs from increased nutrient inputs, this species can rapidly reproduce and dominate a system. This often leads to massive die-offs, which cause oxygen depletion, changes in water clarity, and potentially the production of toxins. Shifts in the abundance of cyanobacteria may be an early indication of deteriorating water quality.

5. Euglenophyta (euglenoids): The euglenoids are planktonic algae, which are present in all reaches of the Sheyenne River. This group has been singled out for monitoring because of the wide distribution, relative few species, and its tolerance to high concentrations of sulfate. Changes in this group may be indicative of changes in water quality.

6. Devils Lake taxa: Several species of algae in Devils Lake are not present in the Sheyenne River. Monitoring for these taxa, or the occurrence of other "lake-like" taxa above Lake Ashtabula, should be conducted for assessment of how much foreign biota is entering the Sheyenne River. While many of the exotic taxa may not survive or coexist with the native taxa, shifts in overall community structure could indicate changes in water quality or hydrology.

The relative abundance of these groups should be enumerated and compared spatial and temporally.

Macrophytes

Specific information on aquatic vegetation abundance and distribution is lacking. Information on distribution and community composition could possibly be obtained from LIDAR and infrared aerial photographs. Distribution and abundance of macrophytes should be considered in habitat transect selection. The following is a list of suggested species to monitor:

1. Sago pondweed (*Potamogeton pectinatus*): This is one of few species confirmed to occur throughout the Sheyenne and Red Rivers. Sago is the most tolerant of the pondweeds (potamogetons) to high alkalinity, salinity, and turbidity. Found in most substrate types, sago pondweed provides food and cover to a wide variety of vertebrate and invertebrate species and may be a key aquatic species in eutrophic systems. The potamogetons may also be studied as a group, as they best represent the submerged vegetation in the system. Curly-leaf pondweed (*Potamogeton crispus*) is a hardy but invasive species of pondweed that has been identified in the lower Sheyenne River. This species may be singled out for monitoring in the lower reaches and the Red River due to its aggressive nature.

2. Eurasian water milfoil (*Myriophyllum spicatum*): This exotic species was identified by Bonnie Alexander near Baldhill Dam in 1996, but subsequent draw-downs may have frozen out the population, as no specimens have been observed since 1996. Changes in water levels may prevent the natural removal of this species and could lead to spreading. This species should be monitored as a representative of submerged habitat and to control the spread of an exotic species.

3. Cattail (*Typha latifolia* and/or *Typha glauca*): This emergent plant is believed to be present in shallow water areas throughout the study area. Cattails are useful for evaluating the effects of increased water elevations, as they can be drowned out by high water yet survive short periods of drying. In general, cattails are tolerant to a wide range of water quality conditions and are hardy enough to withstand scouring and flooding that many other plants cannot. Cattails also colonize recently disturbed areas and may monopolize any new habitat that develops. Monitoring the populations and distribution of cattail can serve as a measure of the amount of shallow-water (marsh) habitat that changes in response to the hydrologic alterations.

4. Arrowhead (*Sagittaria* sp.): This is another emergent species that occupies the shallow water areas along the riverbanks and would be a good indicator of hydrologic changes. Arrowhead is more sensitive to changes in water quality, flooding, and scour than cattail, and may represent changes to the habitat and water quality not demonstrated by cattail.

5. Sedge, rush, willow communities: Many of the riverbanks are believed to be composed of a herbaceous community composed of various *Carex*, *Scirpus*, *Eleocharis*, and *Salix* species. Many of these species require spring inundation, but thrive in areas that are relatively dry for much of the growing season. Changes in hydrology will alter the

available habitat for this group. Under the proposed changes, these areas may have flowing water during the season when no water would usually be present. The bank community is critical for wildlife habitat and bank stability.

6. Abundance of submerged, emergent, and bank communities: As a rough estimate of impacts, the relative abundance of submerged, emergent, and bank vegetation should also be monitored. Because of changes in hydrology under the proposed operating alternatives, the overall amount, or type, of habitat available may be altered. This information can be quantified from cross-sectional transects, but may be best estimated from aerial photographs. This would also allow for statistical analysis and comparisons to historical conditions.

Relative abundance of these species groups should be compared temporally and spatially throughout the Sheyenne River.

Invertebrates

Seasonal invertebrate data are currently being collected throughout the Sheyenne River at several habitat segments. This survey should continue to establish baseline invertebrate conditions in the Sheyenne River. Data should be analyzed by species sensitivity to chloride and sulfate, functional feeding group, habitat preferences (depth and flow), and substrate preferences. Invertebrate results could also be analyzed by ordination analysis similar to that conducted by Phillips *et al*. (2000) for algae and Koel (1997) for fish.

Other parameters that should be measured for spatial and temporal comparison include Rapid Bioassessment Metrics (RBP metrics-Barbour *et al*. 1999); richness measures, composition measures, tolerance/intolerance measures, feeding measures, and habit measures.

Mollusks

Unionids were last sampled in the Sheyenne and Red River in early 1990. The distribution of unionids with respect to habitat transects should be established. Qualitative and quantitative samples should be collected in each bed. Metrics that are needed for spatial and temporal comparison include position of unionid beds, and density, species richness, recruitment and mortality within unionid beds (Dunn 2000).

Fish

Fish should also be sampled within each of the habitat transect areas. Metrics that might be used for spatial and temporal comparison could include those suggested by Goldstein *et al*. 1994: species richness and composition, trophic composition, reproductive guild, functional guild, and fish abundance and condition.

PRE-OPERATION MONITORING—Red River

Effects in the Red River are expected to be limited to water quality changes in Reaches 1 through 3 and hydrological changes in Reach 1. Benthic invertebrates are perhaps the best monitor for these changes, as species exhibit different responses to water quality and habitat change (Barbour *et al.* 1999). An RBP approach would most likely be adequate to establish a baseline for temporal and spatial comparison. The RBP approach includes collecting habitat, water quality, and land use variables at each site.

Pre-operation and Post-Operation Monitoring

Once an adequate baseline has been established, monitoring using the above methods should continue, but perhaps on a less frequent basis until pumping or overflow actually begins. Sampling should then be repeated on an annual basis (including a seasonal element) until biota stabilize. Sampling frequency could then be reduced until pumping or overflow stopped. After pumping (300MOD50 or 480MOD55) or natural overflow (WETOF), monitoring should be reinitiated on a seasonal basis until biota again stabilize.

Mercury

No information was available on how methyl mercury availability would increase under the three alternatives. A relationship between the methyl mercury in surface water, sediment, and fish tissue should be established. A monitoring program could include the following elements:

- Monitor surface water, sediment, and fish tissue.
- Collect samples from every reach in habitat transect areas.
- Establish appropriate time(s) of year to collect samples and be consistent every year.
- Sample similar numbers of each species of fish within each reach; identify sex, as there is evidence that mercury may be more toxic to male fish.
- Establish most appropriate fish tissue to analyze (e.g., fillet vs. whole fish); may have to do both (fillet for human health; whole fish for fish toxicity, wildlife toxicity).
- Establish appropriate type and number of macroinvertebrates to collect and analyze.

Mercury levels in substrate subject to inundation during the alternatives need to be determined. A model should be developed to estimate the effects of this additional mercury release on fish and invertebrates.

Possible Mitigation

All Alternatives

Increasing (or restoring) the storage capacity of the Devils Lake and Sheyenne River watersheds could perhaps help influence pumping levels and related impacts.

A healthy system can withstand more damage than an unhealthy system, whether it is an organism or an ecosystem. Enhancing the Sheyenne River watershed prior to pumping could potentially increase the river's ability to withstand impact and recover. Establishing riparian buffer throughout the river would be the first step in this process. This would decrease current erosion rates and reduce erosion due to alternatives. This buffer would also provide a sediment trap and nutrient/pesticide filter between the surrounding farms and the river. Other enhancement ideas could be developed with the assistance of North Dakota fish and wildlife agencies.

300MOD50 Pumping

Changes likely to occur with 300MOD50 pumping include increases in sulfate and chloride concentrations in Reaches 1 and 3 and habitat changes in Reaches 3 and 5 of the Sheyenne River. Reducing the concentration of chlorides so that levels do not exceed 50 mg/l and sulfates so that levels do not exceed 150 mg/l would probably protect all of the taxa in the Sheyenne River. However, this is not practical, as levels under MOD50 baseline are expected to exceed these criteria, at least in Sheyenne River Reach 1. Under 300MOD50 pumping, sulfate would be limited to 450 mg/l and chloride is not expected to exceed 80 mg/l. These levels should be sufficient to protect tolerant invertebrates and most mollusks, and not inhibit fish reproduction. However, effects of increased sulfate on algal species is unknown. Perhaps sensitive algal species in Reach 1 of the Sheyenne River could be tested for toxicity and water quality limits adjusted accordingly.

Increased depth and velocity would likely cause habitat changes that would not severely deplete any communities, but would alter the species composition. Habitat and species composition should be monitored as discussed above. The potential effects of scouring and deposition are not known, but are not expected to change by any order of magnitude. However, the magnitude of these effects could be underestimated, and scouring and deposition could have greater effects than the other parameters. These effects should be modeled. If they are believed to be significant, something as simple as a slow increase in the pumping of water to reduce scouring, and a slow decrease such that animals are not left stranded, may mitigate this effect. However, this mitigation would also need to be modeled to estimate its efficacy.

480MOD55 Pumping and Natural Overflow

The impacts of these alternatives could be dramatic, particularly in Reach 1 of the Sheyenne River, which is essentially isolated from recolonization sources. Under both alternatives, water quality, scouring, deposition, and turbidity could severely deplete much of the aquatic community in the Sheyenne River, except very tolerant species. Limiting pumping such that water quality parameters do not exceed levels lethal to algae, unionids, and invertebrates in the

Sheyenne River would mitigate some effects; however, pumping may have to be reduced to 300MOD50 to accomplish this effect.

Changes in hydrology could be mitigated by modifying discharge such that biologically significant hydrological parameters fall within or near RVA limits most of the time.

The effects of erosion, deposition, and turbidity are also likely to substantially modify the Sheyenne River aquatic biota. Perhaps the potential for adverse effects is overestimated, but it needs to be determined before designing mitigation.

It is possible, given this analysis, that the non-tolerant aquatic biota of Sheyenne River Reach 1 may be extirpated, and the aquatic biota through Reach 5 may be depleted. If this were the case, stream rehabilitation measures that would assist with stabilizing substrates and habitats would be needed. Once habitats are stabilized, macrophytes could be reintroduced. Invertebrates should recolonize from downstream or nearby systems within time. Fish and unionids would probably need to be reintroduced.

Relocating existing unionid communities out of the Sheyenne River is not recommended for several reasons:

- Most of the species in the upper reaches (anodontines) have a short life span (less than 10 years).
- Those with a longer life span (amblemines and lampsilines) are not rare in the Mississippi River basin.
- Finding, and moving unionids from one system to another is labor intensive and very costly.
- Survival rate of unionids moved to ponds is low (Newton *et al.* 2001).

However, unionids should be sampled and tested for genetic stock differences from those in the Maple River, Red River, and nearby Mississippi River Basin Rivers. If differences are detected, salvage efforts may be worthwhile. If genetic stocks are not different, several techniques (most of which are experimental at this time) could be used to reestablish unionids in the Sheyenne River. Unionids have successfully been reintroduced into areas where water quality was the initial cause of extirpation and has been improved, however, habitat had not been disturbed in these areas. Habitat rehabilitation has been less successful. By the time pumping or overflow ceases, methods for habitat rehabilitation and reintroduction may be better defined, or this would be an ideal opportunity for research into this possibility.

Methods for restocking fish and restoring fish habitat are well-established. Additionally, fish are more mobile and resilient to change. Recolonization would eventually occur if habitat and water quality improve sufficiently to support fish. Habitat could be enhanced and fish stocked, particularly in Reach 1. The monitoring program should provide sufficient data to determine where enhancement is needed and what species need assistance with recolonization.

Photos C-1 through C-6 identify some of the concerns associated with the operation of an outlet. These include: increase in river stage, increased groundwater levels near the river, changes in floodplain vegetation composition, increased erosion, loss of streambank cover, changes in quantity and type of aquatic habitat, and river access and crossing.

Photo C-1. Aquatic habitat sampling in reach J1 located on the upper Sheyenne River near the town of Sheyenne. In this area the river stage would be increased up to 3 ft with the outlet resulting is some overbank flooding of low areas along the river. At lower stages, groundwater levels would be increased in the floodplain areas affecting vegetation density and composition and access to the river by landowners.

Photo C-2. Aquatic habitat sampling in reach B3 located downstream of Kindred. Note the vegetated banks stabilizing the channel. The outlet would result in increased stages of about 1 ft. Prolonged inundation would result in loss of vegetation, increased bank erosion, and sloughing.

Photo C-3. Aquatic habitat sampling in reach C2 located in the Sheyenne Delta downstream of Anselm. Sandy soils in this area are more subject to erosion. Higher groundwater levels would affect floodplain vegetation density and composition.

Photo C-4. Aquatic habitat sampling in reach E2 located downstream of Valley City. A stage increase of about 1.5 ft in this area would change this shallow pool/riffle habitat to deep pool. This would result in the loss of this type of spawning habitat. Vegetation on the bank would also be affected.

Photo C-5. Aquatic habitat sampling in reach G located upstream of Lake Ashtabula. Stages would increase in this area by about 1.5 ft. Higher stages would increase groundwater levels in the floodplain by a similar amount within about 250 ft of the river. Land uses and access to and across the river would be affected.

Photo C-6. Aquatic habitat sampling in reach D3 located near Lisbon. Increased stages would result in the loss of shallow-water habitat and an increase in bank erosion.

Stream biota are affected on a macro scale by physiography, land use, discharge, variability in discharge, and erosion; and on a micro scale by current velocity, substrate, depth, and in-stream cover. This project will not directly change physiography and land use, but could affect discharge, variability in discharge, and erosion. Frequency of high and low discharge, mean monthly discharge, and average annual discharge were found to explain much of the fish distribution in the Red River (Goldstein *et al*., 1995; Koel, 1997). Discharge also affects unionids. Unionids are typically found in areas with sufficient flow to prevent sedimentation, but without enough flow to render the substrate unstable (Vaughn, 1997). This habitat seems to be a function of discharge, substrate type, and erodibility. Changes to water quality in the Sheyenne River may occur from a natural overflow of Stump Lake and from the outlet alternatives, as water quality in Devils and Stump Lakes and the Sheyenne River differ in many respects.

High discharge (at or over bank full) is generally limited to spring when the ground is frozen. Increasing flow from May to November would not only change water quality, depth, and current velocity, but would also likely result in bank and stream-bottom erosion. In addition to erosion, the wetted area of the streambank is also likely to increase. Mercury naturally occurs in the soil in this region and is released into water during inundation. Increased mercury in the stream water and sediments can bioaccumulate in the biota. Mercury export to Minnesota and Canadian waters could increase mercury beyond total daily maximum load (TDML), and current mercury levels in Red River fish have resulted in fish consumption advisories.

Algal communities in the Sheyenne River have been characterized by Phillips *et al*. (2000) and at NAQWA sites. Phillips *et al*. (2000) used Canonical Correspondence Analysis (CCA) to determine the relationship between algae and water quality parameters. Physical parameters such as increased turbidity, depth, and substrate type also affect stream primary production, but were not included in the CCA.

Aquatic macrophytes are scarce in riverine systems such as the Sheyenne River. Sago pondweed is found in some locations. An introduced species, *Myriophyllum spicatum* (Eurasian watermilfoil), was found in a backwater area near Valley City (Alexander, 1998). Lower water levels in the fall of 1996 exposed the milfoil population to freezing temperature, which apparently eradicated the population (Alexander, 1998). Increased discharge due to the operational alternatives could change the available habitat for aquatic macrophytes. No extensive surveys in the Sheyenne River have been conducted for Eurasian watermilfoil.

Invertebrates are affected by physical and chemical changes. Benthic invertebrate information for the Sheyenne River is limited to Peterka (1972), NAQWA sites, and work by DeLorme (personal communication) in the middle Sheyenne River.

Substrate composition and stability, which are influenced by factors such as stream size and surface geology (Strayer, 1983), hydrological variability (Van der Schalie, 1938; Vannote and Minshall, 1982; Lewis and Riebel, 1984; Way *et al*., 1989; Maio and Corkum, 1995), and riparian vegetation (Morris and Corkum, 1996), are considered to be primary factors affecting unionid distribution. Although habitat may be suitable for unionids, it may be limiting for fish hosts, and water quality could be limiting for either the unionid species or its host. Unionids are affected by changes in physical habitat. Unionids were sampled in the Red and Sheyenne Rivers by Cvancara (1970a, 1976, 1983) and by Kreil *et al*. (no date). Although diversity was similar between sampling years, densities were much reduced and remaining populations appeared to be relic (Dyke, North Dakota Department of Fish & Game [NDF&G], 2001, personal communication). Since little reproduction was evident in the early 1990's, unionid communities may have declined further in the past decade.

Chloride, potassium, and sulfate levels are thought to restrict unionid distribution (see review in USFWS (1999a)). Cvancara (1970a) discussed factors that appear to be influencing unionid distribution in the Red River Basin (prolonged lack of river flow, high chloride, water pollution, and high turbidity

Water quality parameters are anticipated to change under the operational alternatives. Changes in macronutrients could affect primary productivity (growth and development of macrophyte beds and phytoplankton). Higher levels of sulfates and chloride may affect some fish and invertebrate species.

Depth, velocity, substrate, and cover are flow-dependent physical habitat features, which play a vital role in governing the distribution and abundance of stream fishes and macroinvertebrates. Because changes in stream flow translate into changes in these habitat features, stream flow alteration can adversely alter the structure, function, and composition of stream communities by altering the availability of various habitat types on both spatial and temporal scales.

Stream-dwelling species are adapted to and have evolved with the natural hydrograph of the stream system they inhabit. Different life-stages of stream dwellers may require different habitat types as defined by flow. For example, the smallmouth bass is well adapted to riverine life. While preferring shallow, low velocity conditions for spawning and juvenile development, adult smallmouth bass prefer deep, moderate velocity habitat. The seasonal hydrograph of most riverine systems provides a variety of flow-related habitat conditions. Alteration of the natural hydrograph often results in the loss of one or more important habitat types resulting in a habitat bottleneck with resulting reduced system productivity.

To evaluate the potential effects of an outlet on the aquatic community along the Sheyenne River, the hydraulic conditions present through selected habitat reaches on the Sheyenne River were modeled using a two-dimensional model. These simulations provided depth-averaged velocity contour and velocity maps of each habitat reach, as well as bathymetry. The velocity and bathymetry output for a variety of stream discharge conditions was then entered in a GIS database and analyzed using Arc view 3.1.

Significant adverse impacts on aquatic habitat availability and suitability would be expected with an overflow event or with the operation of an outlet. The most flow-sensitive habitat types, such as riffles where shallow, fast habitats predominate, would be almost entirely absent from the habitat matrix for an extended time period. Hydraulic and habitat modeling indicates that at discharges above approximately 400-cfs the habitat matrix would be dominated by deep pool habitat. The loss of these habitat types would adversely affect species life-stages, which are dependent on shallow, fast water for spawning, feeding, or other life requisites provided by riffles. Other habitat types such as shallow, slow habitat would also be significantly reduced. The largest adverse impacts on habitat would likely occur in the Sheyenne River above Lake Ashtabula. Of the fish species present in the Sheyenne River that might be considered obligate riverine species, all have one or more life stages that prefer shallow-pool, slow riffle or fast riffle habitat. The chronic loss of these habitat types with an overflow event would have significant adverse impacts on obligate riverine species.

In addition to the adverse impacts on habitat caused by the significant changes in stream flow, the physical changes in channel geometry caused by the increased occurrence of bankfull or channel-forming flows would also result in a loss of suitable habitat for many aquatic species.

The projected changes in Total Dissolved Solids (TDS) concentrations in the Sheyenne River would also contribute to adverse impacts on aquatic resources. An evaluation of the toxicity of ambient waters from the Sheyenne River, Devils Lake, and East Devils Lake on fathead minnows, *Cerodaphnia spp*. and algae, revealed that East Devils Lake water (TDS concentrations of about 5,700 ppm) was acutely lethal to *Cerodaphnia spp*. Initially, a natural overflow of Devils Lake would result in TDS concentrations approaching/exceeding 5,700 ppm. This projected TDS level would be acutely toxic to *Cerodaphnia spp.* and potentially lethal to other important food-chain organisms. The loss of food-chain organisms would cascade through the food chain, resulting in lost productivity.

The anticipated mixing of waters associated with outlet operation could result in algal blooms with significant adverse impacts on aquatic resources. Bioassay studies with various mixtures of Sheyenne River water and Devils Lake water caused a statistically significant stimulation of algal growth. Increases in algal concentrations would have synergistic effects on other water quality parameters, including dissolved oxygen concentrations, CO_2 concentrations, pH, alkalinity, and the carbonate-bicarbonate balance.

Ambient water samples collected from the Sheyenne River, Devils Lake West, Main, and East Bays, and East Devils Lake were evaluated for the presence of chronic toxicity to green algae (*Selenastrum capricornutum*), *Ceriodaphnia dubia*, and larval fathead minnows (*Pimephales promelas*) during July 8-15, 1998. U.S. EPA algal medium was used as the control water in the algal testing. Sheyenne River test concentrations were made by dilution with algal medium, and Devils Lake West Bay test concentrations were made by dilution with Sheyenne River water. Moderately hard reconstituted water (MHRW) prepared according to U.S. EPA guidelines was used as the primary control water in all fathead minnow and *Ceriodaphnia* exposures. Sheyenne River test concentrations were made by dilution with MHRW, and Devils Lake West Bay Concentrations were made by dilution with Sheyenne River water.

The results of the analysis were as follows:

Fathead Minnow Larval Survival and Growth

- None of the site waters caused a statistically significant decrease in survival of larval fathead minnow.
- None of the site waters caused statistically significant growth inhibition of larval fathead minnow.

***Ceriodaphnia dubia* Survival and Reproduction**

- Only site water from East Devils Lake caused statistically significant lethality for *Ceriodaphnia dubia*. Complete lethality of organisms exposed to East Devils Lake water was observed by 48 hours of exposure, thereby indicating toxicity that was acute in nature.
- None of the other site waters caused statistically significant reproductive inhibition of *Ceriodaphnia dubia*.

Algal Growth Inhibition

- None of the site waters tested caused statistically significant levels of algal growth inhibition when compared to laboratory control algal medium.
- Site waters that caused statistically significant stimulation of algal growth were; 25% and 50% Sheyenne River, 25% and 100% West Bay, and both Main and East Bay waters.

Fathead Minnow Embryo-Larval Teratogenicity and Survival

- None of the site waters caused a statistically significant decrease in fathead minnow hatchability.
- None of the site waters caused a statistically significant decrease in survival of larval fathead minnow.

The loss of habitat due to increased flows, changes in channel geometry, loss of overbank cover and sedimentation, coupled with changes in water quality and algal growth would all contribute to a change in the aquatic community present in the Sheyenne River. Projected TDS levels associated with the overflow event would adversely influence fish reproduction and result in lost-year classes. The cumulative result of all these changes would be a decrease in diversity and density of aquatic species in the Sheyenne River. The threshold chloride levels for some aquatic species, such as mussels, would be far exceeded with the operation of an outlet or with a natural overflow and could, therefore, be reduced in diversity and density.

Erosion and sedimentation would increase with the operation of an outlet or a natural overflow. It is expected that there would be an increase in the amount of sediment deposited in the upper end of Lake Ashtabula. This, combined with the increase in sulfate and TDS levels, would greatly influence the aquatic resources in the lake. A decrease in species diversity and abundance in Lake Ashtabula would be expected.

The changes in the aquatic community would persist for many years after outlet operation has ceased, especially on the Sheyenne River above Lake Ashtabula. The only source for recolonization in this reach of the river would be from fish populations above the insertion point of the spill, as Baldhill Dam is a barrier to upstream migration of fish.

There is an increased risk of the transfer of biota or the increase in the distribution of existing organisms associated with any feature that improves the connectivity between systems that have been segregated for many centuries. The operation of the outlet would be considered such a feature. Based on available information, there do not appear to be any organisms in Devils Lake that are not already present in the Red River of the North basin. However, it cannot be said with certainty that some may not be identified or introduced in the future. In addition, the operation of an outlet or a natural overflow may improve the conditions necessary for the dispersal of organisms currently found in the Sheyenne or Red River. No mitigation feature can be said to be 100-percent effective in eliminating the risk of biota transfer. The actual effects are unknown and cannot be predicted at this time.

Lidar imagery can be used to develop profile information for the channel from the water surface through the floodplain. Lidar has many uses ranging from analysis of aquatic resources to groundwater effect on terrestrial resources. Two profiles are shown below (Figure C-14). The top profile is from the upper Sheyenne downstream of Warwick and covers a distance of about 900 m, the bottom profile is located downstream of Lisbon and covers a distance of about 970 m. The top profile shows the elevation in centimeters while the bottom profile is in ft. The Sheyenne River is near the center of each profile. The flat line at the bottom of the channel shows the water surface at the time of image acquisition and not the bottom of the channel.

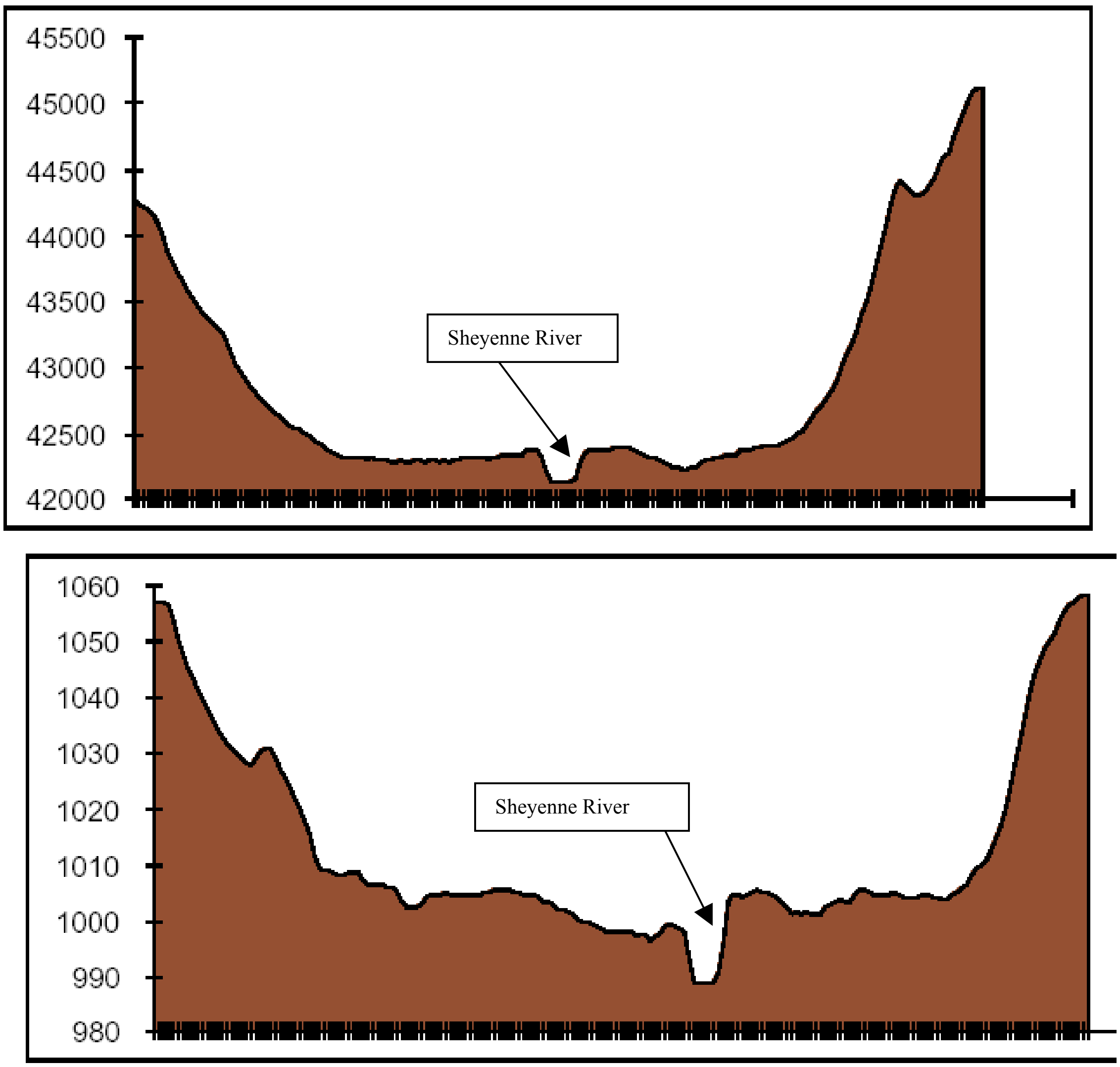


Figure C-14. Typical profiles developed from the Lidar imagery. Top profile is along the upper Sheyenne, bottom profile along the lower Sheyenne River

The profiles indicate that if flows are within channel capacity there could be some overbank flooding and inundation of floodplain areas that are lower than the immediate river bank. These areas would also be more subject to changes in groundwater levels as a result of increased river stage.

Terrestrial Resources

Groundwater studies have been conducted along the lower Sheyenne River in the area of the Sheyenne National Grasslands and along other portions of the Sheyenne River. Based on the studies conducted, it is estimated that a 300-cfs flow event could result in an increase of up to about 1.5 ft in ground water elevations near the river. At a distance of about 1,500 ft, the effect would be less than 4 in. No effect was predicted further than 2,100 ft from the Sheyenne River. Other areas along the Sheyenne River could have groundwater level changes in the order of 0.5 ft up to 300 ft from the river. Figure C-15 below shows the results of the groundwater analysis. Groundwater studies were modeled with a controlled outlet flow. The magnitude and extent of the effects on groundwater would decrease as the flows declined over the duration of the operation. Using a ¼-mile area of influence, groundwater changes could potentially affect about 112,000 acres of riparian lands along the Sheyenne River and 76,000 along the Red River. However, the study showed that only two of the six transects had a rise in groundwater levels of more than 0.5 ft farther than about 250 ft from the river. It is assumed that in areas where current groundwater levels are within 3 ft of the surface, a raise of 0.5 ft has the potential to affect the vegetation and land uses. For the purposes of this analysis it is assumed that the areas of potential groundwater influence are defined by the flooded area outline for a 1,000-cfs flow on the upper Sheyenne River and a 1,500-cfs flow on the lower Sheyenne River. It is assumed that the flooded areas are at lower elevations closer to the river, have current groundwater levels closer to the ground surface, and have the most potential for being affected by groundwater changes. No groundwater effects are anticipated along the Red River due to the small change in river stages. The land use information identified for the flooded area outline is the area potentially affected by changed groundwater levels.

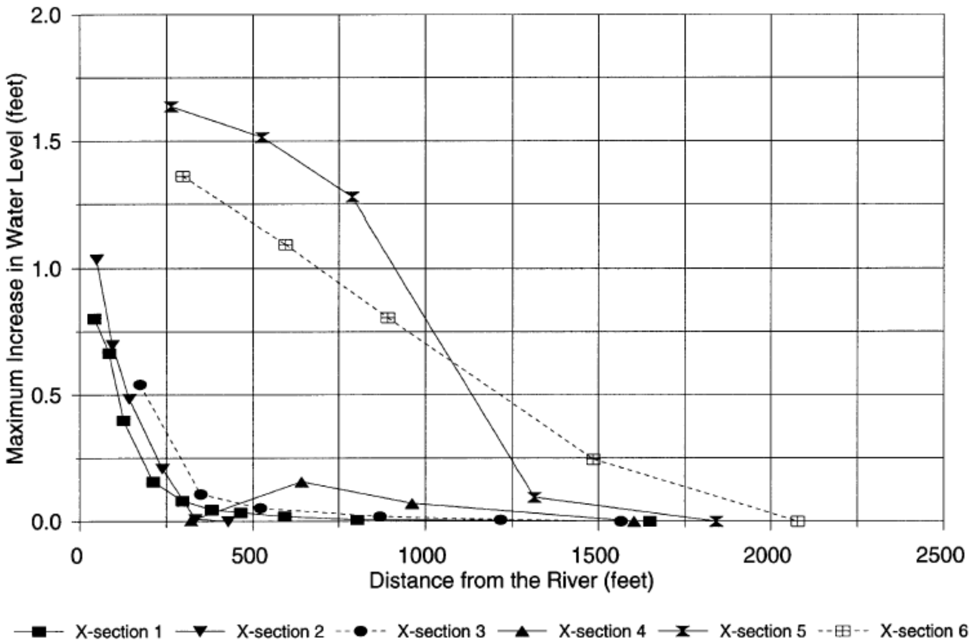


Figure C-15a. Change in groundwater levels due to change in river stage along the Sheyenne River in the area of the Sheyenne National Grasslands upstream of Kindred

Another groundwater study conducted by Barr Engineering in 2002 for other portions of the Sheyenne River indicated that effects would be in the order of about 0.5 ft increase in groundwater levels within about 250 ft of the river. Some of the conclusions from this report are summarized below.

1. The maximum water-level increase in the aquifer, resulting from the 300-cfs increased flow in the Sheyenne River is predicted to be:

Section	Distance from River to Max. 0.5' Increase in Groundwater Elevation Due to 300-cfs Release from Devils Lake
Sheyenne	250 ft
Cooperstown	550 ft
Kathryn	150 ft (0.45 ft maximum)
Sheyenne Delta 1	100 ft
Sheyenne Delta 2	50 ft
Walcott	300 ft

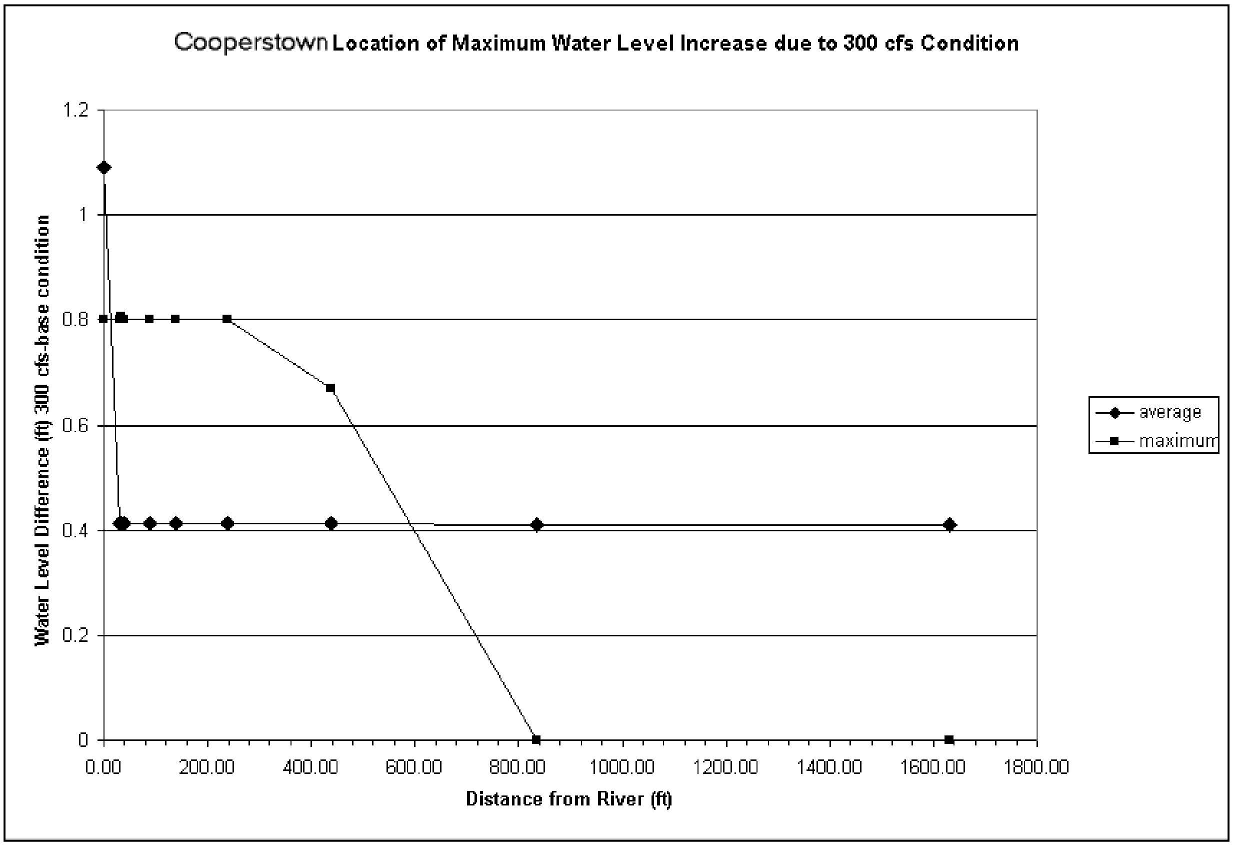
The estimate at Walcott is conservatively high.

2. Groundwater levels for area in which shale or glacial till is the predominant aquifer condition (for example, beyond the immediate river valley areas) respond much more to seasonal variations in precipitation and evapotranspiration than to short-term fluctuations in river levels. Groundwater levels are closely tied to river levels within the alluvial aquifers.

3. The maximum river stage conditions are identical for the base condition and the proposed project condition because the additional 300-cfs is not being released during high-flow events. Thus, near the river, the maximum groundwater elevations are predicted to be nearly identical for both conditions. However, the proposed project will slightly increase the duration of higher stage conditions which this study shows will cause somewhat higher maximum groundwater level increase farther from the river. The likely cause for this is that more water is stored in the alluvium (as bank storage) for the proposed project conditions.
4. Groundwater elevations generally respond within about one day of changes in river stage elevations with the alluvial aquifer, at a distance of approximately 50 ft. Very near the river, the response is likely more rapid. Beyond about 500 ft with sand and gravel deposits, responses are more in the range of 2 to 3 days and the short-term river stage changes are greatly dampened. Within shale and clays, the river stage changes are more seasonal and changes in infiltration rates due to seasonal precipitation rates play a more important role in water level fluctuations than changes in river stage
5. Excursion of Sheyenne River water during the flood event is about 25 to 50 ft. Sulfate was used as a surrogate to evaluate the incursion. The differences in incursion distance and concentration in the aquifer between the two modeled conditions was found to be minimal.

The study indicated that the river-stage increases predicted for the Pelican Lake outlet would not cause changes in groundwater levels beyond the immediate vicinity of the Sheyenne River. Groundwater quality impacts, if any, will be even more restricted to close proximity of the Sheyenne River and will likely not be discernable from current conditions.

An example of the results for the Cooperstown area is shown in Figure C15b.



average	1.090058	0.413086	0.412696	0.413228	0.41305	0.41286	0.412492	0.411881	0.410908	0.409894
maximum	0.8	0.802	0.806	0.8	0.8	0.802	0.802	0.67	0	0

Each data point represents a calculated condition at a location some distance from the River.

Average = (Ave. water level for 10 yrs of simulation for 300-cfs condition – Ave. water level for 10 yrs of simulation for base condition)

Maximum = (Max. water level for 10 yrs of simulation for 300-cfs condition – Max. water level for 10 yrs of simulation for base condition)

Figure C-15b

Difference in average and maximum water levels between base condition and Devils Lake discharge condition: Cooperstown

Table C-15 shows that most of the land use within ¼ mile is cropland or grassland. Depending on the current groundwater elevation, there could be a change in soil moisture and vegetative characteristics. This could occur in areas where the current groundwater level is near or within 3 ft of the surface. On the basis of the groundwater studies conducted, it was determined that the area that could be most affected by changed groundwater levels approximately corresponds to the flooded area outline. In addition to groundwater effects, a 480-cfs outlet would result in overbank flooding. The table below also identifies the land use within the currently identified flooded area outline. Land use within the flooded area outline could be significantly affected due to increased groundwater levels and increased duration of frequency of inundation if overbank flooding would occur due to unforecasted storms during outlet operation.

Table C-15. Land Use Along the Sheyenne River

Land Use	1/4 Mile Buffer (acres)			Flooded Area (acres)		
	Above Baldhill	Below Baldhill	Total	Above Baldhill	Below Baldhill	Total
Cropland	12,166	23,817	35,983	2,234	320	2,554
Woodland	7,181	13,125	20,306	1,273	199	1,472
Grassland	21,141	19,275	40,416	2,296	84	2,380
Grass-Shrub	1,613	2	1,615	89	0	89
Wetland	5,709	5,669	11,378	1,658	433	2,091
Urban	56	2,689	2,745	11	6	17
TOTAL	47,866	64,577	112,443	7,561	1,042	8,603

Source: 30 meter Landsat Thematic Mapper 1987 through 1994
Wetland information from U.S. Fish and Wildlife Service National Wetlands Inventory (NWI)
Total wetland acreage within ¼ buffer includes 4,584 acres classified as river. Flooded area acres does not include area classified as river.

Effects on the terrestrial communities would range from losses associated with erosion to changes in vegetation composition and density as a result of saturated soil conditions from prolonged flooding and elevated groundwater levels. The degree of change that may occur due to changes in soil conditions cannot be quantified without detailed studies. However, it is likely that a large portion of the riparian vegetation would shift from woods to a more open community type, resulting in a concurrent change in animal species composition along the river. Changes in water quality to a more saline condition could also influence the amount and type of vegetation along the river. Some of the larger overstory forest trees may survive a year or longer, but with reduced vigor. Once the outlet operation is completed, recovery of these areas through succession would occur, which could take decades in some areas.

Although the Sheyenne River channel appears currently stable, channel instability may occur if the flows are increased due to the operation of an outlet. The increased flows will cause increased stages and duration of inundation. Shear stresses and velocities will increase, which in turn will increase the rate of bank erosion. It may be expected that the banks will fail and the river will widen due to loss of vegetation. The accelerated bank erosion due to loss of vegetation will tend to increase the overall sediment yield as more sediment is supplied to the river. Bank widening will occur. Over time, vegetation will be gradually reestablished on the berms and the edge of the berms will form the new equilibrium channel banks corresponding to the dominant discharge. The banks will become vegetated and the channel will exhibit a new morphology after the outlet has ceased operation. This erosion/vegetation impact would also affect the aquatic resources of the river. Channel adjustment may take 50 to 100 years or more.

The location of the Federally threatened western prairie fringed orchid was also identified. The orchid is primarily located in the area of the Sheyenne National Grasslands between Anselm and Kindred, North Dakota. The orchid is not found in the floodplain of the Sheyenne River, but is found in low-lying swales in upland areas more than 1 mile from the river. Figure C-16 shows an example of the typical location of the orchid in relation to the Sheyenne River.

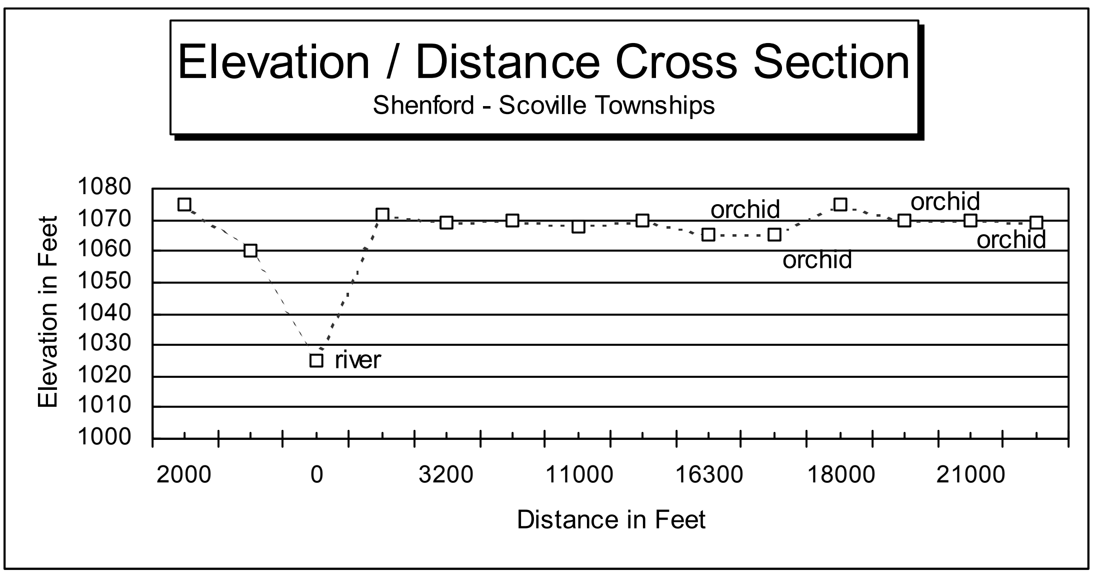


Figure C-16. Location of western prairie fringed orchid in relation to the Sheyenne River. Profile developed from USGS topographic maps

The States of North Dakota and Minnesota have developed lists of Natural Heritage sites that exhibit significant natural resource qualities. These sites include vegetation types, wildlife and plant species, insects, fish, mussels, reptiles, and unique stream reaches. The table presented in the existing conditions section lists the types of sites found in various portions of the basin. There are 219 natural heritage sites located within ¼ mile of the Sheyenne River, area of potential groundwater influence. This represents 25 percent of the natural heritage sites in the entire Sheyenne River basin. Within the flooded area outline along the Sheyenne River, there are 24 listed Natural Heritage Sites. Natural Heritage sites could be affected by changes in flow, duration, storage, and water quality.

Figure C-17. Example of the imagery for a portion of the upper Sheyenne River used to develop the land use information. The land cover data layer is based on 30-m Landsat thematic mapper (TM) data

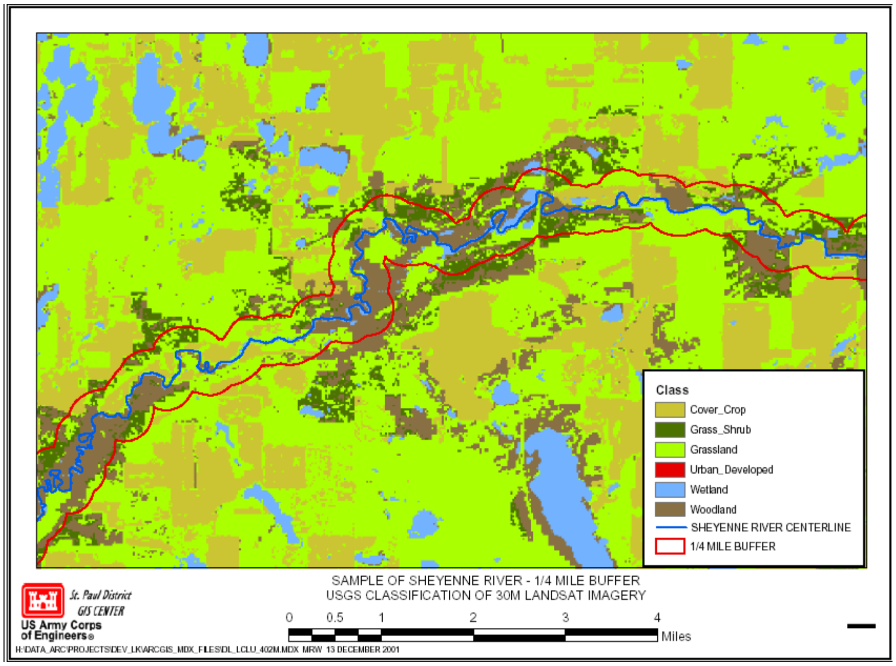
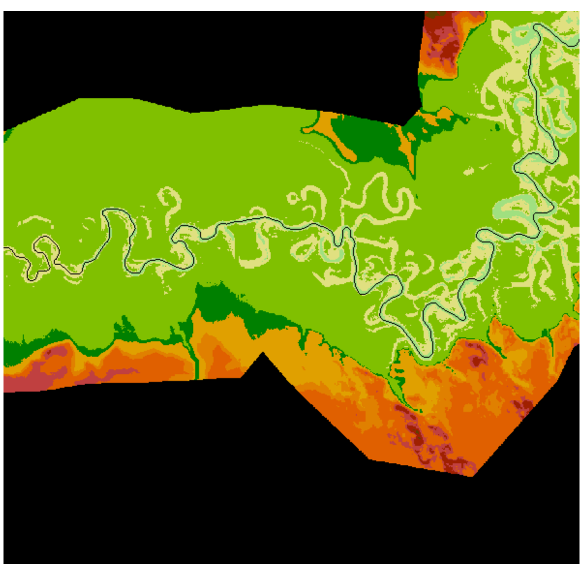


Figure C-18. Example of Lidar image used to develop contour mapping, flooded area outline, soil salinity effects, and groundwater effects for the impact assessment



Red River
Physical habitat is not expected to change on the Red River with project alternatives, but hydrology and water quality changes may occur. The States of North Dakota and Minnesota have listed several stretches of the Red River as impaired for several water quality parameters, including ammonia, turbidity, and fecal coliform. Total maximum daily loads for these parameters are established by the states, and Federal law does not permit new discharges that would add to the exceedences. The Red River is also a drinking water source for the cities of Moorhead, Fargo, Pembina, Drayton, and Grafton. Effects on the Red River are expected only from changes in water quality. Fishery effects are not expected to be major.

The Red River is known for its recreational fishery, particularly for trophy catfish (MNDNR and NDG&F, no date). Various agencies including the MNDNR, NDG&F, COE, and local entities are in the process of modifying or replacing some of the low head dams on the river with raceways, and are trying to reestablish lake sturgeon in the river. This river also has water quality criteria within the United States (500 mg/l TDS, 250 mg/l sulfate, 100 mg/l chloride), and at the Canadian border (500 mg/l TDS, 250 mg/l sulfate, 100 mg/l chloride, 5.0 mg/l DO, 200 per 100 ml of fecal coliform) (USACE background information on water quality). Mercury accumulation is of particular concern, as methyl mercury levels in Red River fish are currently high and additional methyl mercury could be released in newly flooded areas. Background stream-bottom and fish-tissue mercury, other metals, and pesticides can be found in Brigham *et al.* (1998). Sediment transport into the Red River from the Sheyenne River with increased flows could also increase suspended sediment and sedimentation of riparian habitats (MNDNR, 1998).

Land use in the riparian area of the Red River is shown in Table C-16. Cropland is the dominant use.

Table C-16. Land Use Along the Red River

Land Use	1/4 Mile Buffer (acres)		
	N. of Grand Forks	S. of Grand Forks	Total
Cropland	26,475	20,831	47,306
Woodland	7,294	6,933	14,227
Grassland	1,739	2,302	4,041
Grass-Shrub	5	39	44
Wetland	6,072	2,557	8,629
Urban	1,650	709	2,359
TOTAL	43,235	33,371	76,606

Source: 30 meter Landsat Thematic Mapper 1987 through 1994
Wetland information from U.S. Fish and Wildlife Service National Wetlands Inventory (NWI)
Total wetland acreage includes 6,493 acres classified as river.

Little effect to land use is expected along the Red River. The flows are expected to have little effect on river stage and remain in the channel. Overbank flow is not anticipated. Groundwater effects are anticipated to be minimal.

Along the Red River there are 82 listed Natural Heritage sites within ¼ mile of the river. These sites include aquatic and terrestrial wildlife species, vegetation types, and unique communities.

Biota Transfer Risk Analysis

A Biota Risk Analysis was conducted for the study (Peterson Environmental Consulting, Inc.), and is summarized below.

Although fish and algae communities have been fairly well-documented, data sources on other biota were relatively few and incomplete. Regional experts had little knowledge of Devils Lake biota, and most agreed that the biota of the Devils Lake and Red River basins had not been particularly well-studied. The most complete record of Devils Lake biota was a very old account of the lake during a period of falling water level and increasing salinity.

Published information on plants of the basins was more scarce than data found for other biota. The separate investigation of vascular plants produced several sources of information among local experts and institutions, although none explicitly defined the flora of either basin. Consultation of these sources plus site visits allowed team members to assemble a partial list of candidate PBOC vascular plants.

Some published Devils Lake parasite information was found, but consultations and literature searches for records of Devils Lake basin fish pathogens produced no information. The lack of pathogen data was an area of concern, and field study is warranted because of the economic importance of fish diseases. However, it seemed unlikely that any pathogens would be confined to Devils Lake because, at one time or another, every major lake in the state has served as both source and destination of wild-caught fish for stocking, so natural barriers to fish pathogen transmission have been repeatedly circumvented by human actions.

The candidate PBOC list included 527 algae, 353 plant species, 94 free-living protozoa taxa, 146 invertebrate taxa, 12 fishes, 8 fish parasites, and 1 avian pathogen (no fish pathogens or fungi were included). This was believed to be the most complete list of Devils Lake Basin biota that could be assembled based on authoritative information sources. However, this list must certainly have been incomplete because very many data gaps were found, and some taxa on the list may no longer exist in Devils Lake because its habitat conditions have changed dramatically since the earlier records were published.

Selection/Deselection of PBOC

To produce the PBOC list (Table C-17), deselections were made from the Candidate PBOC list based mainly on distribution criteria. Then, insects and water mites were deselected because of their obvious and very effective existing interbasin transfer mechanisms. These deselections produced a PBOC list of 387 taxa: 215 algae, 73 invertebrate taxa, 94 protozoa, 1 fish species, 0 plants, 3 fish parasites, and 1 avian pathogen. Finally, the 42 automatically listed taxa were added to the 386 selected as PBOC, so the final PBOC list consisted of 429 taxa.

Table C-17. Taxa automatically listed as Potential Biota Of Concern (PBOC).

Vascular Plants

[1]*Butomus umbellatus* Linnaeus - flowering rush
[2]*Cabomba caroliniana* Gray - Carolina fanwort or fanwort
[1]*Crassula helmsii* (Kirk) Cockayne - Australian stonecrop
[1]*Hydrocharis morsus-ranae* Linnaeus - European frog-bit
[1]*Hydrilla verticillata* (Linnaeus) Royle -hydrilla
[1]*Hygrophila polysperma* (Roxburgh) Anders - Indian swampweed
[1]*Lagarosiphon major* (Ridley) Moss ex Wagner - African oxygen weed
[1]*Lythrum salicaria* Linnaeus, *Lythrum virgatum* Linnaeus, or any variety, hybrid, or cultivar thereof - purple loosestrife
[2]*Myriophyllum aquaticum* (da Conceicao Vellozo) Verdcourt - parrot's feather
[1]*Myriophyllum spicatum* Linnaeus - Eurasian water milfoil
[2]*Nymphaea* spp. Linnaeus, or any variety, hybrid, or cultivar thereof except *N. odorata odorata* Aiton, *N. leibergeii* Morong, and N. *odorata tuberosa* (Paine) Wiersema & Hellquist. - non-native waterlilies
[1]*Potamogeton crispus* Linnaeus - curly-leaf pondweed
[1]*Salvinia molesta* Mitchell - aquarium watermoss or giant salvinia
[1]*Stratiotes aloides* Linnaeus - water aloe or water soldiers
[1]*Trapa natans* Linnaeus - water chestnut

Invertebrates

[2]*Bythotrephes cederstroemi* Schoedler - spiny water flea
[2]*Cipangopaludina* spp. Hannibal (e.g. *C. chinensis*, *C. chinensis malleata*, *C. japonica*) - Chinese mystery snail, Japanese mystery snail, Japanese trap door snail
[1]*Dreissena polymorpha* Pallas - zebra mussel
[2]*Orconectes rusticus* Girard - rusty crayfish

Fishes

[2]*Alosa pseudoharengus* Wilson - alewife
[2]*Carassius auratus* Linnaeus - goldfish
[1]*Ctenopharyngodon idella* Valenciennes - grass carp
[2]*Cyprinus carpio* Linnaeus - common carp, koi
[1]*Gymnocephalus cernuus* Linnaeus - ruffe
[1]*Hypophthalmichthys molitrix* Valenciennes - silver carp
[1]*Hypophthalmichthys nobilis* Richardson - bighead carp
[1]*Morone americana* Gmelin - white perch
[3]*Morone saxatilis* Walbaum - striped bass
[1]*Mylopharyngodon piceus* Richardson - black carp
[1]*Neogobius melanostomus* Pallas - round goby
[2]*Osmerus mordax* Mitchell - rainbow smelt
[1]*Petromyzon marinus* Linnaeus - sea lamprey
[1]*Scardinius erythrophthalmus* Linnaeus - rudd
[1]*Stizostedion lucioperca* Linnaeus - zander
[2]*Tilapia* spp., *Oreochromis* spp., *Sarotheradon melanotheron* Rüppell – tilapia

Pathogens & Parasites of Fish

[3]*Heterosporis* Schubert (species unknown), the protozoan "Yellow Perch Parasite"
[3]Infectious Pancreatic Necrosis Virus (IPNV)
[3]Infectious Hemotopoietic Necrosis Virus (IHNV)
[3]Largemouth Bass Virus (LMBV)
[3]*Myxobolus cerebralis* Hofer, the protozoan pathogen of whirling disease, and its intermediate invertebrate host *Tubifex tubifex* Müller, an annelid worm
[3]Parasites/pathogens of striped bass
[3]*Renibacterium salmoninarum* Sanders and Fryer, Bacterial Kidney Disease (BKD)

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[1]Minnesota Prohibited Species
[2]Minnesota Regulated Species
[3]Species named in Statement of Work

Data Gaps

Perhaps the most important finding of this study was the revelation of just how poorly the biota of the Devils Lake basin and (to a somewhat lesser extent) the Red River basin are known. Many Devils Lake taxa had to be selected as PBOC solely because no data could be found regarding their presence or absence in the Red River basin. The deficiencies in the available data could be summarized as problems of poor comparability of studies from each basin, and gaps in coverage.

Lack of comparability of Devils Lake basin and Red River basin data arose because: (1) studies were conducted in dissimilar habitats in the two basins, (2) sampling intensity differed between basins, (3) studies varied in taxonomic focus and resolution, (4) studies were widely separated in time, resulting in (5) studies being carried out under very different environmental conditions.

Coverage gaps found in the existing data included: (1) very poor coverage of the wide range of aquatic habitats found in each basin, (2) poor coverage of temporal changes that occur seasonally in aquatic communities, and (3) inconsistent coverage of biota groups. This last type of data gap was particularly obvious in the complete lack of data on Devils Lake basin fish pathogens, the poor coverage of fish parasites, the lack of vascular plant studies, and the near lack of studies on non-planktonic invertebrates in all waters of the basins in question, except Lake Ashtabula and Lake Winnipeg.

Biology and invasiveness of PBOC

Review of the biology and distributions of PBOC revealed that none of the taxa, other than automatically listed species, were known to be particularly invasive. None of the automatically listed exotic, invasive PBOC species were known to occur in the Devils Lake basin. The proposed outlet project could change downstream physical and chemical habitat parameters, but it was not apparent that these changes would dramatically enhance the invasiveness of any PBOC species.

Devils Lake habitats were found to be increasingly varied in response to water-level increases. The changes occurring in the lake are likely to favor the majority of species in the lake, but are increasing the similarity between Devils Lake habitats and downstream lentic habitats, thus reducing the magnitude of expected chemical chemical changes in the Sheyenne River and Lake Ashtabula. The increased freshening of Devils Lake water has caused many halophilic (salt-adapted) species to be increasingly confined to the more saline, eastern portions of the lake. These species, once the dominant forms in the lake, are likely to continue to be marginalized and limited to saline refuges far from the projected pump intake locations.

The question of biota transfer from Devils Lake to the Sheyenne River must involve consideration of the likelihood that Devils Lake species can already be transferred across the basin boundary by existing natural or anthropogenic means. Such transfers are considered common and effective for most PBOC taxa. Natural dispersal vectors likely to be important in the Devils Lake/Red River region are wind and vertebrate animals. Anthropogenic vectors are abundant and include recreational boats and trailers, baitfish transfer, and an active fish stocking program that has effected reciprocal transfers among many waters in the state.

Based on review of dispersal mechanisms of PBOC, and consideration of the topography and other conditions in the region, it was concluded that natural pathways between the basins are, and have been, effective means of biota transfer for a very long time. Almost all PBOC taxa were considered to already have adequate means of transfer such that the project would have little impact on their invasiveness. The project would certainly have the effect of transferring organisms from Devils Lake to the Sheyenne River, but it seems very unlikely that any such transfers would involve first-time introductions.

The greater concern was the possibility that downstream water chemistry changes would favor shifts in communities toward more salt-adapted and eutrophy adapted species compositions. Salinity changes would likely affect the Sheyenne River and Lake Ashtabula most, with effects much less substantial in the Red River due to dilution. Higher salinity and/or nutrient concentrations, however modest, could possibly tilt competitive balances toward new equilibria favoring more halophilic and/or eutrophication-indicator species. This is only a biota transfer concern to the extent that the outlet provides a new source of these species, enhancing the numbers already likely to be present in downstream habitats. In this case, the outlet would simply accelerate a process that would occur naturally.

Selection/Deselection of BRA

The large majority of PBOC were ultimately classified as "non-BRA" species because they were found to be widespread in distribution, and/or able to disperse readily among water bodies. They were also found to have no history of being particularly invasive or of causing human-defined problems in their usual habitats. It is impossible to predict the effects of any species' new introduction to a system, as the history of past exotic species introductions clearly shows, but existing published information suggests that the species classified as non-BRA are likely to be benign in the RRB.

Several PBOC taxa were retained for further analysis, including the fish parasites and certain species of nuisance algae. These further analyses determined that:

A. Two of the three parasite species were, in fact, known to occur in the Red River basin, but had not been recorded in the published literature.

B. The one remaining parasite was very probably a very common parasite in the region that was misidentified by the single author who reported it.

C. Two algae species had been associated with toxic algae blooms in the past, but more recent studies found their toxicity to be very low.

D. One algae species was from a genus known for damaging fish gills, but the species in question was not known to cause such problems.

E. One algae species was known to create toxic blooms, but further evidence suggested that it is very likely to already occur in the Red River basin waters, and that it is unlikely to be transferred through the outlet because it is a halophile and presently only found in eastern portions of Devils Lake.

Finally, two species were retained for full risk analysis: striped bass and Eurasian watermilfoil. Striped bass were introduced into Devils Lake in the past, but their continued presence there is doubtful. Nonetheless, the small possibility that a reproducing population exists in the lake poses some risk to the Sheyenne/Red River system and Lake Winnipeg. Eurasian watermilfoil, on the other hand, is not known to occur in Devils Lake, but a small population has been found in the Sheyenne River below Lake Ashtabula. Increased flows in the river resulting from an outlet would cause an increased risk of the species spreading downstream, though this risk is only incrementally greater than the already existing high risk of spread.

Conclusions and Recommendations

Conclusions of the study were as follows: (1) Based on all available information, it appeared highly unlikely that downstream habitats would suffer substantially as a result of biota transfer caused by the Devils Lake outlet project. (2) Available information was inadequate to allow conclusive statements to be made regarding all aspects of biota transfer.

However, several concerns were considered worth noting as follows.

(1) The risk of striped bass transfer to downstream waters is considered very low, primarily because the species is not believed to be reproducing in Devils Lake. This belief should be confirmed or refuted with larval and juvenile fish surveys.

(2) The outlet would only marginally increase the risk of downstream spread of Eurasian watermilfoil, which is highly likely to occur with or without an outlet.

(3) Though unlikely to occur, transfer of significant concentrations of toxic algae could cause substantial problems downstream.

(4) Salinity and nutrient changes to the Sheyenne River and Lake Ashtabula could cause community composition changes in these waters.

(5) It is presently unknown whether any known exotic, invasive species are now present in Devils Lake.

Therefore some things to consider include:

(1) The known Eurasian watermilfoil population should be eradicated as soon as possible.

(2) Chemical and algal monitoring programs should accompany the outlet project.

(3) Fish pathogen screening should be implemented (already under way).

(4) Surveys for the following invasive species (at minimum) should be carried out in Devils Lake before the outlet begins operation: striped bass juveniles, rusty crayfish, spiny water flea, zebra mussel, and Chinese mystery snail and relatives.

As secondary concerns, consideration should be given to monitoring Devils Lake for species that are known to occur in the Red River basin, but are not known to have invaded the lake yet (e.g. Eurasian watermilfoil, curly-leaf pondweed). A boat ramp monitoring/public education program should also be considered in North Dakota to attempt to minimize anthropogenic biota transfers.

Table C-18. Summarized Project Results: Screening of All Devils Lake Taxa and Automatically-Listed Taxa (ALT) from Candidate PBOC Through BRA Stages, with Recommendations for Further Action

BIOTA GROUP	# of Candidate PBOC Taxa	# of 1st-Round Deselections	1st-Round Deselection Reasons[1]	# of PBOC (w/ALT)	# of 2nd-Round Deselections	2nd-Round Deselection Reasons	Results: further analysis of remaining species	# of BRA taxa	Recommendations
Algae	526	310	All deselected taxa: A	**216 (0)**	212	B, D (& probably A)	4 species: hazard probability very low	**0**	Monitor concentrations of nutrients, salts, & toxic Cyanobacteria in outlet
Vascular Plants	368	353	All deselected taxa: A	**15 (15)**	15	4 ALT: A 11 ALT: C	None	**0**	Consider monitoring for "reverse" transfers FROM Red River basin TO Devils Lake
Protozoa	94	0	n.a.	**94 (0)**	94	B, D (& probably A)	None	**0**	None
Invertebrates	161	88	All 52 insect and mite taxa: B 36 other taxa: A	**69 (4)**	69	4 ALT: C All others: B, D (& probably A)	None, but see Recommendations	**0**	Initial survey, future monitoring for zebra mussel, rusty crayfish, spiny water flea in Devils Lake
Fishes	27	11	All deselected taxa: A	**16 (16)**	14	C	None, but see Recommendations	**0**	Future monitoring for zander, grass carp in Devils Lake
Fish Parasites	8	5	All deselected taxa: A	**3 (0)**	0	n.a.	3 species: already found in Red River basin	**0**	Find Acanthocephalan worms in Devils Lake fishes and obtain authoritative identification
Fish Pathogens	7	0	n.a.	**7 (7)**	7	C	n.a.	**0**	Screen Devils Lake basin fishes for pathogens
Other Pathogens	1	0	n.a.	**1 (0)**	1	B	n.a.	**0**	None

[1]Deselection Codes: A - known/believed to be already present in Red River basin; B - existing interbasin transfer pathways believed to be very effective; C - not known to exist in Devils Lake basin; D - not known to cause problems; believed to be benign

As part of the biota analysis, the Corps contracted with the U.S. Fish and Wildlife Service Missouri River Fish and Wildlife Management Assistance Office in Bismarck and the Bozeman Fish Health Center in Bozeman to collect fish from Devils Lake and the Sheyenne and Red Rivers and screen them for pathogens. The result of this effort is summarized below.

Sampling - Fish from Devils Lake were sampled during October 2001. The Red and Sheyenne rivers were sampled in August 2002. Fish were collected by the U. S. Fish & Wildlife Service, Missouri River Fish and Wildlife Management Assistance Office, using a variety of gear types including variegated gill nets and modified fyke nets. Nets and traps were generally set overnight for approximately 12 - 18 h durations. At Devils Lake, nets and traps were set in Six Mile Bay for two consecutive days. Two sample sites were selected on each river and were designated as upstream and downstream in relation to each other. River sampling sites were fished one day each. On the Sheyenne River, the upstream site was located where North Dakota Highway 20 crosses the river along the southeastern border of the Spirit Lake Reservation. The downstream site was located near Valley City from Chautauqua Park to Valley City National Fish Hatchery. On the Red River, the upstream sample site was located in Fargo upriver from the bridge at 52nd Avenue south. The downstream sites was in Grand Forks near the bridge on State Highway 2.

Fish were sorted by species, measured (mm) for total length, and then examined externally and internally for clinical signs of disease or other abnormalities. Tissues samples for pathogen testing were collected using aseptic techniques and packed in coolers with ice for transfer to the laboratory. Samples were assayed at Bozeman Fish Health Center, Bozeman, Montana according to protocols and procedures for the NWFHS. Principle fish pathogens of the NWFHS included specific organisms that are known to cause disease in cultured or wild fish, and are considered prohibitive organisms in most state and federal fish health inspection programs (see table below). Additionally, many of the general screening methods used for the survey were also sensitive to other bacterial and viral fish pathogens.

List of primary fish pathogens included in the survey of fish.

Type of pathogen	Pathogen and associated disease
Virus	Channel Catfish Virus, CCV disease
	Infectious Hematopoietic Necrosis Virus, IHN
	Infectious Pancreatic Necrosis Virus, IPN
	Largemouth Bass Virus, LMBV disease
	Oncorhynchus masou Virus, OMV disease
	Viral Hemorrhagic Septicemia Virus, VHS
Bacteria	*Aeromonas salmonicida*, furunculosis and ulcer disease
	Renibacterium salmoninarum, bacterial kidney disease
	Yersinia ruckeri, enteric redmouth disease
	Edwardsiella ictaluri, enteric septicemia of catfish
	Edwardsiella tarda, edwardsiellosis
Parasite	*Myxobolus cerebralis*, whirling disease

A total of 180 fish were collected from Devils Lake and processed for pathogen testing in 2001. Samples were collected from four species including black crappie *Pomoxis nigromaculatus*, northern pike *Esox lucius*, walleye *Stizostedion vitreum*, and yellow perch *Perca flavescens*. The target sample size of 60 fish for each species was collected for walleye and yellow perch, however fewer northern pike and black crappie were obtained. Net catches were not necessarily representative of species composition due to sampling design and windy weather.

On the Sheyenne River, a total of 275 fish were collected from two sites during August 2002. Samples were collected from ten different species and consisted of black bullhead *Ictalurus melas*, black crappie, common carp *Cyprinus carpio*, green sunfish *Lepomis cyanellus*, northern pike, smallmouth bass *Micropterus dolomieui*, tadpole madtom *Noturus gyrinus*, walleye, white sucker *Catostomas commersoni*, and yellow perch. The target sample size of 60 fish was obtained for black bullhead at both the upstream and downstream sample sites and for black crappie at the downstream site. Poor catch rates for other species was attributed primarily to low abundance.

On the Red River, we collected a total of 83 fish from two sampling sites during August 2002. Samples were collected from eight species which included black bullhead, common carp, channel catfish *Ictaluris punctatus*, drum *Aplodinotus grunniens*, mooneye *Hiodon tergisus*, northern pike, shorthead redhorse *Moxostoma macrolepidotum*, and white sucker. The target sample size was collected for channel catfish at the upstream site but catch rates were much lower for other species.

Bacterial Fish Pathogens.– Primary culture tests from across the survey area were negative for *Aeromonas salmonicida*, bacterial agent of furunculosis, *Yersinia ruckeri*, causative agent of enteric redmouth disease, *Edwardsiella ictaluri*, cause of furunculosis, and *E. tarda*, cause of edwardsiellosis.

Antigen of *R. salmoninarum*, causative agent of bacterial kidney disease (BKD), was detected by ELISA in kidney tissue of northern pike, walleye, and yellow perch from Devils Lake. Walleye had the lowest percentage of positive OD readings (18.7%) while northern pike had the highest (43.9%). The proportion of yellow perch with positive OD values was only slightly higher than walleye although only five perch samples were tested because most fish were too small to obtain sufficient kidney tissue for assay. The mean level of *R. salmoninarum* antigen was low for all species and many positive sample were just slightly above the negative threshold. Tests were unable to confirm active infection of *R. salmoninarum* in fish from Devils Lake. DNA of *R. salmoninarum* was not detected with PCR in any sample tested (n = 7) regardless of ELISA OD value or host species. No fish, regardless of species or size, had any external or internal clinical signs indicative of BKD. Black crappie were not test for *R. salmoninarum* because fish were too small to obtain sufficient kidney tissue.

On the Sheyenne River, over 200 kidney samples were screened for *R. salmoninarum* with the ELISA. Antigen was detected in all species collected on the Sheyenne River although four species collected at the downstream site were negative. All fish with detectable antigen were in the low level category except a single green sunfish which had a medium OD reading. Corroborative PCR testing of 23 samples with positive ELISA readings failed to detect DNA of *R. salmoninarum*. Results of *R. salmoninarum* screening with samples from the Red River show a similar pattern to Devils Lake and the Sheyenne River. A total of 83 kidney samples were tested and all species were represented with positive ELISA readings. The mean antigen level category was low for all species except common carp which had medium antigen level. Corroborative PCR testing of 16 samples with positive ELISA readings failed to detect DNA of *R. salmoninarum*. As with Devils Lake, none of the fish from the Red and Sheyenne rivers had any external or internal clinical signs indicative of BKD or other diseases.

Viral pathogens.– A total of 132 samples were collected from across the survey area and tested for listed viruses. No viral fish pathogens were detected with the variety of standardized cell culture assays used during the survey.

Parasitic pathogens.– *M. cerebralis*, the myxospoean responsible for whirling disease, was the only parasitic fish pathogen included for testing in this survey. A total of 21 samples (5 pooled fish/sample) were collected and processed from across the survey area. At Devils Lake, 2 yellow perch samples were tested and found to be negative. On the Red River, 1 sample of black bullhead and 7 channel catfish samples also tested negative. On the Sheyenne River, we tested 6 samples from black bullhead and 3 from tadpole madtom and all were negative for the parasite. A small number of spores with morphology similar to *M. cerebralis* from 2 pooled samples of white sucker were observed from the Sheyenne River. DNA from the suspect spores was extracted and tested with the *M. cerebralis* PCR assay . The PCR confirmed that suspect spore were not *M. cerebralis*.

A relatively small number of macroparasites were observed during gross examination of fish. Identification of parasitic worms was beyond the scope of this survey however we provide a general description here. Several surveys for fish parasites have been completed in and around the current survey area including those by Forstie and Holloway (1984), Reinisch (1981), and Sutherland and Holloway (1979). A nematode (round worm) infestation was observed in black bullheads collected from both sampling sites on the Sheyenne River. The worms were encysted along the mesentary mostly associated along the lower gastrointestinal tract. Also, a small number of nematodes were seen in the mesentary of a single walleye collected in the Sheyenne River near Valley City. A nematode similar in appearance was observed in the mesentary of two walleye from Devils Lake. On the Red River, leeches were observed attached to three channel catfish. Judged solely by general fish condition, these parasites did not appear to have a significant impact on either fish growth or survival.

Fungal pathogens.– One walleye, collected from the upstream sample site on the Sheyenne River, had numerous lesions on surface of the liver and spleen. The lesions were a creamy white color and circular but did not appear raised. The lesions ranged in diameter from about 1 to 5 mm. Affected tissues were preserved in Davidson's solution, processed with standard histological techniques, stained with either hematoxylin and eosin or Giemsa, and viewed with light microscopy. Microscopic examination showed the walleye was affected by a systemic fungal infection. Numerous fungi were observed in blood vessels and throughout liver and spleen tissues.

During October 2001 and August 2002, more than 500 fish were examined and tested for a list of specific fish pathogens using protocols for the National Wild Fish Health Survey. Overall, the health and condition of fish from Devils Lake and from the Red and Sheyenne rivers appeared to be very good. None of the fish examined, regardless of species, size, or sample site had any external or internal clinical signs that would indicate infection by a fish pathogen included in this survey.

Engineering Research and Development Center Analysis

As part of the Devils Lake study the Corps of Engineers Engineering Research and Development Center conducted an analysis on biota transfer and rapid response for invasive species. Possible monitoring protocols and potential rapid response plans were developed. These can be used as a starting point to develop procedures to follow. Further agency coordination would be needed to finalize any plans. The following is an indication of some of the features that could be considered.

Devils Lake Biota Transfer Plan- Fish

Introduction

Basin transfer of fishes established in Devils Lake could be facilitated by natural and anthropogenic means including other vertebrate animals, recreational boats, and baitfish release (Peterson 2002). Information is provided below on invasive fish species of concern, techniques to prevent establishment of invasive species, monitoring locations, fish sampling techniques, and if invasive species are identified, a procedure to eradicate fish.

Fish Species of Concern

Fish species are well documented for Devils Lake basin and the Sheyenne/Red River basin. The ichthyofauna is diverse, consisting of over 80 species including introduced fishes (e.g., trout, common carp, white bass) that have become established in the Sheyenne/Red River basin (Crossman and McAllister 1986; Leitch and Tenamoc 2001). Based on current information striped bass is the only fish species of concern that may occur in Devils Lake and can potentially be transferred to the Sheyenne/Red River basin. However, Devils Lake is in close proximity to major corridors of movement by invasive species (e.g., Mississippi River system, Great Lakes), so other biota could become established.

Monitoring

Basin transfer of fishes can occur directly through controlled releases from Devils Lake into the Sheyenne River. Fish entrained in the outflow may survive and establish reproductive populations in the Sheyenne/Red River system. Therefore, monitoring and eradication must occur in a relatively confined area at the outlet of the project to maximize probability of encountering the invasive species before dispersing throughout a larger geographic area. The regulation reservoir can be designed to contain invasive species dispersing downstream, provide relatively easy access for monitoring, and if necessary, provide accessible sites for widespread eradication if an invasive species is identified.

A two-stage design of the reservoir would improve detection probability. The first stage should be of rectangular shape, relatively shallow (maximum depth less than 5 feet), but deep enough to launch boats for monitoring. Side slopes of at least 1:5 are recommended to provide shallow shorelines for invasive species, including juveniles, which prefer or are attracted to littoral zones. Shallow littoral zones will also provide easily accessible areas for routine monitoring. The second stage should be bowl-shaped with steep banks (1:2 to 1:3) and deeper water (maximum depth of 10 feet). This design will concentrate fish and other invasive species, and can be intensively sampled with relatively little effort. Boat access should be provided into each reservoir. The size of the two reservoirs should be minimized to concentrate invasive species.

Three additional monitoring and eradication sites should be strategically placed to increase detection probability at the following locations: immediately behind the Devils Lake pumping plant(s), immediately below the pipe outlet into the Sheyenne River, and at the confluence of the Sheyenne and Red Rivers. Monitoring should be conducted on a bi-monthly basis (i.e., 6 times per year) if invasive species are suspected in Devils Lake, otherwise annual monitoring will suffice.

Sampling Techniques

Life stage, swimming ability, and behavior of these fishes are primary factors that will influence design of a monitoring and rapid response plan. Many of the invasive species are strong swimmers capable of making long distance movements (e.g., striped bass, Asian carp), while others are benthic and less mobile (e.g., round goby). Therefore, gear selectivity to capture and monitor a multi-species assemblage of invasive fishes must consider both pelagic and benthic zones.

Monitoring sites should be sampled using three techniques: boat-mounted electrofisher, gill nets, and seines. Combined use of these three gears will maximize capture of pelagic and benthic fishes of various life stages that are being dispersed downstream. Icthyoplankton nets would be necessary to monitor dispersal of eggs and larvae. However, sample processing and lack of taxonomic resolution for most eggs and larvae impose constraints that will result in high costs and low probability of detection.

Using commercially available electrofishing equipment, the current and voltage gradient in the water can be adjusted to target specific species, sizes, and depth zones. Pulsed, direct current is recommended to elicit galvanotaxis (forced swimming towards the anode), making fish easier to capture with dipnets. An electrofisher is an active sampling gear, so large areas can be sampled in a short period and all species are susceptible to the collecting gear. However, some benthic fishes when stunned may not be detected by the net dipping crew, and the efficacy of electrofishing may become slightly diminished near the substrate.

Gill nets will target benthic zones. Experimental mesh, monofilament gill nets are recommended to target a wide range of fish sizes. Panels of 4 to 5 different mesh sizes ranging from ½ to 2½-inch stretch mesh are recommended. For ease of handling, nets should be 100 to 200 feet long depending on size of waterbody, and 5 to 6 feet in width. Nets should be set on the bottom across the waterbody (multiple nets may be required) and periodically checked. Both day and night sets are recommended since fish may exhibit diel variability in movement patterns.

Beach seines of ¼ inch mesh will capture small (<50 mm total length), young-of-year fishes, which are least susceptible to electrofishing and gill netting. The seines should be 8-ft deep to ensure that the float line remains above the water while seining. Maximum length of the seine should not exceed 30 ft because of the difficulty in filtering water with small mesh nets. The entire shoreline of each monitoring site should be sampled. Taxonomic resolution of small fishes is reduced, which may hamper on-site identification. Therefore, some fishes may have to be preserved in buffered formaldehyde and identified in the laboratory.

<u>Point-Source Eradication</u>

If an invasive fish species is identified, a rapid eradication program could be implemented using fish toxicants. Other than complete dewatering, fish toxicants are the only method that can be used in large areas with 100% lethal effects. However, fish toxicants are non-selective, so all species (native and invasive) in the treated area will be eradicated.

The re-regulation reservoir is designed to rapidly eradicate invasive fish before dispersing further downstream. Fish toxicants could be applied to the two additional monitoring sites, but incidental fish kills may increase. A downstream block net of ¼ inch mesh may be required at some sites to collect dead fish. It's likely that attempted eradication in other areas of the

Sheyenne and Red Rivers would result in major fish kills with a low probability of contact with the invasive species.

Devils Lake Biota Transfer Plan- Invertebrates

Invertebrate Biota of Concern

Free-living invertebrate groups of concern include:

- The spiny water flea (*Bythotrephes cederstroemi*)
- The zebra mussel (*Dreissena polymorpha*)
- The rusty crayfish (*Orcononectes rusticus*)
- The Chinese mystery snail or Japanese trap door snail (*Cipangopaludina chinensis*)
- A complex of closely related species or subspecies of brine shrimp, the most common of which in North America is *Artemia franciscana*
- Twenty genera of rotifers
- *Clam shrimp (small benthic crustaceans of the order Conchostraca)*
- Water fleas (zooplanktonic crustaceans of the order Cladocera of which the spiny water flea is a particularly noteworthy example)
- *Copepods (including the zooplanktonic Cyclopoida and Calanoida and the benthic and often sediment interstitial Harpacticoida)*
- Seed shrimps (small benthic crustaceans of the class Ostracoda)
- Free living flatworms (class Turbellaria)
- Gastrotrichs or microscopic organisms similar to rotifers but of the phylum Gastrotricha
- Roundworms (phylum Nematoda)

Sand filtration System and Invertebrate Biota Transfer

A sand filtration system is sufficient to control interbasin transfer of invertebrates from Devils Lake to the Sheyenne River.

Devils Lake Biota Transfer Plan- Plants

Vegetation species of concern includes:

- Eurasian watermilfoil (*Myriophyllum spicatum* L.)
- Curlyleaf pondweed (*Potamogeton crispus* L.)
- Canada thistle (*Cirsium arvense* (L.) Scop.)
- Leafy spurge (*Euphorbia esula* L.)
- Flowering-rush (*Butomus umbellatus* L.)
- Purple loosestrife (*Lythrum salicaria* L.)
- Scentless chamomile (*Tripleurospermum perforatum* (Mérat) Wagenitz)
- Saltcedar (*Tamarix* spp.)

The process for selecting these plants involved: reviewing the literature for information regarding the life history, distribution, habitat requirements, and dispersal mechanisms for each species; consulting state and local extension personnel regarding local distribution of each plant; and reviewing pertinent invasive weed laws. In summary, plants were included on our species list if they met the following criteria:

- Their current range of distribution includes North Dakota, Minnesota, and Canada.
- They are regulated, invasive species in either North Dakota, Minnesota, or Canada.
- They are aggressive, exotic species that typically inhabit disturbed wetland and aquatic sites.
- They possessed dispersal characteristics conducive of spread via water discharge.
- They were identified as species of concern by local experts.

With the exception of Canada thistle and leafy spurge, there are no published accounts citing the occurrence of the six other species in the Devils Lake area, however, without an up-to-date vegetation survey of these areas, we cannot definitively conclude that they are absent. Based on distribution records found in the literature and consultation with local experts, we feel that the likelihood that they do exist is high. A systematic vegetation survey for the Devils Lake and the Red River Basin is currently needed. Knowledge of existing populations would improve management success and minimize the risk of transferring undesirable biota into waters downstream from the proposed outlet.

Invasive Species Early Warning Rapid Response Management Plan

In 1999, the President issued Executive Order 13112 establishing the National Invasive Species Council that is co-chaired by the Departments of the Interior, Agriculture and Commerce. On a national level, the primary strategies for addressing invasive plant species became prevention, early warning rapid response (EWRR), and restoration. However since a large percentage of introduced plant species have entered North America undetected prevention is no longer an option and the only strategy available to combat them is EWRR implemented at the local level. In reaction to the federal initiative, the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) developed a draft action plan (FICMNEW, 2002) for a

"National Early Warning and Rapid Response System for Invasive Plants in the United States" that forms a framework for action at the local level.

The EWRR developed by FICMNEW includes the following components:

- Development of local, state, and regional partnerships (To be operational, EWRR must combine and focus the resources and expertise of federal agencies, state and local governments, and the private sector).
- Early detection and reporting (The most critical step in addressing new invasions is to know they exist)
- Identification (Development of booklets, expert keys and/or web-based tools to enhance plant identification)
- Verification and vouchering (Requires the assistance of botanists or plant diagnostic laboratories for positive plant identification and in the case of new invasives, the vouchering of any state or national records)
- Rapid assessment (The determination of what should be done about the invasive plant and methodology on how to do it)
- Rapid response action plan (Site specific appropriate action required to eradicate or contain the invader)
- Action plan assessment and revision (Monitoring or surveillance to assess effectiveness of the rapid response action plan and development of modifications if necessary)

The outlet project would have the potential for transferring organisms from Devils Lake to the Sheyenne River. In addition, potential changes to water quality, stream morphology, and riparian habitats as a result of the project could further influence the introduction and spread of plant biota to the Red River basin. Disturbance from construction of the outlet also has a high probability of providing conditions that favor the introduction and spread of invasive species. In light of these findings, an EWRR plan specific for the Devils Lake project is of high priority.

Several steps are necessary to implement an invasive species management program (Figure C-18A). The initial step requires a vegetation survey of Devils Lake and the Red River basins for plant biota of concern. Data collected during the survey can provide the basic information for a beginning database on the plant biota of concern. Such information is not limited to but often includes plant name, location of the population, population size, site description, type of habitat, proximity to water, presence of other plant species, and presence of any threatened or endangered plants. A survey also offers an opportunity to document any other plant biota of concern that had not been considered for listing because they were not known to exist in North Dakota at the time of this report.

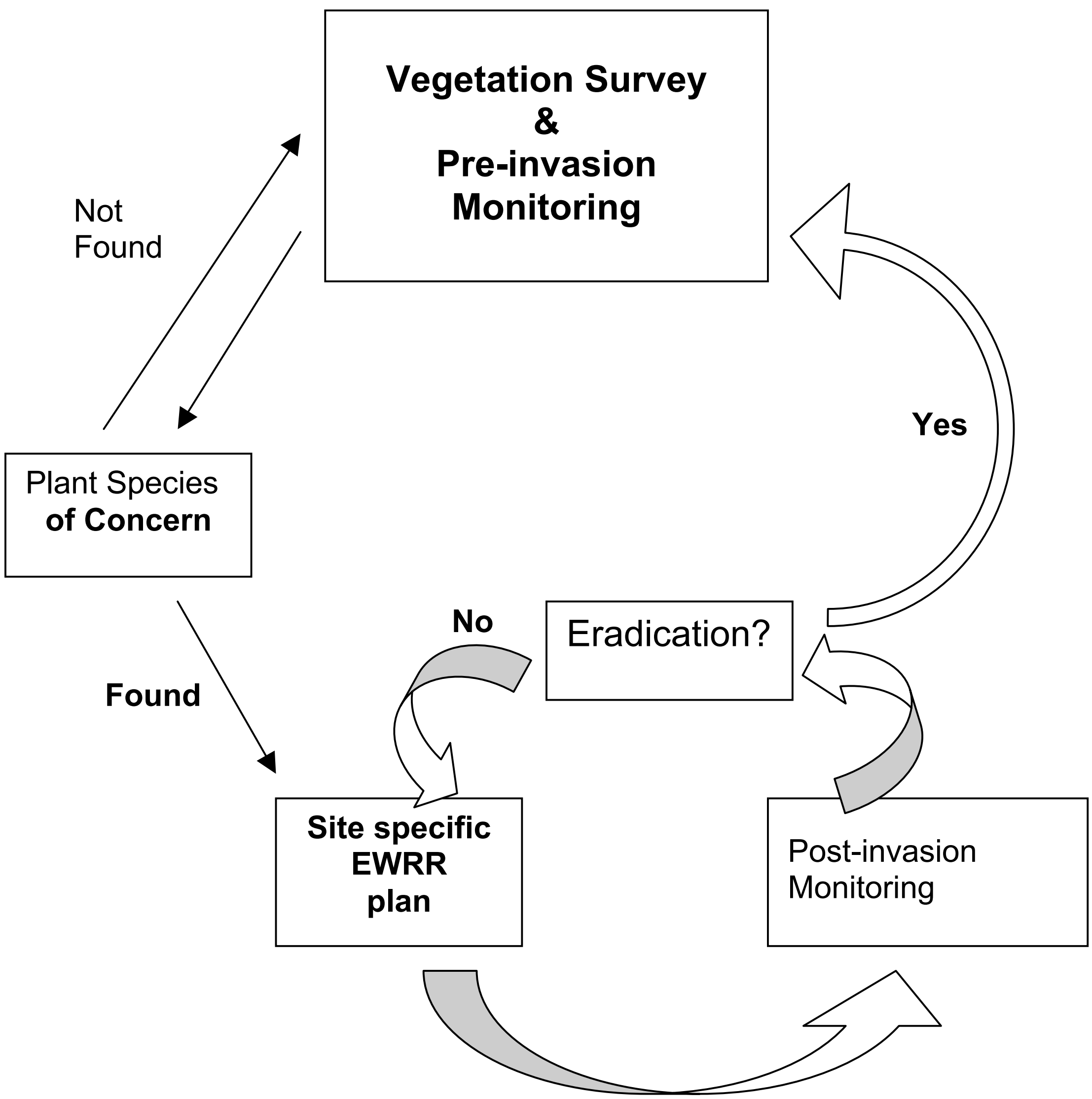
For each plant population of concern identified in either the initial survey or subsequent pre-invasion monitoring of Devils Lake and the Red River basins, an associated site-specific rapid response plan (EWRR) is required. Included in each response plan are control strategies, implementation procedures, post invasion monitoring techniques and frequencies, and criteria for treatment evaluation. While a number of control strategies exist for each species of concern, it is the individual invasion site that will dictate which options can be implemented. If several options are available they should be evaluated in terms of potential effectiveness, advantages, drawbacks, costs, and permits. Integrating control options is highly desirable and can often provide the best long-term management approach with the least environmental impacts. This approach examines all the alternatives with regard to such factors as:

- The extent of the plant infestation
- Scale, intensity, and timing of the treatment
- Effectiveness against the target plant
- Duration of control
- Human health concerns
- Endangered or threatened species impacts
- Other environmental impacts and the associated mitigation, if needed
- Program costs
- Permit requirements (Federal, State, local)

Eradication is the goal of any EWRR plan and is achievable if infestations are detected when they consist of relatively few plants. However, some of the plant biota of concern (i.e. leafy spurge, purple loosestrife, Canada thistle) have established populations in the region and containment is the only option. These three species plus saltcedar are on North Dakota's invasive species list and by law must be controlled. Once a response plan has been put into effect, post invasion monitoring continues until eradication has been achieved or remains an ongoing process if containment is the only option. If treatments are not limiting the spread, the response plan will need to be reevaluated and new control procedures implemented.

For the duration of the Devils Lake pumping project, pre-invasion monitoring of Devils Lake and the Red River basins will remain the core of the EWRR plan. Only through continual monitoring can new infestations be detected. At a minimum, a professional survey of the region should be conducted every 3-5 years preferably every year. During the growing season, more frequent monitoring on a monthly basis is recommended at the re-regulation reservoir if constructed, the outlet to the Sheyenne River, the confluence of the Sheyenne and Red Rivers, the Red River entry into Canada and high use areas such as boat ramps and other public access areas. It will require the cooperation of all stakeholders in the project from federal, state, and local agencies to members of the private sector.

Figure C-18A. Preparing an Invasive Species Rapid Response Plan.



Sampling Techniques

The point intercept method and the line intercept method, two standard terrestrial techniques for assessing plant communities, can be easily applied to aquatic systems to collect large quantities of data that provide information on species diversity and plant abundance (Madsen 1999). In particular, the point intercept method can incorporate Global Positioning System (GPS) technology to pinpoint locations of species of interest.

In the point intercept method, pre-selected or defined locations are generated using a Geographic Information System (GIS) or desktop mapping software package to avoid subjectively selecting locations in the field (Madsen 1999) and are laid out in a grid-like pattern over the area to be surveyed. Areas of a lake that are too deep for plant growth are excluded from the sampling grid. The selected points are entered into the navigation software of a GPS system to rapidly find the locations in the field. The sophistication of the system is a determinant in accurately pinpointing positions in the field (i.e. low-cost units can locate points within 30 m while the more sophisticated units have an accuracy of 5 m or less).

Using navigation software, an area is surveyed in a regular pattern. Plants can be observed directly in clear shallow water or if the water is too deep or turbid for direct observation a collection device like a rake can be used. At each grid point, biota of concern presence/absence can be documented. If present, additional information can be collected including water depth, Secchi disk depth, water movement parameters, and presence/absence of other plant species. For each area surveyed, it is recommended that one set of voucher specimens of each species be collected and sent to a qualified taxonomist for verification. The vouchers are extremely important because they provide a definitive record of the presence of a species at a specific location (Hellquist 1993).

The line intercept method employs the use of transects of a set length (e.g., 100 m) that are set up in a study area (Madsen 1999). A transect line is prepared using yellow nylon rope with markings every 1 m and intervals flagged every 5 to 10 m. Several transects are deployed in each study area. Species presence are noted along set line intervals of the transects.

Data collected using either method are entered into a spreadsheet or database program for accessibility and updated as necessary. The information in the database can then be used for monitoring the status of plant biota of concern, assessing the spread, containment, or eradication of a targeted population, and assessing the effectiveness of the control options employed.

Impacts of Plant Biota of Concern

In addition to their non-native status, the eight species identified herein all possess certain definable characteristics that set them apart from other, less-aggressive, plant species. These characteristics include one or more of the following features: abundant seed production, rapid population establishment, seed dormancy, long-term survival of buried seeds, adaptations for spread, production of vegetative reproductive structures, and the capacity to occupy sites disturbed by human activities. All of these features increase the likelihood of plant survival and persistence under a wide range of environmental conditions.

While all of the listed plants are capable of downstream spread with or without construction of the Devils Lake outlet, it is our opinion that the rate of spread would likely increase as a result of increased flows currently defined under the proposed plan. Moreover, new introductions into habitats currently not infested with these species are inevitable. Although it is impossible to accurately predict the full impact of increased dispersal under the proposed plan, there is sufficient scientific evidence that indicates without containment, all of the plants described above can quickly establish and subsequently degrade the productivity and diversity of downstream habitats. Of the plants identified on our species list, isolated populations of Eurasian watermilfoil, flowering-rush, purple loosestrife, curlyleaf pondweed, and saltcedar have been unofficially reported in the Red River basin according to the report by PEC. However, it is not clear whether voucher specimens were collected or the taxonomy confirmed for these sightings.

Vegetation Management Strategies

In general, the goals of all vegetation management programs are prevention, control, and eradication. Prevention is the practice of keeping nuisance plants from being introduced into an uninfested area. Successful implementation involves sanitation practices to prevent spread of plant propagules and laws and regulations enacted to meet this objective. Prevention is the most efficient and cost-effective approach to combating invasive species, however early awareness of potential plant problems is the key. Moreover, legislation is only effective if enforced. Control is defined as the suppression or “containment” of a particular plant species once it becomes established in an area. Control methods do not always prevent plants from reproducing, therefore treatment must be continued year after year. Eradication is the complete elimination of all plants and plant parts of a target species from an area. Eradication usually can be achieved only in the case of new, small infestations. Although prevention and eradication can and should play important roles in most vegetation management programs, emphasis is usually placed on control and containment once invasive plants are established.

There are several control methods or strategies currently available for managing undesirable vegetation. The traditional weed scientist categorizes weed control practices as either: preventive, mechanical, cultural, biological, or chemical. Selecting the proper control method should be based on several factors including: the use objectives of the land; the effectiveness of a particular control method on the target plant; environmental factors; economics; policy and legal restrictions; and the extent and nature of the infestation. A program consisting of several steps or practices rather than a single treatment usually is the proper approach for managing invasive vegetation.

Rapid Response Plan

Once a plant species of concern has been identified (either in Devils Lake or the Red River Basin), a management response plan should be implemented. Management options will vary depending on the plant species and the size and locale of the infestation. With respect to this project, the objectives for managing the listed plants of concern are as follows:

1. Eradication if infestations are recent and small (< 100 plants)

2. Containment or control if plants are well-established and populations are large in size (>100 plants).

1. Eradication: If the infestation is defined as recent (first year of growth with no propagule bank) and is small in size (less than 100 plants; isolated stems), the management objective should be eradication. This can be achieved by mechanical methods such as hand-pulling, hand-hoeing, raking or digging. Hand removal of vegetation is labor intensive and time consuming but the advantages are that it is a selective control method and that it can be very effective if done properly. For effective hand removal of nuisance plants, these guidelines must be followed:

- Remove as much as the root system as possible. Complete removal of the root system is required because broken roots may sprout new plants.
- Do not let plants reproduce. Manually remove plants before they flower and set seed.
- Remove and dispose all plant materials (roots, stems, flower stalks) from the infected site. Most of the plant species on our list can regrow from root and stem pieces left behind.
- Follow-up monitoring is necessary. Sites where plants have been removed should be mapped and monitored monthly during the growing season for potential regrowth.

2. Containment and Control: If the infestation is well-established (present for more than one growing season; propagule bank present) and large in size (> 100 plants), the management objective should be "containment." Selecting the most effective control method is site and species specific. Many factors should be considered including: plant growth stage, environmental factors (soil type, temperature, water quality, erosion potential, etc.), herbicide use restrictions, the presence of sensitive plants or animals, irrigation or potable water issues, economics, site accessibility to list a few.

Treatment Plan and Survey

Eight plant species were identified as biota for concern should the proposed outlet be constructed between Devils Lake and the Sheyenne River. At the present time, it cannot definitively be said whether any of the species exist in the Devils Lake basin although according to Okerson (2001) leafy spurge and Canada thistle are present in Ramsey County, ND. Established populations of leafy spurge, Canada thistle, and purple loosestrife already occur in the Red River basin and reports of Eurasian watermilfoil, curlyleaf pondweed and saltcedar suggest they may also be present. We concur with PEC that substantial data gaps are present in a number of taxonomic groups and that further field investigations in both the Devils Lake and Red River basins are necessary to render a definitive analysis of this question. With increased use of Devils Lake for recreational purposes combined with the natural dispersal mechanisms of many invasive species, the risk is extremely high that all the biota of concern outlined in this report plus other highly invasive species not included in the report could already be present or have a high risk of being introduced into the Devils Lake watershed at any time in the future. If biota of concern are present or invade Devils Lake the risk is also extremely high that these biota will be transferred via a pumping operation from Devils Lake into the Sheyenne River if a preventative filtering system is not in place.

There is a potential for outlet-related habitat changes in the Sheyenne and Red Rivers. Such changes may create colonization opportunities for species that have not been successful there in the past. Any changes that induce disturbance offer habitat changes that favor invasive species establishment and spread.

All of the listed species can be water dispersed either by vegetative propagules or by seeds. They may not be currently present in the Devils Lake basin but future invasion is almost a certainty for most of these species and a proactive system to combat them should be developed and in place at the start of operation of the pumping facility.

If 100% of the water pumped from Devils Lake is filtered, plant biota escape from Devils Lake via water transfer will be highly unlikely. However, areas exposed to the environment plant biota could invade either into the waters or along the edges of a canal and the possibility of biota transfer via water would be a possibility. All of the plant biota of concern are aggressive invasive species and have numerous mechanisms for dispersal other than by water. The likelihood of transfer by anthropogenic means is extremely high.

A vegetation survey of Devils Lake and the Red River basin is needed and is a feasible operation. The technology and methodology has already been developed to implement such surveys (Madsen 1999; Madsen et al. 2002). Many states including Minnesota have surveyed and mapped distributions of invasive species that occur within their state and publish annual reports on their findings (Exotic Species Program 2002). A management plan for biota of concern in the Devils Lake and Red River basins would be in compliance with Executive Order 13112 as well as Section 63-01.1-13 of the North Dakota noxious weed law (North Dakota Department of Agriculture 2000).

Erosion Potential

The operation of outlets to the Sheyenne River could have substantial erosion effects on the Sheyenne River. The geomorphology analysis (West Consulting) and changes in channel morphology are summarized below.

To estimate the potential increase in erosion due to the operation hydrograph, historic aerial photography and 1998 aerial photography were compared to determine the historic rate of channel migration of the Sheyenne River. The number of days of high flow conditions from the overflow hydrograph was then compared to the number from historic gauge records. Estimates of erosion for various segments of the Sheyenne River (see Figure C-19 below) were then made based on the ratio of these durations.

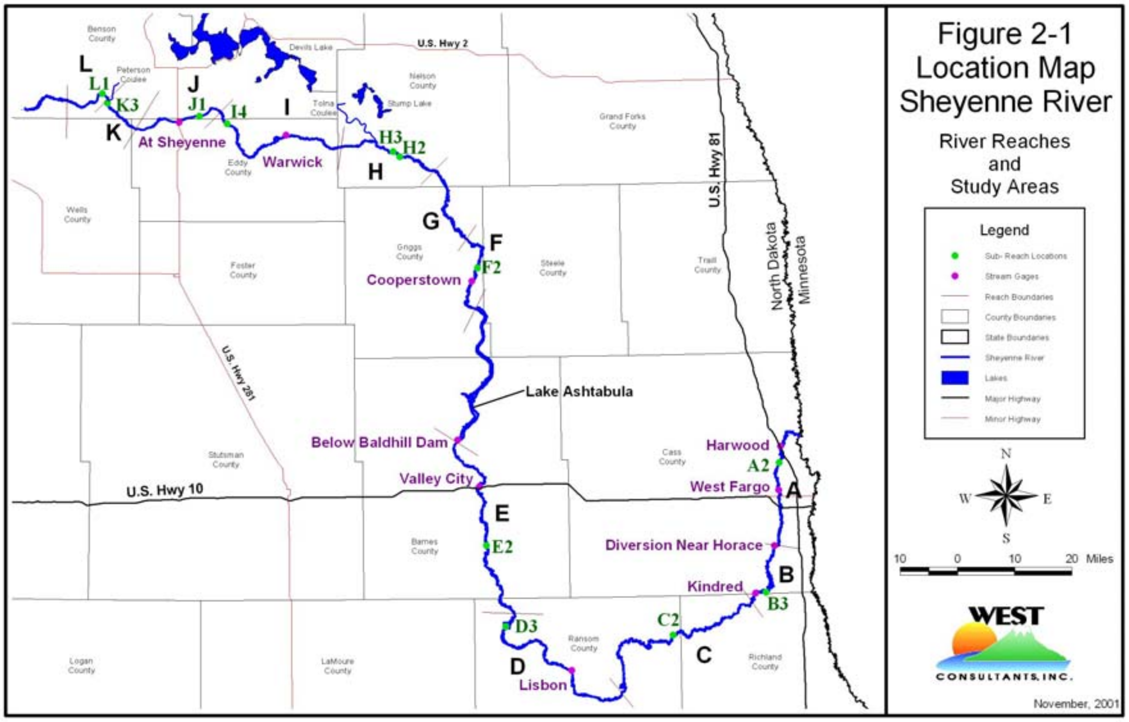


Figure C-19: Sheyenne River Segments

Table C-19. Change in Average Theoretical Channel Width in Feet by Trace

Reach	No. of Values Averaged	Mdnp	Md300	Md480	Wtnp	Wt300	Wt480
A2	1	1	3	4	15	17	20
B3	2	0	0	1	19	20	21
C2	2	-2	-2	-2	24	25	25
D3	6	-3	-3	-2	15	15	15
E2	3	-3	-3	-3	13	14	15
F2	1	-6	-6	-5	25	25	27
H2	1	-6	-5	-5	16	16	18
H3	1	-12	-9	-8	36	36	38
I4	1	-3	-2	-1	20	20	21
J1	2	-8	-7	-8	61	61	61
K3	1	-3	-3	-1	36	36	36

Table C-20. Change in Average Theoretical Meander Length in Feet by Trace

Reach	No. of Values Averaged	Mdnp	Md300	Md480	Wtnp	Wt300	Wt480
A2	1	17	34	45	170	198	226
B3	2	0	2	13	217	225	247
C2	2	-18	-18	-24	274	288	288
D3	6	-37	-37	-23	175	175	178
E2	3	-35	-35	-30	150	159	174
F2	1	-74	-70	-54	291	291	306
H2	1	-69	-63	-63	183	183	206
H3	1	-133	-100	-89	414	414	436
I4	1	-31	-27	-16	227	227	239
J1	2	-94	-85	-90	704	704	703
K3	1	-32	-32	-16	411	411	416

Table C-21. Change in Average Theoretical Meander Amplitude in Feet by Trace

Reach	No. of Values Averaged	Mdnp	Md300	Md480	Wtnp	Wt300	Wt480
A2	1	7	14	19	71	83	95
B3	2	0	1	5	90	94	103
C2	2	-8	-8	-10	116	122	122
D3	6	-15	-15	-10	72	72	73
E2	3	-14	-14	-12	62	65	72
F2	1	-30	-29	-22	121	121	127
H2	1	-27	-25	-25	73	73	82
H3	1	-56	-42	-37	176	176	185
I4	1	-12	-11	-6	91	91	96
J1	2	-40	-37	-38	307	307	306
K3	1	-13	-13	-6	169	169	171

From Tables C-19, C-20, and C-21 above it can be seen that the average channel widths are predicted to decrease for nearly all reaches for the moderate climate scenario with or without pumping. This is due to the overall drier than average conditions for the moderate future trace over the 50-year time span. The largest predicted increase in channel width is 4 ft for the most downstream reach (A), an amount 3 ft greater than the future without pumping scenario. For the wet climate future, predicted widening is much greater, up to 61 ft. However, because widening is also predicted for the no pump scenario, the differences between the with- and without-project options are relatively small: up to 2 ft for the Wt300 scenario and up to 5 ft for the Wt480 scenario.

As seen in Tables C-19 through C-21 above, the predicted meander lengths and amplitudes are a function of the channel width and follow the same pattern. Changes in the predicted meander length between the with and without pumping futures are relatively small for the moderate climate scenarios. Maximum changes of 33 ft and 44 ft were predicted for the Md300 and Md480 scenarios, respectively. Note that the change would be applied over the entire meander length, between 500 and 1,500 ft for existing conditions. The results for the wet climate scenarios follow a similar pattern, with a predicted maximum increase in meander length of 28 ft and 57 ft for the Wt300 and Wt480 scenarios, respectively.

The predicted change in meander amplitude between with and without project conditions is also small, with maximum values of 14 ft and 19 ft for the Md300 and Md480 scenarios, respectively. Maximum predicted changes between with and without project conditions are 12 ft and 24 ft for the Wt300 and Wt480 scenarios, respectively. These predicted changes would be applied to existing meander amplitudes, measuring 60 to 650 ft under current conditions.

The proposed project would cause an increase in the total area eroded due to predicted increases in average channel width (see table below). The minimum predicted increase due to the project is 8 acres for the Md300 scenario (difference between the Md300 and Mdnp results) while the maximum predicted increase is 85 acres under Wt480 scenario (difference between the Wt480 and Wtnp results). Note that the effect of the proposed project was calculated by comparing the amount of erosion predicted with and without pumping from Devils Lake. The minimum change due to the project occurs during the moderate hydrologic scenario when 300-cfs is pumped from the lake (Md300). The maximum change due to the project occurs during the wet hydrologic scenario when 480-cfs is pumped from the lake (Wt480). It should also be noted that the future climatic conditions (moderate or wet) have a far greater impact on predicted erosion rates than any of the proposed pumping scenarios.

The magnitude of the increase in erosion due to planform changes caused by pumping may be estimated by assuming that one half of a complete meander loop takes the form of an ellipse. The area lost due to increases in the meander length and/or amplitude is then defined as the area between two ellipses (see Figure C-20 below). Assuming that each half meander loop changes the average amount over the entire length of a reach will provide an estimate of the quantity of land eroded. Tables C-22 and C-23 below provide a summary of these calculations. A conservative assumption (that is, one yielding *higher* eroded land results) would be to assume that the planform erosion given in Table C-23 (due to flow changes) and the historical average (27 acres per year, based on meander migration) are additive.

Table C-22. Acres Eroded Due to Increase in Average Channel Width by Trace

Reach	Mdnp	Md300	Md480	Wtnp	Wt300	Wt480
A	7.6	15.2	20.4	76.5	89.3	102.1
B	0.0	0.5	4.0	65.9	68.6	75.3
C	0.0	0.0	0.0	200.5	211.3	211.3
D	0.0	0.0	0.0	108.3	108.3	110.3
E	0.0	0.0	0.0	109.1	115.4	126.0
F	0.0	0.0	0.0	131.2	131.2	138.2
H2	0.0	0.0	0.0	33.8	33.8	38.0
H3	0.0	0.0	0.0	75.9	75.9	79.8
I	0.0	0.0	0.0	102.9	102.9	108.1
J	0.0	0.0	0.0	139.7	139.7	139.5
K	0.0	0.0	0.0	47.6	47.6	48.1
Total	**7.6**	**15.7**	**24.5**	**1091.3**	**1123.9**	**1176.6**

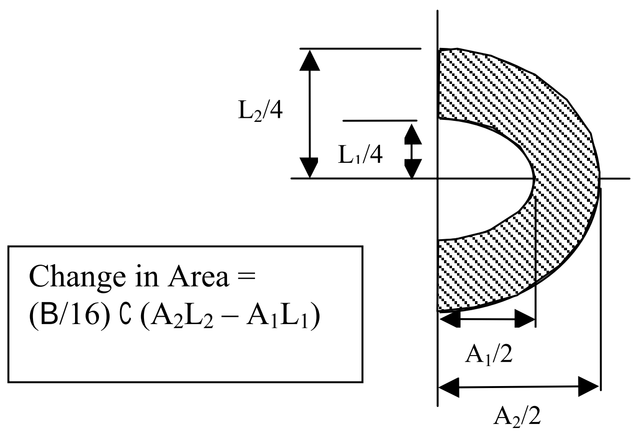


Figure C-20. Schematic for computing change in area due to planform changes

Table C-23. Acres Eroded Due to Planform Changes Caused by Pumping

Reach	Md300-Mdnp	Md480- Mdnp	Wt300- Wtnp	Wt480- Wtnp
A	19.6	32.9	33.1	65.7
B	1.2	10.1	7.9	24.5
C	0.0	0.0	28.6	28.6
D	0.0	21.6	0	6.4
E	0.0	9.7	16.9	44.0
F	4.6	22.3	0	18.2
H2	2.6	2.6	0	10.5
H3	15.5	20.8	0	10.3
I	4.7	17.5	0	13.1
J	4.9	3.3	0	0.1
K	0.0	4.6	0	1.3
Total	**53.1**	**145.4**	**86.5**	**229.1**

As can be seen from this analysis, the change in meander length and amplitude will result in more erosion than changes in channel width. The changes in channel planform would take from 5 to 26 years to stabilize depending on the cross section location, therefore causing continuous unstable conditions for a long period of time.

In addition to the adverse impacts on habitat caused by the significant changes in stream flow proposed, the potential for physical changes in channel geometry caused by significantly increased occurrence of bankfull or channel-forming flows is also of concern. The changes in channel geometry and length of the adjustment time result in effects on habitat and aquatic populations.

The geomorphology study also investigated the effects of flow on riparian vegetation and in turn the effects of any loss of riparian vegetation on subsequent erosion.

Several studies conducted independently have established that flooding can adversely impact vegetation. Flooded conditions cause the depletion of free oxygen in the soil. The absence of oxygen creates a reducing environment in the soil that favors the growth of anaerobic bacteria. These organisms produce a variety of byproducts that are toxic to plants. Therefore, under flooded conditions, a plant has to contend with a lack of oxygen as well as toxic soil conditions (Whitlow and Harris 1979).

Riparian vegetation is especially sensitive to changes in minimum and maximum flows. It is possible to cause substantial changes in riparian vegetation without changing mean annual flow (Auble et al. 1994).

The geomorphology study found that under the moderate climate scenario over the next 50 years, compared to the "no-pump" alternative, the 300-cfs constrained pumping alternative may cause the flow to exceed bankfull and result in up to 50 continuous days of additional flooding during at least 1 or 2 of those years. For the 480-cfs unconstrained pumping alternative under the moderate climate scenario, the flow may exceed bankfull and cause up to 150 continuous days of additional flooding during at least 4 years out of the 50.

Compared to the "no-pump" alternative under the wet climate scenario, the 300-cfs constrained pumping alternative may cause the flow to exceed bankfull and result in 30 to 50 days of continuous flooding during at least 3 to 7 years out of the 50 analyzed. Similarly, the 480-cfs unconstrained pumping alternative under the wet climate scenario may cause the flow to exceed bankfull and result in up to 150 days of continuous flooding during at least 29 years out of the 50. This additional flooding is expected to occur mainly in the upper reaches of the Sheyenne (approximately section H3-f to section K3-j).

A comparison of the flood tolerance of various species to the projected flooding duration of the pumping alternatives shows that all species identified as "intolerant" and "somewhat tolerant" cannot be expected to survive the additional flooding due to the 480-cfs unconstrained pumping for either the moderate or wet scenarios. The 300-cfs constrained pumping alternative can be expected to cause some flooding damage from which the vegetation could be expected to recover, provided flooding is not repeated in consecutive years.

The increased flows in the river due to pumping may have other indirect adverse effects apart from flooding. Flow alteration downstream of dams and channel straightening activities can cause stream channel degradation, a fact well documented in the literature. The effect of altered flow regimes downstream of dams on riparian trees such as willows, cottonwoods, and poplars has also been widely studied. Riparian vegetation establishment is dependent upon the dominant fluvial geomorphic processes that form surfaces suitable for establishment. Successful establishment from seed occurs only in channel positions that are moist, bare, and protected from removal by subsequent disturbance. Point bars form ideal surfaces for the growth of trees (Scott et al., 1996). If depositional surfaces such as point bars are lost as a result of processes such as degradation, the successful establishment from seed is prevented.

Similarly, if depositional surfaces such as point bars remain continuously inundated during the active growing season due to pumped flows, the successful establishment from seed on these surfaces will be prevented. The active growing season usually lasts from May through October and most of the pumped releases into the Sheyenne River would occur during this season. To evaluate the effect of the maximum increases in stage on in-channel depositional surfaces, a range in maximum depth increase of 4 to 8 ft was assumed. This value is based on field observations and the assumption that a 4- to 8-ft increase in stage would inundate most depositional surfaces. It was further assumed that this increase in stage would have to be continuously sustained for 150 days or more to prevent the successful establishment of vegetation.

Although the existing riparian vegetation increases the resistance of the bank to erosion and failure, it is expected that some vegetation along the edges of the banks will be lost as the banks widen. This is because the current vegetation is not thick enough and bank failure is evident in locations of increased hydraulic stresses. The loss of vegetation along the banks will make the banks more susceptible to erosion. The failed bank material will be deposited along the toe of the banks and will be gradually entrained.

The geomorphology study concluded that the effect of long-term channel change will be limited to near-bank riparian vegetation loss in some reaches due to localized bank failures and may be considered minor in nature.

Both pumping alternatives have the potential to prevent the establishment of seed on riverine depositional surfaces. However, the 300-cfs constrained pumping alternative would cause much less damage than the 480-cfs unconstrained pumping alternative for both the moderate and wet climate scenarios.

The effect of long-term channel change on the vegetation will be limited to near-bank riparian vegetation loss in some reaches due to localized bank failures and may be considered minor in nature.

The influence of long-term vegetation changes for the 300-cfs constrained pumping alternative on the channel morphology is expected to be of a minor nature for both the moderate and wet climate scenarios. However, long-term vegetation changes due to the 480-cfs unconstrained pumping alternative could have significant adverse impacts on channel stability for both climate scenarios. The loss of vegetation is thought to have more of an effect on the rate of erosion to reach the predicted ultimate values rather than the values themselves.

Soil Salinity Effects

The outlet operation has the potential to effect soil salinity in downstream areas. The effects on soil salinity and use of Devils Lake water by irrigators on soil salinity were assessed (Peterson Environmental Consulting, Inc.).

There are three salinization hazards associated with a constructed outlet alternative:

(1) Induced floodplain salinization resulting from the raising of watertables of floodplain and adjacent soils in the Sheyenne Valley above a "critical depth."

(2) Additional salt loading to the floodplain could result from both over-bank flooding with mixed Devils Lake/Sheyenne River water and intrusion of this water into adjacent floodplain soils as infiltrated floodwater and groundwater flow. Seepage outflow of mixed Devils Lake/Sheyenne river water could produce additional salt loading to adjacent floodplain soils during periods when the river is contained within the channel.

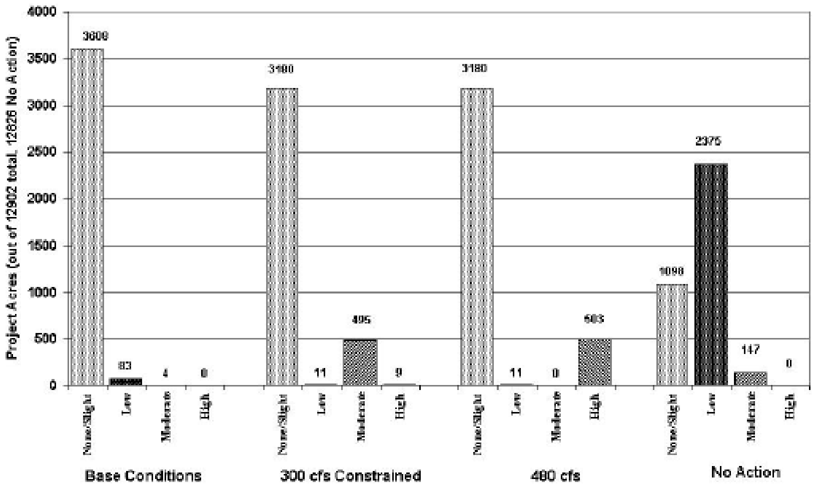
(3) Continued permitted use of mixed Devils Lake/Sheyenne River water to irrigate agricultural fields adjacent to the Sheyenne River and the Red River of the North.

IRRIGATION WATER QUALITY

There are approximately 120 surface-water appropriation permittees in North Dakota and Minnesota, based on the North Dakota State Water Commission (NDSWC) and Minnesota Department of Natural Resources (MnDNR) permit databases) appropriating river water from either the Sheyenne or Red Rivers. The outlets have a potential to effect these users.

Distribution statistics including mean, median, standard deviation, minimum, maximum, and range were determined for HEC5Q predicted TDS and SAR values (all control points, all outlet alternatives) under the Wet7 climatic scenario. Distribution statistics for the outlet alternatives were restricted to the "*Blended Water Only*" dataset to avoid misinterpretations due to dilution with baseflow values. Predicted TDS and SAR values were also plotted on a template similar to the salinity/sodicity irrigation water classification system of the NSSL, again for all control points and all outlet alternatives. The data indicated that (1) the magnitude of TDS and SAR decreased with increasing distance from the point of insertion, (2) predicted mean TDS and SAR values for the 300-cfs constrained and the 480-cfs unconstrained outlet alternatives were quite similar and were uniformly below 1,000 mg/l TDS and an SAR of 4, and (3) dilution reduced TDS and SAR values dramatically in the Red River. TDS and SAR values predicted under the no action (natural spill) alternative were far greater, with a high TDS mean of 1,616 mg/l for the Cooperstown data set, and a high mean SAR of 6.98, again for the Cooperstown data set.

Figure C-21. Acreage of irrigated lands falling into the various salinity hazard classes based on TDS for the various alternatives using blended and baseflow plus blended water



TDS Exceedances, Baseflow plus Blended Water, Sheyenne Irrigated Lands

Figure 8 A. Irrigated acres along the Sheyenne River by TDS hazard class and alternative. Figure 8A was developed from percent exceedance tables developed for the entire growing-season HEC5Q water quality dataset including TDS values for *Baseflow-plus-Blended Water*. Figure 8B (below) was developed using TDS values for *Blended-Water-Only* water as discussed in Section 2.1.1.1. Note increase in severity associated with the No Action alternative between Figures 8A and B , and the greater hazard associated with Sheyenne River water when compared to the full project.

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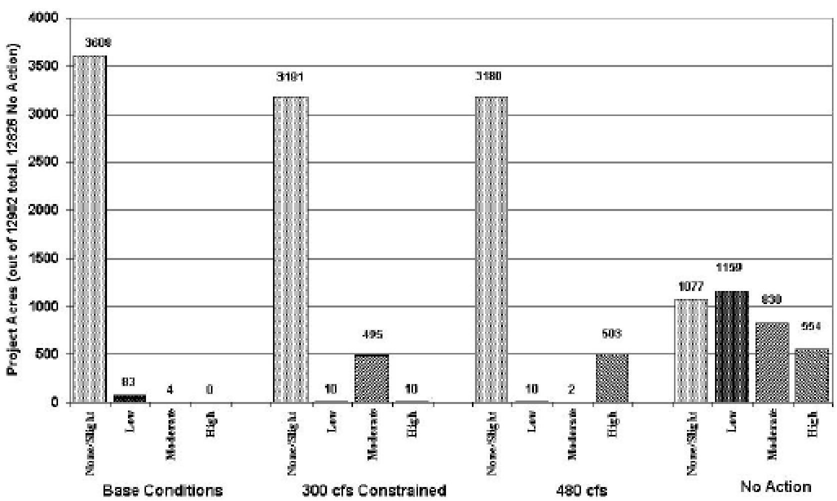

TDS Exceedances, Blended Water Only, Sheyenne River Irrigated Lands

Figure 8B. Irrigated acres along the Sheyenne River by TDS hazard class and alternative. Figure 8B was developed using TDS values for *Blended-Water-Only* water as discussed in Section 2.1.1.1. Note increase in severity associated with the No Action alternative between Figures 8A and B, and the greater hazard associated with Sheyenne River water when compared to the full project.

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Figure C-22. Acreage of irrigated lands falling into the various salinity hazard classes based on SAR for the various alternatives using blended and baseflow plus blended water

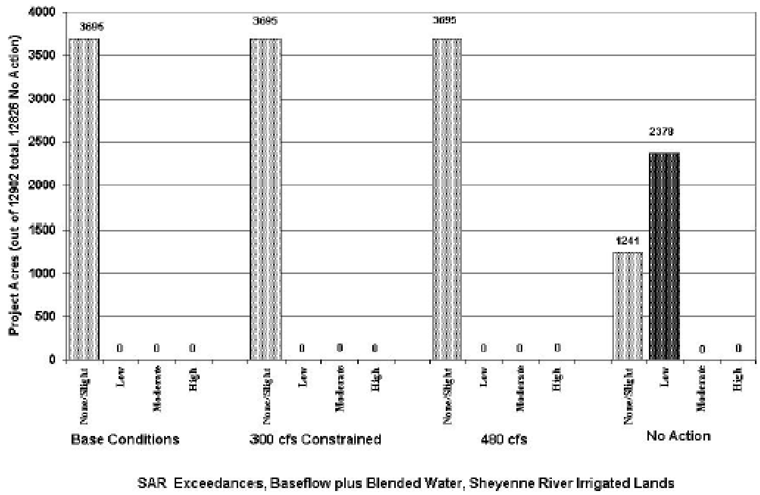

Figure 9A. Irrigated acres along the Sheyenne River by SAR hazard class and alternat ive. Figure 9A was developed from percent exceedance tables developed for the entire growing-season HEC5Q water quality dataset including SAR values for *Baseflow-plus-Blended Water*. Figure 9B (below) was developed using SAR values for *Blended-Water-Only* as discussed in Section 2.1.1.1. Note increase in severity associated with the No Action alternative between Figures 9A and B, and the greater hazard associated with Sheyenne River water when compared to the full project.

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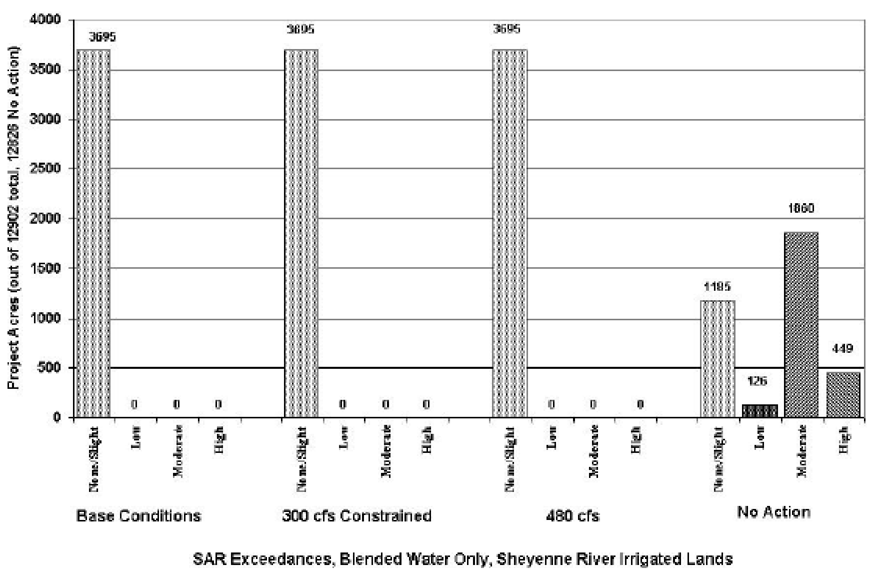

Figure 9 B. Irrigated acres along the Sheyenne River by SAR hazard class and alternat ive. Figure 9B was developed using SAR values for *Blended-Water-Only* as discussed in Section 2.1.1.1. Note increase in severity associated with the No Action alternative between 9B and A , and the greater hazard associated with Sheyenne River water when compared to the full project.

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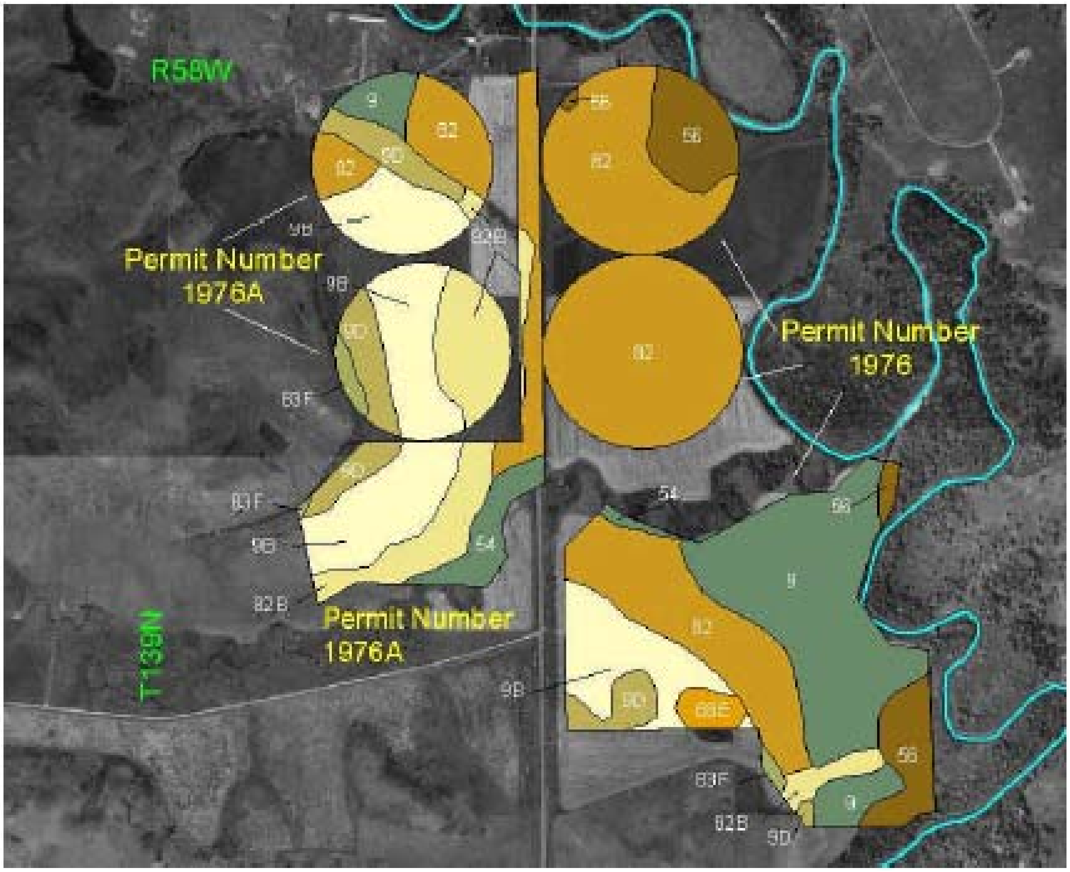
NSSL (National Soil Science Laboratory) irrigation hazard plots indicated that while TDS and SAR values under the alternatives are elevated along the Red River, dilution of blended water with Red River water reduced TDS and SAR levels to the point where the water quality stayed within the baseline NSSL category, even under the no action (natural spill) alternative. However, irrigation hazards along the Sheyenne River resulting from increased TDS and SAR in blended Devils Lake/Sheyenne River water were indicated to a moderate degree for the 300- and 480-cfs constructed outlet alternatives, and to a much greater degree under the No Action (natural spill) alternative. At the most elevated levels of TDS and SAR, the decline in the quality of the irrigation water compromises its use for irrigation (see Figures C-21 and C-22).

Of 12,902 irrigated acres evaluated for the entire project (exclusive of the non-irrigable or no group acreage), 3,695 acres (29 percent) lie along the Sheyenne River. Both salinity and sodicity hazards were found to be substantially greater on the Sheyenne than the Red River. Using the more conservative *Blended-Water-Only* dataset, both constructed outlet alternatives would increase salinity hazards over baseline conditions on approximately 428 acres along the Sheyenne River. The 480-cfs unconstrained outlet alternative had a somewhat higher salinity hazard than the 300-cfs constrained outlet alternative. On the Sheyenne River, the no action (natural spill) alternative generated much more significant salinity and sodicity hazards than baseline conditions or either constructed outlet alternative.

Effective mitigation of salinity/sodicity hazards under the outlet alternatives involves a program of (1) initial detailed assessment of soil irrigibility to establish baseline conditions, (2) monitoring TDS and SAR in blended water and irrigated soils to minimize the use of poor quality irrigation water and to determine impacts before they become serious problems, and (3) mitigating impacts as they occur. The following mitigation strategies could apply and should be considered in the development of the long-term monitoring plan.

- *Monitor TDS and SAR contents in Sheyenne River water.*
- *Assess soil irrigibility characteristics of potentially affected irrigated land to establish baseline salinity/sodicity.*
- *Test soils for sodium and salinity and regularly monitor crops/plants for salinization/sodification impacts.*
- *Fall-apply excess irrigation water to leach salts out of the root zone in soils found to be affected by salinity.*
- *Ensure that adequate drainage exists for leaching to occur.*
- *Practice irrigation scheduling.*
- *Plant salt-tolerant crops.*
- *Apply calcium amendment on lands found to have irrigation-induced sodicity problems.*
- *Cease irrigation.*

Figure C-23 is an example of the information developed for the irrigation soil salinity analysis.



Irrigation Permits

For Project Location, see Figure B2-1

N

Devils Lake, North Dakota

FIGURE B2-10

PETERSON ENVIRONMENTAL CONSULTING, INC.

PEC Project No. 2001-026

Figure C-23

Effects of the alternatives on salinity in Sheyenne river water

Based on an assessment of TDS and SAR relationships in HEC5Q predictions for a conservative, 45-year trace (Wet7 climatic scenario) it has been concluded that:

1. When compared to base conditions, the increase in SAR and TDS in Sheyenne River/Devils Lake blended water under the constructed outlet alternatives is not, by itself, of sufficient magnitude to create significant soil salinization/sodification problems in soils to which it is intermittently applied.

2. TDS and SAR values associated with the no action (natural spill) alternative are well above the recommended maximum values for most irrigated soils in North Dakota, and would represent a significant salinization/sodification hazard for the typical soils found on the floodplain along the Sheyenne River Valley.

Of the three outlet alternatives, the 300-cfs constrained alternative has the least salinization hazards because operational constraints limit both overbank flooding and stage increases in the Sheyenne River. River stages and overbank flooding would increase under the 480-cfs alternative, causing higher salinization hazards. While the differences appear minor, they may be greater upstream of Lake Ashtabula where the shallow entrenchment of the Sheyenne and the presence of poorly and very poorly drained soils would magnify the effects of even minor increases in overall mean stage.

The 300-cfs constrained outlet alternative would generally generate the lowest salinization hazard due to constraints on outlet operation. As compared to the 480-cfs unconstrained outlet alternative, the 300-cfs constrained outlet alternative will generate lower discharges, less overbank flooding, and smaller mean watertable increases adjacent to the river. Under the 300-cfs constrained alternative, the highest potential salinity hazards would exist in the shallowly entrenched till plain reach of the Sheyenne River compared to the more deeply entrenched reaches below Baldhill Dam. The till plain reach is nearest the point of discharge, has the highest levels of mean salinity/sodicity in blended water and has extensive areas where the Sheyenne River is shallowly entrenched with adjacent poorly and very poorly drained soils. Many of these soils are already saline (e.g. Ryan and Lamoure saline), are near or have included saline soils, or have substantial amounts of subsoil salinity (e.g. Rauville and Ludden soils). Problems would not necessarily be limited to the poorly and very poorly drained soils. Moderately well drained Fairdale and LaDelle soils that are in low positions may also have increased salinization hazards in response to raised water tables and more frequent flooding with blended water (see Table C-24).

Downstream of Baldhill Dam salinity hazards would be substantially reduced because the Sheyenne River is more deeply entrenched. Many areas of the floodplain downstream of the dam apparently do not flood regularly. Poorly and very poorly drained soils that are susceptible to salinization are largely confined to abandoned meanders and channeled areas. These soils may be affected by increased mean watertables and possible groundwater intrusion from the Sheyenne River during outlet operation.

Moderately well-drained soils that occupy levees and low rises on the floodplain were given a slight-to-moderate hazard due to the potential for additional salt loading from flooding and water table rise. Salinization hazards are less than the moderate to severe category because of less frequent flooding, little or no groundwater intrusion, and deeper seasonal high watertables. Just under 8,000 acres of primarily fine and medium textured, moderately well-drained floodplain soils were placed in the slight-to-moderate salinization categories. LaDelle soils may be the most affected because of potential high levels of subsoil salinity, occasional flooding, and seasonal high water tables within 3 to 4 ft of the soil surface.

Salinization hazards in the upstream associations result from; (1) the shallow entrenchment of the Sheyenne River, and (2) the presence of extensive areas of poorly and very poorly drained, fine-textured, slowly permeable soils that are already saline or have substantial, readily mobilized subsoil salinity.

Table C-24. Acreage Summary of Soil Salinization Hazard Class by Soil Association

Soil Association	None	None-to-Slight	Slight-to-Moderate	Moderate-to-Severe	Not Rated	Grand Total
Soil Associations Upstream of Lake Ashtabula						
Lamoure-LaDelle-LaPrairie-Ryan	627	2803	3036	7674	172	14312
LaDelle-Ludden-Wahepeton	1515	510	4923	2366	50	9364
Subtotals (acreage)	***2142***	***3313***	***7959***	***10040***	***222***	***23676***
Subtotals (percent)	***9.0***	***14.0***	***33.6***	***42.4***	***0.9***	***100.0***
Soil Associations Downstream of Baldhill Dam						
LaDelle-Nutley	3006	3038	752	502	41	7339
Fairdale-LaPrairie-LaDelle	139	5002	7991	357	18	13507
Fairdale-LaDelle-Wahpeton-Delta	1884	2255	2676	-	17	6832
Fargo-Fairdale	6169	2144	5201	228	-	13742
Subtotals (acreage)	***11198***	***12439***	***16620***	***1087***	***76***	***41420***
Subtotals (percent)	***27.0***	***30.0***	***40.1***	***2.6***	***0.2***	***100.0***
Grand Totals (acreage)	**13340**	**15752**	**24579**	**11127**	**298**	**65096**
Grand Totals (percent)	**20.5**	**24.2**	**37.8**	**17.1**	**0.5**	**100.0**

All three salinization mechanisms would act to salinize soils in the moderate-to-severe hazard category under the constructed outlet alternatives, including; (1) added salt provided from overbank flooding, (2) added salt from groundwater intrusion, and (3) elevated water tables resulting in a mobilization of existing subsoil salts. Mobilization of existing subsoil salt is probably the most significant hazard in the Upstream Associations.

Stage increases would likely be less important downstream of Baldhill Dam, where the Sheyenne River is deeply entrenched and lacks extensive areas of adjacent poorly and very poorly drained soils. Stage differences between the 380-cfs constrained and the 480-cfs unconstrained outlet alternatives would result in relatively minor increases in bank stage relative to the water table (see Figures C-24 and C-25).

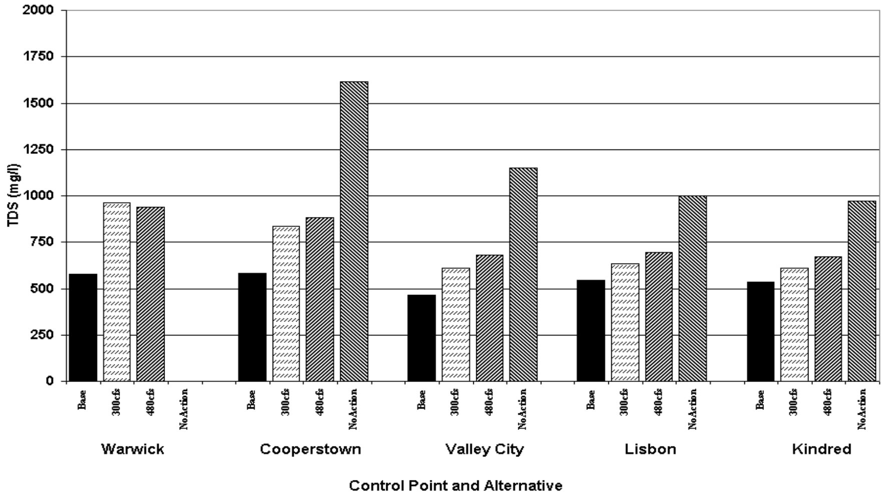


Figure C-24. Mean TDS values for base conditions and blended water only by outlet alternative and control point. Base conditions include all samples. Outlet alternatives were restricted to the blended water only data set (baseflow conditions removed)

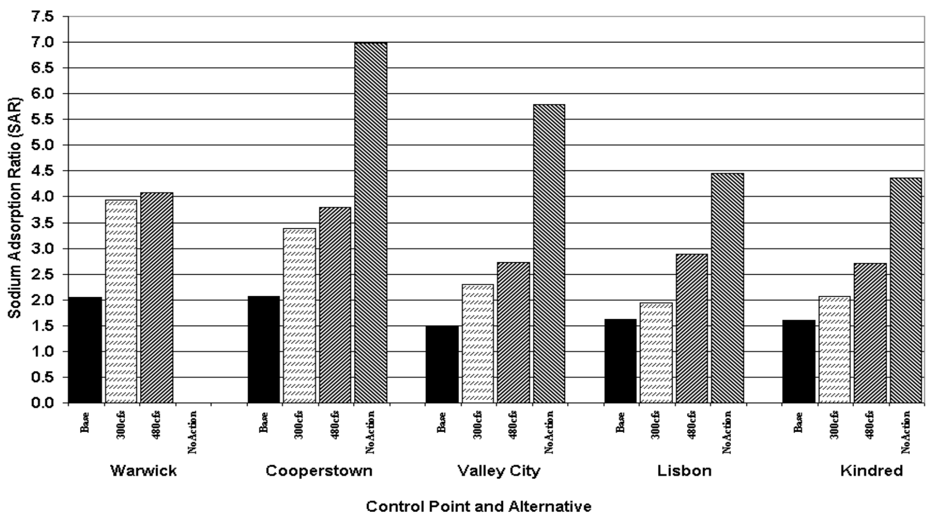


Figure C-25. Mean SAR values for base conditions and blended water only by outlet alternative and control point. Base conditions include all samples. Outlet alternatives were restricted to the blended water only data set (Baseflow conditions removed)

Similarly, while water quality differences exist between the two constructed outlet alternatives, the differences are not of a sufficient magnitude to substantively affect salinization hazards. Regarding water quality, the salinization hazards associated with the two constructed-outlet alternatives are essentially the same.

The development of the long-term monitoring plan and the outlet operation plan could consider the following. They are identified as possible features or mitigating measures for impacts related to soil salinity and irrigation.

Professional soil scientists licensed to practice in the states of North Dakota and Minnesota can perform initial soil assessments. Irrigators using mixed Sheyenne River/Devils Lake waters for irrigation under any of the outlet alternatives many want to consult with NDSU Extension Service representatives while irrigating under the outlet alternatives and prior to mitigating for perceived salinity/sodicity problems.

Under the constructed outlet alternatives, the only available operational mitigation measure may be managing the initiation of outlet operations to begin after the recession of spring flooding. Based on the broad range of spring flooding events observed at various control points, the initiation of outlet operations could normally be delayed by about 2 weeks in most years. This can be considered in the development of an operating plan.

A variety of site-specific mitigation measures could be applied to manage salinity and sodicity problems on affected lands. These include: (1) performing detailed site-specific assessments of soil texture, drainage class, and existing in situ salinity/sodicity to identify problem areas, (2) increasing minimum tillage or no tillage, (3) increasing the area of forages, pastures, and tree crops, (4) using crops that are more salt-tolerant in rotations, (5) and ensuring adequate drainage.

Figures C-26 through C-29 are examples of the GIS information developed for the soil salinity analysis along the Sheyenne River.

Figure C-26. Low meander in shallowly entrenched portion of the Sheyenne River. Adjacent soils are poorly drained Lamoure, Ryan, and LaDelle soils characteristic of the adjacent floodplain of this reach

Shallowly entrenched meander, upper reach

Devils Lake salinity study: Sheyenne River

Eddy County, North Dakota

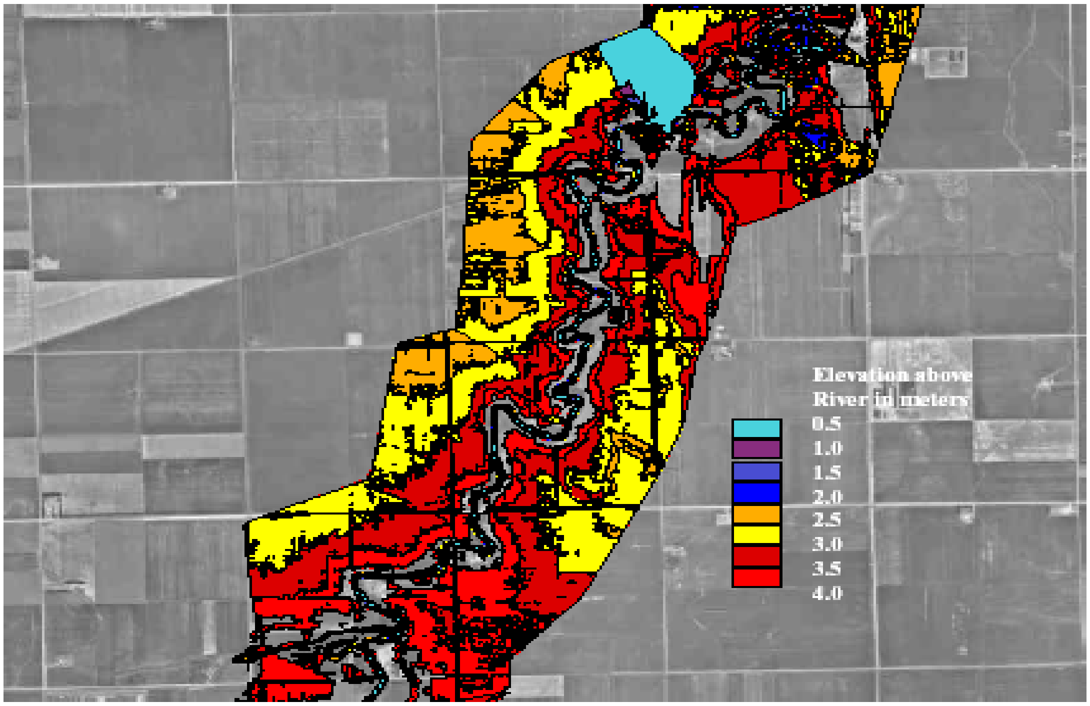
N

FIGURE C-26

PETERSON ENVIRONMENTAL CONSULTING, INC.

PEC Project No. 2001-026

Figure C-27. Lidar elevation data shows natural levees along the Sheyenne River downstream of Kindrcd.



Manipulation of Lidar elevation data to show natural levees along the Sheyenne River. River elevations were buffered in upwards in 0.5 meter elevation increments. Note the area immediately adjacent to the river is not flooded even at + 4.0 meters above the river' s elevation at the time the Lidar data was collected. The blue area at the top of the picture is an error in river placement where the river line feature provided by the USACE did not overlap exactly with the Lidar data for the river.

Natural Levees Adjacent to the Sheyenne River on the Lake Agassiz Plain

Devils Lake Salinity Study: Sheyenne River

Cass County, North Dakota

N

FIGURE 6

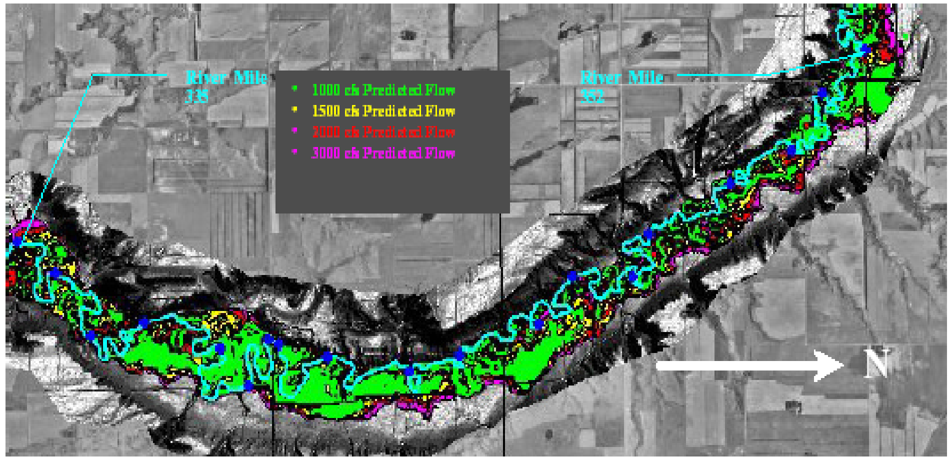
Devils Lake Salinity Study
Sheyenne River Valley

Report Figures

Page 6

Devils Lake Salinity Study: Sheyenne River Valley   Report Figures   Page 16

(A) HEC-RAS predicted flow for the upper portion of the Sheyenne beginning at river mile 335 and extending to river mile 352. Extensive overbank flooding occurs at 1000 cfs, and much of the valley is flooded at the 3000 cfs flow.



(B) Characteristic soil distribution in the shallowly entrenched upper reach. Note the saline map units (magenta) and map units with major saline components (red). Map units with saline inclusions are confined to meanders and backswamp/low positions. Natural salinity associated with this portion of the upper reach is fairly high. Most of the yellow units are Ludden soils that have high subsoil salinity.

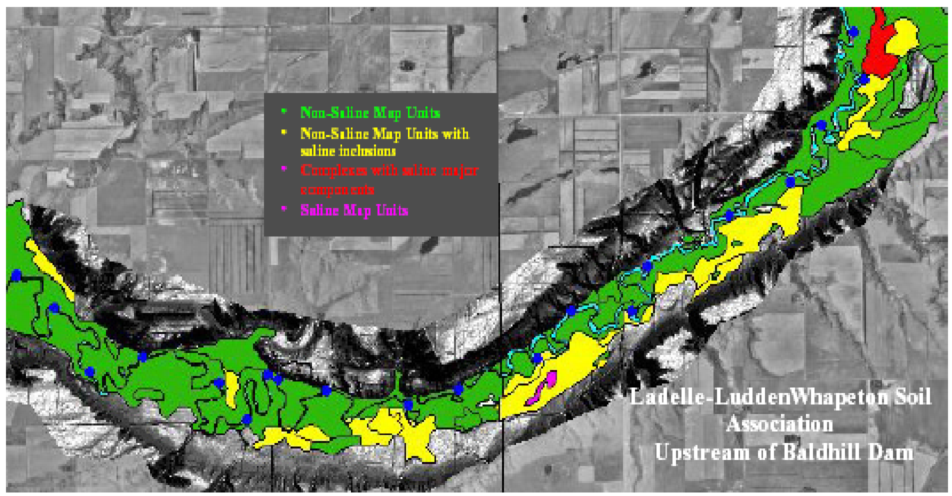


Figure 16. HEC RAS predicted flooded area outlines compared to the listed saline composition of soil map units for the portion of the Sheyenne River extending from river mile 352 to river mile 335. The 1000 cfs flow value has been indicated by the St. Paul District, USACE as the "normal" flood stage for this portion of the of the Sheyenne River. Considerable overbank flooding at 1000 cfs is indicated in this low relief portion of the upper reach of the Sheyenne River. Basemaps are hillshaded Lidar DEMs overlaid onto MrSID ortho-rectified aerial photography.

Peterson Environmental Consulting, Inc.

Figure C-28. Example of relationship of 480-cfs outlet flooded area outline to soil map units and salinity

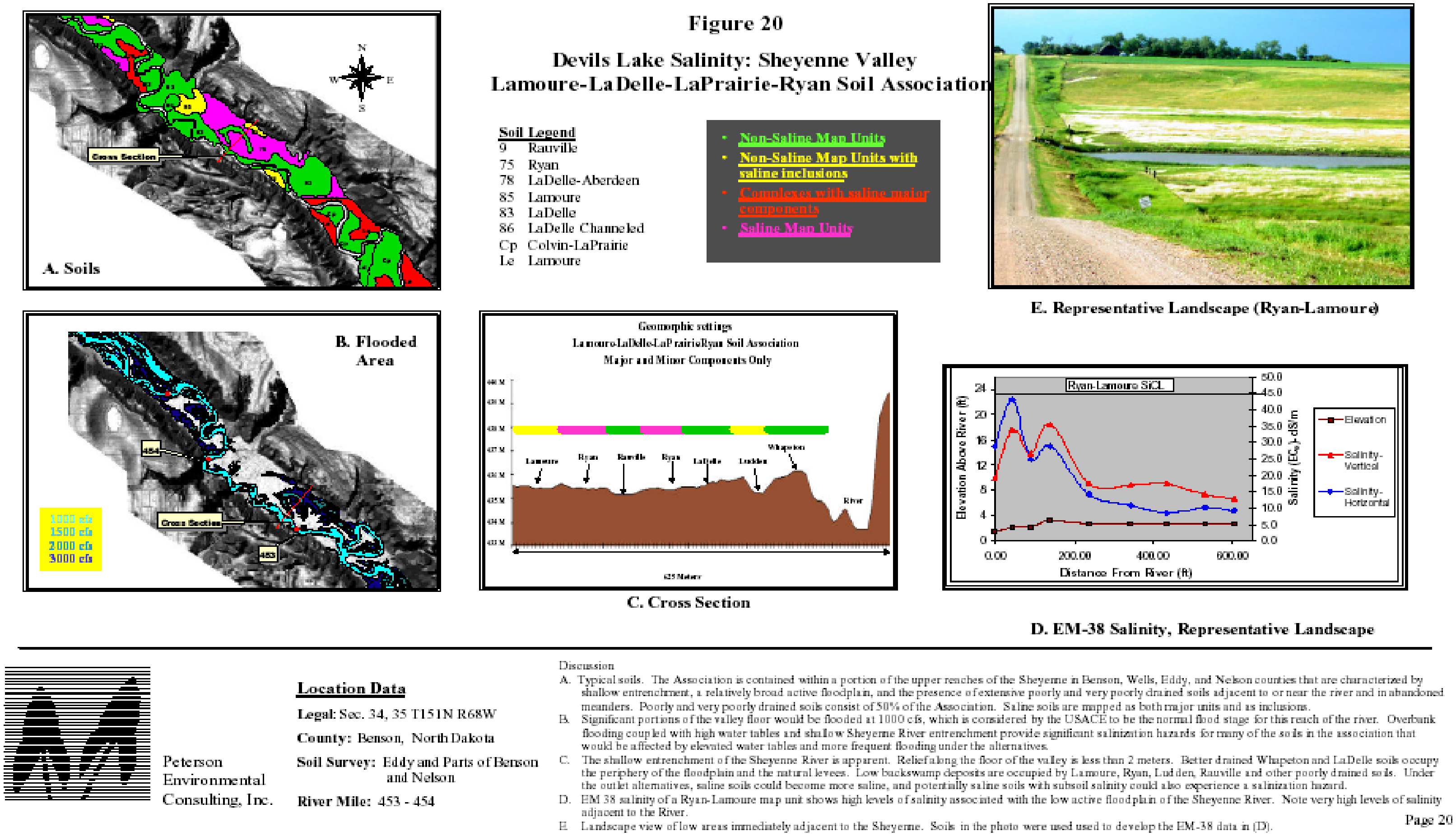


Figure C-29. Soils, potential flooded area for 480 cfs outlet, soil salinity, and profile GIS data developed for the soil salinity analysis

Environmental Justice Analysis

In February 2000, a study titled the "Social Impacts of the Proposed Emergency Outlet to Control Flooding at Devils Lake, North Dakota: An Assessment of Environmental Justice" was conducted by the U.S. Army Engineer Protection Agency. The following is a summary of the results of that study.

Introduction and Background

Since the inception of Executive Order #12898, "Federal Actions to Address Environmental Justice in Minority and Low Income Populations" (February 1994), Federal agencies have increasingly acknowledged the importance of environmental justice considerations with regard to environmental decision-making. This study assesses of the perceived social impacts of the emergency outlet proposed by the Army Corps of Engineers to control flooding in Devils Lake, North Dakota.[1] The alternative being considered at that time was an outlet from West Bay along Peterson Coulee. The results may not be applicable to the current plan but identify the important issues to be considered. The study has been designed as a qualitative examination of perceived impacts of the proposed outlet on various communities surrounding Devils Lake, taking into account feedback from farmers, ranchers, tribal members, residents of low-income communities, and others. An environmental justice assessment includes examining the following areas:

- Demographics.
- Disproportionate impacts.
- Stakeholder involvement.
- Potential benefits and burdens.

In light of these four areas, this study seeks to gain an understanding of:

- The demographics of the communities involved.
- Level of public participation with regard to the scoping and decision-making processes.
- Potential disporportionate environmental impacts (including human health, economic, and social effects) to low-income communities or federally recognized Tribes.
- Communities potentially benefitting from (or shouldering burdens from) the proposed project.

By looking at these areas, an assessment can be made prior to Federal decisions that takes into consideration the impacts to potential environmental justice communities.[2]
Environmental justice concerns have played an increasingly larger role in the National Environmental Policy Act (NEPA) review process. Clark and Canter point out that NEPA has been a principal avenue for public involvement in both the planning and decision-making processes of Federal agencies.[3] They add that NEPA's broad mandate allows it to incorporate

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[1] Details of the proposed project can be found in the "Draft Scoping Document, Devils Lake Emergency Outlet Environmental Impact Statement," dated June 1998.

[2] Environmental Justice Communities are defined as low-income communities, minority communities, or federally recognized tribes. Please see complete definition on page 1.

[3] *Environmental Policy and NEPA, Past, Present, and Future* Ray Clark and Larry Canter, eds. 1997.

and integrate other regulatory requirements and emerging objectives, including biodiversity, conservation, environmental justice, and risk analysis. In addition, according to the Environmental Justice Guidelines under NEPA developed by the Council on Environmental Quality (CEQ) the Executive Order "recognizes the importance of research, data collection, and analysis... thus, data on (these) exposure issues should be incorporated into NEPA analysis as appropriate."[1] The U.S. Environmental Protection Agency, under Section 309 of the Clean Air Act, is authorized to review the environmental impacts of certain proposed actions of other federal agencies. Under this authority, and as a cooperating agency, EPA, Region 8, has assisted the U.S. Army Corps of Engineers, St. Paul District, in providing input on environmental justice considerations for the proposed Devils Lake emergency outlet. Goals of this study are:

- To examine the perceived impacts to various individuals and groups in the Devils Lake Region.
- To determine the potential environmental justice implications of the proposed Emergency Outlet.
- To provide recommendations to the Army Corps of Engineers based on the study's findings.

Methodology

Section 1508.14 of the Council on Environmental Quality NEPA regulation states that "when an environmental impact statement is prepared and economic or social and natural or physical environmental effects are interrelated, then the environmental impact statement will discuss all of these effects on the human environment." Clark and Canter (1997) refer to a consensus outlined by the Interorganizational Committee for Social Impact Assessments (SIA), recommending that social, cultural, demographic, economic, social-psychological, and political impacts be considered. These factors have been emphasized in data collected for this study in order to examine the full range of perceived impacts of the proposed Devils Lake emergency outlet and how those perceptions vary between groups and individuals.

Sampling Strategy. A purposive sample[2] was chosen for this study, since it was important to obtain opinions and ideas from individuals who had voiced particular interest in the proposed emergency outlet or specific ideas about other water management options for the Devils Lake area. For this reason, initial respondents for the study were obtained from reviewing written comments in the *Draft Scoping Document, Devils Lake Emergency Outlet Environmental Impact Statement*, U.S. Army Corps of Engineers (June, 1998). Initial participants were also obtained from news articles covering various aspects of Devils Lake flooding in North Dakota papers (between June and September 1998) in which specific individuals were quoted. Efforts were made to obtain respondents from all communities within the Devils Lake Region, as well as from the Spirit Lake Sioux Nation and communities downstream on the Sheyenne River. Snowball sampling techniques[3] were used to obtain additional participants, resulting in a final sample size of 45 respondents. Participants were initially contacted to inform them of the purpose of the

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[1] *Environmental Justice: Guidance Under the National Environmental Policy Act*. Council on Environmental Quality. December 10, 1997. p. 3.

[2] A purposive sample is one in which participants are selected based on specific experience or characteristics, in order to obtain particular kinds of data, and is not considered a random or probability sample.

[3] Snowball sampling involves obtaining additional respondents for a study based on the recommendations or referral of other study participants. This is done in order to include a larger number of respondents in the sample who have similar experience or characteristics.

study, to request their participation, and inform them that their participation was strictly voluntary.

Initial interviews were conducted by telephone from January through April 1999, and respondents were asked a specific set of questions. Question topics included respondents' assessment of solutions to flooding in Devils Lake, opinions on the proposed emergency outlet, perceived impacts to themselves and others of the proposed outlet, and assessments of the Army Corps of Engineers Scoping Process. A majority of interview questions were open-ended, providing the opportunity for individualized responses. In addition, respondents were encouraged to provide opinions and ideas on other topics related to water management in the Devils Lake area. Follow-up interviews were conducted from October 1999 through January 2000 to assess opinions and attitudes on recent developments in the Devils Lake Region and to obtain additional demographic and other information.

A central goal of this study was to determine whether low-income communities or federally recognized tribes would shoulder a disproportionate burden or benefit (economically, environmentally, or culturally) as a result of the proposed outlet project. For this reason, emphasis was placed on examining the responses of communities in various regions of Devils Lake to compare and contrast the perceived impacts of the proposed project and other water management options. For analysis purposes, respondents were categorized by tribal membership, and geographic proximity to Devils Lake.

Limitations of the Study. The primary limitation of a qualitative study such as this is the inability to generalize the findings to the larger population in North Dakota or to the Devils Lake region as a whole. However, based on the relative uniformity of responses among members of specific communities, these findings can be said to be fairly representative of perceptions and opinions within those communities. An additional limitation of this study is the relatively small sample size, resulting from both time and resource constraints. A larger number of respondents would allow the data to be more easily generalized to various areas of the Devils Lake Region and provide an opportunity for interview data to be "quantified" more substantially.

Data were collected on respondents' views on potential impacts of the proposed emergency outlet, which some may argue is less substantive than data collection based on "hard" facts. However, a goal of this study was to gain an understanding of the views of those in the Devils Lake Region, and to determine the potential impacts to various communities based on information available to members of those communities. Findings from this study revealed a noticeable lack of definitive information available from agency sources on a number of issues, such as the impacts of the proposed outlet on the level of Devils Lake, on water quantity and water quality in the Sheyenne River, and impacts to Devils Lake flooding of upper basin drainage. Interview data showed that in many cases, respondents sought out local research institutions, engineers, geologists, and other professionals to inform their views. For this reason, it can be stated that respondents in this study represent an informed, educated group of individuals from various communities within the Devils Lake Region.

Findings

Demographics. In the Devils Lake Region, there is one federally recognized tribe, the Spirit Lake Nation Sioux Tribe, south of Devils Lake. Other areas of Devils Lake do not include federally recognized tribes or significant populations of communities of color. For this study, comparisons between tribal and non-tribal respondents are used to assess differences in perceptions between federally recognized tribes and other communities.

Low-income communities are located in Benson County, located south and southwest of Devils Lake, and in some communities along the Sheyenne River. For purposes of this study, a 5-mile buffer on either side of the river between Cooperstown and Fort Ransom, was identified as the "downstream community." Based on the percent of those living in poverty as compared to the state average, areas west and southwest of Devils Lake and in downstream areas are considered low-income communities, based on U.S. Census data. In order to assess differences in perceptions between respondents in low-income communities and respondents in other communities, responses various geographic areas of the Devils Lake Region are compared. In this report, these areas are referred to as "communities."

For purposes of this study, tribal respondents, respondents in communities west and southwest of Devils Lake, and the downstream community, are considered respondents from potential environmental justice communities. Responses of these groups are compared to those of other groups in examining disproportionate impacts, stakeholder involvement, and potential benefits and burdens of the proposed emergency outlet.

Benefits and Burdens. The study indicates mixed support for the proposed emergency outlet. To some degree, these findings illustrate a NIMBY ("not in my backyard") attitude, in that those in one geographic area support an outlet only if it is constructed in another area of the Devils Lake region, and not in their own community.

The two most likely outlet routes currently being considered (the Peterson-Coulee Route and the Twin Lakes Route) would be constructed through potential environmental justice communities. The Peterson-Coulee Route would run through the west end of Devils Lake in Benson County. Low-income residents in Benson County would shoulder a majority of burdens if an outlet is constructed along the Peterson Coulee Route. Similarly, the tribal community on the Fort Totten Reservation would shoulder most of the burden if the Twin Lakes Route is chosen. It should be noted, however, that although a slight majority of tribal respondents indicated that they did not want an outlet built, other tribal respondents indicated that they favored an outlet, feeling that it would help alleviate flooding on the Fort Totten Reservation.

It is important to acknowledge the number of respondents in low-income communities and tribal members that do not want any kind of outlet project built. The lack of consensus with regard to support of the proposed west end outlet project is significant, in that a number of respondents (primarily tribal members and those from low-income communities) are not in favor of any outlet project, and see other alternatives as more beneficial to them. Such alternatives include letting nature take its course, minimizing or stopping upper basin drainage, and continuing infrastructure improvements.

Findings from this study also point to the need for more specific information on the impacts of upper basin drainage on Devils Lake. This appears to be an area of concern to many respondents in this study. Some tribal respondents and many respondents in low-income areas have expressed concern about the potential economic, environmental, and other impacts to themselves and their communities. Based on the severity of these potential impacts, many of these respondents feel that if upper basin drainage is minimized or stopped completely, the proposed outlet may be unjustifiable or unnecessary.

Disproportionate Impacts. Many respondents, in all groups, viewed the town of Devils Lake, as well as farmers and ranchers in the surrounding area, as benefiting from the outlet. However, this view was more common among respondents from higher income communities and non-Tribal communities. Tribal respondents, as well as respondents in low-income areas of the lake region tended to see the proposed outlet as primarily benefiting agencies, such as state officials, the Army Corps and its contractors, and saw little advantage of the outlet to themselves. Findings in this area may illustrate differences between tribal members and those in low-income communities, as compared to other communities, in the perception of economic and political power. In addition, the data point to a need for a more comprehensive sharing of information with different publics on how the proposed outlet would be managed. Respondents who would be in the direct path of the proposed outlet have expressed concern about easements required for the pipeline and the lack of compensation provided for damage done to property as a result of outlet construction.

In terms of perceived impacts to themselves of the proposed outlet, tribal respondents and respondents from low-income communities were far more likely than others to report concerns about damage to property, a decrease in property values, potential flooding, noise from pumps, flooding of roads and problems raising cattle. Respondents from these communities also tended to voice more awareness of the impacts to others of the proposed outlet. These findings point toward more disproportionate impacts perceived by potential environmental justice communities, and few, if any, adverse impacts perceived by more advantaged groups.

Stakeholder Involvement. Data from this study indicate that a majority of respondents, from all groups, feel that their views either have not been heard, or have been heard, but not acted on. These findings call into question the effectiveness of the current public involvement process. Comments from respondents in various communities indicate that different groups may need different types of involvement, such as focused outreach for tribal members, as well as communities in which homes or livelihoods would be directly impacted by the proposed outlet project. Respondents in lower-income communities have also felt a greater need than others to take specific actions to ensure that their interests have been represented. In some cases, these respondents felt that the efforts of their community groups were more effective than participation through more traditional channels, such as attending scoping meetings, or writing letters to the state and federal agencies involved.

Findings from this study also indicate that many respondents felt that the scoping process did not allow for or welcome input from the public. While some respondents believed that the Army Corps was simply following mandates already set for them, others felt that the scoping meetings should have considered a variety of viewpoints and options. Some respondents felt that these meetings should have been held as a forum for gathering information on public opinion instead of limiting the meetings to providing a set agenda of information about the proposed outlet project, as many respondents reported.

Data from this study suggest that since the proposed outlet routes would be constructed through low-income and/or tribal communities, these potential environmental justice communities have felt inadequately represented, with little influence on actual decisions made with regard to the proposed outlet project.

Maximum and Expanded Infrastructure Protection

The flood damage reduction measures include road raises, levees, relocations, and in the case of expanded protection, construction of dams along selected roads to protect areas from inundation by rising lake levels. The impacts resulting from this would be similar to the proposed future without-project conditions; only differing in the time at which these measures would be implemented.

Impacts to aquatic and terrestrial resources would occur due to loss of vegetation and aquatic resources from fill, excavation, removal of vegetation, increased sedimentation, relocation of structures, etc. (500 and 3,800 acres of habitat effected with maximum and expanded infrastructure protection respectively requiring about 1000 and 7,700 acres of mitigation). There would be no effects in the upper basin or downstream in the Red River basin with this alternative.

If Devils Lake would continue to rise, about 155,000 additional acres would be inundated around Devils Lake and Stump Lake up to elevation 1459. Around Devils Lake, the majority of this acreage is currently cropland and fallow. Wetlands and grasslands are the next largest category of land use. Around Stump Lake, most of this area is currently grassland and wetland with cropland/fallow being the next largest category. These lands would be converted to open water wetland habitat with a corresponding change in wildlife. There are a number of Fish and Wildlife Service Wetland Easements and Waterfowl Production Areas located around the lake.

As the lake continues to rise, the Devils Lake fishery resource would probably expand up to some elevation. Natural reproduction would increase, and the density and size of the aquatic resource would probably shift to larger populations of smaller fish. As the lake continues to rise, the existing waterfowl staging area, aquatic resource, and National Wildlife Refuge at Stump Lake would be lost.

Upper Basin Storage

The restoration of depressions in the upper basin has been identified as an alternative and a significant issue in the study. The selection of depressions for storage was not optimized. It is possible that the same hydrologic results could be realized with fewer depressions. The analysis does show that there may some merit to increasing storage in the upper basin. However, additional study should be conducted to identify the most economically feasible and socially acceptable plan.

There would be no effects downstream with this alternative.

This alternative would keep some fresh water from entering Devils Lake by storing it in the upper basin. Upper basin storage would reduce the amount of fresh water entering Devils Lake. This would affect the water quality and in turn the aquatic resources of the basin. It would result in the lake reaching higher TDS and sulfate levels sooner than compared to without storage conditions. Due to the small amount of annual inflow reduction, ranging from 13,000 (stochastic) to 16,000 (wet scenario) acre-ft, there would be little long-term effect on water quality and the aquatic resource (based on restoration of 50 percent of the possibly drained depressions).

This alternative would store water in depressions and convert its current land use. About 75 percent of the land use in the depressions is classified as cropland or grassland (see Table C-25). Acreage estimates for land use in the drained depressions and total depression acreage vary slightly due to GIS projections of different types of data sets (DEM vs. landsat). The upper basin storage alternative uses 50 percent of the total drained depressions and depressions over 6 in. in depth for the economic analysis. This alternative would take lands out of crop production, at least temporarily. Natural resource benefits would result from this alternative and require no mitigation.

Table C-25. Land Use at the Upper Basin Storage Sites

Subbasin	Land Use (acres)							**Total Drained**
	Cropland	Woodland	Grassland	Wetland	Urban	Other	**TOTAL**	**Depression**
Big Coulee	4,300	49	1,535	3,207	22	636	9,749	9,290
Calio	5,378	19	650	1,234	2	257	7,540	7,388
Comstock	299	2	99	211	0	65	676	631
Edmore	18,630	240	1,627	3,910	18	445	24,870	24,474
St. Joe	3,725	17	528	1,354	3	287	5,914	5,871
Starkweather	13,794	61	1,121	2,613	11	819	18,419	18,326
Mauvais-Gage 6100	6,063	75	1,990	2,418	7	413	10,966	10,696
Hurricane	1,313	52	596	1,132	3	19	3,115	3,091
TOTAL	53,502	515	8,146	16,079	66	2,941	81,249	79,767
50% of Total Acres	26,751	258	4,073	8,040	33	1,471	40,625	39,884
% of Total Acres	65.85	0.63	10.03	19.79	0.08	3.62	100.00	100.00

Source: 30-m Landsat Thematic Mapper (TM) 1987 through 1994

Wetland information from U.S. Fish and Wildlife Service National Wetlands Inventory (NWI)

Total land use acreage (LTM) and total drained depression acreage (West) do not agree due to differences in resolution of imagery

Other category includes areas classified as wetland on TM but not identified as NWI wetland

Some of the NWI wetlands could be seasonal and consist of cropland or grassland

The Natural History Inventory lists seven natural heritage sites located in the depression storage areas in the upper basin.

This alternative would enhance storage of water in the upper basin watershed of Devils Lake, primarily by restoring wetlands that have been partially or effectively drained for agriculture. Diversions and water-control structures would also be used to provide additional storage. This alternative has the potential to salinize additional lands by raising the water tables in areas adjacent to the storage wetlands. Areas at particular risk are existing saline wetlands or areas that are adjacent to wetlands that characteristically have a periphery of saline or saline-sodic soils. While some lateral movement will result in the mobilization of salts from the historic wetland edge to the new edge of the enlarged wetlands, the majority of the secondary salinization produced by the upper basin storage alternative will result from a mobilization of salts from deep in the profile to the soil surface in areas where the watertables rise above the "critical depth."

Not all wetlands will be similarly affected. A considerable number of seasonally ponded wetlands have a groundwater recharge function, and have profiles that are leached and non-saline. Soils on the periphery of these wetlands are frequently non-saline and somewhat poorly drained. A lack of stored salt in these soils combined with the freshness of the runoff-component would reduce the salinity risk associated with the restoration of these wetland types.

The effects of upper basin storage on soil salinity were also evaluated. An evaluation was conducted by Peterson Environmental Consulting, Inc. The findings of that analysis are summarized below.

The Upper Basin of Devils Lake consists of 2,616 square miles in seven North Dakota counties and encompasses seven major watersheds. Upper Basin topography is dominated by low, undulating relief with poorly integrated drainage networks. The majority of the acreage in the Upper Basin is agricultural cropland. Saline soils in the Upper Basin are extensive, and are typically associated with wet areas where the groundwater is at or near the surface.

The Upper Basin Storage (UBS) alternative has a potential soil salinization hazard by raising the watertables in areas adjacent to the restored wetlands and mobilizing subsoil salts. Areas at particular risk are existing saline wetlands and areas that are adjacent to wetlands that characteristically have a periphery of saline or saline-sodic soils. Salt accumulation in North Dakota is associated with specific hydrogeologic settings generally associated with groundwater discharge, shallow groundwater depths, and infrequent ponding. Salts accumulate in the vadose (i.e., unsaturated) zone when unsaturated flow brings groundwater containing dissolved salts into the rooting zone. The attendant evapotranspirative withdrawal of pure water leaves the salts to accumulate. Although saline soils are the product of long term hydrogeologic conditions, salts are readily mobilized when recharge/discharge/ponding dynamics change.

In the Upper Basin, most wetlands can be classified as recharge, flowthrough, and discharge types based on hydrology, water chemistry, and soil physical and chemical characteristics. Recharge wetlands are: (1) typically located in higher positions in the landscape, (2) seasonally ponded with fresh water, and (3) characterized by soils that have a morphology associated with frequent wetting and drying cycles and dominantly downward water movement. Recharge wetlands are typically non-saline. Flowthrough wetlands: (1) are located in intermediate landscape positions, (2) are typically more permanently ponded, and (3) receive more of their water from groundwater discharge and are thus generally brackish (i.e., moderately saline). Discharge wetlands are permanently saturated or semi-permanently to permanently ponded, reflecting the dominance of groundwater discharge. Soils are calcareous and are usually quite saline, especially around the wetland periphery.

Much of the research on salinity in the northern prairies has been performed in hummocky till topography with relief of 10 to 20 m. Recharge-flowthrough-discharge relationships between wetlands and salinity are distinct and easily studied in such areas. However, much of the Upper Basin has low relief on the order of 1 to 5 m. The relationships between groundwater flow and salinity still hold in low relief landscapes but the topography and the relationships between recharge and discharge are more subtle and are dominated by localized groundwater recharge and discharge. The flowthrough zone is essentially the wetland periphery and groundwater discharge occurs in the low relief areas adjacent to the wetland. In these areas, the presence of a groundwater mound associated with recharge maintains elevated watertables in soils that are transitional between wetland and upland conditions. These elevated water tables supply a source of dissolved solids that can be concentrated by evapotranspiration in the soil profile in the somewhat poorly drained soils that are adjacent to the wetlands.

Hydrologic alterations in and around wetlands can reorganize groundwater flow patterns developed over time, resulting in a significant mobilization of existing salts. Wetland drainage by surface ditching essentially moves the edge of the wetland to the pond interior adjacent to the ditch. Strongly saline soils can develop near such ditches over just a few decades. Drainage of flowthrough and discharge type wetlands typically results in (1) the mobilization of salts to the pond interior, (2) the translocation of salts from the subsoil of the drained wetland to the soil surface, and (3) the desalinization of soils at the wetland edge. It is the remobilization of salts historically translocated by drainage that is primary soil salinization issue associated with wetland restoration in the Upper Basin.

A quantitative, predictive assessment of salinization hazards associated with the UBS alternative is precluded by the (1) magnitude of the area to be assessed (2,616 square miles), (2) large number of potential restoration candidate wetlands identified (13,457), (3) complexity of the geomorphic, sedimentary, pedologic, and geochemical factors involved, and (4) non-specific nature of the soil map units in the county soil surveys. Accordingly, a qualitative/semiquantitative assessment of salinization hazards was carried out. Wetlands were classified as either drained or undrained; partial drainage of wetlands was not considered. It was assumed that drained wetlands would be restored to their original dimensions, that no additional acreage would be flooded and that salinization hazards would be limited to mobilization of existing soluble salts in the soils or subsoils in and within a 200-ft buffer around each drained wetland. For purposes of this assessment, saline soils have been limited to those mapped by the Natural Resources Conservation Service (NRCS) as consociations (a single dominant saline soil) and as major saline components of soil complexes. Salinization hazards have been semiquantitatively estimated based on the percentage of mapped saline soils within each drained wetland and its surrounding 200-ft buffer.

Digital soils data (SSURGO, STATSGO) were obtained from the NRCS for Ramsey, Cavalier, Walsh, Towner, and Rolette Counties. Data from these counties were extrapolated to Pierce and Benson Counties, for which digital data were unavailable. All potentially restorable wetlands identified by West were incorporated into an Arcview GIS and Access database. Polygons were created to represent each individual wetland and a 200-ft buffer around it. Each buffer was attributed with the unique polygon ID assigned to the potential restoration candidate wetland by West. GIS polygon clipping methods were employed to exclude all soils outside of the wetland and its associated 200-ft buffer. Existing and historic salinity conditions were assessed using digital and hardcopy soil survey data (SSURGO and county soil surveys, respectively), combined with MUIR attribute data. Some drained wetlands were examined in the field to provide representative examples in hydrogeologic settings with soil catenas that include saline or potentially saline soil components and to verify concepts regarding wetland drainage and salinity. In general, map units with major soil components that had listed salinities greater than 4 dS/m were considered saline soils.

For the purposes of evaluation, the soil polygons contained within the buffer and the drained wetland were reduced to two categories: saline soils and non-saline soils. Saline soils consisted of somewhat poorly drained or wetter soils that were listed in the soil survey as being saline soils or saline variants of non-saline soils or that had ECspe values in the MUIR database greater than 4 dS/m in the surface soil layers. Only major map unit components were considered and included soils of minor percentage were ignored. The acreage and percentage of saline soils within the wetland boundary, and within the surrounding 200-ft buffer were determined using GIS and database methods. Salinization hazard classes were developed for each wetland and wetland buffer based on the percentage of saline soils included within each polygon pair.

Five salinization classes were developed:

- None to slight (0-5%).
- Low (>5-25%).
- Moderate (>25-50%).
- High (>50-75%).
- Severe (>75-100%).

Wetland and wetland buffers were analyzed separately. Restoration candidate wetlands lacking saline soils within the buffer or wetland polygons were placed in the none-to-slight salinity category. The presence of inclusions, uncertainties regarding accurate mapping, and the broad ranges in ECspe provided as representative of individual soil series precluded the development of a pure "None" category. Restoration candidate wetlands that contain >75-100% soil map units with major saline components have been placed into the severe category. Soils that have intermediate percentages of soil map units with major saline components have been placed in intermediate categories (>5-25%, >25-50%, and >50-75% represent low, moderate, and high salinity hazard categories, respectively). The intermediate categories are somewhat arbitrary and were developed to represent a representative, equally spaced gradation of salinization hazards from Low to Severe.

Database methods were used to associate the potential restoration volume (in acre-ft) and wetland area calculated by West with the salinity hazard class of individual wetlands. The results are provided in Arcview format, permitting the identification of potentially restorable wetlands. Each potential restoration candidate wetland was color coded to its respective wetland and buffer hazard class.

RESULTS

Soil Associations

Surface geology and the STATSGO map unit data exhibit similar distribution patterns because of the close relationship between soil associations and geological parent material and topography. Seven soil associations comprise over 2,330 square miles (89 percent) of the Upper Basin area. The three most extensive STATSGO soil map units include ND046 (Barnes-Svea-Hamerly, 896 square miles), ND043 (Svea-Buse-Hamerly; 765 square miles), and ND040 (Hamerly-Tonka-Svea, 223 square miles). These three soil associations comprise 1,884 square miles, or just over 72 percent of the 2616 square mile total for the entire Upper Basin. All three associations are mapped on hummocky collapsed till and share many of the same soil components. They vary mainly as to relief. Two additional associations comprise slightly less than 10 percent (over 253 square miles) of the total area of the Upper Basin and are associated with water-worked glacial drift. ND005 (Bearden-Great Bend-Overly) accounts for over 127 square miles of the total basin area and is associated with relatively fine-textured lacustrine material derived from ice-walled, glacial lake sediments. ND041 (Hegne-Hamerly-Fargo) accounts for 126 square miles of the total Upper Basin area and is associated with wave-washed (eroded) glacial sediment. One additional STATSGO map unit accounts for a significant area within the Upper Basin. ND051 (Svea-Cresbard-Hamerly) comprises 198 square miles and is generally associated with hummocky collapsed till similar to ND043 (Svea-Buse-Hamerly); however, sodicity is more common in ND051, likely because of shallower depths to Pierre Shale and a more significant shale component to the local tills. NRCS data indicate sodic soils in somewhat poorly, poorly and very poorly drained landscape positions are of very limited extent in the Upper Basin. Accordingly, this analysis focuses on salinity alone.

Wetland soil series in the Upper Basin are dominated by non-saline Tonka (fine, smectitic, frigid Argiaquic Argialbolls), Parnell (fine, smectitic, frigid Vertic Argiaquolls) and Hegne soils (fine, smectitic, frigid Typic Calciaquerts). Saline and potentially salinizable soils on wetland peripheries consist predominantly of Hamerly (fine-loamy, mixed, superactive, frigid Aeric Calciaquolls), Vallers (fine-loamy, mixed, superactive, frigid Typic Calciaquolls) and Bearden soils (fine-silty, mixed, superactive, frigid Aeric Calciaquolls).

Distribution Statistics and the Relationship between Salinity Hazard Class and Potential Storage Volume

The majority of the potentially restorable wetlands are extremely small with limited water storage potential. The majority of the storage associated with wetland restoration would come from the restoration of a few larger wetlands with higher storage volumes. For the None/Slight Buffer Salinization Hazard class, just under 50,000 acre-ft of storage (75 percent of the total) is contained within only 10 percent (approximately 900) of the 9,107 restoration candidates identified by West (exclusive of wetlands in Benson and Pierce counties). Similarly, for the None/Slight Wetland Salinization Hazard class, approximately 45,000 acre-ft of storage (71 percent of the total) is contained within only 10 percent (approximately 960) of the 9,625 wetlands in the None/Slight Wetland Hazard Class. These data demonstrate that efforts to acquire and restore wetlands under the UBS alternative should be focused on a subset of larger wetlands that represent the majority of the recoverable storage volume.

Salinization Hazards Associated with Wetland Restoration

Table C-26 presents a breakdown of wetland acreage and potential restoration volumes by Buffer Salinization Hazard Class and county. The salinity hazard classification category with the largest number, acreage, and storage volume is the none/slight category, followed by the low, moderate, high, and severe categories. The lowest percentage of total storage volume in the none/slight salinity hazard category was in Cavalier County (45.3 percent), followed by Ramsey (50.7 percent), Towner (76.4 percent), Rolette (87.2 percent), and Walsh (91 percent) Counties. Benson and Pierce Counties were not analyzed because spatial digital soils data on map unit distribution were lacking. However, based on the percentages in the five counties where salinity was assessed, a 50-percent value for total storage volume in the none/slight category would be a conservative estimate for Benson and Pierce Counties. Even though Ramsey and Towner Counties have the smallest percentage of wetlands in the none/slight hazard class, they have the largest number of restorable wetlands and available storage, followed by Cavalier, Rolette, and Walsh Counties.

Exclusive of Benson and Pierce Counties, 66,861 acre-ft of storage are in the none/slight category, representing approximately half of the total available storage of 127,853 acre-ft. Since the UBS alternative assumes restoration of 50 percent of the available storage identified by West (63,926 acre-ft), the data suggest that this restoration percentage is attainable with limited salinization hazards. If a conservative estimate of 50 percent of the available storage is assumed to be in the none/slight salinity hazard category for Benson and Pierce Counties, the total recoverable storage volume would rise from 66,861 acre-ft to 71,570 acre-ft.

Table C-27 below presents a breakdown of wetland number, acreage and potential restoration volumes by Wetland Salinization Hazard Class and county. In general, the data are very similar to that discussed above for the 200-ft buffer around each wetland. Again, the salinity hazard classification category with the largest number, acreage, and storage volume is the none/slight category. The distribution of wetlands by Wetland Salinity Hazard category is slightly different in that the none/slight category is followed by the moderate, then low and severe categories. The lowest percentage of total storage volume in the none/slight salinity hazard category was in

Cavalier County (40.4 percent), followed by Ramsey (51.3 percent), Walsh (54.3 percent), Rolette (71.7 percent), and Towner (71.9 percent) Counties. Benson and Pierce Counties were not analyzed because spatial digital soils data on map unit distribution were lacking. However, based on the percentages in the five counties where salinity was assessed, a 50-percent value for total storage volume in the none/slight category would be a conservative estimate for Benson and Pierce Counties. Even though Ramsey and Towner Counties have the smaller percentage of wetlands in the none/slight hazard class, they have the largest number of restorable wetlands and available storage, followed by, Cavalier, Rolette, and Walsh Counties.

Exclusive of Benson and Pierce Counties, 63,512 acre-ft of storage fall in the none/slight category, again representing approximately half of the total available storage of 127,853 acre-ft. Again, as stated above, the UBS alternative assumes restoration of 50 percent of the available storage identified by West (63,926 acre-ft). Wetland Salinity Hazard data suggest that this restoration percentage is attainable with limited salinization hazards occurring within the restored wetlands. If a conservative estimate of 50 percent of the available storage is assumed to be in the none/slight salinity hazard category for Benson and Pierce Counties, the total restorable storage would rise from 63,512 acre-ft to 68,220 acre-ft. Based on a linear regression analysis, a strong statistical relationship was found between Buffer and Wetland Salinity Hazard classes for restoration candidate wetlands.

MANAGEMENT AND MITIGATION OF SOIL SALINITY

Salt and sodium in soils can limit their use, reduce crop yields, and influence. Depending on crop salt tolerance, significant yield reductions of intolerant crops occur beyond an EC of 4 dS/m. Crop tolerances to soil salinity/sodicity have been quantified and management techniques to reduce the negative impacts of soil salinity are known. Many of these techniques are already in general use on saline/sodic soils in the region. Secondary soil salinization associated with the UBS alternative may have a negative economic impact that can be quantified through an assessment of increased management costs, limits to use, and reduced crop yields. Soil water compatibility issues are well-documented and salinity hazards can be readily identified and mitigated for. Common management techniques use adapted crops and manipulate water tables and groundwater flow to minimize soil salinization in sensitive areas. Land and water management practices that can help producers to reduce the risk of dryland salinization include, but are not limited to:

- Increasing minimum tillage or no-tillage.
- Increasing the area of forages, pastures, and tree crops.
- Reducing summer-fallow area.
- Including crops that are more salt-tolerant in rotations.
- Using inputs such as mineral fertilizers and animal manure more effectively.
- Using precision farming.
- Installing interceptor forage strips or strategic subsurface tile drainage.

CONCLUSIONS

Wetland restoration does not add salts to the landscape but rather remobilizes existing salts that have been translocated by drainage. With wetland restoration, salts are frequently translocated back to positions in the landscape that remain saline or that were saline prior to wetland drainage. When mobilized salts accumulate in locations where salinity was not common or was not a problem before, growers will perceive a salinization problem and possibly attribute it to wetland restoration. The data suggest that well over 60,000 acre-ft of storage are available with a minimum of salinization hazards.

Restoration should be focused primarily on candidate wetlands in the none/slight and low salinization hazard classes. Few salinization problems are likely to be perceived in these wetlands and they represent the majority of the recoverable storage volume in the Upper Basin. Restoration of wetlands with intermediate salinization hazards (e.g. those wetlands in the Moderate Salinization hazard classes for both the wetland and the wetland buffer) should be avoided. Restoration of such wetlands would be likely to result in a perceived salinity problem associated with the existing saline land and potentially saline adjacent land. However, many candidate wetlands in the high and severe hazard classes may be good candidates for restoration because they may no longer represent productive cropland. Many such wetlands are now unsuited or marginal for agriculture due to drainage-related salinity problems. Placing restored saline wetlands and their surrounding buffer zones into a conservation reserve program may be an attractive option to farmers whose land is not producing efficiently because of existing, drainage-related salinity problems. Existing programs such as the NRCS conservation set-aside program for saline lands and the Extended Storage Acreage Program (ESAP) could be combined to provide incentives for landowners to enroll in wetland restoration programs.

If upper basin storage is pursued, candidate wetlands would likely have to take into consideration members of all salinization hazard groups due to uncertainties in land acquisition, the need to restore wetlands in certain locations, and the need to focus on larger wetlands with greater storage potential. GIS queries could be applied to the Arcview data layers generated by this study to rank wetlands by salinity hazard class, size, storage volume and location to develop the best possible mix of restoration alternatives that would maximize long term storage, grower, and wildlife concerns. An on-site assessment would be important to identify saline soils that may be incorrectly mapped as non-saline and to identify the presence and extent of saline inclusions.

Table C-26. Summary Breakdown of Wetland Acreage and Potential Restoration Volumes by Buffer Salinization Hazard Class and county[1]

COUNTY	Buffer Salinity Hazard Class	Number of Wetlands in Hazard Class	Wetland Acreage in Hazard Class (Acres)	Wetland Volume in Hazard Class (Acre Feet)	Total Volume by Hazard Class (Percent)	Restore Hazard Class None/Slight
All Counties exclusive of Benson and Pierce	None/Slight (0)	9107	44392	66861	56.5	
	Low (1)	1114	17735	32222	27.2	
	Moderate (2)	1004	9307	14546	12.3	
	High (3)	532	3060	4006	3.4	
	Severe(4)	250	785	801	0.7	
Grand Totals		***12007***	***75280***	***118436***	***100***	
County Breakdowns						
Cavalier	None/Slight (0)	1378	7935	13325	45.3	13325
	Low (1)	341	5912	12016	40.9	
	Moderate (2)	312	2523	3490	11.9	
	High (3)	135	497	490	1.7	
	Severe(4)	32	98	78	0.3	
Subtotal		2198	16966	29399	100	
Ramsey	None/Slight (0)	3587	19820	29711	50.7	29711
	Low (1)	533	9520	16694	28.5	
	Moderate (2)	488	5365	8699	14.8	
	High (3)	271	2157	3036	5.2	
	Severe(4)	116	454	449	0.8	
Subtotal		4995	37315	58589	100	
Rolette	None/Slight (0)	932	1974	2844	87.2	2844
	Low (1)	8	227	302	9.3	
	Moderate (2)	16	41	32	1.0	
	High (3)	10	21	34	1.0	
	Severe(4)	11	34	51	1.6	
Subtotal		977	2296	3263	100	
Towner	None/Slight (0)	3044	13636	19592	76.4	19592
	Low (1)	211	1974	3097	12.1	
	Moderate (2)	183	1356	2306	9.0	
	High (3)	115	382	444	1.7	
	Severe(4)	90	196	220	0.9	
Subtotal		3643	17544	25660	100	
Walsh	None/Slight (0)	166	1027	1388	91.0	1388
	Low (1)	21	102	113	7.4	
	Moderate (2)	5	23	19	1.3	
	High (3)	1	3	3	0.2	
	Severe(4)	1	3	2	0.2	
Subtotal		194	1159	1525	100	
Benson	Not Analyzed	1060	3595	8351		4175.5[2]
Pierce	Not Analyzed	390	891	1066		533[2]
Grand Total		**13457**	**79766**	**127853**		**66861**
						71570[2]

[1] The last column provides a breakdown assuming that all wetlands in the none/slight buffer salinity hazard class are restored.
[2] Assumes a conservative value of 50% restoration candidate wetlands in Benson and Pierce Counties in the none/slight wetland salinity hazard category.

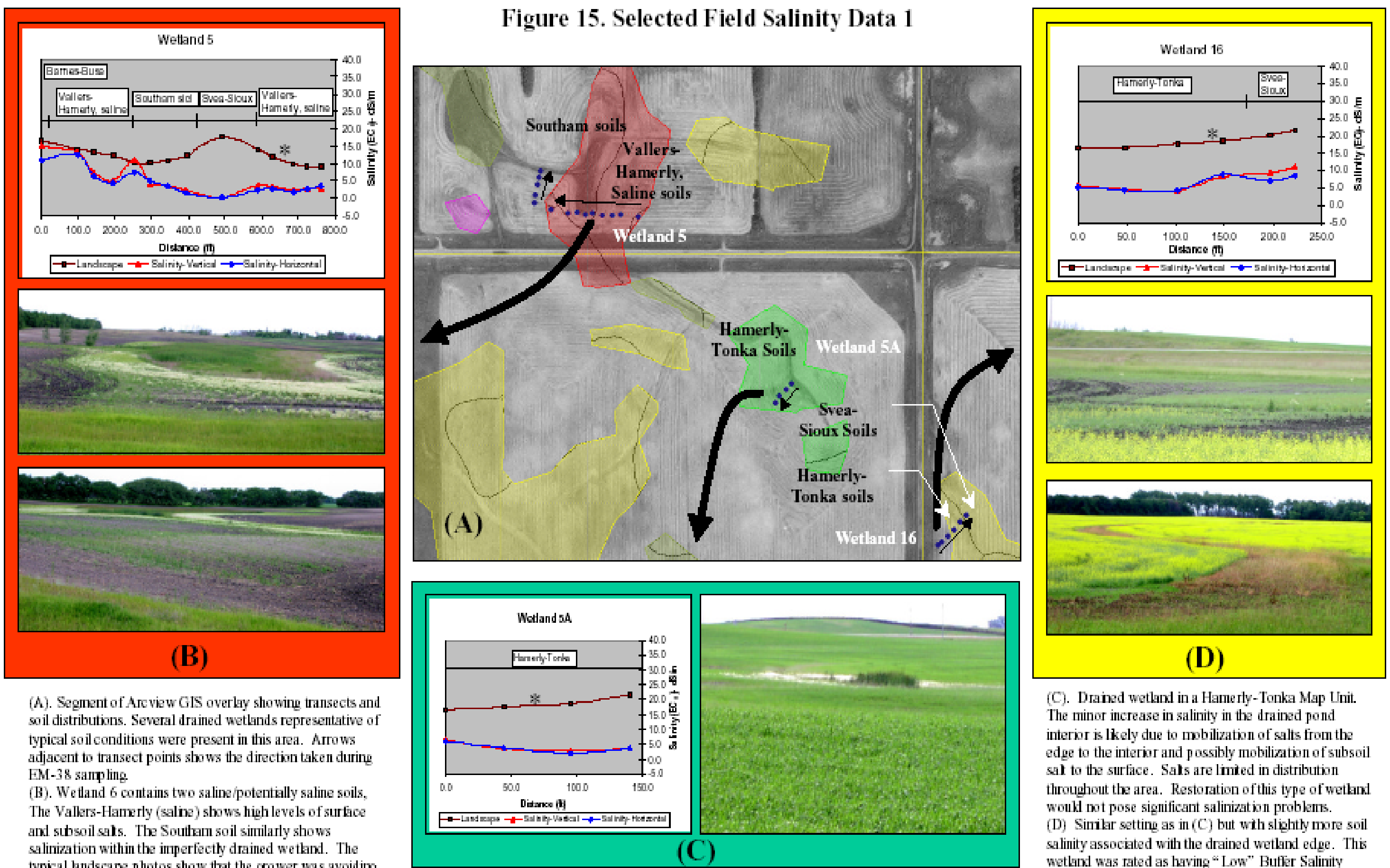
Table C-27. Summary Breakdown of Wetland Acreage and Potential Restoration Volumes by Wetland Salinization Hazard Class and County

COUNTY	Wetland Salinity Hazard Class	Number of Wetlands in Hazard Class	Wetland Acreage in Hazard Class (Acres)	Wetland Volume in Hazard Class (Acre Feet)	Total Volume by Hazard Class (Percent)	Restore Hazard Class None/Slight
All Counties exclusive of Benson and Pierce	None/Slight (0)	9625	44156	63512	53.6	
	Low (1)	401	9188	16656	14.1	
	Moderate (2)	485	10583	20237	17.1	
	High (3)	500	5885	10730	9.1	
	Severe(4)	996	5467	7302	6.2	
Grand Totals		***12007***	***75280***	***118436***	*100*	
County Breakdowns						
Cavalier	None/Slight (0)	1485	7408	11877	40.4	11877
	Low (1)	92	1963	3820	13.0	
	Moderate (2)	160	3660	7376	25.1	
	High (3)	185	2182	3890	13.2	
	Severe(4)	276	1754	2436	8.3	
Subtotal		*2198*	*16966*	*29399*	*100*	
Ramsey	None/Slight (0)	3855	20705	30029	51.3	30029
	Low (1)	223	5348	9022	15.4	
	Moderate (2)	243	5813	11099	18.9	
	High (3)	224	2791	4875	8.3	
	Severe(4)	450	2657	3564	6.1	
Subtotal		*4995*	*37315*	*58589*	*100*	
Rolette	None/Slight (0)	937	1873	2339	71.7	2339
	Low (1)	4	289	684	21.0	
	Moderate (2)	7	51	112	3.4	
	High (3)	6	22	36	1.1	
	Severe(4)	23	61	92	2.8	
Subtotal		*977*	*2296*	*3263*	*100*	
Towner	None/Slight (0)	3182	13499	18438	71.9	18438
	Low (1)	76	1370	2757	10.7	
	Moderate (2)	72	889	1451	5.7	
	High (3)	76	855	1886	7.4	
	Severe(4)	237	930	1127	4.4	
Subtotal		*3643*	*17544*	*25660*	*100*	
Walsh	None/Slight (0)	166	671	828	54.3	828
	Low (1)	6	218	371	24.4	
	Moderate (2)	3	169	199	13.0	
	High (3)	9	35	44	2.9	
	Severe(4)	10	66	82	5.4	
Subtotal		*194*	*1159*	*1525*	*100*	
Benson	Not Analyzed	1060	3595	8351		4175.5[2]
Pierce	Not Analyzed	390	891	1066		533[2]
Grand Total		**13457**	**79766**	**127853**		**63512**
						68220[2]

[1] The last column provides a breakdown assuming that all wetlands in the none/slight wetland salinity hazard class are restored.
[2] Assumes a conservative value of 50% restoration candidate wetlands in Benson and Pierce Counties in the none/slight wetland salinity hazard category.

Examples of the type of GIS information developed for the upper basin storage soil salinity analysis are presented in Figures C-30 and C-31. Much of this data would be very useful in identifying depressions that could be used for water storage.

Figure C-30. Example of field data developed for the soil salinity analysis



(A). Segment of Arcview GIS overlay showing transects and soil distributions. Several drained wetlands representative of typical soil conditions were present in this area. Arrows adjacent to transect points shows the direction taken during EM-38 sampling.

(B). Wetland 6 contains two saline/potentially saline soils, The Vallers-Hamerly (saline) shows high levels of surface and subsoil salts. The Southam soil similarly shows salinization within the imperfectly drained wetland. The typical landscape photos show that the grower was avoiding the wet Southam area. During drier periods this area may be farmed. However, soil salinity will would likely affect crop yields.

STATSGO Map Unit ND043

* - Relative landscape elevations (feet) are provided for reference but have not been benchmarked.

(C). Drained wetland in a Hamerly-Tonka Map Unit. The minor increase in salinity in the drained pond interior is likely due to mobilization of salts from the edge to the interior and possibly mobilization of subsoil salt to the surface. Salts are limited in distribution throughout the area. Restoration of this type of wetland would not pose significant salinization problems.

(D) Similar setting as in (C) but with slightly more soil salinity associated with the drained wetland edge. This wetland was rated as having "Low" Buffer Salinity Hazard indicating the presence of >5-25% saline soils within the 200-foot wetland buffer.

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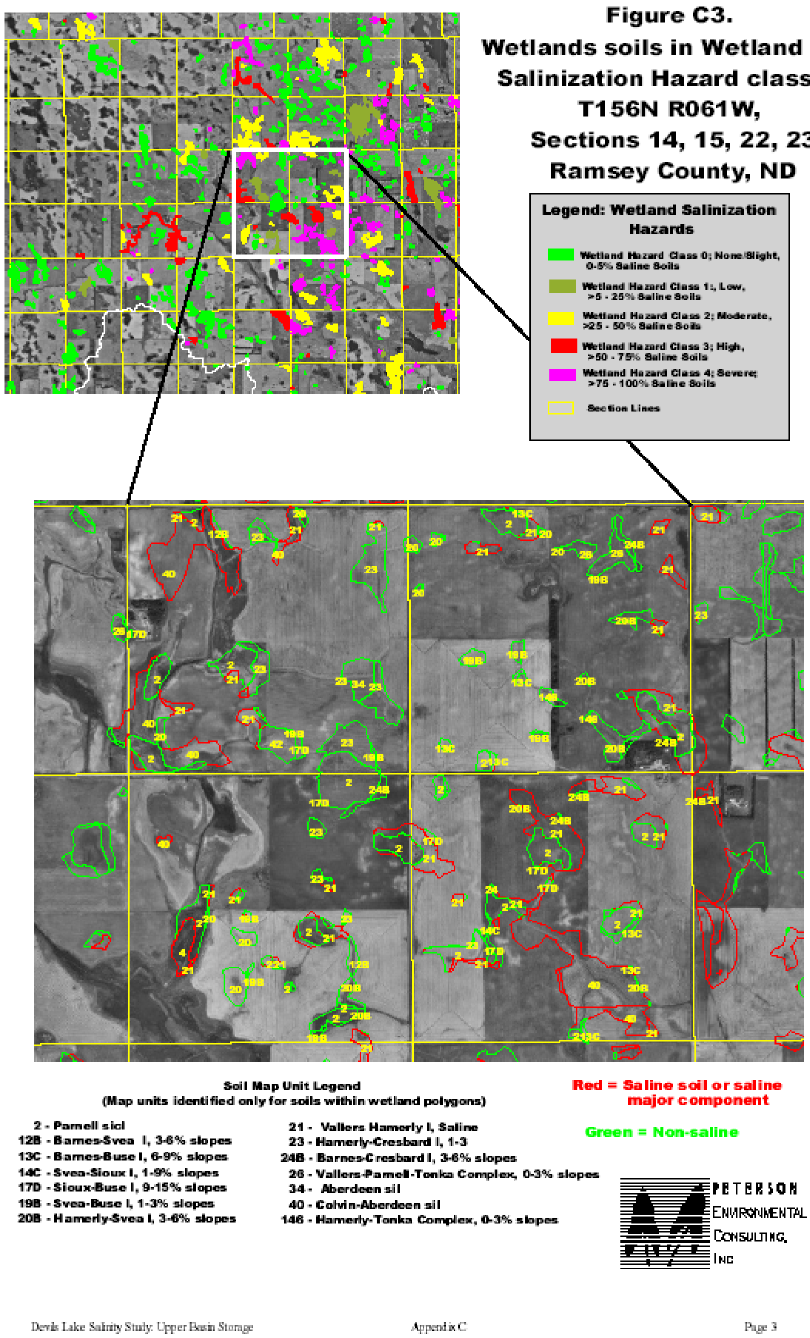

Figure C-31. Potential restoration sites were mapped based on soil salinity hazard classes for the GIS analysis

Watershed management activities were studied in 1999 by the U.S. Environmental Protection Agency. The study identified a number of land management programs available in the upper basin to landowners. The study also made suggestions on upper basin management. Some of the findings of that study are presented below.

Basin-wide watershed management planning authority should be assigned to a specific agency by consensus between the North Dakota Governor's office and the North Dakota congressional delegation. An agency with substantial resources, either Federal or State funding, should be given the mandate to coordinate a comprehensive review of the properties in the basin, and to coordinate all the available programs. This approach would result in a more equitable distribution of available funding to private landowners and would make implementation of watershed programs more efficient. Both long-term approaches, such as 30-year or permanent easements, and short-term programs, such as the ASAP, should continue to be pursued. In addition, the state law restricting permanent easements should be reevaluated, as this reduces the financial options of landowners.

The Federal agency that may be most able to coordinate watershed management efforts is the NRCS. The NRCS has a long-standing relationship with the agricultural community by virtue of its historical role of assisting farmers to improve their agricultural practices to protect and enhance their land, and the NRCS also currently manages the most watershed programs in the basin. The standing of NRCS in the community, the relatively high level of trust placed in this agency, and the resources available to this agency, makes the NRCS the agency at the Federal level to coordinate the initiatives for private landowners. The NRCS could work with Federal, state, local, and private agencies to streamline the available programs and to provide the highest compensation available to landowners.

Citizen participation and support in developing a comprehensive plan that accounts for the entire local economy is extremely important to the success of any planning effort. Cooperation between local, state, and Federal agencies, and between private interests is central to the success of any comprehensive plan. There are several approaches that citizens of other watersheds, such as Lake Tahoe (California and Nevada), Portland (Oregon), and the Vermillion River (South Dakota), have employed to improve their land use planning, improve water quality, and reduce flood damage. The residents of Devils Lake basin could use these communities' efforts as a starting point for their own unique situation.

A significant effort and funding for education of local government, citizen groups, and individuals regarding the local hydrology and climatology, as well as benefits of wetland and grassland restoration should also be considered. To be most effective, this task should be accomplished by a group of agencies with different expertise and a high level of credibility. Local agencies would be preferred, but may lack the resources necessary. Thus, state agencies, such as the NDDA, NDDH, NDGFD, and SWC may be best-suited to this task. Federal grant money from EPA and other agencies may be available to assist in these education efforts.

GIS should be used to track the parcels involved in any of the watershed programs. However, only a few agencies currently use GIS. These agencies are: USBR, USFWS, and SWC. These agencies' data and maps are available to other agencies, groups, and individuals upon request. The USACE and USGS also have extensive GIS abilities, and their data should also be incorporated into a comprehensive database for the basin. Much of the information is available through the internet. All watershed information available for the Devils Lake basin should be collected by a designated lead agency and used to compile comprehensive maps of the basin, which should include such information as land use, wetlands, drains, and acreage associated with different conservation or water storage programs. While all of the agencies currently using GIS have excellent capabilities in this area, the SWC, as a state agency, should be considered to lead this coordination effort.

In addition to cost-benefit analyses and model scenarios, it will be important to consider the balance between restoring and creating upper basin storage and adverse agricultural consequences. Landowners may need to be compensated for taking their land out of production at a level that is comparable, if possible, to the gains they would receive for farming or selling the land. Permanent easements would create long-term storage and wildlife habitat.

It may be desirable to conduct a comprehensive economic analysis of the potential impacts of additional wetland restoration and water storage in the basin. This should include impacts to farmers from removing land from crop production, potential impacts to property taxes, as well as the impacts of the cost sharing and transfer payments from implementing these programs. Existing watershed management programs should also be evaluated to determine whether they fully compensate private landowners for the public benefits that may result from enhanced watershed practices.

Actions or programs that increase the profitability of agriculture while incorporating watershed management techniques could be explored. One concept, labeled "conservation agriculture," employs the strategy of focusing farm efforts into the most productive soils while incorporating alternative uses on land that is not prime farmland. This strategy could make farms more profitable by lowering input costs on the farm by only farming land likely to produce high yields, and increasing alternative payments for acreage that is less productive but that provide watershed management functions. This type of approach has the potential to improve agriculture, improve watershed management, and create alternative industries. Implementation of this type of multipurpose concept should be explored and should include analysis by economists, agronomist, soil scientists and conservation planners.

The recreational and tourism potential of wetland restoration and wildlife management should be explored, as activities ranging from hunting to bird watching and wildlife observation have the potential to become significant contributors to local economies. In turn, this may result in a more diversified economy and the ability to attract new industry. This potential should be acknowledged at the local level. Local government officials should be willing to adapt to the changing landscape in the basin, should explore different taxation structures to support government functions, and should remove institutional restrictions that have prevented some landowners from pursuing conservation of their land.

Given the trends in the agricultural economy, which many experts predict will continue into the foreseeable future, it may be that activities associated with preserved or restored wetlands and enhanced wildlife management could generate greater, more sustained income on selected parcels of land than would the current crop production.

Pelican Lake Outlets

Outlets from Pelican Lake would have impacts similar to those identified for the West End outlets. They would differ in some respects in water quality.

The Pelican Lake outlets would remove more fresh water from the lake resulting in more effects to Devils Lake aquatic resources. The lake would become saltier sooner.

Downstream, the initial effects would be less because water removed would be similar to existing Sheyenne River water, only impacts resulting from increased flows would occur. Flow impacts would be similar to the West End outlets described above. In the long-term effects to the Sheyenne River system would be similar to the other West End outlets because eventually fresh water is not available and the West Bay water, which has become saltier, because diluting fresh water has been removed, has to be taken.

A Pelican Lake outlet that only removes the inflow from the lake was also considered. This plan would not use West Bay water. Outlet release is based on inflow, no inflow, no release. This plan would have less water quality effects on the Sheyenne and Red Rivers than the other plans. Outlet flows on the Sheyenne would probably also be lower than with the other outlets, but there would still be some effects on aquatic habitat.

The water quality in Devils Lake would be degraded over the future without or as compared to other outlet alternatives because most of the freshest inflow would be diverted to the outlet. Devils Lake would reach lower levels sooner and would be subject to higher TDS, sulfate, and other constituent levels. Upper basin lakes would be used to store water and would be subject to increased fluctuations. Habitat values in these lakes would also be effected. Lake Alice National Wildlife Refuge would be impacted and a Refuge Compatibility Statement would be needed. Silver Lake National Wildlife Refuge, Waterfowl Production Areas, and Wetland Easements are also located in the Pelican Lake area. About 50,000 acres would be inundated if the area north of Highway 19 was used for storage. Aquatic and wildlife values in the upper basin lakes have not been evaluated in detail and would require further analysis.

Cultural Resources

Little of the Intake Channel alignment from Pelican Lake to Minnewaukan has been previously surveyed for cultural resources. That part of the intake channel alignment paralleling Highway 19 was surveyed in 1995 in connection with the relocation of United Power Association's DV Line in Benson and Ramsey Counties. This 1995 cultural resources survey covered an eighth-mile-wide strip on the north side of Highway 19, which includes much of the currently proposed Dam Embankment alignment. Three historic archeological sites are recorded along the intake channel alignment, two of which are also along the dam embankment alignment. There are unverified leads to one prehistoric archeological site and one historic archeological site for these alignments as well.

Minnewaukan itself contains two National Register of Historic Places listed properties, the Benson County Courthouse and Grace Episcopal Church. In addition, the Harriman House (241 Main Street East) has been determined eligible for listing on the National Register. Eleven other houses and two churches at Minnewaukan have not had their National Register eligibility evaluated, but are potentially eligible. There is also an unverified lead to the original Minnewaukan townsite. All of these properties are located in Section 15, Township 153 North, Range 67 West, Benson County.

The Pelican Lake outlet alignment from the Pelican Lake pump station to its junction with Peterson Coulee south of Stony Lake has not been previously surveyed for cultural resources. Except for the above mentioned buildings and historic archeological sites at Minnewaukan, there are no recorded sites or unverified site leads along or near this part of the Pelican Lake outlet alignment. Burns & McDonnell surveyed the outlet alignment along Peterson Coulee from Stony Lake to the coulee's confluence with the Sheyenne River in June 1998. They recorded one historic archeological farmstead site (32BE68) at the north end of the coulee and one prehistoric archeological site (32BE21) and one prehistoric isolated find (32BEx129) on the river terrace at the mouth of the coulee. Site 32BE21 needs archeological testing to determine its eligibility to the National Register. The farmstead site and the prehistoric isolated find have been determined not eligible to the National Register. The National Register listed West Antelope Bridge (32BE41) is located within a mile downstream of the outlet into the Sheyenne River.

The western Pelican Lake outlet alignment alternative extending from Pelican Lake west then south to Peterson Coulee south of Stony Lake has also not been surveyed for cultural resources. The only recorded cultural resources sites along this outlet alternative are in that portion which follows Peterson Coulee from south of Stony Lake vicinity to the coulee's confluence with the Sheyenne River. Historic archeological farmstead site 32BE68 is located at the north end of Peterson Coulee, and prehistoric archeological site 32BE21 and prehistoric isolated find 32BEx129 are on the river terrace where the coulee empties into the Sheyenne River. Site 32BE21 needs archeological testing to determine its eligibility to the National Register. The farmstead site and the prehistoric isolated find have been determined not eligible to the National Register. The National Register listed West Antelope Bridge (32BE41) is located within a mile downstream of the outlet into the Sheyenne River.

Most of the eastern Pelican Lake outlet alignment alternative extending from the Pelican Lake pump station southeastward along Highway 281 to Round Lake, then paralleling the southeast side of Round, Long and Stony Lakes to Peterson Coulee, thence along Peterson Coulee itself to the Sheyenne River has been surveyed for cultural resources. In November 1987 and June 1988 Burns & McDonnell of Kansas City, Missouri surveyed the proposed Peterson Coulee outlet alignment. In 1989 Kent Good inventoried buildings and structures along Highway 281 through Minnewaukan as part of Highway 281 curb and gutter work in that city. In 1988, Floodman surveyed various landforms along potential outlet routes, including several 80-acre areas at Round, Long and Stony Lakes. The National Register listed Grace Episcopal Church and eligible Harriman House in Minnewaukan are adjacent to Highway 281 as are up to 12 other potentially eligible houses and churches in that city. Three historic archeological sites (32BE19, 32BE68, 32BE69) and two prehistoric archeological sites (32BE18 and 32BE22) were recorded along the alignment southeast of Long and Stony Lakes. All but 32BE22 have been determined not eligible to the National Register. Site 32BE22 southeast of Stony Lake and prehistoric archeological site 32BE21 on the river terrace at the confluence of Peterson Coulee and the Sheyenne River need archeological testing to determine their National Register eligibility. The isolated find (32Bex129) on that same river terrace is not eligible to the National Register. The National Register listed West Antelope Bridge (32BE41) is located within a mile downstream of the outlet into the Sheyenne River.

East Devils Lake Outlet

An East End outlet would have similar types of effects as a West End outlet differing primarily in the magnitude of the effects.

An outlet from East Devils Lake would result in the freshening of Devils Lake. This may or may not be desirable from a fishery standpoint because the TDS concentration is a factor in natural reproduction and reduced levels could enhance natural reproduction. The long-term effect of this could be the production of more small fish and fewer large fish.

Downstream effects would be greater than with the other outlet alternatives because poorer water is released to the Sheyenne and Red Rivers.

Natural Overflow Event

A wet scenario future without involves a continuation of wet conditions resulting in increases in the level of Devils Lake to the point where the lake naturally drains through Stump Lake and the Tolna Coulee to the Sheyenne River. The scenario based future is an alternate to the stochastic (probability) based future. The probability of a natural overflow ranges from 2 percent to 9.4 percent, depending on the period of record used in the analysis.

A natural overflow would have similar types of effects as a constructed outlet differing primarily in the timing, magnitude, and duration of the effects. Therefore the discussion of outlet affects above also apply to a natural overflow but to a different degree.

The natural overflow event would freshen Devils Lake by removing water from the east end of the system. The effect on the aquatic resource are described in the future without project conditions. The freshened lake would result in increased natural reproduction, possibly producing more smaller fish.

The effect on terrestrial resources around the lake would be the inundation of habitat. Recovery would take a long time until the lake recedes naturally.

Downstream flow and water quality effects of a natural overflow event would be similar to an outlet but would be more sudden. An overflow event based on the wet scenario would have a peak discharge of about 550-cfs. Other years would have an average discharge ranging from minimal to 550-cfs. By comparison, mean monthly flows on the Sheyenne River near Cooperstown range from around 11-cfs in January to a high of 549-cfs in April. Mean monthly flows near Lisbon (below Baldhill Dam) range from a low of 25-cfs in October to a high of

600-cfs in April. The maximum overflow would be similar to a 480-cfs unconstrained outlet but would be of a shorter duration, approximately 10 years. At elevation 1459, the water would be fresher but would still result in significant and long-term effects to downstream aquatic resources.

Impacts to downstream terrestrial resources and erosion would be similar to those described for the outlet alternatives.

The natural overflow has essentially the same salinity hazards of floodplain soil salinization and irrigated soil salinization as those associated with the constrained and unconstrained scenarios of the Outlet Alternatives described under the stochastic future. However, the magnitude of the associated salinization hazards is greater because of the higher levels of salinity that would be associated with Stump Lake water.

Raise Natural Outlet (Dam on Tolna Coulee)

Under the wet scenario, it is predicted that the lake would rise to about elevation 1463 if a dam was constructed at Tolna Coulee and the water was kept in the lake and not allowed to overflow to the Sheyenne River. This alternative was evaluated as a sensitivity analysis.

If the lake were to continue to rise and a dam was constructed at the natural outlet on Tolna Coulee, an additional 186,000 acres of land would be inundated up to elevation 1463. This would adversely affect land uses around the lake but would eliminate any downstream effects due to a natural overflow or erosion of the natural outlet. Mitigation estimates were not identified for this alternative. Additional information would be needed on project design and elevation/frequency/duration curves developed. If this alternative were considered for further analysis or implementation mitigation needs would have to be determined.

Cultural Effects

If there is no natural overflow from Devils Lake via Stump Lakes to the Sheyenne River, erosion of archeological sites along the Sheyenne River will continue as at present. Cultural resources sites on the shoreline of Devils Lake below 1447' have already been inundated or otherwise adversely affected by the prolonged flooding, and this will continue until the lake level drops. Sites on the Devils Lake shoreline at whatever level the lake is at would potentially be subject to wave-caused erosion. Sites along the shoreline of Stump Lakes would be inundated and/or eroded once there is overflows from East Devils Lake, which starts at 1446.5 ft.

Environmental Effects – Sensitivity Analysis

Introduction

The following alternatives were evaluated as a sensitivity analysis. A comparative summary of the effects of the various sensitivity alternatives on the major resource areas is presented in the following Impact Matrix Table (Table C-28).

TABLE C-28. IMPACT MATRIX TABLE

Devils Lake Study Sensitivity Analysis Matrix

Sensitivity	**Resource**				
	Devils Lake Aquatic Resources	**Devils Lake Terrestrial Resources**	**Downstream Terrestrial Resources**	**Downstream Aquatic Resources**	**Biota Transfer**
No Action	Fishery in lake will continue to improve to a point. Eventually lake will recede and fishery will decline.	Wetlands, woodlands, grasslands, and other habitats will be gained and lost as lake fluctuates.	Similar to future without conditions. No effect downstream if lake does not overflow naturally. Natural overflow would have significant effect on downstream resources. Natural overflow would have significant effect on current land uses. Potential for natural overflow is small.	Similar to future without conditions. Aquatic resource could be lost depending on magnitude of overflow due to natural spill. Potential for spill is small. Not much change expected from current conditions. Fishery will maintain itself. Potential for natural overflow is small.	Unknown. Similar to future without conditions. Potential for transfer and introduction of new species may increase. Natural overflow or other water resource projects increases potential for introduction of new organisms.
Erosion of Natural Outlet	Would tend to improve water quality by removal of TDS and sulfates. Would improve natural reproduction, which may or may not be desirable for recreational fishery.	Would result in exposure of inundated areas sooner than no erosion. Would lower natural overflow elevation and change future high lake level potential.	Downstream flow resulting from uncontrolled erosions would be about 6,000-cfs causing severe erosion, loss of riparian vegetation, increased sedimentation, and degraded water quality. Significant loss of riparian zones and habitat. Recovery period would be very long.	Downstream flow resulting from uncontrolled erosions would be about 6,000-cfs causing severe erosion, loss of riparian vegetation, increased sedimentation, and degraded water quality. Significant loss of aquatic habitat, loss of species, and lower density and diversity. Recovery period would be very long.	Unknown. Similar to future without conditions. Potential for transfer of existing or introduced species increased now and for future high lake levels.

Moderate Lake 1450 - West Bay Outlet - 300-cfs	Fresh water removed from lake and lake level lowered, which could impact fishery. Lower lake levels reached sooner than without outlet.	Outlet would lower lake levels about 3 ft. Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	6, 212, and 72 Natural Heritage sites located within 1/4 mile, potential groundwater influence, of Upper Sheyenne, Lower Sheyenne, and Red River respectively. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities.	Release constrained by water quality standards although increase in levels of constituents. Most effect on aquatic resources in upper Sheyenne due to increase flows. Limited effects due to operation constrained by water quality and channel capacity. Increased groundwater could effect composition of some communities. Changes in water quality could have significant effects on aquatic communities. Most effect on aquatic resources in upper Sheyenne due to increase flows.	Unknown. Potential for transfer and introduction of new species would increase due to outlet operation. Similar to future without conditions. Potential for spread of Eurasian water milfoil due to increased flows.
Moderate Lake 1450 - West Bay Outlet 480-cfs	Outlet would reduce the potential for inundation of new aquatic habitat with resultant effect on fish resource. Outlet would not totally stabilize lake, therefore, some fluctuation in lake levels would continue. Fishery would decline sooner than future without conditions due to lower lake levels and increased water quality constituent levels.	Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	Similar to West Bay 300-cfs outlet. Significant downstream effects on community structure due to degraded water quality, increased flows, and increased shoreline erosion. 25 natural heritage sites located within flooded area of Sheyenne River. Over 600 landowners potentially affected within flooded area outline. Overbank flooding could inundate almost 16,000 acres. Potential loss of riparian vegetation and shoreline vegetation due to inundation and erosion.	Degraded water quality, increased flows, increased erosion, and loss of riparian vegetation. Dramatic change in aquatic communities such as decline in invertebrate, fish, and mussel species abundance and diversity.	Similar effects as West Bay outlet.
Moderate Lake 1455 - West Bay Outlet 300-cfs	Similar effects as West Bay 300 - cfs outlet.	Similar effects as West Bay 300 - cfs outlet.	Similar effects as West Bay 300 outlet.	Similar effects as West Bay 300 outlet.	Similar effects as West Bay outlet.

Moderate Lake 1455 - West Bay Outlet 480-cfs	Outlet would reduce the potential for inundation of new aquatic habitat with resultant effect on fish resource. Outlet would not totally stabilize lake, therefore, some fluctuation in lake levels would continue. Fishery would decline sooner than future without conditions due to lower lake levels and increased water quality constituent levels.	Future inundation of shoreline would be reduced. Lower lake levels would expose shoreline sooner resulting in quicker successional recovery of terrestrial habitat.	Similar to West Bay 300-cfs outlet. Significant downstream effects on community structure due to degraded water quality, increased flows, and increased shoreline erosion. 25 natural heritage sites located within flooded area of Sheyenne River. Over 600 landowners potentially affected within flooded area outline. Overbank flooding could inundate almost 16,000 acres. Potential loss of riparian vegetation and shoreline vegetation due to inundation and erosion.	Degraded water quality, increased flows, increased erosion, and loss of riparian vegetation. Dramatic change in aquatic communities such as decline in invertebrate, fish, and mussel species abundance and diversity.	Similar effects as West Bay outlet.
State Outlet Along Peterson Coulee	Similar effects as West Bay 300 -cfs outlet. Lake level would be about 1 ft lower than without project.	Similar effects as West Bay 300 -cfs outlet. Lake level would be about 1 ft lower than without project.	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.
Pelican Lake Outlet with more restrictive sulfate constraint of 300 mg/l	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.	Similar effects as West Bay 300 -cfs outlet.

Natural Resources

Erosion of Natural Outlet

Due to the significant effects of erosion of the natural outlet, it was reasonable to assume that minimal erosion protection features would be instituted to prevent such erosion and was included as part of the without-project condition.

A sensitivity analysis was conducted allowing the natural outlet to erode. The analysis is based on the materials present at the site; not whether the site in the past. There is debate over whether the site eroded in the past or accrued sediment. Materials at about 7 ft are over 7,000 years old. Devils Lake is estimated to have spilled to the Sheyenne River within the last 1,200 years; therefore it did not erode at that time.

If the outlet were allowed to erode, the effects would be much more significant. It is estimated that the outlet could erode down to elevation 1450 with a maximum discharge of about 6,000-cfs eroding over 400,000 yd^3 of material. In the lake, the lands would be exposed quicker and recovery would be more rapid. There are approximately 151,000 acres between elevations 1459 and 1450 around Stump and Devils Lakes.

Downstream effects resulting from the erosion of the natural outlet would be significant. There would be increased sedimentation in the Sheyenne River and Lake Ashtabula. Erosion would also increase in the Sheyenne River. There would be substantial effects to the downstream aquatic resource on the Sheyenne and Red Rivers. Higher flows, changed water quality, sedimentation, erosion, increased groundwater levels, and overbank flooding would result in the loss of aquatic and riparian habitats.

Moderate Lake Levels of 1450 or 1455

The effects of outlets if more moderate climate scenarios (sensitivity analysis) were anticipated would be similar to those described for the other outlet alternatives. The major difference would be in the duration of the operation of the outlets. Downstream effects on aquatic and terrestrial resources, erosion, sedimentation, biota transfer, etc., would be similar.

No Action

This sensitivity analysis assumes that no actions would be taken in the basin to reduce or compensate for damages caused by rising lake levels. All of the effects identified for infrastructure protection and any associated with the various alternatives would occur under this assumption.

State Outlet Alternative and 300 mg/l Sulfate Constraint Feature

This sensitivity analysis assumed the State outlet along Peterson Coulee would be constructed and operated as needed for the 50-year period of analysis with a more restrictive sulfate constraint of 300 mg/l. The in-lake and downstream effects of reducing the sulfate constraint from 450 to 300 are not expected to be significant. They would be similar to the effects described for the Pelican Lake 450 sulfate outlet. The water quality effects on natural resources resulting from the state proposed outlet along Peterson Coulee are also expected to be similar to the effects described for the Pelican Lake 450 sulfate outlet. The flow effects resulting from the state outlet are expected to be less than those described for the Pelican Lake outlet because less water would be pumped overall and at any particular time. The lower outlet flow would result in smaller changes in river stage, less groundwater effects, and less flow in the river than would result from the Pelican Lake outlet. This would result in less effect to aquatic habitat and riparian vegetation.

Cultural Effects

Construction of an outlet, either open channel or pipeline, would directly impact any cultural resources sites within the construction alignment. Sites on the shorelines of Devils Lake and Stump Lakes will be affected by inundation and erosion due to wave action. Sites along the Sheyenne River will be subject to prolonged flooding/inundation and an increased potential for bank erosion. Other sites along the Sheyenne River may be subject to burial due to increased overbank deposition at some locations.

Downstream Water Users Analysis

Effect on Fish Hatchery and Recreation

The effects of an outlet and natural spill on the operation of the National Fish Hatchery and on the recreational fishery were studied (Barr Engineering).

Three water appropriation permits for fish and wildlife were identified (although it is likely that two of the permits are held by one facility). The U.S. Fish and Wildlife Service also holds five permits with use listed as “recreation.” All facilities are in Barnes County, North Dakota, and appropriate water from the Sheyenne River. Annual water use information was obtained through telephone interviews with Cheryl Willis and Ginger Price of the U.S. Fish and Wildlife Service. Ms. Willis identified an average annual water appropriation of 170 acre-ft by the Bald Hill National Fish Hatchery and 1,000 acre-ft by the Valley City National Fish Hatchery. These appropriated volumes are well below the permitted water use appropriation for the six permits held by the facilities (total permitted appropriation of about 4,000 acre-ft). Ms. Price indicated that the river water is used throughout the year to raise sportfish (northern, walleye, perch, and bluegill) and some non-game species including catfish, sturgeon, and bony-tailed chub.

Relevant threshold values for fish hatcheries are the water quality standards developed by the U.S. EPA, as well as North Dakota’s water quality standards for the protection of aquatic life. These standards are based on chronic toxicity of the most sensitive species and include a margin of safety. Therefore, they are very protective of fish. Unfortunately, for salt-related parameters, the only applicable U.S. EPA water quality standard is the criterion continuous concentration for chloride, which is 230 mg/L. North Dakota regulations for water quality standards (N.D. Chapter 33-16-02) classifies the Sheyenne River as a Class IA stream, which has a maximum limit for total chloride of 175 mg/L, a maximum limit for total sulfate of 450 mg/L, and a sodium limit defined as 60 percent of total cations as meq/L. Based on the HEC-5/5Q modeling results, the Sheyenne River will not exceed the chloride and sulfate limits with the additional flow from the Devils Lake emergency outlet. The sodium limit was not calculated, but sodium is not considered a toxic constituent to fish (see below).

Saline Sensitivities of Fishes

Salinity (i.e., total dissolved solids or soluble salts) affects the osmoregulatory ability of fishes (the process of maintaining fluid balance across membranes). In freshwater species, body fluids are maintained by active transport against external osmotic gradients. Fish gain water and lose ions through the gills, oral membranes, intestinal surface, and skin. Larval fish have less osmoregulatory ability and, therefore, are generally less tolerant than adult fish or eggs to salinity change.

A study, prompted by Peterka in 1971, examined the effects of various levels of saline water upon the fathead minnow (Pimephales promelas), northern pike (Esox lucius) and walleye (Stizostedion v. vitreum). These are considered to be important game species in rivers and lakes of North Dakota. More importantly, northern pike and walleye are raised in fish hatcheries that use the Sheyenne River water for raising fish. Results of laboratory experiments showed that eggs of all three species hatched well in water having a concentration of about 850 mg/L (specific conductance of 1,300 µmhos/cm), but there was no hatching of walleye and very poor hatching of northern pike eggs in water with a concentration of about 2,600 mg/L (4,000 µmhos/cm). Northern pike sac fry did not survive in water with a concentration of about 7,800 mg/L (12,000 µmhos/cm). An important limitation of this study was the selected salinity concentrations used in the study. Only the following four concentrations were tested: 325, 850, 2,600, and 3,900 mg/L (specific conductance of 500, 1,300, 4,000, 6,000 µmhos/cm). Thus, it is not known from this study how well the eggs would hatch in concentrations between 850 and 2,600 mg/L. This is a gap of critical information for the Devils Lake study because the concentrations could be as high as 1,100 mg/L, which is only 30 percent higher than the 850 mg/L concentration. Using the 850 mg/L as the threshold TDS value for the fish hatchery would be very conservative given the lack of information for egg hatching in water concentrations between 850 and 2,600 mg/L.

Peterka concluded that the ionic composition of the water is more important to fish survival than is the level of total dissolved solids (TDS). In Nebraska saline lakes, fathead minnows could not survive more than 2,000 mg/L TDS, whereas in Saskatchewan and North Dakota saline lakes, fathead minnows were found in water of 15,000 mg/L TDS. The former were high in sodium bicarbonate and potassium carbonate, while the latter were higher in sodium and magnesium sulfate.

A study by Hart et al. in 1990 concluded that 1,000 mg/L salinity (i.e., TDS) was an appropriate threshold value for freshwater systems. This would protect the macroinvertebrates and plants, which were considered more sensitive to salinity than the fish community. Therefore, based on this limited set of information, an appropriate threshold value is closer to 1,000 mg/L for TDS. Two theses were also completed in 1990 and 1993 under John Peterka, at North Dakota State University, examining the salinity toxicity of fish in Devils Lake water. There are no changes from the work that Peterka reported on in the earlier studies reviewed above. There is information on the upper salinity limits for more fish species, but the theses do not include information on the species raised at fish hatcheries. There was some general information on the Devils Lake chain such as the salinity in Devils Lake is referred to as “sodium-sulfate type” waters.

In 1987, Rieniets et al. discussed how exposing northern pike eggs to a NaCl solution (6.95 g/L) greatly improved the fertilization rate. This seems to counter the concerns about salinity toxicity, but it only calls for using the salt solution during fertilization, not raising the fish in it.

A study conducted by AScI on toxicity of Devils Lake water (August 1998) reported no significant toxicity to algae, Ceriodaphnia, or fathead minnows throughout most of Devils Lake. The one exception was in East Devils Lake, where the toxicity killed off the Ceriodaphnia.

Specific Ion Sensitivities
It is important to also look at the constituents of the TDS. The seven common ions that in sum constitute total dissolved salts are sodium (Na+), potassium (K+), calcium (Ca++), magnesium (Mg++), chloride (Cl-), sulfate (SO4--), and bicarbonate (HCO3-).

Aquatic test species have been shown to have different sensitivity to these ions (Tietge et al., 1994). The zooplankton species, Daphnia magna, and the fathead minnow (Pimephales promelas), in 48-hour observations, had the following comparative sensitivities (survival):

K+ > Mg++ > HCO3- > Cl- > SO4__

These test species did not show a significant response to changes in Na+ or Ca++. The relative sensitivity changes slightly in 96-hour observations, with HCO3- > Mg++. These test results indicate that sulfate is the least toxic constituent to the fish. In the Devils Lake with-outlet modeling results, sulfate appeared to be the primary contributor to the increase in instream-TDS with the additional flow from the emergency outlet. Because sulfate is the least toxic ion, it is possible that the increase in TDS may not impact the hatcheries at all.

Because fish tolerance data for sulfate was unavailable, threshold levels for sulfate (with respect to fish mortality) were not established for this report. For TDS, a conservative estimate of 1,000 mg/L was used in assessing potential impacts of the Devils Lake outlet.

Fish Hatcheries Effects
The U.S. Fish and Wildlife Service is listed as having ten permits, although this study identified only two fish hatcheries (Bald Hill and Valley City hatcheries, both located in Barnes County, North Dakota). The Trace 6262 with-outlet data indicates a maximum monthly average TDS Concentration of about 1,050 mg/L in this reach. This TDS concentration is approximately at the threshold level, which indicates that there would be a potential for effects. The effects would likely be more prevalent in larval fish, affecting the fish’s osmoregulation (the fluid balance across membranes). The extent of potential damages would be dependent on the type of fish raised, the age of the fish, any treatment of the water, and the timing of river water use. This analysis is based on taking water from West Bay. The present plan would have less effects than presented here because water is taken from Pelican Lake.

Recreational and Fish and Wildlife Effects

The U.S. Fish and Wildlife Service (FWS) indicated that there are no specific water quality requirements for their fish hatcheries but that there are several water quality parameters that could adversely affect stream fish. The FWS also indicated that there are no other water sources that they could feasibly use. Those interviewed were concerned that a decline in fisheries productivity would result in lost recreational opportunities that could cost several million dollars.

Stump Lake Overflow Effects on Fishery

Fish can also be affected by high TDS concentrations. River water is used throughout the year by fish hatcheries along the rivers to raise sport fish (northern, walleye, perch, and bluegill) and some non-game species including catfish, sturgeon, and bony-tailed chub. For TDS, a conservative estimate (based on very limited data) of 1,000 mg/L was used to assess potential impacts of the Stump Lake overflow. Data regarding fish tolerance to sulfate was unavailable; therefore threshold levels for sulfate (with respect to fish mortality) were not established.

3. Environmental Resources Section

NEPA PROCESS AND SCOPING

This section of the Report summarizes the issues identified during the scoping process.

The following issues were identified by the Corps through input from public scoping meetings and agencies as significant, requiring evaluation in the Report. Due to supplemental scoping meeting input, social issues were added to this list and biota transfer was identified as a separate issue rather than a component of other issues. The importance of these issues may change as the NEPA process proceeds.

Downstream Water Quality

This issue includes questions about sulfates, total dissolved solids, mercury, and other water quality parameters in the Sheyenne and Red Rivers.

Downstream Water Quantity

This issue includes downstream flooding both with and without storm events, effects on the operation of the fish hatchery at Lake Ashtabula, questions regarding specific water levels at specific locations on the Sheyenne and Red Rivers, and discussions of the application of flood modeling (including the Virtual Flood model) to impact predictions.

Water Quantity in Devils Lake

This issue covers most aspects of the current flooding issue. It includes consideration of future flooding potential, damage to public and private lands and infrastructure, effects on businesses (including those related to recreation), and consideration of low water levels as well as the current high water levels. The effects on the upper Devils Lake basin will also be included here.

Social Issues

This issue includes impacts to neighborhoods, increases in stress and clinical depression due to the rising lake level and project impacts (such as property impacts and cultural and spiritual values), and the evaluation of the potential for impacts to environmental justice communities.

Economic Issues

This issue includes questions about infrastructure impacts (such as sewers, roads, and levees), as well as specific issues around tax base, economic viability of businesses including farms, and the effects on agriculture and other businesses. It also includes treatment of cost-benefit and other standard economic analyses.

Water Users/Water Supply

This issue includes topics concerning irrigators, municipal and industrial water supply, water treatment facilities (capacity, potential need for upgrading and related costs), and issues affecting permitted dischargers, especially downstream.

Downstream Natural Resources

This issue includes potential effects on designated special areas (such as scientific and natural areas, wetlands, wildlife areas, and forests), as well as any threatened or endangered species that may occur in the geographic scope of analysis. This issue will be analyzed due to legal requirements related to Federal threatened and endangered species.

Biota Transfer

This issue includes the potential for the transfer of biota from Devils Lake to the Sheyenne and Red Rivers and the potential for the introduction of invasive species.

Other States and Nations

This issue includes topics such as conformity with the 1909 Boundary Waters Treaty with Canada and certain specific topics of interest to the state of Minnesota. This issue will be analyzed due to legal requirements.

Spirit Lake Tribe

This issue includes numerous legal topics, including a lawsuit regarding the specific boundaries of the Spirit Lake Reservation, as well as the overall issue of sovereignty, the status of tribal Trust resources, the nature and location of any cultural resources (including traditional cultural properties) that might be eligible for the National Register of Historic Places, economics, environmental justice, and impacts on groundwater under the reservation. This issue will be analyzed due to legal requirements and coordination with the Spirit Lake Tribe will continue.

Downstream Erosion and Sedimentation

This issue includes impacts to riverbanks and shorelines on the Sheyenne and Red Rivers, as well as Lake Ashtabula. It involves questions about bank stabilization (mitigation), severity of erosive effects, overbank flooding, elevation of the floodplain, effects on river stage, short- and long-term water level changes, and combined discharges. It is clearly related to downstream water quality and operations.

Operational Issues

This issue includes numerous specific topics, including who pays for the project (construction, maintenance, operations, decommissioning); the nature of operational constraints or conditions (such as water quality standards, ice jams, or storm events); under what circumstances an outlet would "kick in" (elevation or other release triggers, seasonal or other operating windows); design pump capacity and direction of flow; fish entrapment; and notifications and other day-to-day operational parameters. Overall efficiency and effectiveness of the proposed outlet under various conditions are included as well.

Groundwater

This issue includes questions of the relationship of Devils Lake with the Spiritwood Aquifer, including water quality, water quantity, flood levels, and soil salinity. Effects of outlet operation on groundwater levels along the Sheyenne River.

Devils Lake Agriculture

This issue includes topics such as the effects of higher water tables, reduced land base, and soil salinity on agriculture in the Devils Lake basin currently affected by flooding. This issue is closely related to economic issues.

Downstream Agriculture

This issue includes topics such as the effects of higher water tables during outlet operation, potential problems at river crossings during high water, the nature and availability of water for livestock, and potential for bank erosion (related to downstream erosion and sedimentation and groundwater).

Devils Lake Natural Resources

This issue includes potential effects on designated special areas (such as scientific and natural areas, wetlands, wildlife areas, and forests) as well as any threatened or endangered species that may occur in the geographic scope of analysis. This issue will be analyzed due to legal requirements related to Federally threatened or endangered species.

Cultural Resources

This issue includes potential effects on archaeological and historical resources (including traditional cultural properties) that may be eligible for the National Register of Historic Places. This issue will be analyzed due to legal requirements.

Water Quality in Devils Lake

This issue includes sulfates, total dissolved solids, mercury, and other water quality parameters currently affecting the communities surrounding Devils Lake, including business and industry (agriculture and recreation). Water quality in Devils Lake is also related to operational constraints for the proposed outlet and to downstream water quality.

Downstream Aquatic Resources

This issue includes topics related to fishery health, effects on riverbank (riparian) vegetation, Red and Sheyenne River fishery, mussels, and plankton and other nutrients.

Devils Lake Aquatic Resources

This issue includes potential effects on the recreational fishery in Devils Lake, along with water quality, bioaccumulation of mercury, plankton, and other nutrients.

Devils Lake Recreation

This issue includes potential effects on the recreational fishery at Devils Lake, as well as any boating hazards associated with the alternatives.

Downstream Recreation

This issue includes potential effects on the Sheyenne and Red Rivers, as well as Lake Ashtabula, and includes both fishery and boating (summer) recreation and snowmobiling and other winter recreation activities.

<u>Issues to be Summarized or Not Addressed in this EIS</u>

The following issues were identified as not significant, not significantly impacted by the project, or beyond the scope of analysis for this EIS. They would be summarized in the EIS or dismissed as not significant.

Rocketing and Weather Patterns

One written comment was submitted regarding this issue, in which the use of rockets and their possible perturbations on weather patterns was suggested as a cause of the current flooding problems at Devils Lake and elsewhere. Because this is not a potential environmental impact of the Devils Lake Study, it is outside the scope of analysis.

Noise

Noise was not identified as a significant issue.

Air

Air was not identified as a significant issue.

Mineral Resources

Mineral resources were not identified as a significant issue.

Energy Production

Energy production was not identified as a significant issue.

Inlet to Devils Lake

As stated in PL 105-62, this issue is outside the scope of the EIS.

FUTURE ACTIONS

Cultural

A Programmatic Agreement needs to be negotiated between the St. Paul District, Corps of Engineers, the North Dakota State Historic Preservation Officer, the Advisory Council on Historic Preservation, and the Spirit Lake Tribe to cover monitoring and mitigating adverse effects (erosion) to significant cultural resources sites along the banks of the Sheyenne River resulting from operation of the proposed Devils Lake outlet. If other than the Peterson Coulee outlet route is chosen, additional cultural resources survey work of the selected route and testing to determine the National Register of Historic Places eligibility of any cultural resources sites in the area of potential effects will be necessary. All such survey and testing work will need to be coordinated with the North Dakota State Historic Preservation Officer to ensure compliance with Section 106 of the National Historic Preservation Act of 1966, as amended.

Environmental

The final Integrated Report/EIS and Record of Decision are scheduled for 2003. Items yet to be completed include coordination with Canada and determination of compliance with the Boundary Waters Treaty of 1909.

Previous legislation has stated that the project must be "environmentally acceptable" in order to be authorized for construction. The project may be acceptable or unacceptable to a number of agencies, interest groups, or individuals for a variety of reasons. An indication of the acceptability of the project is reflected in the comments received during the scoping process and the anticipated impacts. Based on results to date from the scoping process, it is clear that there will always be significant opposition to an outlet and upper basin storage. Therefore, consensus on environmental acceptability is unlikely. The data provided and views expressed by interested parties will be considered in the Corps' technical evaluation and determination of environmental acceptability.

Early in the scoping process, a number of letters received from various agencies concerning the project. The following are cited as examples. The States of Minnesota, Missouri, Illinois, and Iowa have stated opposition to the project until a full analysis of alternatives is completed. Canada, the Environmental Protection Agency, and the North Dakota Chapter of the Wildlife Society have also stated that alternatives need to be considered. Both Canada and Missouri have expressed serious concerns about the future construction of an inlet to Devils Lake. They feel that the impacts of an inlet should also be included in any project documentation.

Numerous comments were received during the scoping process over the last 3 years. The broad categories of concern include:

a. Landowner concerns cover a wide range of topics including flooding, water quality, water quantity, water use, livestock, erosion, septic systems, health, economics, and evaluation of alternatives including outlet location, upper basin storage, effectiveness of outlet, and benefit-cost ratio.

b. The public opinion around the lake is that something has to be done and done now. The majority of the lake area residents feel that an east end outlet is the best alternative, and that water quality, erosion, aquatic resources, and other problems can be addressed later.

c. Many downstream interests expressed concern with potential significant problems associated with the outlet. They felt that more solutions should be implemented within the Devils Lake basin and not just transferred downstream.

The comments to date indicate that there is no consensus on the need, justification, or effectiveness of the outlet. Significant concerns and issues have been identified with the study and various alternatives. There are significant concerns related to an outlet and the evaluation of its effects. At this time environmental acceptability cannot be determined. The Corps will continue coordination with State, Federal and local agencies, and continue to solicit public comment. The Corps will recommend a plan that addresses environmental acceptability based upon the Corps' evaluation of the overall public interest.

U. S. Fish And Wildlife Service Coordination

The U.S. Fish and Wildlife Service prepared a Coordination Act Report for the Devils Lake Study in compliance with the Fish and Wildlife Coordination Act. The full text of the Coordination Act Report prepared by the Service is reproduced in Volume 1 of the Integrated Report/EIS (see Appendix 1, Coordination Act Report, in Volume 1 for more details on the Service's assessment of existing conditions, impacts, and recommendations). Some project features will require additional coordination with the Service to determine Compatibility under the Refuge Administration Act.

4. Mitigation of Environmental Effects

Construction and operation of an outlet from Devils Lake would require the development and implementation of a mitigation plan to alleviate adverse effects. General geographic areas of potential impact would be: Devils Lake, the Outlet Route, the Sheyenne River, Lake Ashtabula, and the Red River. Investigations to date indicate the greatest potential for significant adverse impacts to natural resources, cultural resources, and downstream water users are associated primarily with increased flows and water quality changes on the Sheyenne River. While detailed studies may identify some impacts in and around Devils Lake or along the Red River, it appears that these impacts may be of such minor magnitude or probability of occurrence, when compared to impacts along the Sheyenne River, as to constitute only a minor percentage of overall mitigation costs. Mitigation for the alternatives is described in the main report. Mitigation sites may be modified based on additional analysis or real estate concerns.

A part of the study, potential mitigation features and monitoring procedures were developed. A summary of these findings are presented below. Alternatives and potential features were developed by Peterson Environmental Consulting in their report "Devils Lake Flood Control Project, 300 cfs Outlet Alternative Interim Mitigation Plan". *Possible monitoring protocols and rapid response plans were developed and potential mitigation areas identified. These can be used as a starting point to develop procedures to follow. Further agency coordination would be needed to finalize any plans. The following is an indication of some of the features that could be considered in the development of a final plan.*

The Pelican Lake constrained outlet alternative would capture water from Pelican Lake before it enters Devils Lake proper and convey this water via open channel and pipeline to a discharge point 22 miles to the south on the Sheyenne River. Operation of the outlet would be limited to a 7-month period (May 1 through November 30) and would also be constrained by bankfull capacity of the Sheyenne River at the point of insertion (600 cfs) and by the sulfate constraint for the Sheyenne River (300 mg/l). Outlet operation would be curtailed or halted if the flow magnitude or water quality criteria were exceeded by blended waters in the Sheyenne River below the point of insertion. The target drawdown elevation is currently 1443 feet.

In spite of avoidance and minimization measures incorporated into the Pelican Lake 300 cfs outlet plan, construction and operation of the outlet could result in changes to the environment in and along the outlet route and in the Sheyenne and Red rivers downstream of the discharge point. The Corps contracted analyses prepared as part of the EIS process have identified a variety of potential environmental impacts based on the Pelican lake outlet operating plan. This mitigation and monitoring analysis supports the EIS and planning process by:

- describing mechanisms to avoid adverse effects of outlet operation to the extent possible,
- minimizing impacts where they are unavoidable,
- mitigating the remaining impacts to the greatest practical extent, and
- tracking the effects of the project and mitigation with a monitoring program.

There are identified changes to terrestrial habitat affects due to changes in groundwater levels. These effects could include changes in species composition and wildlife use. The acres of natural habitat within the flooded area outline (similar to zone of groundwater influence) are distributed as follows above and below Baldhill Dam.

Cover Type	Above Baldhill Dam	Below Baldhill Dam
Woodland	1,273	199
Grassland	2,385	84
Wetland	1,658	433
Total	5,316	716

Potential Mitigation and Monitoring Features

The potential monitoring and mitigation program outlined in this document involves a phased approach. Existing physical and biological conditions along the Sheyenne River as described in previous project studies would be verified and refined during the initial implementation phase through additional surveys. Where impacts are fairly certain to result from the proposed outlet, mitigation measures have been proposed to directly address impacts or to indirectly improve conditions through restorative means. The final phase of implementation rely heavily on monitoring designed to provide data that can be used to identify changes in baseline conditions, to evaluate the effectiveness of implemented mitigation measures, and to identify unexpected conditions.

The entire set of potential activities and alternatives outlined in this analysis includes:

Phase I: Baseline Condition Verification

- Rare species survey along Dry Lake Diversion and outlet corridor route.
- Cultural resources survey along Dry Lake Diversion and outlet corridor route.
- Aquatic habitat mapping in the Sheyenne River
- Vegetation survey in the 6000-acre area of potential impact.
- Phase I cultural resources survey and (one additional cultural resource site is included in the bank stabilization for erosion control) Phase II evaluations in the 6000-acre area of potential impact.

Phase II: Mitigation Measures

- Best Management practices to minimize WQ impacts and erosion during construction
- Adjust pipeline alignment during construction to avoid construction in wetlands to extent practicable
- Buried pipeline avoids potential induced drainage affects to wetlands adjacent to alignment and minimizes affects where alignment intersects wetlands
- Buried pipeline avoids long term impacts to land owners along alignment
- Drawing water from Pelican Lake minimizes affects to the extent practicable
- 300 mg/l WQ constraint and 600 cfs constraint minimizes impacts on Sheyenne River and Red River related to WQ and flooding to the extent

- Bank stabilization at 23 sites in high gradient areas near the discharge and below Bald Hill dam for erosion control.
- Acquisition (fee or easement) and management of 133 acres near the discharge point to reduce sediment loading.
- Bank stabilization at 53 sites (one additional cultural resource site is included in the bank stabilization for erosion control) in order to protect known cultural resources.
- Soil/water compatibility assessment for potentially affected irrigators without one or without one of sufficient detail.
- Excavation of nine diversion channels to protect instream aquatic habitat by maintaining existing flow levels in associated river reaches.
- Selection of six thousand acres of land for mitigating vegetation impacts from a potential pool of approximately 8000 acres.
- Ramping flows during operation to minimize flow effects on aquatic resources
- Mussel relocation during project operation and restocking
- Installation of a sand filter at pumping station to minimize, to the extent practicable, transfer of biota from Devils Lake
- Extensive Monitoring and Rapid Response protocol for biota of concern
- Riprap at low-head dams for safety concerns
- Increased collection/analysis of fish on the Sheyenne River for mercury and modification of consumption advisories if warranted
- Modifications at Lake Alice (sub-impoundments, levees, control modifications) to maintain management capabilities with increases and payments to FWS for increased operation costs
- Management of Lake Ashtabula water levels during the period of outlet operation to protect existing operation of the Valley City Fish Hatchery.
- Initiation of additional chemical treatment of water by downstream municipal and industrial water users during outlet operation.
- Assistance to farmers including provision of salt-tolerant crops, soil amendments, and compensation for lost crop yields.
- Purchase of affected farmland if other mitigation efforts are unsuccessful.

<u>Phase III: Monitoring</u>

- Collection of data for dissolved oxygen, conductivity, temperature, salinity, turbidity, chloride, and total dissolved solids at 15 locations in the outlet channel, the Sheyenne River, and the Red River of the North.
- Collection of phosphorus data from three locations in the Sheyenne River 3 times a year.
- Distribution of water quality data to all interested parties through a web-based server and dial in telephone system.
- Collection and review of aerial photography every five years to evaluate changes in river morphology.
- Yearly population surveys of known rare plant sites in the area of potential impact.
- Establishment of approximately 30 sites distributed proportionally in each of the general vegetative communities in the area of potential effect and collection of data yearly during the period of operation to track changes in vegetative community composition.

- Collection of fish in three locations in the Sheyenne River and testing for mercury levels.
- Sampling of soil chemistry along 16 transects in each of six soil associations the area of potential impact.
- Sampling of groundwater chemistry at four locations in the area of potential impact.
- Determination and tracking of soil salinity levels along 20 transects in cropped and hayed areas highly susceptible to adverse salinization impacts.
- Tracking of crop yields on lands in the area of potential effect with high salinization hazards.
- Collection of aquatic habitat and community data at 18 locations along the Sheyenne River.
- Monthly sampling during the pumping season for potentially invasive biota in Pelican Lake and the upper Sheyenne River.
- Yearly surveys of cultural resource sites in the area of potential impact, using canoe and foot-based inventories in alternating years.
- Yearly evaluation of Valley City Fish Hatchery infrastructure.

The overall goal of the proposal is, at a minimum to maintain the ecological integrity of the Sheyenne River and its riparian corridor during outlet operation to the extent feasible. Where ecological integrity cannot be fully maintained, the goal is to preserve all components of the system in such quantities and locations that would allow rapid recolonization and recovery after the diversion of Devils Lake water ceases. Post operation restoration may be necessary in some locations and the need for such would be identified by the monitoring program. The activities for such restoration can not be identified until the monitoring is completed. Cost for total restoration could be millions of dollars.

The various protocols presented in this proposal are potential approaches. However, the actual monitoring, mitigation, and restoration activities that would be implemented, and the locations for implementation, would be dependent upon further agency coordination with interested parties and the availability of funding.

Potential Implementation Plan

This section describes a potential mitigation and monitoring plan that could be instituted before, during, and after project operation. This section provides a framework for the monitoring process which would need to be refined by field verification and coordination with the operating committee and natural resource agencies involved.

Installation of mitigation measures prior to discharge is the only way that effects of the project can be avoided and minimized to the greatest feasible extent. Therefore, successful implementation of a mitigation and monitoring program requires that proposed mitigation measures be installed prior to the initiation of outlet operation. To meet this need, the following implementation approach is suggested to acquire access, perform final inventories and mapping, design and construct mitigation measures, establish monitoring sites, and collect additional baseline data before pumping begins. Monitoring data would then be collected during the pumping period to identify changes in baseline conditions, evaluate the effectiveness of mitigation measures, and identify unexpected conditions.

Implementation of various mitigation and monitoring activities could occur in three phases. Phase I would include verification of baseline conditions to ensure appropriate siting of mitigation and monitoring measures. Phase II would include final identification, design, and implementation of mitigation measures and the setup of monitoring stations. Phase III would include ongoing collection of monitoring data and reporting to interested parties, as well as any further mitigation measures needed during or after the pumping period.

Implementation of tasks would occur sequentially when: 1) subsequent activities were dependent upon completion of another activity, or 2) when a particular activity must occur at a given time of year. Otherwise activities would run concurrently. The proposed implementation schedule is based on certain assumptions:

- project approval and funding appropriation would occur in year 1 so that work on the project could begin on or around January 1 of year 2,
- the 6000-acre area of potential impact would be accessible for survey activities by the Spring of year 2,
- access to all the proposed erosion mitigation sites, cultural resource mitigation sites, and diversion channels sites would be available no later than 18 months prior to the initiation of discharge, and
- it would take three years from project approval until the outlet begins operation.

The various activities necessary to implement the mitigation and monitoring proposal are discussed below, organized by the year that the task would be initiated. The estimated duration for each activity is identified during the season when a task would be initiated and is considered to be the minimum amount of time required.

<u>Spring Year 1</u>

- Project approved and funding appropriation made.

<u>Winter Year 2</u>

- Landowner contact and negotiation of approval for botanical and cultural resource survey access to lands along the outlet corridor and lands potentially affected by discharges (duration 4 months).
- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (duration two years).
- Initiation of water users group to facilitate exchange of information and feedback from interested parties (ongoing for duration of project).

<u>Spring Year 2</u>

- Landowner contact and negotiation of approval for botanical and cultural resource survey access to lands along the outlet corridor and lands potentially affected by discharges (continued).
- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (continued).

- Phase I cultural resources survey along Dry Lake Diversion and outlet corridor route (duration 1 month).
- Late spring vegetation survey in the 6000-acre area of potential impacts (duration 1 month).
- Baseline monitoring: macroinvertebrates and algae (May)
- Phase I cultural resources survey in the 6000-acre area of potential impact (duration 3 months).
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail. This task would continue until complete, probably over the course of 18 months.

Summer Year 2

- Baseline monitoring: fish, mussels, aquatic macrophytes (July): and macroinvertebrates and algae (August)
- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction.
- Survey of known Natural Heritage sites identified in the area of potential effect to evaluate the need for mitigation/monitoring (duration 3 weeks).
- Late summer vegetation survey in the 6000-acre area of potential impacts (duration 1 month).
- Phase I cultural resources survey in the 6000-acre area of potential impact (continued).
- Aquatic habitat mapping in the Sheyenne River (duration 1 month), followed by assessment of proposed sites for habitat mitigation to ensure their suitability. Revise mitigation site location if necessary.
- Evaluation of erosion mitigation sites, cultural resource mitigation sites, and diversion channel locations following negotiation of access (duration 1 year).
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued)

Fall Year 2

- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (continued).
- Phase I cultural resources survey in the 6000-acre area of potential impact (continued).
- Evaluation of erosion mitigation sites, cultural resource mitigation sites, and diversion channel locations following negotiation of access (continued).
- Development of erosion mitigation, cultural resource mitigation, and diversion channel engineering designs and application for necessary permits (duration 14 months).
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued)

Winter Year 3

- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (continued).
- Evaluate erosion mitigation sites, cultural resource mitigation sites, and diversion channel locations following negotiation of access (continued).
- Development of erosion mitigation, cultural resource mitigation, and diversion channel engineering designs and application for necessary permits (continued).
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued).
- Contract for erosion buffer construction advertised.

<u>Spring Year 3</u>

- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (continued).
- Evaluation of erosion mitigation sites, cultural resource mitigation sites, and diversion channel locations following negotiation of access (continued).
- Development of erosion mitigation, cultural resource mitigation, and diversion channel engineering designs and application for necessary permits (continued).
- Phase II evaluation of sites identified as warranting such during the Phase I study (duration 12 months).
- Baseline monitoring: macroinvertebrates and algae (May)
- Construction oversight of erosion mitigation sites, cultural resource mitigation sites, and diversion channels (duration 18 months)
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued).
- Let contract for erosion buffer construction.

<u>Summer Year 3</u>

- Landowner contact and negotiation for fee or easement acquisition for vegetation and erosion mitigation lands, erosion and cultural resource mitigation construction, and diversion channel construction (continued).
- Evaluation of erosion mitigation sites, cultural resource mitigation sites, and diversion channel locations following negotiation of access (continued).
- Development of erosion mitigation, cultural resource mitigation, and diversion channel engineering designs and application for necessary permits (continued).
- Phase II evaluation of sites identified as warranting such during the Phase I study (duration 12 months).
- Baseline monitoring: fish, mussels, aquatic macrophytes (July): and macroinvertebrates and algae (August)
- Construction oversight of erosion mitigation sites, cultural resource mitigation sites, and diversion channels (continued)
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued).
- Construct erosion buffer (duration 6 weeks).

Fall Year 3

- Develop erosion mitigation, cultural resource mitigation, and diversion channel engineering designs (continued).
- Phase II evaluation of sites identified as warranting such during the Phase I study (duration 12 months).
- Completion of soil/water compatibility assessments for potentially affected irrigators without one or without one of sufficient detail (continued).
- Let contract for construction of bank erosion and cultural resource mitigation.
- Let contract for construction of diversion channels.

Winter Year 4

- Phase II evaluation of sites identified as warranting such during the Phase I study (duration 12 months).
- Let construction contracts for erosion mitigation sites, cultural resource mitigation sites, and diversion channels with completed engineering designs (continued).
- Creation of web site system for distribution of water quality data (duration 1 month).

Spring Year 4

- Establish groundwater and soil salinity monitoring transects (duration 1 month).
- Finalize set of vegetation mitigation lands, establish monitoring transects, and collect late spring baseline vegetation data (duration 6 weeks).
- Construction oversight of erosion mitigation sites, cultural resource mitigation sites, and diversion channels (continued).
- Installation of water quality monitoring stations and base station set up, connection to web site (duration 1 month).
- Begin collection and web site distribution of water quality data (ongoing for duration of project).
- Baseline monitoring: macroinvertebrates and algae (May)
- Evaluate success of erosion buffer; modify as necessary (duration 3 weeks).

Summer Year 4

- Groundwater and soil salinity baseline data collected (duration 4 weeks)
- Construction oversight of erosion mitigation sites, cultural resource mitigation sites, and diversion channels (continued).
- Collection and web site distribution of water quality data (ongoing for duration of project).
- Baseline monitoring: fish, mussels, aquatic macrophytes (July): and macroinvertebrates and algae (August)

Fall Year 4

- Construction oversight of erosion mitigation sites, cultural resource mitigation sites, and diversion channels (continued).
- Identify areas to track agriculture effects due to groundwater and collect baseline data (duration 4 weeks)
- Collect fall baseline vegetation data (duration 4 weeks).
- Twenty-one erosion transects selected and baseline data collected (duration 4 weeks).

- Fly erosion study baseline aerial photography scan it to digital format (duration 1 month).
- Collection and web site distribution of water quality data (ongoing for duration of project).

Winter Year 5

- Collection and web site distribution of water quality data (ongoing for duration of project).

Spring Year 6

- Outlet ready for operation and discharges begin.
- Remaining monitoring programs commence

Following initiation of discharge, monitoring could occur according to the schedule shown in Table C-29. This table provides a framework for the development of a formal monitoring plan. Details of a possible monitoring plan for each monitoring activity is provided in Peterson Environmental Consulting report on Mitigation and Monitoring. The final monitoring protocol would have to be developed in cooperation with the operating committee that would be formed to oversee the mitigation and monitoring process.

Table C-29. Suggested monitoring elements for the Pelican Lake 300 cfs constrained outlet to control flooding in Devils Lake North Dakota.

Monitoring Activity	Schedule
Collection of data for dissolved oxygen, conductivity, temperature, salinity, turbidity, chloride, and total dissolved solids	Logged every half hour at 15 locations including the outlet channel, the Sheyenne River, and the Red River of the North.
Collection of phosphorus data from three locations in the Sheyenne River.	Four times a year
Collection of fish in three locations in the Sheyenne River and testing for mercury levels.	Yearly
Distribution of water quality data to all interested parties through a web-based server and dial in telephone system.	Data would be downloaded for distribution every six hours, year round, for the duration of the project.
Resurveying 21 historic transects to examine erosion patterns.	Before and after the yearly period of discharge. The year before discharges begin, once a year for the first five years, then every other year thereafter.
Collection and review of aerial photography to evaluate changes in river morphology.	The year before discharges begin, then once every five years.
Population surveys of known rare plant sites in the area of potential impact.	Yearly
Establishment of approximately 30 sites distributed proportionally in each of the general vegetative communities in the area of potential effect and collection of data during the period of operation to track changes in vegetative community composition.	Yearly in late spring and late summer. Every year for the first five years then every other year thereafter.

Sampling of groundwater chemistry at four locations in the area of potential impact.	Once Yearly
Determination and tracking of soil salinity levels along 20 transects in cropped and hayed areas highly susceptible to adverse salinization impacts.	3 Times per year
Tracking of crop yields on lands in the area of potential effect with high salinization hazards.	3 Times per year
Collection of aquatic habitat data at 18 locations along the Sheyenne River and in habitat mitigation reaches.	Yearly for first 5 years. Biannually for remainder of pumping period. Yearly for first 5 years post-pumping.
Collection of fish, mussel, and aq. macrophyte data at 18 locations along the Sheyenne River and in habitat mitigation reaches.	Yearly for first 5 years. Biannually for remainder of pumping period. Yearly for first 5 years post-pumping.
Collection of aq. macroinvertebrate and algae data at 18 locations along the Sheyenne River and in habitat mitigation reaches.	Twice yearly for first 5 years. Twice bi-annually for remainder of pumping period. Twice yearly for first 5 years post-pumping.
Sampling for potentially invasive biota in Pelican Lake and open channel portion of outlet.	Every year of pumping and 3 years post-pumping: Monthly during the 7-month pumping season
Surveillance for transferred biota and other invasive species in Sheyenne River.	Ongoing during all biota sampling efforts.
Surveys of cultural resource sites in the area of potential impact.	Yearly, using canoe and foot-based inventories in alternating years.
Evaluation of Valley City Fish Hatchery infrastructure.	Yearly

Rapid Response Plans

Rapid response plans are also needed in case an invasive or undesirable species is introduced or becomes established in downstream areas. Additional details concerning possible response procedures can be found earlier in this Appendix under Biota Transfer Risk Analysis and in the Engineering Research and Development Center's report on early detection and rapid response. The development of the final response plan would require the coordinated effort of many natural resource agencies and the operating committee and may depend on the species found and its distribution.

FISH AND INVERTEBRATES

If an invasive fish species is identified, a rapid eradication program could be implemented using fish toxicants. Other than complete dewatering, fish toxicants are the only method that can be used in large areas with 100% lethal effects. However, fish toxicants are non-selective, so all species (native and invasive) in the treated area will be eradicated.

The re-regulation reservoir is designed to rapidly eradicate invasive fish before dispersing further downstream. Fish toxicants can also be applied to the two additional monitoring sites, but incidental fish kills may increase. A downstream block net of ¼ inch mesh may be required at some sites to collect dead fish. It's likely that attempted eradication in other areas of the Sheyenne and Red Rivers would result in major fish kills with a low probability of contact with the invasive species.

Eradication is not a practical, effective, or even acceptable response to a fish introduction. The sand filter is the best approach to addressing biota transfer and should prevent any species being introduced from Devils Lake. If the monitoring identifies the presence of a new or invasive species downstream, the outlet should be turned off until an appropriate action can be developed by the operating committee.

The proposed sand filter system is sufficient to control interbasin transfer any life stages of fish, zebra mussels, spiny water fleas, or crayfish from Devils Lake to the Sheyenne River.

PLANTS

Once a plant species of concern has been identified (either in Devils Lake or the Red River Basin), a management response plan should be implemented. Management options will vary depending on the plant species and the size and locale of the infestation. With respect to this project, the objectives for managing the listed plants of concern are as follows:

1. Eradication if infestations are recent and small (< 100 plants)
2. Containment or control if plants are well-established and populations are large in size (>100 plants).

1. Eradication: If the infestation is defined as recent (first year of growth with no propagule bank) and is small in size (less than 100 plants; isolated stems), the management objective should be eradication. This can be achieved by mechanical methods such as hand-pulling, hand-hoeing, raking or digging. Hand removal of vegetation is labor intensive and time consuming but the advantages are that it is a selective control method and that it can be very effective if done properly. For effective hand removal of nuisance plants, these guidelines must be followed:

- Remove as much as the root system as possible. Complete removal of the root system is required because broken roots may sprout new plants.
- Do not let plants reproduce. Manually remove plants before they flower and set seed.
- Remove and dispose all plant materials (roots, stems, flower stalks) from the infected site. Most of the plant species on our list can regrow from root and stem pieces left behind.
- Follow-up monitoring is necessary. Sites where plants have been removed should be mapped and monitored monthly during the growing season for potential regrowth.

2. Containment and Control: If the infestation is well-established (present for more than one growing season; propagule bank present) and large in size (> 100 plants), the management objective should be "containment." Selecting the most effective control method is site and species specific. Many factors should be considered including: plant growth stage,

environmental factors (soil type, temperature, water quality, erosion potential, etc.), herbicide use restrictions, the presence of sensitive plants or animals, irrigation or potable water issues, economics, site accessibility to list a few.

Potential Mitigation and Monitoring Sites

The following mitigation and monitoring area maps show the locations of the potential mitigation and monitoring sites. Figures MA-1 and MA-2 are overall maps of the Sheyenne River showing sampling locations, erosion protection sites, cultural protection sites, and aquatic mitigation restoration sites. Figures A-2 through A-13 are more detailed location maps. Figures MA-3 and MA-4 show the erosion protection sites downstream of the insertion point and Baldhill Dam. Figure MA-5 is one example of the nine aquatic mitigation high flow by-pass channels. These identify potential sites that could be modified based on additional evaluation.

Legend for Biotic and Soil Mitigation and Monitoring (Figures MA-2 and A2 through A13)

- USGS Well Locations
- Natural Heritage Plant Community Locations
- Natural Heritage Plant Species Locations
- Mercury Monitoring Sites
- Water Quality Monitoring Locations
- Macro-invertebrate Monitoring Sites
- Habitat Monitoring Transect Locations
- EM-38 Monitoring Locations
- Alluvial Soils Test Sites
- Grassland Monitoring Locations
- Wetland Monitoring Locations
- Woodland Monitoring Locations
- Sheyenne River Centerline
- Devils Lake Overflow Alignment
- Vegetation Communities Mitigation Sites
- Aquatic Habitat Protection Areas
- Aquatic Habitat Protection Diversion Channels

Legend for Archaeological and Cultural Sites and Erosion Mitigation Projects (Figure MA-1)

- **Archaeological Mitigation Sites**
- **Cultural Survey and Monitoring Sites (Hemisphere Report)**
- **Cultural Survey and Monitoring Sties (106 Group Report)**
- **Proposed Bank Stabilization Projects**
- **Proposed 30 Meter Vegetated Buffer**
- **Sheyenne River**
- **Proposed Devils Lake Overflow Alignment**

Legend for Habitat Diversion Channel (Figure MA-5)

- **Sheyenne River Aquatic Habitat Protection Zone**
- **Proposed Diversion Channel**
- **Sheyenne Centerline**
- **Vegetation Mitigation Area**
- **HEC 1000cfs uppersheyenne2.shp**

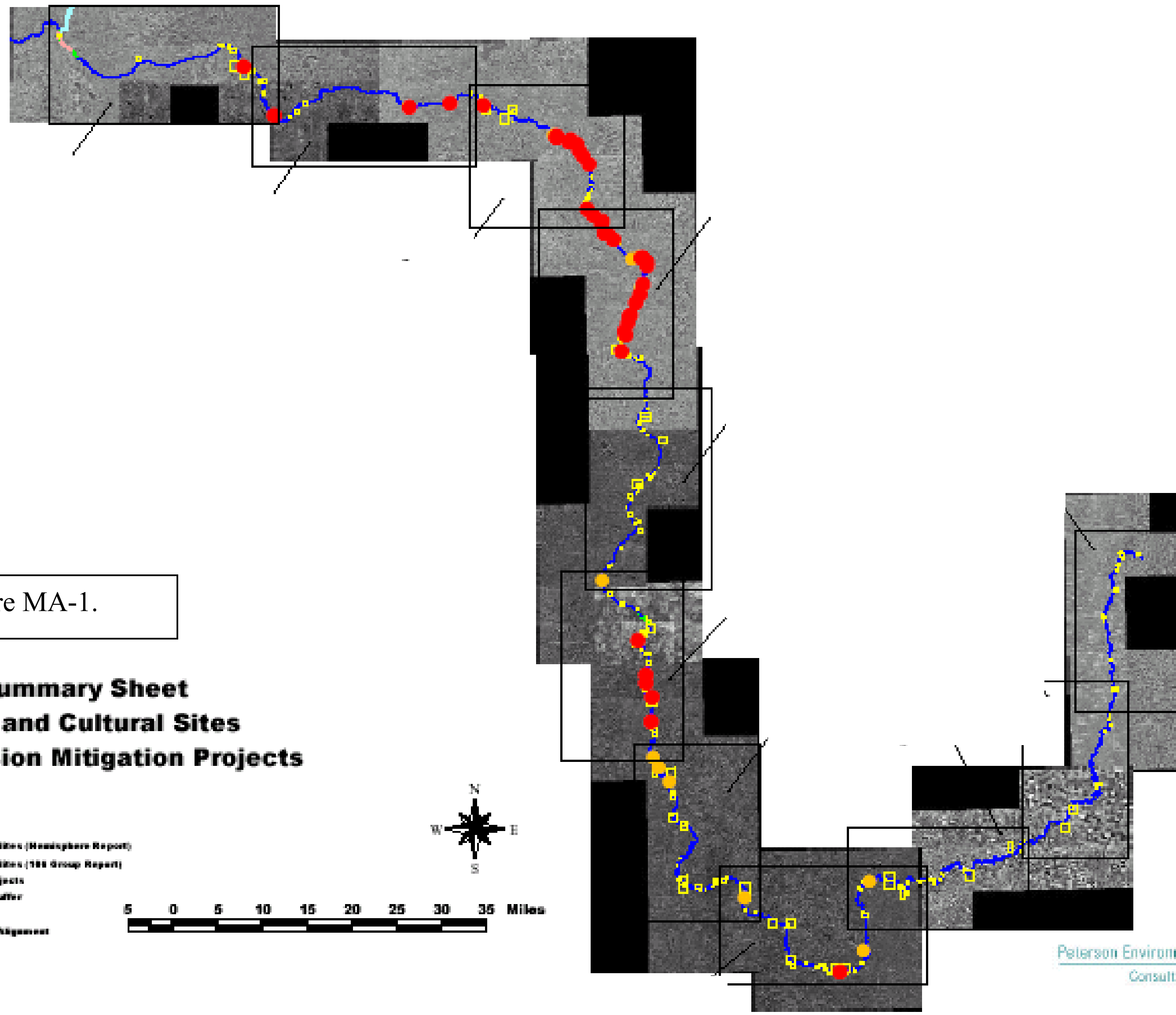

Figure MA-1.

Summary Sheet
Archeological and Cultural Sites
Erosion Mitigation Projects

- Archeological Mitigation Sites
- Cultural Survey and Monitoring Sites (Hemisphere Report)
- Cultural Survey and Monitoring Sites ([illegible] Group Report)
- Proposed Bank Stabilization Projects
- Proposed [illegible] Meter Vegetated Buffer
- Sheyenne River
- Proposed Devils Lake Overflow Alignment

N W E S

5 0 5 10 15 20 25 30 35 Miles

Peterson Environmental Consulting, Inc.

Figure MA-2.


Figure A2
Figure A3
Figure A4
Figure A5
Figure A6
Figure A7
Figure A8
Figure A9
Figure A10
Figure A11
Figure A12
Figure A13
Overview Map
Biotic and Soil
Mitigation and Monitoring
USGS Well Locations
Natural Heritage Plant Community Locations
Natural Heritage Plant Species Locations
Mercury Monitoring Sites
Water Quality Monitoring Locations
Macroinvertebrate Monitoring Sites
Habitat Monitoring Transect Locations
Alluvial Soils Test Site
Grassland Monitoring Locations
Wetland Monitoring Locations
Woodland Monitoring Locations
Sheyenne River Centerline
Devil's Lake Overflow Alignment
Vegetation Communities Mitigation Sites
Aquatic Habitat Protection Area
Aquatic Habitat Protection Diversion Channels
N
W
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S
5 0 5 10 15 20 25 30 35 Miles
Peterson Environmental Consulting, Inc.

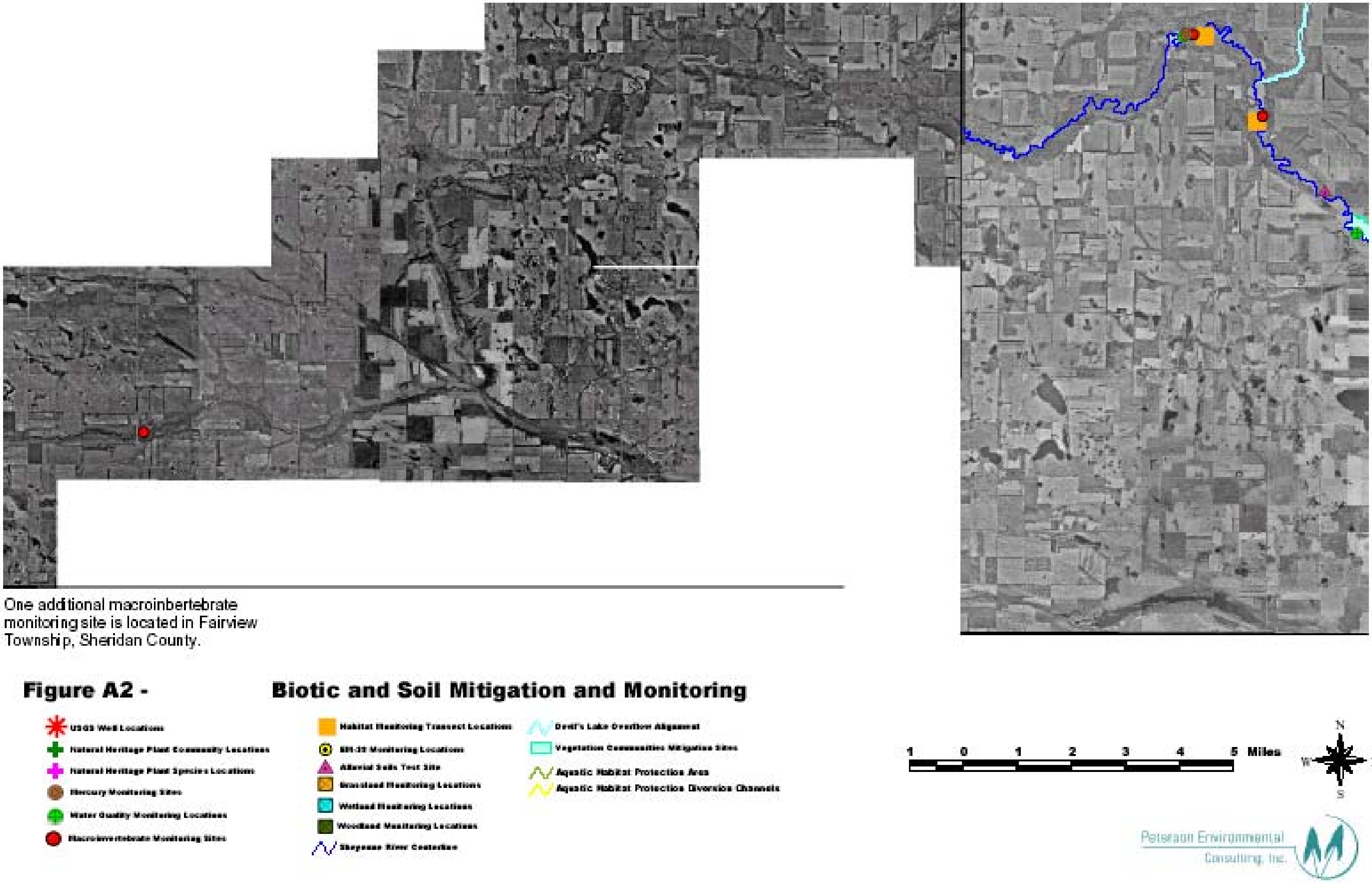


Figure A2 - Biotic and Soil Mitigation and Monitoring

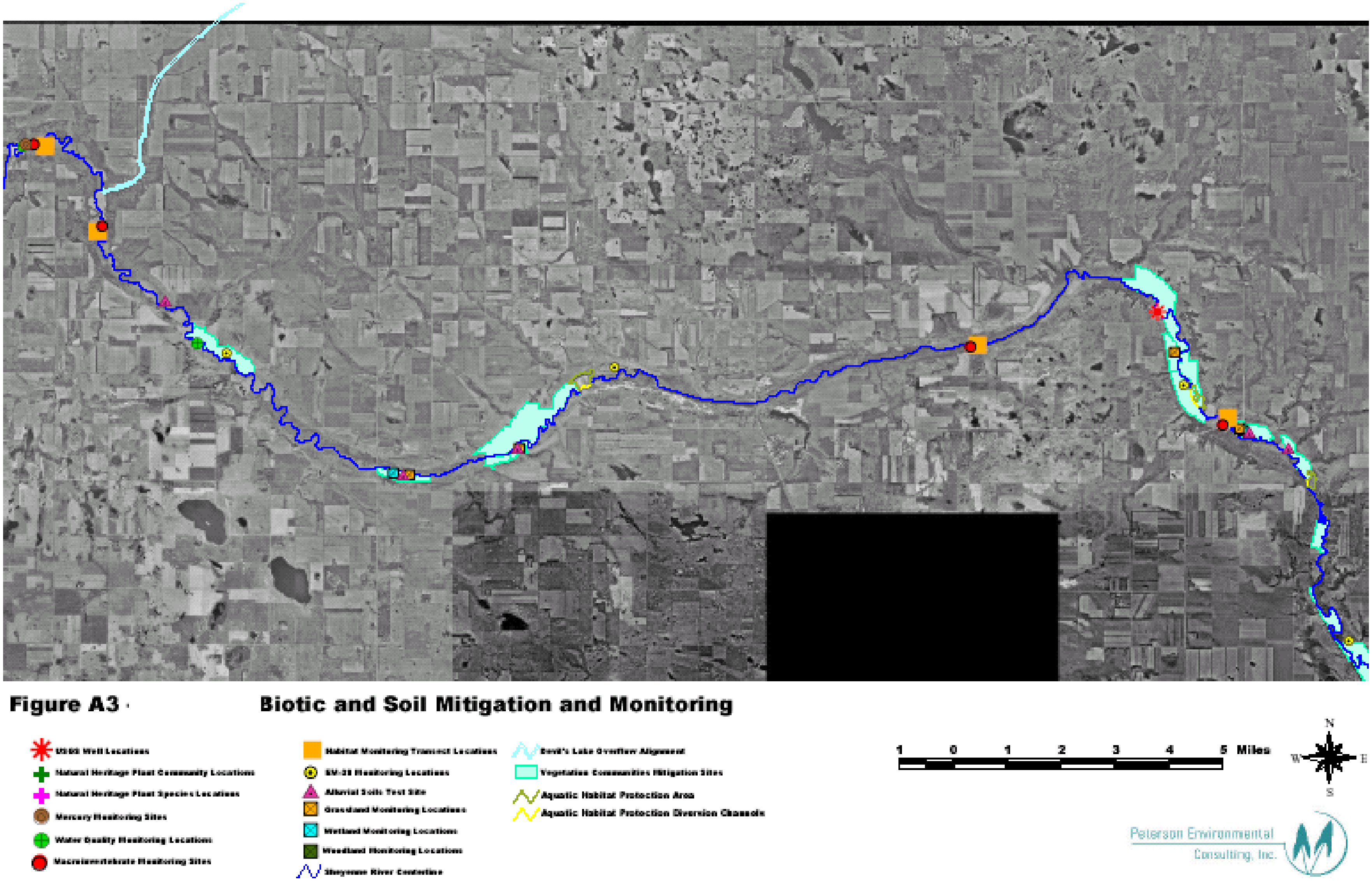


Figure A3 Biotic and Soil Mitigation and Monitoring

Peterson Environmental Consulting, Inc.

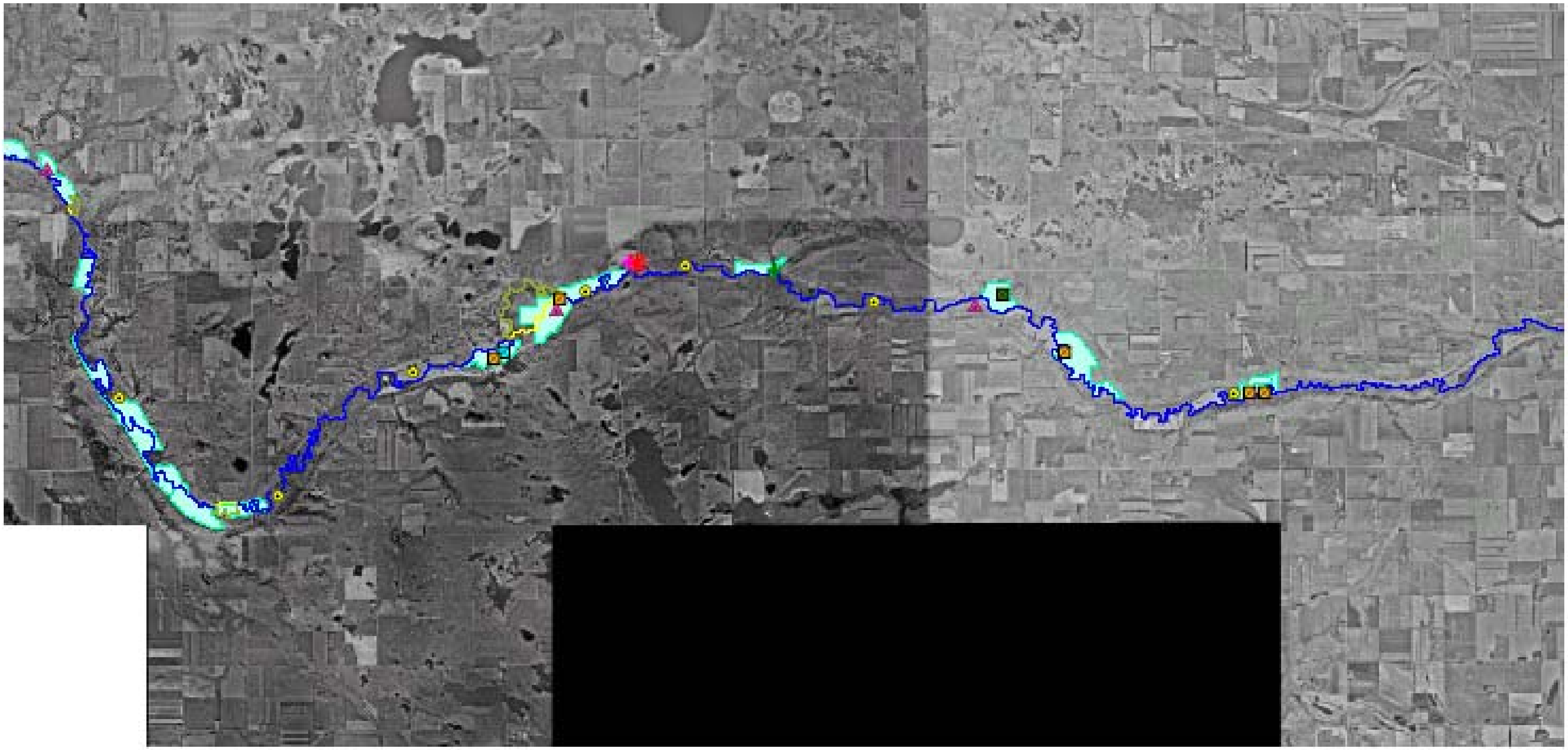
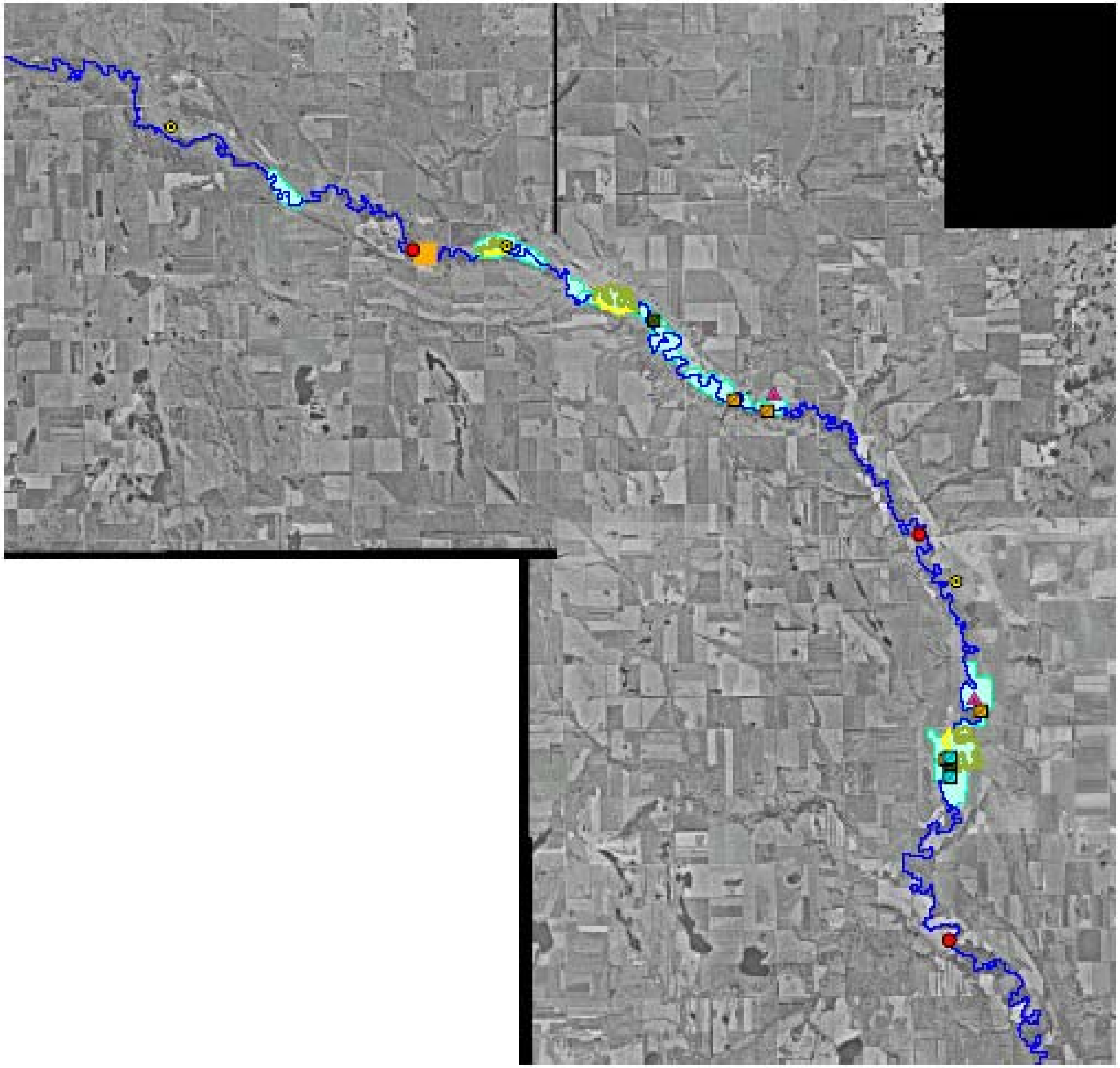
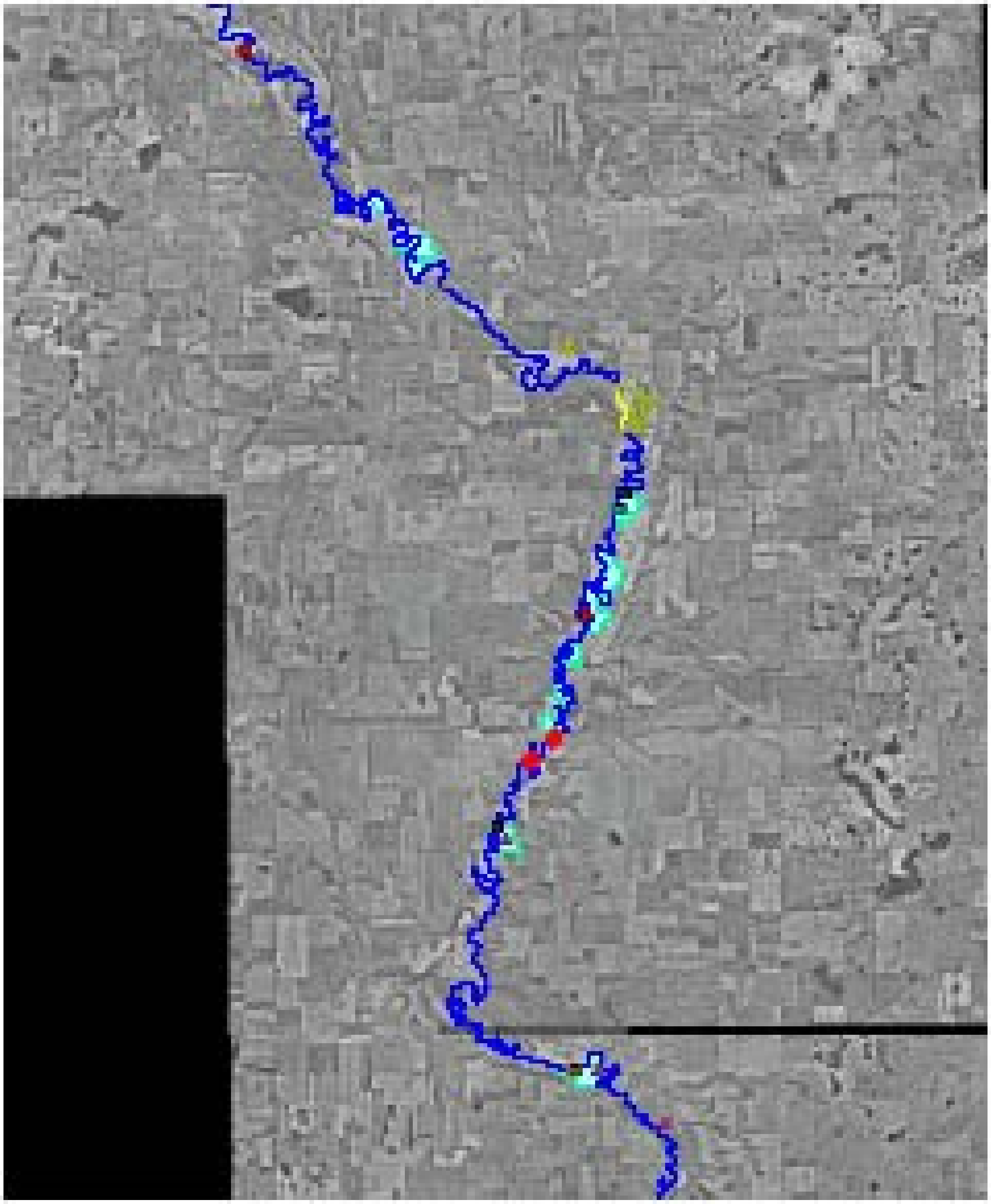


Figure A4 - l Biotic and Soil Mitigation and Monitoring

Figure A5 - Biotic and Soil Mitigation and Monitoring





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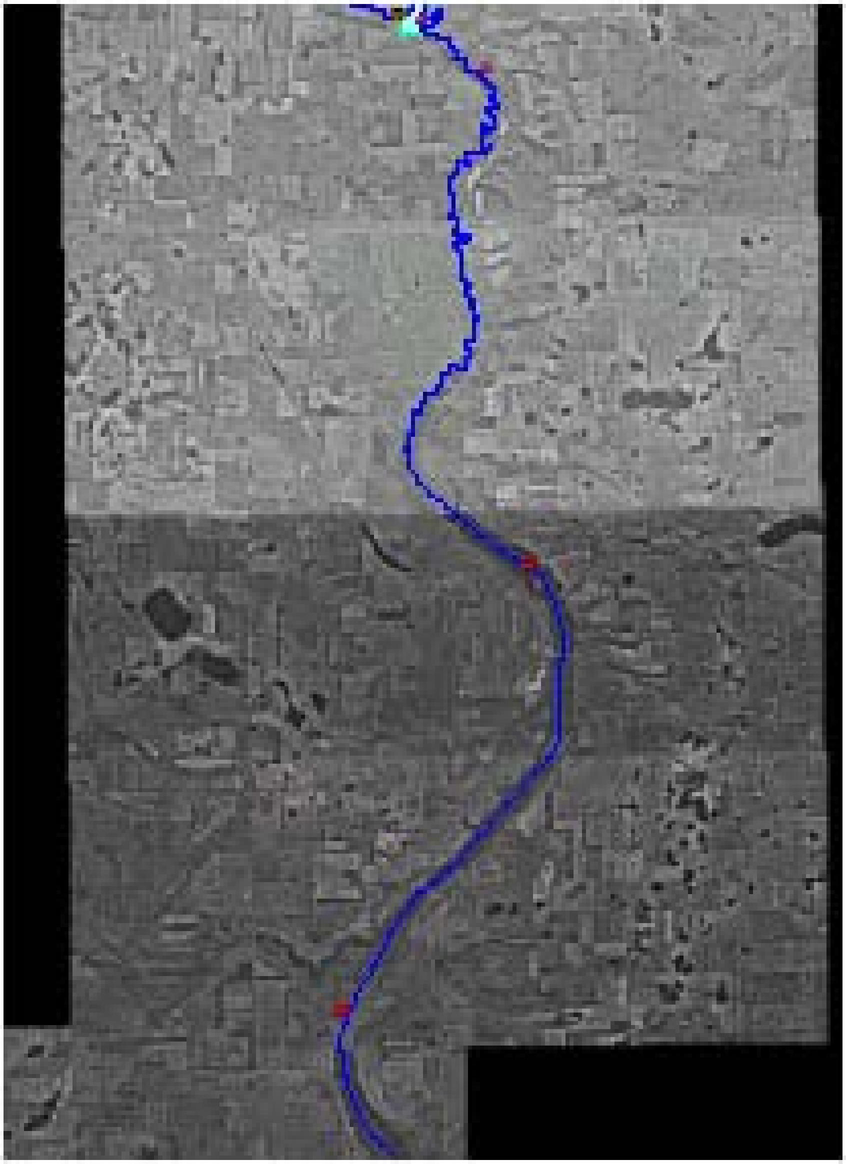
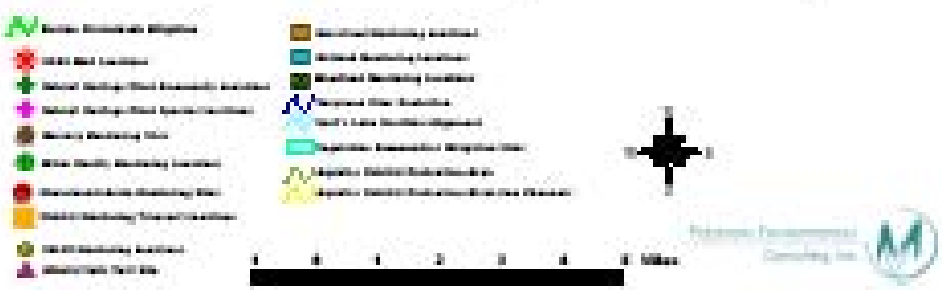
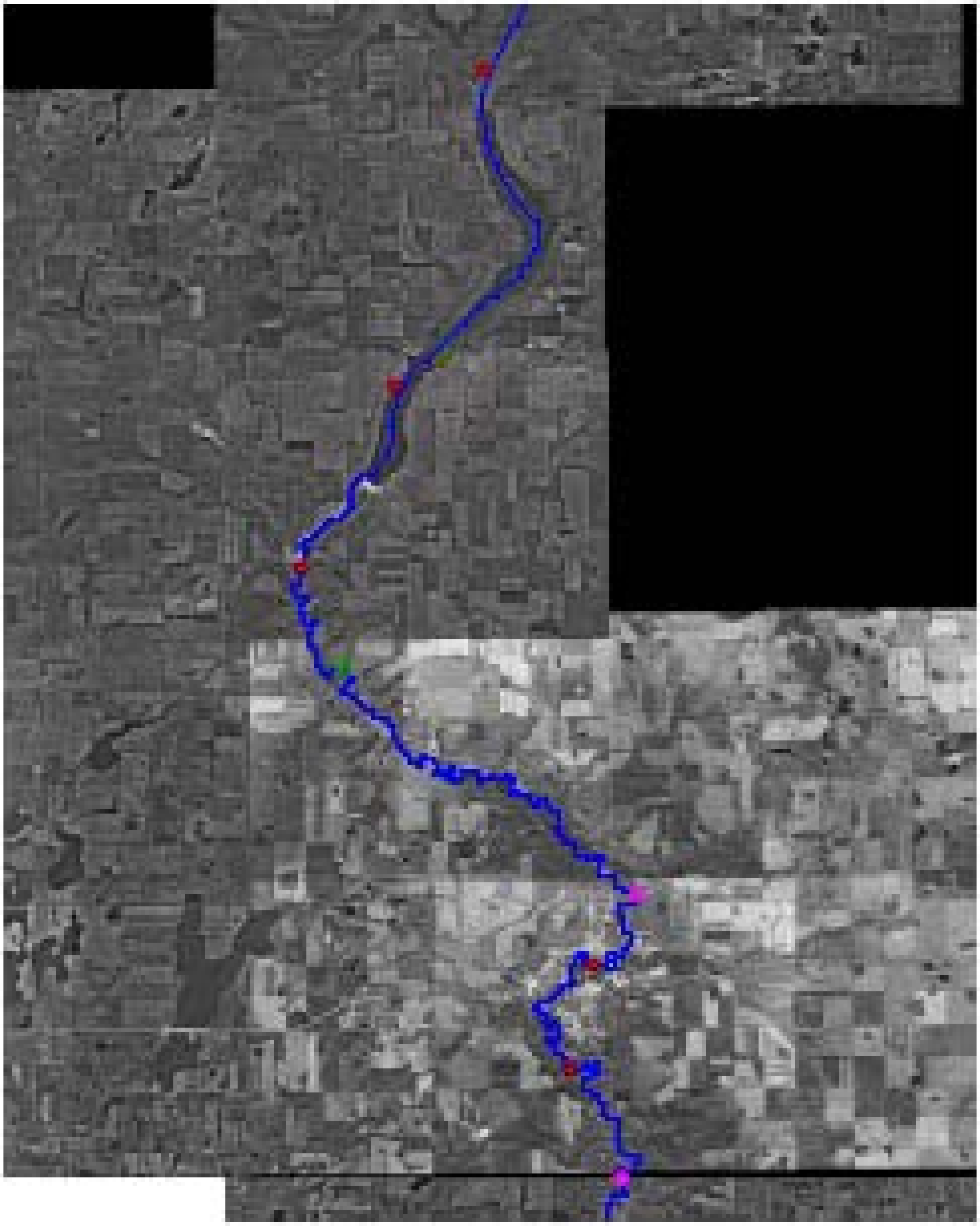


Figure A7 Biotic and Soil Mitigation and Monitoring





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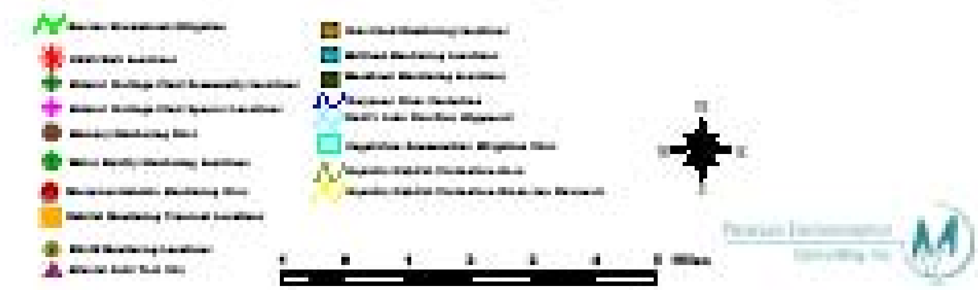


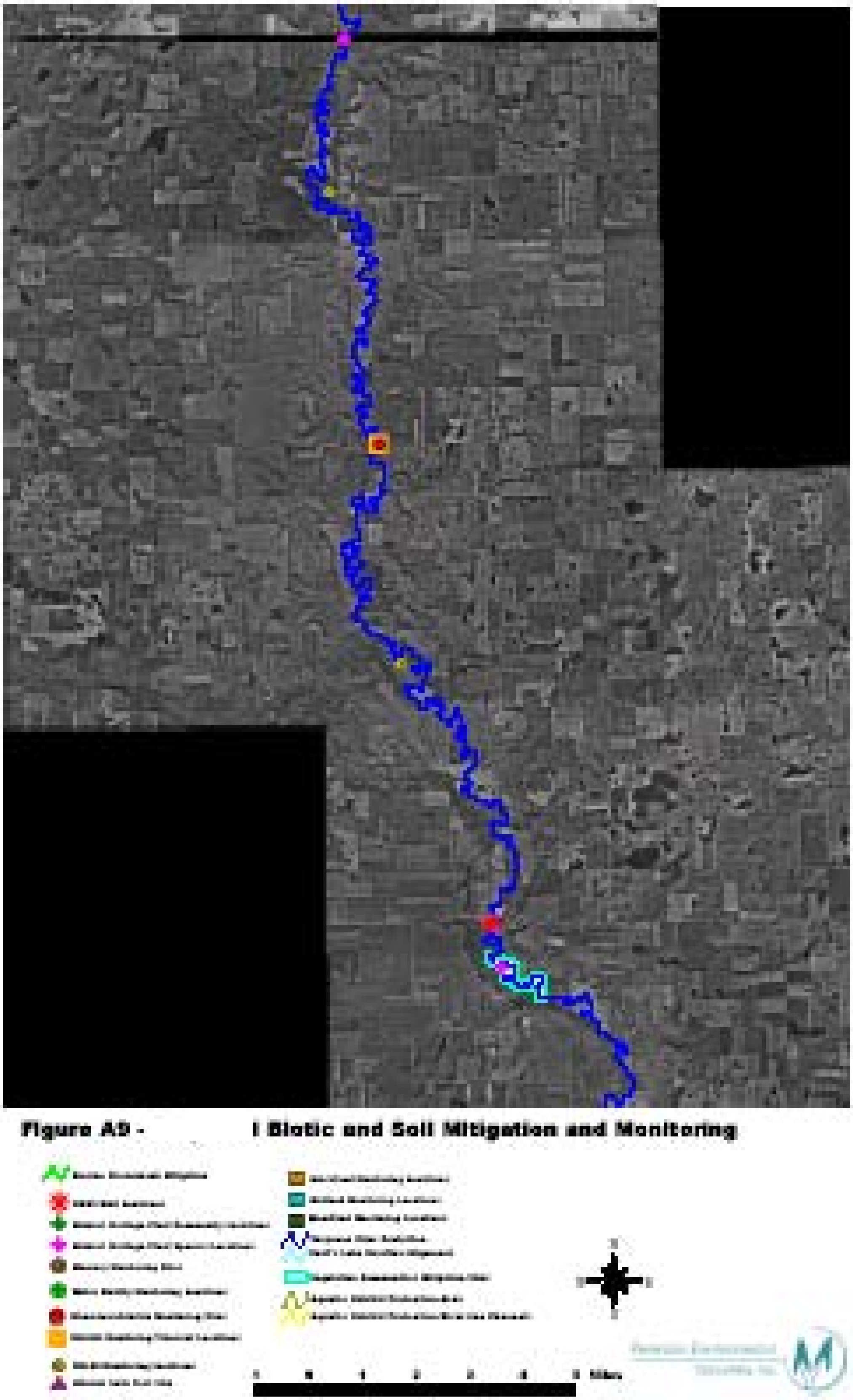


Figure A9 -
I Biotic and Soil Mitigation and Monitoring

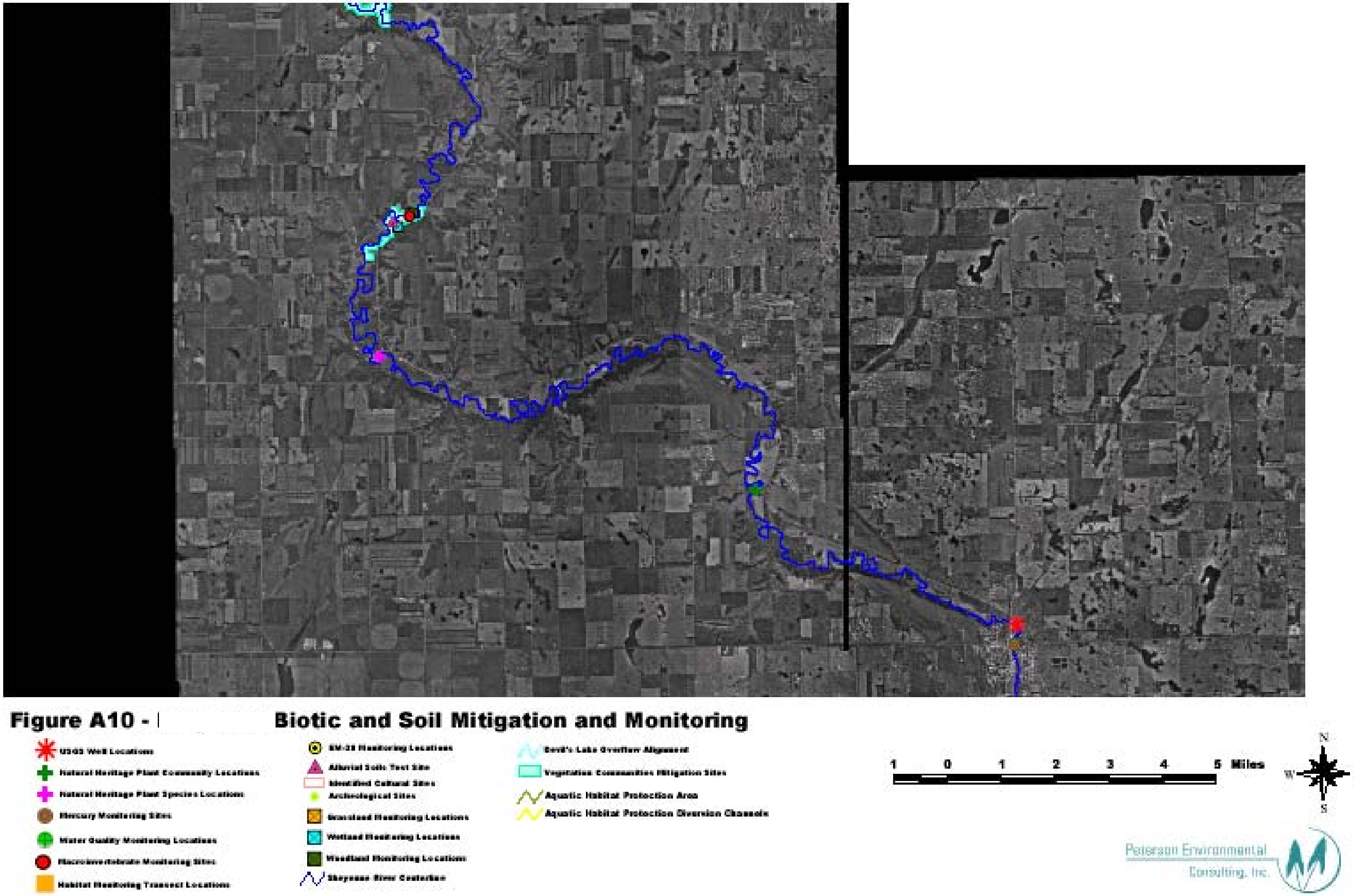


Figure A10 - Biotic and Soil Mitigation and Monitoring

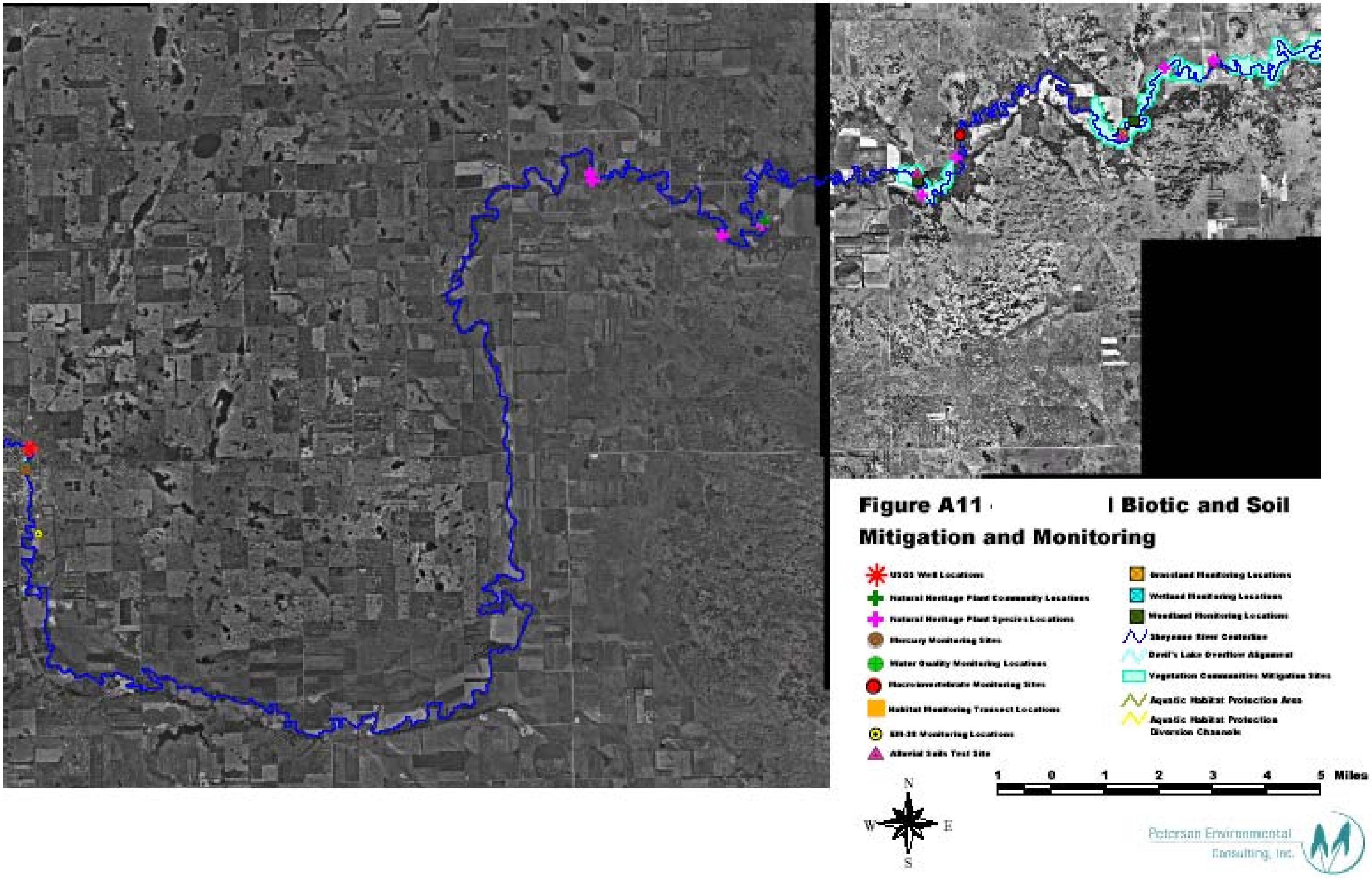


Figure A11 · I Biotic and Soil Mitigation and Monitoring

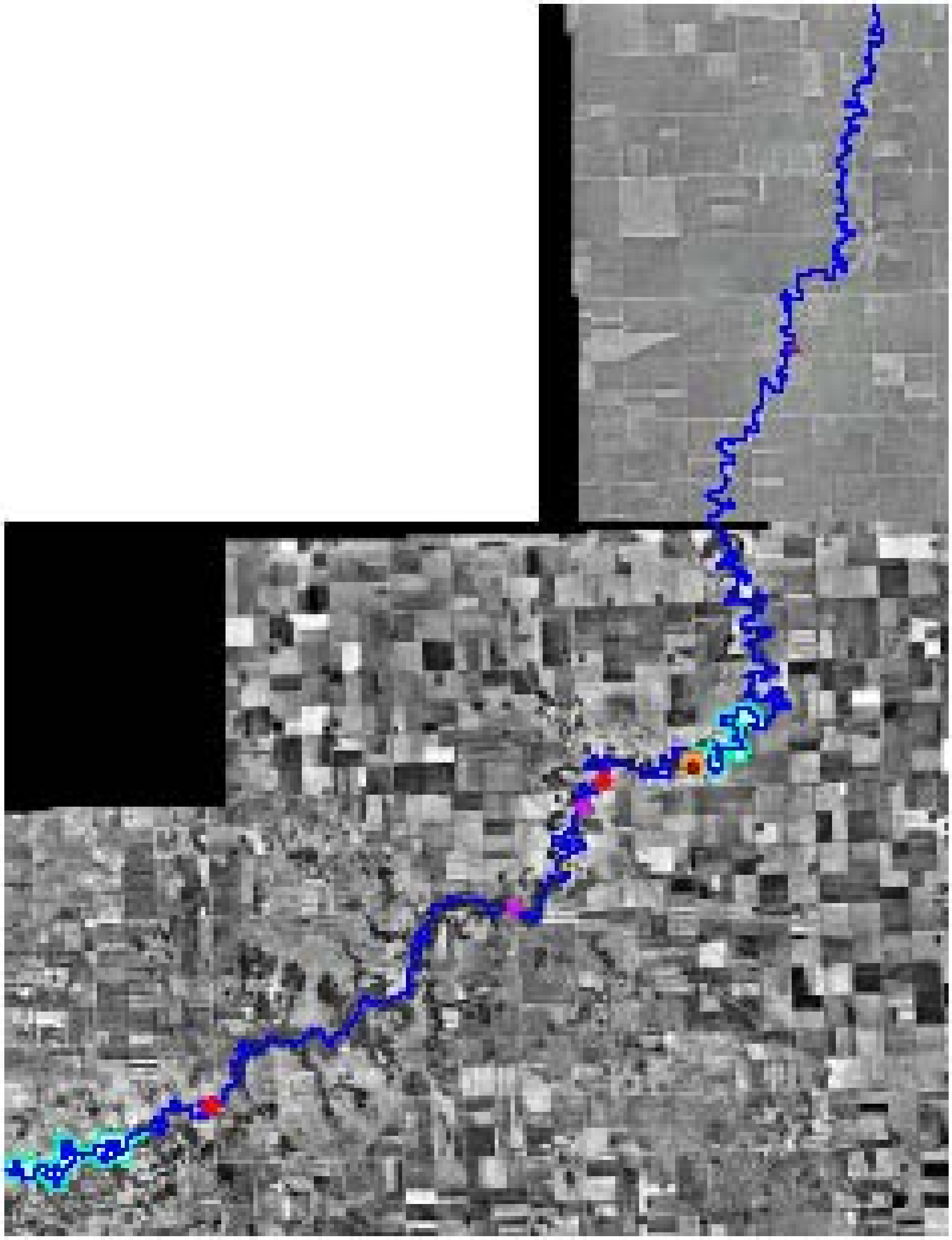


Figure A12 - Biotic and Soil Mitigation and Monitoring

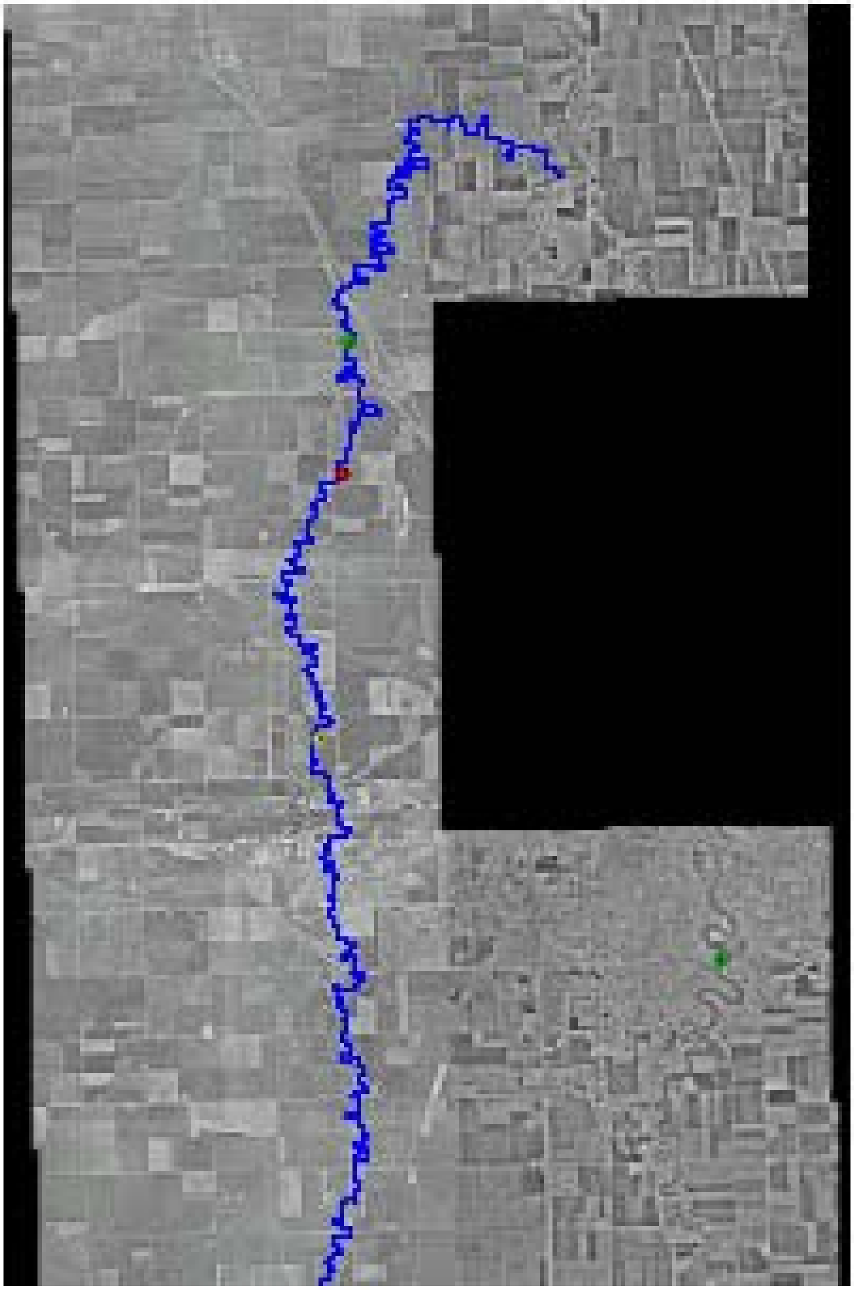


Figure A13 - Biotic and Soil Mitigation and Monitoring

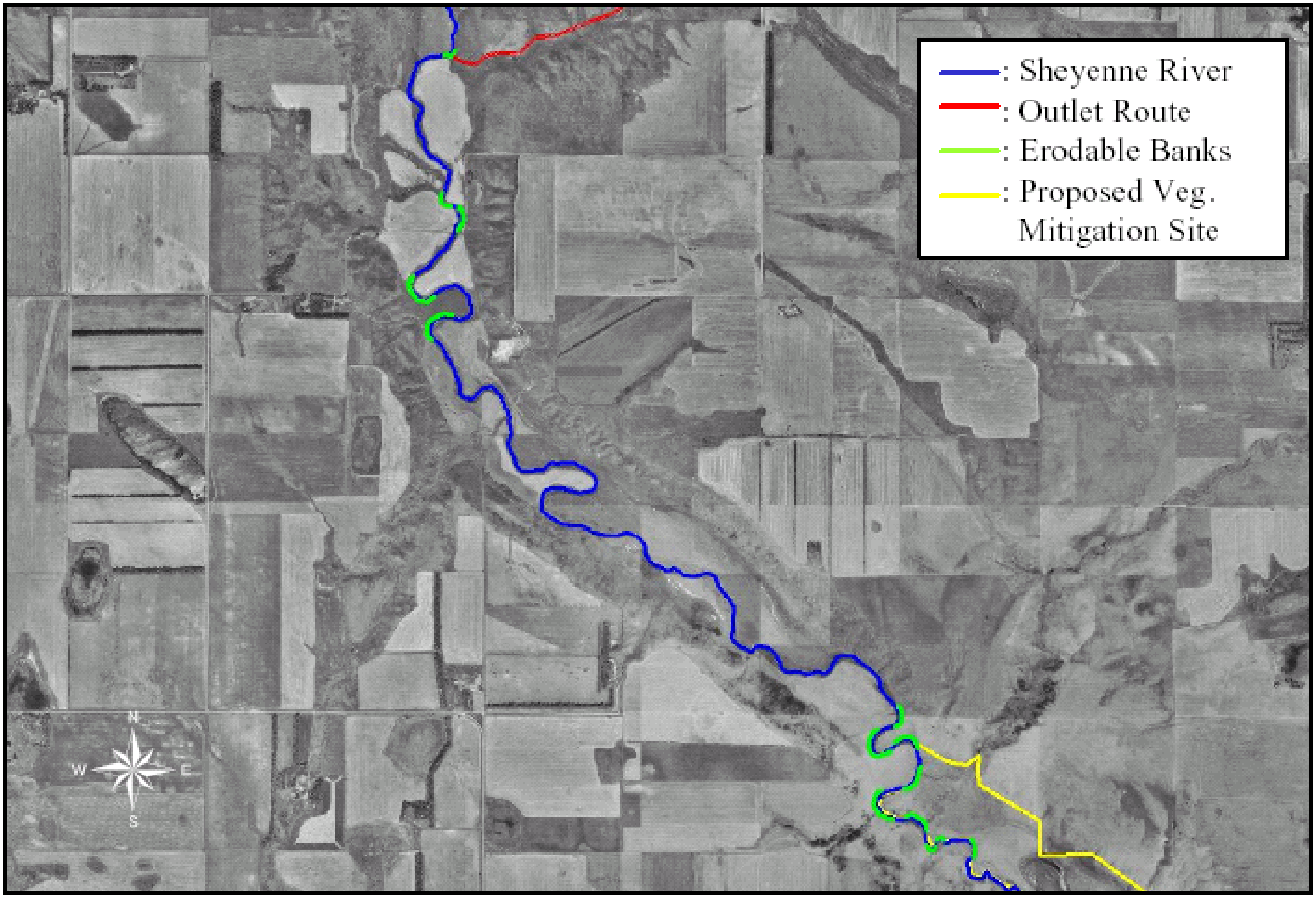


Figure MA-3.

Bank Stabilization Sites on the Upper Sheyenne

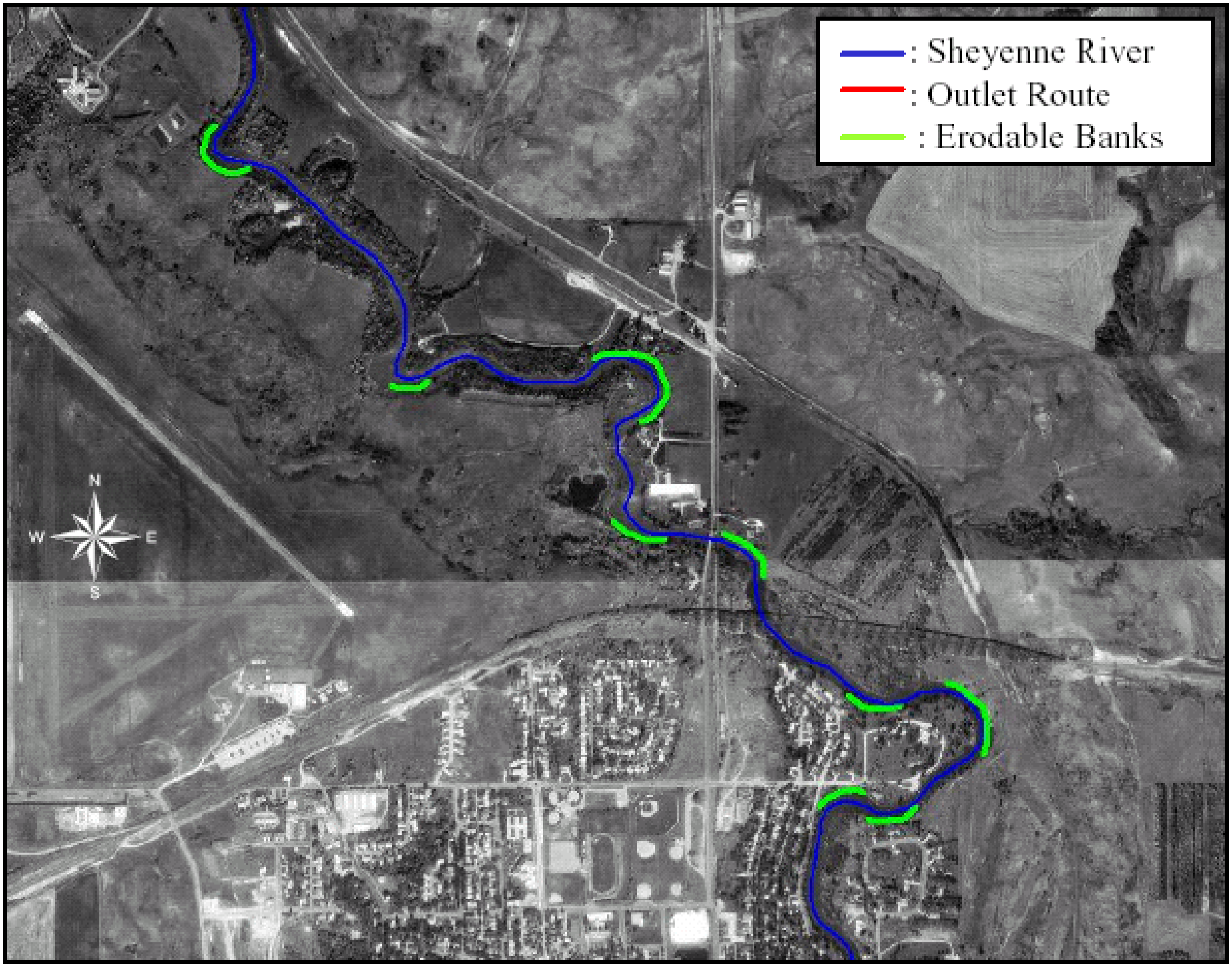


Figure MA-4.

Bank Stabilization Sites on the Lower Sheyenne

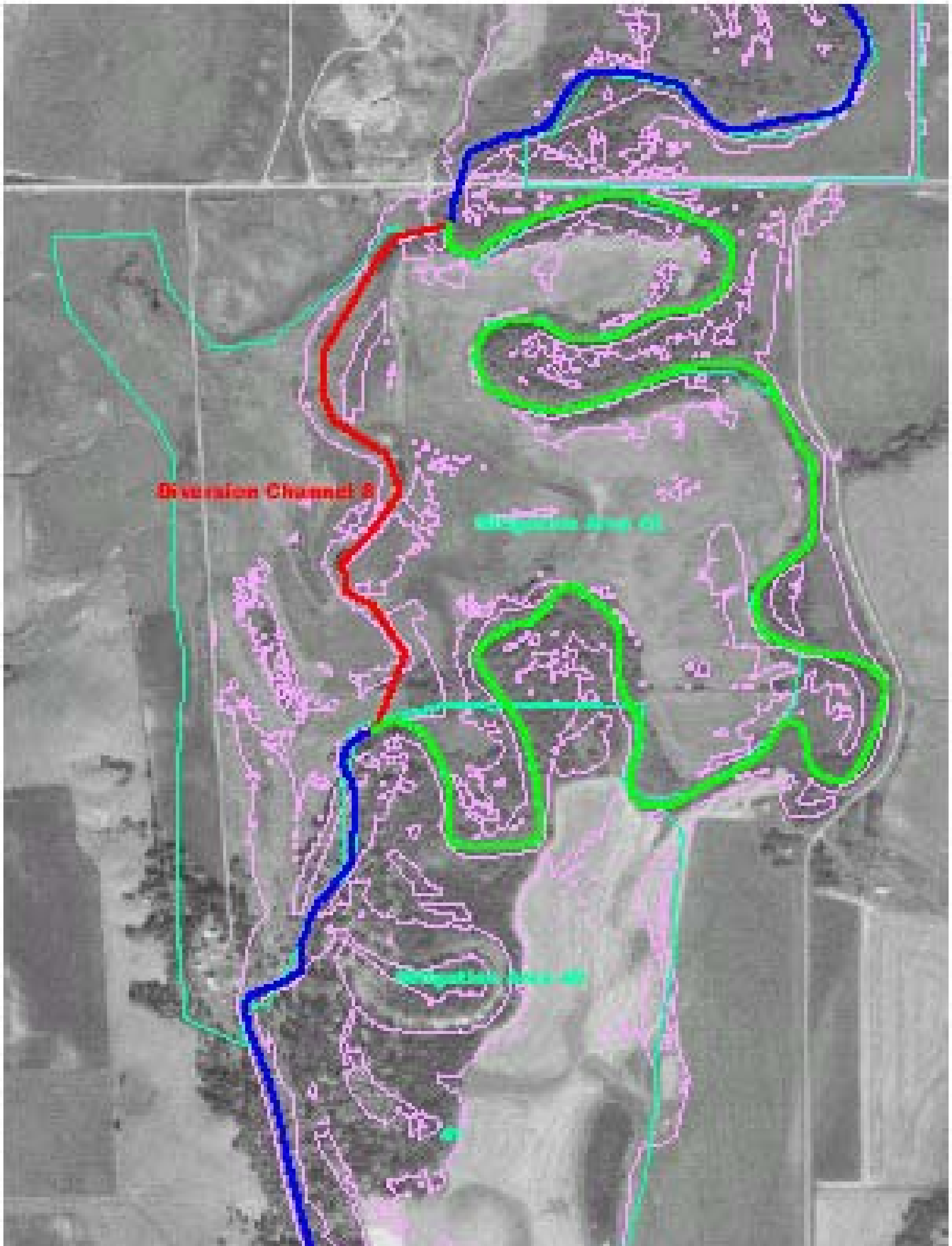
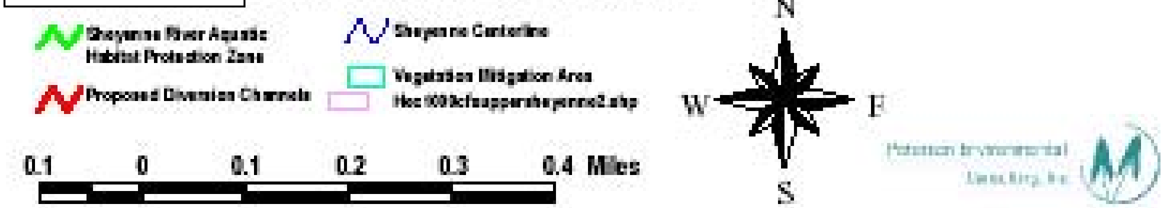


Figure MA-5. Habitat Diversion Channel 8



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ENDNOTE

The information presented in this appendix is subject to revision if additional studies are conducted.