TIER I

OF

A TWO-TIERED BIOLOGICAL ASSESSMENT

OPERATION AND MAINTENANCE
OF THE UPPER MISSISSIPPI RIVER NAVIGATION PROJECT
WITHIN THE ST. PAUL, ROCK ISLAND, AND ST. LOUIS DISTRICTS,
U.S. ARMY CORPS OF ENGINEERS

April 1999

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A TIERED BIOLOGICAL ASSESSMENT: THE APPROACH

This Biological Assessment (BA) was prepared to establish the impacts of current operation and maintenance activities of the Upper Mississippi River 9-foot Channel Navigation Project by the St. Paul, Rock Island and St. Louis Districts, upon species which are protected by the Endangered Species Act. The information developed by this assessment will establish baseline conditions that will be incorporated into the on-going Upper Mississippi River System Navigation Study. While the U.S. Army Corps if Engineers is not required by the Endangered Species Act to provide the attached BA for continuation of the operation and maintenance of the Upper Mississippi River System, the BA is being voluntarily submitted to the U.S. Fish and Wildlife Service for processing in accordance with the procedures of the Endangered Species Act, for the purpose of fulfilling the Corps' commitment to conservation of endangered species.

The Assessment addresses actual or potential impacts of operation and maintenance of the navigation project on seven federally threatened or endangered species that may occur in the project area. The Mississippi Valley Division is currently addressing an eighth species that occurs in the Middle Mississippi River, the interior least tern (*Sterna antillarum*). The Biological Assessment for the least tern addresses operation and maintenance activities for the entire range of the species within the Mississippi River Valley. As such, this Biological Assessment will not address the least tern, but will rely on the ongoing Section 7 consultation for that species. This Biological Assessment also addresses two Category 1 Species, the sicklefin chub (*Macrhybopsis meeki*) and the sturgeon chub (*M. gelida*), which are anticipated to be proposed for listing within the foreseeable future. These species currently have no regulatory standing under the Endangered Species Act.

The U.S. Fish and Wildlife Service provided a list of species that are likely to occur within the project area in a letter dated June 9, 1998 (Appendix A). In a letter dated May 15, 1998, the U.S. Fish and Wildlife Service provided a suggested Biological Assessment outline describing what was "required for the Service to render its Biological Opinion." That letter also included an outline for the consultation process. In previous telephone discussions, the Service also agreed to an incremental approach to assessing project effects (Appendix A). The U.S. Fish and Wildlife Service provided the following guidance with respect to the incremental, or tiered, approach:

> The consultation may be conducted in incremental steps, i.e., this first tier can be of a programmatic nature on the system-wide impacts of operation and maintenance of the 9-foot navigation project. Following conclusion of the consultation, the action agency may continue with the proposed action provided: 1) our Biological Opinion does not conclude that the incremental steps would violate section 7(a)(2) of the ESA, i.e., cause jeopardy to any listed species or destroy or adversely modify critical habitat; 2) the action agency continues consultation with respect to the entire action and obtains biological opinions, as required, for incremental steps; 3) the action agency fulfills its continuing obligation to obtain sufficient data upon which to base the final biological opinion on the entire action; 4) the incremental step does not violate section 7(d) concerning irreversible and irretrievable commitment of resources; and 5) there is a reasonable likelihood that the entire action will not violate section 7(a)(2) of the ESA, i.e., cause jeopardy. We would consider incremental steps to include such actions as the selection of new dredge material disposal sites, construction of new wing dikes, closing dams and bendway weirs, channel changes, mooring cells, guide walls, lock extensions and any other new construction or changes in operation of the 9-foot navigation project.

Based on the guidance provided by the U.S. Fish and Wildlife Service, this Biological Assessment was developed using a two-tiered approach. A generic impact assessment (Tier I Biological Assessment) was made for each species that may occur in the project area. In some circumstances the Tier I Biological Assessment will suffice for minor actions, and a Tier II Biological Assessment will be made on new operations, for operations that significantly deviate from current operations, or for actions with potential site-specific impacts. This determination will be made in coordination with the U.S. Fish and Wildlife Service. Site-specific Tier II Biological Assessments will be conducted for future projects having localized impacts on an as-needed basis. The rationale for using a tiered approach is that it is difficult to prepare a generic impact assessment addressing future operation and maintenance actions without knowledge of site-specific conditions. Future operation and maintenance projects will require site inspections (to determine potential for impact) and may require the preparation of a site-specific Tier II Biological Assessment or informal discussions with the Service if impact potential appears to be minor.

The U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service developed a set of "Ground Rules" establishing a procedure for preparing the generic impact assessment for each species (Appendix B). This effort was designed to develop impact scenarios in a cooperative manner. Two interagency coordination team meetings were held during the development of this Biological Assessment. During the first meeting on May 20, 1998, the species impact matrix and outline provided by the U.S. Fish and Wildlife Service in a May 15, 1998, letter and the coordination process and team approach were discussed. Draft impact assessments and potential Conservation Measures were discussed at the second meeting held on February 4, 1999.

The species' impact assessments were prepared by a Corps of Engineers team member and reviewed by a U.S. Fish and Wildlife Service team member. A Corps of Engineers team member and a U.S. Fish and Wildlife Service team member were assigned to each species (Table 1). The final impact assessment is a Corps of Engineers product. In some instances, consensus was not reached between the Corps of Engineers and the U.S. Fish and Wildlife Service, and it was agreed to disagree.

The Biological Assessment follows the outline provided by the U.S. Fish and Wildlife Service in their species impact matrix. The Service indicated that they would use this outline in their Biological Opinion and requested that the Corps follow the same outline during preparation of the Biological Assessment. A "not applicable" determination indicates that the species will not be affected by a given action (i.e., Clearing and Snagging - Not applicable). This determination was made in coordination with the U.S. Fish and Wildlife Service and was based on information provided by the Service in their species impact matrix, during formal consultation meetings, and during the coordination process between team members working on individual species.

TABLE 1. List of Corps of Engineers and U.S. Fish and Wildlife Service team members for each species addressed.

Species	Corps of Engineers	U.S. Fish and Wildlife Service
Decurrent false aster	Thomas Keevin	Gerry Bade
Higgins' eye pearly mussel	Peter Fasbender	Chuck Kjos
Fat pocketbook pearly mussel	Thomas Keevin	Gerry Bade
Winged mapleleaf pearly mussel	Peter Fasbender	Chuck Kjos
Pallid sturgeon	Thomas Keevin	Joyce Collins
Sturgeon chub	Thomas Keevin	Joyce Collins
Sicklefin chub	Thomas Keevin	Joyce Collins
Bald eagle	Peter Fasbender	Gerry Bade
Interior least tern	Thomas Keevin	Joyce Collins
Indiana bat	Scott Estergard	Joyce Collins

1.0 PROJECT DESCRIPTION

The Upper Mississippi River Navigation System includes the commercially navigable portions of the Mississippi, Illinois, Kaskaskia, Minnesota, St. Croix, and Black Rivers. The U.S. Army Corps of Engineers is responsible for maintaining navigation by means of a series of 37 locks and dams, channel training structures, and dredging on over 1,200 miles of navigable waterway. In addition, the Corps operates and maintains recreation areas and provides for stewardship of the natural resources on project lands and waters. There are also outgrants to Federal, State, public and private institutions and individuals for various purposes, including cottage leases, wildlife management, and recreation.

The 9-Foot Channel Navigation Project encompasses three separate Corps of Engineers districts. Its area is defined as the entire Illinois Waterway from the confluence with the Mississippi River at Grafton, Illinois (River Mile 0.0) to T. J. O'Brien Lock in Chicago, Illinois (River Mile 327.0). The segment of the Mississippi River starts at the confluence with the Ohio River (River Mile 0.0) and extends to Upper St. Anthony Falls Lock in Minneapolis-St. Paul, Minnesota (River Mile 854.0). It also includes the navigable portions of the Kaskaskia, Minnesota, Black and St. Croix Rivers.

The St. Louis District includes the Mississippi River from its confluence with the Ohio, River Mile 0.0 to River Mile 300.1, near Saverton, Missouri, and the navigable portion of the Kaskaskia River. It also includes the Illinois River from its confluence with the Mississippi at Grafton, Illinois, to immediately below La Grange Lock and Dam at River Mile 79.8. The Rock Island District includes the Mississippi River (River Mile 300.1) near Saverton, Missouri, through Guttenberg, Iowa (River Mile 615) and the Illinois River from the junction of the Calumet-Sag Channel and the Chicago Sanitary Canal (River Mile 303.4) to the La Grange Lock and Dam (River Mile 79.8). The St. Paul District includes the Mississippi River from Guttenberg, Iowa (River Mile 615) to Minneapolis-St. Paul, Minnesota (River Mile 854.0), as well as the navigable portions of the Minnesota, Black, and St. Croix Rivers.

1.1 MIDDLE MISSISSIPPI RIVER

The first modification to the river for navigation began in 1824 with clearing and snagging to remove hazards for wooden hull vessels. In the 1830's, the first channel stabilization works were built. In 1881, a comprehensive plan was authorized to maintain an 8-foot channel through bankline revetments and permeable dikes. Congress authorized the existing 9-foot channel project in 1927 for the purpose of securing a 9-foot-deep by 300-foot-wide channel between St. Louis, Missouri, and Cairo, Illinois.

1.2 UPPER MISSISSIPPI RIVER

Modifications to the Mississippi River for navigation began in 1824 when the Government authorized removal of snags, shoals, and sandbars; excavation of rock at several rapids; and closing off of meandering sloughs and side channels to maintain flows in the main channel. The first comprehensive modification of the river was authorized by the Rivers and Harbors Act of June 18, 1878.

A 4½-foot channel was maintained from the mouth of the Missouri River to St. Paul, Minnesota, by constructing dams at the headwaters of the Mississippi River to impound water for low-flow supplementation, and by bank revetments, closing dams, and longitudinal dikes. In 1890, the 4½-

foot channel was extended to Minneapolis, Minnesota. A 6-foot channel was authorized by the Rivers and Harbors Act of March 2, 1907. The additional depth was obtained primarily by construction of rock and brush wingdams designed to constrict low-water flows to a narrower channel.

Dam 19 at River Mile 364.2 (Keokuk, Iowa) was constructed in 1913 and is the only dam not federally owned or operated. It is one of two sites generating hydropower on the system, the other being at Lock and Dam 1 in the Twin Cities which is partially owned by the Ford Motor Company. Congress authorized the 9-Foot Channel Navigation Project in the Rivers and Harbors Act of July 3, 1930, to be achieved by a series of locks and dams and supplemented by dredging. The project extended from the mouth of the Missouri River to Minneapolis, Minnesota. The Rivers and Harbors Act of August 26, 1937, authorized a 4.6-mile extension of the project to ascend St. Anthony Falls.

1.3 ILLINOIS RIVER

Between 1871-1878, the State of Illinois built two locks and dams for navigation on the Illinois River and the Federal Government built two locks and dams for the 7-foot navigation project. The 1900 completion of the Chicago Sanitary and Ship Canal created a connection between Lake Michigan and the Illinois River. This increased Illinois River flows and diverted urban wastes into the Illinois River. By 1930, the State had completed 75% of the 9-Foot Channel Navigation Project but was unable to raise funds for completion. The Rivers and Harbors Act of July 3, 1930, authorized the Corps of Engineers to complete the project and assigned responsibility to the Federal Government. The Rock Island District is responsible for operating and maintaining eight locks and dams along 327 miles of the system, and the St. Louis District is responsible for the lower 80-mile reach from La Grange Lock to Grafton, Illinois, the Illinois Waterway portion of Alton Pool.

1.4 KASKASKIA RIVER

The Kaskaskia River Navigation Project was authorized by the 1962 Rivers and Harbors Act to provide a navigation channel 9 feet deep and 225 feet wide on the lower 50.5 miles of the Kaskaskia River. The project shortened the river between its mouth and Fayetteville, Illinois, from 52 to 36 miles. Meanders were left as cutoffs, much of the channel was excavated, and flow was partially regulated by a lock and dam near the river's mouth.

1.5 MINNESOTA RIVER

A 4-foot navigation channel on the Minnesota River to Mile 25.6 near Shakopee, Minnesota, was authorized by the Rivers and Harbors Act of July 13, 1892. Congress authorized a 9-foot channel on the Minnesota River up to Mile 14.7 near Savage, Minnesota, in the Rivers and Harbors Act of July 3, 1958. The Peavey Company maintains a 9-foot channel from Mile 14.7 to its grain terminal at Mile 21.8.

1.6 ST. CROIX RIVER

The Rivers and Harbors Act of June 18, 1878, authorized a 3-foot navigation channel on the St. Croix River from the mouth to Mile 51.8 at Taylors Falls, Minnesota. A 6-foot channel to Mile 24.4 at Stillwater, Minnesota, was authorized by the Rivers and Harbors Act of January 21, 1927. The present 9-foot channel to Stillwater was authorized by the Rivers and Harbors Act of August 30, 1935, and was assured as a result of the completion of Lock and Dam 3 in 1938.

1.7 BLACK RIVER

The Rivers and Harbors Act of August 26, 1937, authorized a 9-foot navigation channel on the Black River at La Crosse, Wisconsin, to a point 1.4 miles above the mouth. Dredging a channel approximately 300 feet wide, which is considered adequate for existing commerce, was completed in 1941.

2.0 BASELINE

The baseline conditions under Section 7 Consultation include an analysis of the effects of all past and ongoing human and natural factors leading to the current status of the species, its habitat, and the ecosystem. It includes all past Federal and non-Federal actions, including such factors as agriculture, levees, commercial mussel harvest, commercial fishing, environmental contaminants, urban development, recreation, and fish and wildlife management. This Biological Assessment addresses the impacts of continued operation and maintenance of the 9-Foot Channel Navigation Project. Normally this analysis would determine the difference between the baseline condition of each species (1998) and their anticipated response to future and ongoing operations and maintenance actions (including direct, indirect, interrelated, and interdependent effects of the Federal action). To accomplish this, both the baseline condition and the proposed action would be projected 50 years into the future for the life of the proposed action. These two projections would be compared and the resulting difference would be considered as the effects of the proposed action on the listed species. However, this method of analysis cannot be done for this Biological Assessment because the proposed action is to continue the operation and maintenance of the 9-Foot Channel Navigation Project for the next 50 years. The baseline condition on the Upper Mississippi River for the past 60 years has included operation and maintenance that is much the same as the proposed action. New operation and maintenance practices or other activities would be included as needed in the form of Tier II assessments in the future, or as separate Section 7 consultations if they are not operation and maintenance activities. The baseline condition thus includes the future operation and maintenance activities outlined in the proposed action. A "no action" alternative for this Biological Assessment is not available since the proposed action is to continue operation and maintenance, and therefore all alternatives including a discontinuance of operation and maintenance are by default action alternatives.

The proposed action is evaluated for its effects on listed species and compared from time to time with "discontinue operation and maintenance." These comparisons are hypothetical and used where needed for illustrative proposes. A separate alternative under "discontinue operation and maintenance" was not prepared. Such an alternative would involve significant environmental, economic, and social effects far beyond the scope needed to complete this Biological Assessment.

Numerous efforts have produced studies, reports, and assessments of the Upper Mississippi River System. A list of those efforts as related to this Biological Assessment is found in the Literature Cited. Pertinent information describing the existing conditions of the ecosystem and factors influencing the habitat and the species being evaluated herein is discussed in more detail in appropriate sections.

2.1 UPPER MISSISSIPPI RIVER BASIN

The Upper Mississippi River System is considered to be a tremendous natural resource. In accordance, the U.S. Congress, in the Water Resources Development Act of 1986, recognized the Upper Mississippi River System as a "nationally significant ecosystem" as well as a "nationally significant commercial navigation system." The 9-Foot Channel Navigation Project provides an important shipping artery for the region and Nation with its 37 locks and dams, channel training structures, and dredging on over 1,200 miles of navigable waterway. Farm products are the largest single commodity transported on the system. The average annual tonnage of all commodities shipped on the Upper Mississippi between 1986 and 1995 was 80.9 million tons and on the Middle Mississippi was 107 million tons. The average of 43.6 million tons was shipped on the Illinois River.

The ecosystem consists of hundreds of thousands of acres of bottomland forest, islands, backwaters, side channels, and wetlands which support over 270 species of birds, 57 species of mammals, 45 species of amphibians and reptiles, 113 species of fish, and nearly 50 species of mussels (USACE 1990a, USFWS 1991b, EMTC 1998). More than 40% of North America's migratory waterfowl and shorebirds depend upon the food resources and other life requisites (shelter, nesting habitat, etc.) that the system provides. It also provides fishing, boating, camping, hunting, trapping, and other recreational opportunities.

The Mississippi River Basin is home to over 30 million people. Of that population, Mississippi River counties within St. Paul District (Pools 1-10) include 2.2 million, Rock Island District (Pools 11-22) includes 1 million, and St. Louis District (Pool 24-Ohio River) includes 2.6 million. The Illinois River counties, not including Chicago, have approximately 1 million inhabitants. Nearly 80% of the population resides in urban areas such as Minneapolis-St. Paul, the Quad Cities, Peoria, St. Louis, and smaller cities like Dubuque, Muscatine, La Crosse, Hannibal, Quincy, and Cape Girardeau (EMTC 1998). Economic activities mainly revolve around machinery manufacturing, food and beverage processing, and crop, dairy, and livestock production. Regional industries produce canned, frozen, and dairy foods, and manufacture broadcast equipment, construction equipment, agricultural machinery, ammunitions, chemicals, and aluminum sheet.

2.2 WATER QUALITY

Similar to many water bodies, the Mississippi and Illinois River systems have been polluted by contaminants from industrial, residential, municipal, and agricultural sources. Water quality in the Upper Mississippi River is described in Meade (1995) and in Chapter 7 of the *Status and Trends of the Upper Mississippi River System* report (EMTC 1998). Chapter 14 of the EMTC report (1998) discusses the Illinois River.

The implementation of clean water laws, the Farm Bill with its Conservation Reserve Program (CRP), improved wastewater treatment, and changes to industrial and agricultural processes have resulted in generally fewer contaminants in the Nation's waterways. However, environmental contaminants and specific areas of the system that are contaminated continue to be items of concern. Contaminants found in the system include heavy metals, pesticides, and synthetic organic compounds. Further discussion of water quality issues can be found in the following description of contaminants.

2.3 CONTAMINANTS

The following narrative describes sources of environmental contaminants and known areas of concern and summarizes the potential for effects on living organisms. It is meant to be an overview of the current state of the system and relies on referencing specific sources of information. Individual species discussions will include more detail on potential contaminant-related effects, as applicable.

On the Illinois River, pollution has been well documented. After construction of the Chicago Sanitary and Ship Canal in 1900, untreated municipal waste impacted the river, contributing to the loss of the aquatic macroinvertebrate community and impacting freshwater mussels as well as other species such as fish and waterfowl (EMTC 1998). Fish populations also declined, and Lerczac *et al.* (1994) described that fishes associated with sediment showed a high incidence of external abnormalities in the 1960's, then decreasing in recent years (EMTC 1998). Surveys found that by

1971 over one-half of mussel species in the Illinois River were extirpated, although some recovery was found by 1997 surveys (Starrett 1971, Whitney *et al.* 1997).

A description of organic contamination in the Mississippi River is found in Barber *et al.* (1995). Historically, population centers such as the Twin Cities, Minnesota, and Chicago, Illinois, have been sources of organic contaminants. With as much as 2%-4% of Mississippi River volume made up of municipal discharge, organic chemicals continue to be found in water and sediments throughout the system. Today, levels of concentration are usually within health limits and have reduced greatly since improvements to municipal sewage treatment facilities and passage of the Clean Water Act.

Inorganic forms of nitrogen and phosphorous (nitrate, nitrite, orthophosphate, and ammonium) also pose a water quality concern. Sources of these substances include agriculture and municipal wastewater. High concentrations can result in fish kills, algae blooms, and human health effects. Since the Upper Mississippi River System drains the most intensively farmed region in the country, agriculture is most likely the main contributor to the loads of these chemicals in the rivers. As much as 75% of nitrate is estimated to come from agricultural sources; however, municipal sources such as lawn fertilizer and household cleaners also contribute (Antweiler *et al.* 1995). Although the compounds are found both naturally and from human sources throughout the basin, the highest concentrations occur in summer months during and after fertilizers have been applied to farm fields. The implementation of the CRP and removal of a large amount of highly erodible lands from production has assisted in the reduction of runoff.

In addition to fertilizers, agricultural pesticides are heavily applied throughout the region. Both insecticides and herbicides are currently used, with herbicides making up the majority (Goolsby and Pereira 1996). After World War II, organochlorine insecticide use became widespread. The effects of these chemicals have been well documented and included eggshell thinning in bald eagle, peregrine falcon, and other bird species. Like other agricultural practices, chemical use has changed and is continuing to change. First generation insecticides such as DDT or chlordane are insoluble in water and have higher potential to remain attached to sediment particles, thus attributing to their continued persistence (Goolsby and Pereira 1996). Many agricultural insecticides now are water-soluble and have half lives in the hours, thus making them less likely to impact aquatic insects (Mike Coffey (U.S. Fish and Wildlife Service, personal communication). Herbicides have also been documented to be in high concentrations in areas of the river, especially from May through July. With longer half lives, they have higher potential to remain attached to sediments; however, they are also generally less likely to have direct toxic effects to animals.

Like most large river systems, the Mississippi and Illinois Rivers transport large quantities of sediment. Settlement of the basin, conversion of land to agriculture, and clearing of forests contributed to large increases in the amount of sediments carried into the river. Though changes in agricultural practices are showing a noticeable decrease in the amount of sediments discharged, there continues to be high turbidity in the rivers. Since lock and dam construction in the 1930's, sediments have accumulated in the pooled portion above the dams and in side channels and backwaters. Bhowmik and Demissie (1989) discuss the amount of sedimentation occurring in backwater lakes throughout the Illinois River and found an average annual sediment deposition between 20.5 mm and 53.3 mm yr^{-1}. This deposition is contributing to the conversion of backwater lakes to terrestrial habitat. The majority of sediment was estimated to be from uplands and the remainder from bluff areas. The implementation of programs in the Farm Bill in the 1990's has reduced the contribution of sediment from uplands. Though suspended sediments are part of a natural process and contribute to the river ecosystem, high turbidity can be detrimental by reducing the amount of light reaching submergent vegetation and harming aquatic organisms. Suspended material also carries organic materials and environmental contaminants.

Environmental contaminants in the system include heavy metals and synthetic organic compounds with some specific areas known to have contaminated sediments. Examples include the highest PCB concentration in lower Pool 2 and elevated levels in Pools 3-6, as well as Pool 15 (Steingraeber *et al.* 1994). Pools 2-4 also have elevated levels of cadmium and mercury in fine sediments (Beauvais *et al.* 1995). Garbarino *et al.* (1995) also describe heavy metals found within the Mississippi River and concentrations of lead, mercury, and associated metals found in Lake Pepin, Pools 12, 19, and 26. The source of these heavy metals is both natural and from human activities. The lead and zinc found in the river can be attributed to two of the largest lead-zinc mining areas in the world that are along the Upper Mississippi River. Other heavy metals can be attributed to current or former use in major industries along the river. Synthetic organic contaminants such as PCB and chlordane are discussed in Rostad *et al.* (1995). They found that PCB concentrations in silts from the Illinois River were greater than those in the Mississippi River. Though many of these chemicals have now been banned in the U.S., they are not easily degraded and continue to persist, often associated with fine sediments. Since they are not water-soluble and associate with sediments, the substances often bioaccumulate and can affect invertebrates, fish, birds, and mammals, including humans. Mayflies (*Hexagenia* spp.) are considered an important species to assess ecosystem contamination and have been studied to document substrate contamination by PCBs, mercury, and cadmium in reaches of the Upper Mississippi River (Steingraeber and Weiner 1995, Steingraeber *et al.* 1994, Beauvais *et al.* 1995).

Any or all of the environmental pollutants discussed above are lethal at some level and can also cause chronic effects. At toxic levels, any of the contaminants discussed above possibly can directly affect both aquatic and terrestrial species. However, the potential for chronic effects also exists. Persistent exposure to these substances makes it likely that they will accumulate within the tissues of aquatic organisms. Bioaccumulation is possible in fish species that are continually exposed and feed upon contaminated aquatic insects. Other species that may feed upon these insects or fish could be receptors of those contaminants.

As benthic filter-feeding organisms, freshwater mussels are exposed to contaminants dissolved in water, associated with suspended particles, and deposited in bottom sediments. Thus, freshwater mussels can bioaccumulate contaminants to concentrations that greatly exceed those dissolved in water (USFWS, unpublished data). The *Draft Revised Higgins' Eye Mussel Recovery Plan* discusses potential effects of traditional pollutants as well as organic and inorganic contaminants on freshwater mussels. The same potential for exposure exists for other aquatic invertebrates and those species that feed upon them. For spawning fish, contaminated sediments may expose their eggs or juveniles to toxic substances. The accumulation of toxins in fish occasionally requires issuance of consumption advisories, especially for bottom-feeding fish with high body fat content.

Many potential sources of spills exist throughout the study area, including highway and railroad crossings, pipelines, municipal and industrial discharges, barge traffic, and terminals. Potential spill sources are discussed in detail in the *Upper Mississippi River Spill Response Plan and Resource Manual,* which addresses the navigable portion of the Upper Mississippi River (UMRBA 1991). In addition, the document describes the Federal, State, and private plans and resources available for responding to spills. An analysis of the potential for navigation traffic-related hazardous spills was completed for the Environmental Impact Statement prepared for the Second Lock at Lock and Dam 26 (Mel Price). It found that the probability of a catastrophic navigation-related spill event is low but could happen. Hazardous materials with the highest bulk movement and thus highest probability for a spill are chemicals, chemical products, fertilizers, petroleum products, and coke petroleum pitches. The study also found that of 462 facility and vessel spills occurring between 1980-1986, over 93% were less than 1,000 gallons in size (USACE 1988a).

2.4 LEVEES

Federal and private levees were built to manage floodwater as early as 1881 in the open river reach (Yin and Nelson 1995). Prairies, forests, and wetlands that dominated the landscape prior to European settlement have largely been converted to agriculture or urban development. The extent of levees within the floodplain is described in the "Master Plan" (UMRBC 1982). Amounts of floodplain leveed vary throughout the study area. Fifty percent of the Illinois River floodplain, 82% of the open river, 53% of the Rock Island to St. Louis reach, and only 3% from the Twin Cities to Rock Island reach are leveed. Levees separate a large portion of the floodplain from the river and have altered the geomorphic dynamics and assisted in maintaining the channel. Bellrose *et al.* (1983) estimated that the construction of drainage and levee districts from 1909 to 1922 drained almost half of bottomland lakes in the Illinois River Valley. Logging that occurred in the 19th and early 20th centuries assisted in converting large portions of the floodplain. Forests were cleared to provide building materials, fuel, and agricultural land as the area was settled.

2.5 FEDERAL LANDS

The majority of Federal lands on the system are managed for the benefit of fish and wildlife, but also contribute to recreation. A major portion of the lands acquired for the 9-Foot Channel Navigation Project are outgranted to the U.S. Fish and Wildlife Service as part of refuges or managed by state conservation agencies. Three National Wildlife Refuges are included within the Upper Mississippi River. One of these is the 2 387 hectare (ha) Trempealeau National Wildlife Refuge in Pool 6, Wisconsin. The 80 937 ha Upper Mississippi River National Wildlife and Fish Refuge extends from Wabasha, Minnesota, to near Rock Island, Illinois. The Mississippi National River and Recreation Area runs from above the head of navigation to the Dakota/Goodhue, Minnesota, county line and contains numerous significant habitat areas, regional parks and trails, and cultural/historic sites.

The Mark Twain National Wildlife and Fish Refuge includes 12 545 ha extending from near Rock Island, Illinois, to St. Louis, Missouri, and the lower 10 miles of the Illinois River. The Illinois River National Wildlife and Fish Refuges include a complex of four refuges with a total of nearly 4,451 ha, including Chautauqua, Meredosia, Emiquon, and the Cameron/Billsbach Unit. State managed parks and conservation areas include approximately 20 234 ha on the Illinois River. Additionally, private hunting clubs manage areas for waterfowl hunting. The States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin manage over 76 890 ha for fish and wildlife purposes at more than 80 sites along the Upper Mississippi River System.

The St. Croix River includes the Lower St. Croix National Scenic Waterway, which is extremely popular with boaters and includes three state parks, numerous marinas, and beaches. The Minnesota Valley National Wildlife Refuge is located along 32 miles of the Minnesota River and includes approximately 2 873 ha. Also on the Minnesota is Ft. Snelling State Park. Fishing and boating are the major recreation activities in the area, with additional facilities for swimming, hiking, and wildlife observation.

Management of Corps lands includes management for natural resources and recreation areas. The three districts operate and maintain 31 recreation areas along the river. Seventy-three other recreation areas are located on Corps lands but are leased to other organizations that are responsible for operation and maintenance. In addition to recreational facilities on Corps lands, other Federal, State, and local agencies and private interests operate and maintain recreation areas. These recreation areas range from major parks to primitive, and even temporary, facilities. The facilities range from "full service" areas offering picnicking, swimming, camping, etc., with waterborne restrooms, to simple gravel parking lots and launching ramps. Twenty-two major public park areas are located along the river. Boating access to the river is provided by approximately 360 boat access points and/or marinas and 11,500 marina slips along the Upper Mississippi River, excluding the St. Croix and Minnesota Rivers.

The St. Paul District manages day-use areas at most of its locks and dams and operates a project visitor center at Upper St. Anthony Falls. Additionally, the district operates a major recreation area in Pool 9 (Blackhawk Park), about 25 miles south of La Crosse, Wisconsin. This park is the only Corps-operated full service (Class A) campground above Guttenberg, Iowa. There are also three Corps-operated boat access/day-use areas in Pools 9 and 10. The States of Iowa, Minnesota, and Wisconsin and local governments operate other recreational facilities ranging from full campgrounds to simple boat ramps on Corps-owned land. In addition to the cooperative service lands noted below, the U.S. Fish and Wildlife Service operates several boat ramps and participates in other wildlife-related recreational facilities. The Upper Mississippi River is a major recreational resource for the people who live nearby, and private development has occurred adjacent to the Corps-owned shorelines. Private facilities located on the Federal property are managed in accordance with the Shoreline Management Plan, which allows private structures and use while affirming public ownership and management.

The Mississippi River Project within the St. Paul District includes over 8 903 ha above normal pool level owned in fee title by the Corps. Approximately 85% of this land is included in the Upper Mississippi River National Wildlife and Fish Refuge under the 1963 cooperative agreement with the U.S. Fish and Wildlife Service. Approximately 1 668 ha located in Pool 3 is licensed to the Minnesota Department of Natural Resources for wildlife management through a real estate license. The agency receiving the outgrant is responsible for wildlife management on these lands. However, the Corps retained forest management responsibilities on all land held in fee title. St. Paul District's natural resource management goals on project lands include:

- Maintaining an accurate natural resource inventory;
- Perpetuating and improving bottomland forest for wildlife habitat, recreation, aesthetics, timber supply, pest control, and watershed protection;
- Supporting wildlife management goals of the U.S. Fish and Wildlife Service and the Minnesota Department of Natural Resources;
- Maintaining a diversity of productive habitat types through the use of proper forest management techniques;
- Eliminating or reducing adverse impacts to water quality;
- Promoting public awareness and support for the Corps' natural resource program; and
- Establishing and maintaining effective working relationships with Federal, State, and local agencies and all other interested parties.

The project's resource protection program actively works to prevent loss of valuable resources through the protection of shoreline, cultural resources, and the habitat of endangered and threatened species. Details of these goals and the practices in place to achieve them can be found in the St. Paul District, Mississippi River Operational Management Plan (OMP), January 1993. The

OMP is updated annually, and proposed activities are coordinated with appropriate agencies and reviewed for compliance with environmental laws and regulations.

The Mississippi River Project within the Rock Island District includes over 37 635 ha owned in fee title administered by the Corps. This includes approximately 21 448 ha forested land and 16 187 ha water. Under the 1963 cooperative agreement with the U.S. Fish and Wildlife Service, 18 210 ha land and 15 378 ha water are managed for wildlife resource habitat purposes by the Service and State agencies. The Project directly manages the remaining 3 237 ha land and 809 ha water. The Corps retains forest management responsibilities on all lands under the cooperative agreement. The goal of the Project is to provide a continuing public benefit from natural resources by perpetuating ecological diversity on project lands. To this end, active management practices are carried out to sustain the forested riverine ecosystem, inventories and monitoring are ongoing, habitat is protected for "special status species," and there is annual coordination with river managers. A detailed description of the Project is included in the Natural Resource Management Operational Management Plan (USACE 1992). This plan details the lands, practices, and actions carried out to meet the project goals. To meet the project goals, a 5-year plan is coordinated that describes management prescriptions. This plan is coordinated with appropriate agencies and undergoes environmental review. More specific project details as they relate to individual species can be found later in this document.

The Mississippi River Project within the St. Louis District includes over 19 829 ha of lands and waters owned in fee title administered by the Corps Rivers Project Office. The States of Illinois and Missouri and the U.S. Fish and Wildlife Service perform environmental and recreational enhancements under general plan and cooperative agreements on approximately 70% of this acreage.

2.5.1 9-Foot Channel Navigation Project

The 9-Foot Channel Navigation Project includes operating the locks and dams to create stable pools. Maintenance includes upkeep of the lock and dam facilities, wingdams, and navigational aids. Periodic dredging is required to maintain the navigation channel at a minimum depth of 9 feet. Specific description of pool regulation, channel maintenance, and facility maintenance can be found in various documents and description of actions in Section 3.0.

2.5.2 Environmental Management Program

In the 1986 Water Resources Development Act, Congress authorized a multiple element program that has come to be known as the Upper Mississippi River System - Environmental Management Program (UMRS-EMP). The EMP consists of three major elements: Habitat Rehabilitation and Enhancement Projects (HREPs), Long Term Resource Monitoring (LTRM), and Computerized Inventory and Analysis (CIA) dedicated to the study and restoration of the natural resources of the UMRS. To date, HREP construction has resulted in over 11 331 ha of aquatic, wetland, and floodplain habitat being restored, protected, or enhanced. When the 14 HREPs currently under construction are completed, this area will more than double to nearly 27 518 ha. It will increase to over 39 254 ha upon implementation of the 12 projects currently being designed (USACE 1997e).

3.0 DESCRIPTION OF THE PROJECT/ACTIONS

3.1 OPERATION

3.1.1 Lock and Dam Operations

Water levels upstream of the dams are based upon depths needed for navigation and are controlled by systematically raising or lowering the dam gates. Water elevations at all of the dams are regulated based upon discharge. The goal is to maintain a target water level at a control point within each pool. Control ranges are defined within each district. Water level control is described completely in pool operation plans for each lock and dam. An analysis of water level management on the Upper Mississippi River System was completed by the Long Term Resource Monitoring Program and is available in Wlosinski and Hill (1995).

Maintenance at locks and dams is performed on a daily basis or at longer intervals for major work. Personnel perform day-to-day maintenance of operating machinery and minor repair work on the facilities. During major maintenance and rehabilitation, lock gates and valves are removed, sandblasted, and repaired, as are dam gates when necessary. Major rehabilitation at Locks and Dams 2-22 and the Illinois Waterway was evaluated in a Programmatic Environmental Impact Statement (USACE 1989b). The associated Biological Assessment is hereby incorporated by reference.

3.1.2 Recreation

The three districts operate and maintain 31 recreation areas along the river. Seventy-three additional recreation areas are located on Corps lands but are leased to other organizations that are responsible for operation and maintenance. Twenty-two major public parks are located along the river. Boating access to the river is provided by approximately 360 boat access points and/or marinas and 11,500 marina slips along the Upper Mississippi River, excluding the St. Croix and Minnesota Rivers. Carlson *et al.* (1995) estimated that over 12 million daily visits occurred throughout the Upper Mississippi River System during the study year. The study also determined that the top three activities in which those visitors engaged were recreational boating, boat fishing, and sightseeing.

The guiding documents governing operation and management of Corps of Engineers' administered recreational facilities and grounds is the Operational Management Plan (OMP) Part II. Currently, the St. Paul and Rock Island Districts have completed OMPs that include a detailed synopsis describing a 5-year plan of action on how facilities will be operated and maintained. Annual updates of the OMP Part II are reviewed for appropriateness and to ensure that long-term management is provided in an environmentally sound manner. The St. Louis District is currently developing a comprehensive master plan for the river projects and concurrently developing OMPs. The OMPs will be similar in scope to those described above and completed after Master Plan approval. The Kaskaskia OMP was recently approved (USACE 1998c). Complete description of operation and maintenance of recreation areas can be found in the OMP (USACE 1992, USACE 1993). Additional information is found in Land Use Allocation Plans and Master Plans (USACE 1969-1973, 1983, 1989a).

The St. Paul District manages one major recreation area and three boat ramps. Blackhawk Park, about 25 miles south of La Crosse, Wisconsin, is the only full service staffed campground/park that the district operates on the Mississippi River above Guttenberg, Iowa. The district has a few real estate outgrants, but 460 private recreational facilities and a few hundred others on municipal leases are managed in accordance with the Shoreline Management Plan, which allows private structures and use while affirming public ownership and management.

The Mississippi River recreational facilities that the Rock Island District directly manages include six Class A campgrounds (modern facilities), one Class B campground (semi-modern facilities), two Class C campgrounds (primitive facilities), six no-fee primitive campgrounds, 10 day-use areas with day-use fee boat ramps, 10 free day-use areas with boat ramps, 10 no-fee day-use areas with picnic shelters, four lock and dam overlooks, and one Class B project visitor center.

In calendar year 1997, there were approximately 55 million visitor hours of use on Rock Island District Mississippi River Project lands and waters, with about 10% or 5.5 million visitor hours occurring at Corps-administered recreational facilities. Visitor assistance and resource management at these facilities are administered by the Mississippi River Project Office staff located at Pleasant Valley, Iowa; and by park ranger staff assigned to remote field station offices located in Dubuque and Muscatine, Iowa, and Thomson, Rock Island, and Quincy, Illinois. In addition to managing developed recreational facilities, these park rangers are also responsible for managing dispersed recreational activities occurring on all 93,600 land and water acres of the Rock Island District, Mississippi River Project. Mississippi River Natural Resource Management staff are empowered to enforce Part 327, Title 36 of the Federal Code of Regulations in order to protect recreational and natural resource features found within project lands and waters of the Mississippi River Project.

In the Rock Island District, approximately 565 private recreational and residential leases encompass 188 ha. Public Law 99-662 allows for these leases to continue indefinitely until terminated by the lessee or the Secretary of the Army. New leases are not being issued, but existing sites are maintained. If leased areas are returned to the Corps, natural resource management prescriptions are implemented, which include closure or removal of the access road and conversion to natural habitat. The OMP contains additional information on other types of leases.

The St. Louis District manages seven recreation areas, 18 access areas, and five marinas. Eighteen cabin subdivisions (350 recreational cottage leases are still active) dot the riverbanks. The States of Illinois and Missouri operate three recreation areas and 17 accesses on Corps-owned land. The city of Alton operates one marina on Corps land. Local governments, as well as the states, operate an additional 23 access areas. Marinas, harbors, and boating clubs on the Mississippi and Kaskaskia Rivers total 27 and 2, respectively, providing some 3,198 boat slips. The Rivers Project Office operates a regional visitor center at the Melvin Price Locks and Dam area and Class C visitor centers at Locks 27 and Kaskaskia Lock and Dam.

The rivers of the St. Louis District are a major recreational resource for the people living in the bi-state area. A portion of the Great River Road from Melvin Price Locks and Dam visitor center to Hardin, Illinois, was recently designated a National Scenic Byway. Recreational points of interest are the Mark Twain National Wildlife Refuge, Lewis and Clark State Historical Park, the Corps' Environmental Demonstration Area adjacent to Melvin Price Locks and Dam, the multi-agency confluence greenway (Mississippi and Missouri Rivers), and the regional bike trail system. According to a recent survey, recreational use of the area is varied. Fishing from a boat is the most popular (23.4%), followed closely by sightseeing (19.6%) and recreational boating (17.9%). Bankfishing (14.6%) is the fourth most popular activity, followed by waterskiing (7.1%), hiking (6.4%), and swimming (4.1%). Picnicking is participated in by 2.7%, only slightly above camping at 2.7%. All other activity totals approximately 1.6%.

3.1.3 Natural Resource Management

The Corps of Engineers maintains primary administrative authority over all fee title lands and waters acquired for construction and operation of the Mississippi River Project. The Corps has the responsibility and authority to manage the natural resources on fee title lands, which includes forest, fish and wildlife, water, aesthetic, and vegetative resources. Detailed descriptions of the projects are included in the Rock Island District, Natural Resource Management, Operational Management Plan Part I (USACE 1992) and the St. Paul District, Mississippi River Operational Management Plan, January 1993. With the exception of the Kaskaskia River OMP that was recently approved (USACE 1998c), the St. Louis District OMP will be completed after approval of the Comprehensive Rivers Project Master Plan.

The goals of the forest management in the Project are as follows:

1. Complete and maintain a detailed comprehensive standmapping database to use in future forest management decisions.
2. Promote size class diversity through continued silvicultural practices such as TSIs, tree plantings, and timber sales to maintain and improve forest quality for wildlife habitat and provide a regulated and sustained yield of forest products.
3. Protect habitat for all endangered and threatened species found on project lands.
4. Maintain existing and future nesting sites for colonial nesting birds.
5. Manage habitat to provide nesting and feeding sites for local and migratory birds.
6. Maintain and enhance communication with coordinating agencies and the general public.

Specific management practices are outlined within the OMP, and the Management Plan is updated annually. At that time, review and coordination ensure that management is provided in an environmentally sound manner.

3.2 MAINTENANCE

3.2.1 Channel Maintenance

The navigation channel is maintained by periodic maintenance dredging and regulatory structures (wing and closing dams and revetment). Description of channel maintenance in the three districts varies slightly due to differing river conditions. A general description of channel maintenance follows, along with a list of documents in which more specific information can be found.

3.2.1.1 Dredging

Periodic dredging is required in order to maintain a 9-foot channel. In required locations, dredging occurs with hydraulic cutterhead, mechanical, or dustpan dredge. In accordance with the Federal Standard, dredged material placement sites are identified that represent the least costly alternative with sound engineering practices and meet environmental standards pursuant to the Clean Water Act. Placement of dredged material has occurred within the thalweg, shoreline, bottomland forests, agricultural fields, and beneficial use sites and for environmental restoration. Where recurrent dredge cuts occur, long-term site plans have been and are being developed. Placement sites are chosen in conjunction with On-Site Inspection Teams (OSITs), public coordination, and various other committees of river managers and biologists.

Detailed description of the St. Paul District's process and program can be found in their *Channel Maintenance Management Plan* (CMMP) (USACE 1996) and associated Environmental Impact Statement dated March 20, 1997. A Biological Assessment was prepared for the district and is included within the Environmental Impact Statement. That Biological Assessment is hereby incorporated by reference.

Detailed description of the Rock Island District's program is found in the *Long Term Management Strategy for Dredged Material Placement, Main Report, Mississippi River* (USACE 1990c) and *Illinois River* (USACE 1995) and associated Dredged Material Management Plans.

Detailed description of channel maintenance dredging in the St. Louis District is found in the Environmental Impact Statement on operation and maintenance of Pools 24, 25, and 26, Mississippi and Illinois Rivers (USACE 1975b). Dredged material is generally placed adjacent to the main channel where beneficial uses may occur, such as recreational beach creation, least tern island habitat, and island creation. Approximately 150 sites have been dredged in the past, with between 30 to 50 locations in the district dredged regularly for a total of approximately 8 million cubic yards annually.

3.2.1.2 River Regulatory Structures

The Corps of Engineers began building regulatory structures in 1878 with the authorization of the 4-½-foot channel. Since that time, many wingdams, closing dams, and bankline revetment have been constructed and maintained to assist in channel maintenance. Regulatory structures help to reduce channel maintenance dredging, reduce costs and environmental effects of channel maintenance, restore or maintain natural river processes, and restore and enhance habitat quality. Use of structures is mainly limited to the Mississippi River with few used on the Illinois River.

Regulatory structures are described in more detail within various documents, including the 9-Foot Channel Environmental Impact Statements for each district, the CMMP (USACE 1996), and various other project-specific documents. In addition to meeting the goal of reducing channel maintenance, the planning and design of regulatory structures includes consideration of environmental impacts and compliance with various regulations. The process varies within each district, but involves coordination with other agencies. In St. Paul District, the process includes project review by the River Resources Forum. The Rock Island District has the Committee to Assess Regulatory Structures (CARS), which consists of representatives from the engineering, operations, and environmental offices and the U.S. Fish and Wildlife Service. In addition, a document produced by the St. Louis District describes their environmental river engineering project in which biologists and engineers cooperate to improve navigation and habitat diversity through the use of river structures (USACE, no date).

3.2.1.3 Clearing and Snagging

While clearing and snagging was once widespread prior to the completion of the current project, it now takes place only on the St. Croix and Minnesota Rivers. Snags on the river are recognized as providing valuable aquatic habitat and are only removed when safety is a concern. Removal of trees snagged in the navigation channel of the Minnesota River is an infrequent requirement. They are only removed when they become a navigation concern. On the St. Croix River, snag removal is limited to requests from the National Park Service and takes place only during safety concerns and channel blockage (USACE 1996).

4.0 INDIANA BAT

The endangered Indiana bat (*Myotis sodalis*) is a migratory species that occurs throughout much of the eastern United States. During winter, the species occupies hibernacula and in the summer occupies much of its range where maternity colonies are found. The species can be considered to potentially occur anywhere along the Mississippi River downstream of the Quad Cities, Iowa-Illinois, and along the Illinois River downstream of Grundy County, Illinois. Hibernacula are known from Illinois and Missouri but not within the immediate project vicinity.

4.1 HABITAT

During the summer, the Indiana bat frequents the corridors of small streams with well-developed riparian woods as well as mature upland forests. It forages for insects along the stream corridor, within the canopy of floodplain and upland forests, over clearings with early successional vegetation (old fields), along the borders of croplands, along wooded fencerows, and over farm ponds and in pastures (USFWS letter, 1994). It has been shown that the foraging range for the bats varies by season, age, and sex and ranges up to 33 ha. It roosts and rears its young beneath the loose bark of large dead or dying trees. It winters in caves and abandoned mines.

4.1.1 Summer Habitat

During the summer, female and some male bats migrate north. Female bats arrive at maternity roosts as early as May where they give birth in late June to early July before eventually returning to hibernacula from late August to September. An Indiana bat maternity colony typically consists of a primary roost tree and several alternate roost trees. Callahan *et al.* (1997) concluded that the most important characteristics influencing selection of roost trees are most likely structural rather than species related, although the local forest composition most likely influences the species utilized. The use of a particular tree appears to be influenced by weather conditions (temperature and precipitation) (Callahan 1993). For example, dead trees found in locations that are more open were utilized more often during cooler or drier days while interior live and dead trees were selected during periods of high temperature and/or precipitation. It has been shown that pregnant and neonatal bats do not thermoregulate well, and selection of the roost tree with the appropriate microclimate may be a matter of their survival. The primary roost tree, however, appears to be utilized on all days and during all weather conditions by at least some bats. Indiana bats tend to be philopatric, i.e., they return to the same roosting area year after year (USFWS 1996).

The U.S. Fish and Wildlife Service is currently updating the guidelines to determine if suitable habitat may be present within a project area. Those guidelines will describe the characteristics of a site such as forest cover, proximity to water, tree size, and density. The following information describes characteristics of potential habitat. Depending on location and forest composition, different tree species may be used and the species may not be as important as the presence of loose bark or snags. The following tree species are known to have been utilized as maternity roost trees: slippery elm (*Ulmus rubra*), American elm (*U. americana*), cottonwood (*Populus deltoides*), northern red oak (*Quercus rubra*), post oak (*Q. stellata*), white oak (*Q. alba*), silver maple (*Acer saccharinum*), bitternut hickory (*Carya cordiformis*), shagbark hickory *(C. ovata*), green ash (*Fraxinus pennsylvanica*), white ash (*F. americana*), and sycamore (*Platanus occidentalis*). These additional species are known to have been used by summering males: shingle oak (*Q. imbricaria*), sassafras (*Sassafras albidum*), and sugar maple (*A. saccharum*) (Garner and Gardner 1992). This tree list is used in the Habitat Suitability Index model developed by 3D/Environmental (3D/Environmental 1995). The first group represents trees most likely to have exfoliating bark, and the second group is believed to be of lesser value. The model does include an option for all other trees not listed (3D/Environmental 1995). An example of other roost trees being utilized comes from surveys conducted at the Daniel Boone National Forest in Kentucky. Bats were found to utilize snags of pine species, oaks, and other hardwood species, all of which had exfoliating bark or were storm damaged (USFWS 1998a).

Garner and Gardner (1992) recommended the following parameters for summer habitat. Suitable roost trees include dead trees > 23 cm dbh and/or live trees >28 cm dbh with exfoliating bark or cavities. The amount of loose and peeling bark is ranked as follows: Greater than or equal to 25% is high, between 10% and 25% is moderate, and from 1% to 10% has low potential to provide roost sites. Essential Summer Habitat is defined as > 30% deciduous forest cover and water within 1 km and suitable roost trees within 0.4 km. Suitable Summer Habitat is defined as >5% deciduous forest cover and permanent water within 1 km and suitable roost trees within 0.4 km.

4.1.2 Foraging Habitat

A number of studies have been completed on Indiana bat foraging habitat and behavior. Garner and Gardner (1992) found that reproductively active females in Illinois preferred to forage in floodplain forests with > 80% dominant canopy trees. Impounded water (farm ponds) also was utilized extensively for foraging. They noted, however, that these were the least abundant habitat types in the study area. Indiana bats have been found to forage in the canopy of floodplain, riparian, and upland forest, old fields, crop borders, and along wooded fencerows. They have been found to forage from between 6 to 100 feet above the ground and over streams over 6 feet in width (USFWS 1996). Forage range for adult females in Garner and Gardner (1992) was 94 ha, and the geometric center of forage areas from maternity roosts was from 0.40 km to 1.49 km.

Studies conducted near the Meremec River in Missouri indicated that bats there primarily fed within the upland forest canopy (La Val *et al.* 1977, Brack and La Val 1985). However, most of the bats within the studies were male, and floodplain forest had largely been cleared with only about 25% remaining. This selection of feeding habitat may have been due to interspecific competition with local gray bats. Brack and La Val (1985) found that the Indiana bats in their study fed mainly on terrestrial insects. They did explain, however, that a study conducted by Humphrey *et al.* (1977) found riparian habitat to be used almost exclusively and therefore more aquatic insects were available. This suggests that foraging may take place on the type of forested habitat available and that feeding preference will depend on the available prey.

Diets of bats were assessed in the Missouri study and in studies of riparian habitat conducted in Indiana. More aquatic insects were consumed in the riparian habitat (Belwood 1979, Humphrey *et al.* 1977). The conclusion drawn by Brack and La Val (1985) was that insects associated with tree top foraging would logically be those found in the diets of the species. They found that lepidopterans dominated the diet followed by Coleoptera.

4.2 STATUS

The Draft Recovery Plan (Clawson *et al.* 1996) states that the overall population of the species is estimated to have declined by 40% between 1960 and 1995. Causes of population declines are attributed both to human actions and natural hazards. Disturbance of hibernating bats has been documented as a cause of mortality by causing winter fat reserves to be expended. Vandals have also been known to disturb and kill bats in caves. The improper design of cave gates caused the death of an estimated 200,000 bats in Kentucky, and other gate installations have altered the climate of hibernacula, making it impossible for bats to survive winter (USFWS 1996). Forest clearing for various forms of development is suggested as a potential factor adding to the loss of summer habitat. Natural hazards have been documented to attribute to large-scale losses at hibernacula. Flooding caused the death of an estimated 300,000 Indiana bats in Bat Cave, Mammoth National Park, and other cases of flooding are also documented. Ceiling collapse in mines and freezing are also documented factors of effects on the species.

Though pesticides have been implicated in the decline of bats and other species in North America, little work has been done specifically on the Indiana bat. Tuttle (1979) states that several authors report the possible influence of pesticides in causing insectivorous bat population declines (Mohr 1972, Reidinger 1972, Reidinger 1976, Clark and Prouty 1976, Geluso *et al.* 1976). He also discusses work done on gray bats (*Myotis grisescens*) in Missouri where insecticide usage was documented as the probable cause of mortality and population decline (Clark *et al.* 1978). An additional possible cause of population decline in insectivorous bats is contamination in the insect populations upon which the species feed. Tuttle (1979) found that gray bats consume large numbers of mayflies, which are quite susceptible to aquatic pollution. Insect populations with contaminant concentrations could have chronic effects on the Indiana bat.

It is not known whether summer habitat is limiting to the Indiana bat, but the Draft Recovery Plan recommends that habitat loss may be attributing to the decline of the species. In some instances, maternity colonies have been found in felled trees, suggesting that local populations may be affected by clearing.

The range of the Indiana bat within the project area includes potential occurrence throughout Illinois, the southern half of Iowa, and most of Missouri, therefore encompassing two maternity ranges. The Draft Recovery Plan defines the Midwest Maternity Range as occurring in Iowa and Missouri, running through Illinois and into Indiana, Michigan, and Ohio. The Southern Maternity Range is southern Missouri and across Illinois into Kentucky, southern Indiana, and into Virginia. The Midwest region is largely agricultural with highly fragmented forests. The Southern region is heavily forested.

Though hibernacula exist within the region, none are susceptible to project-related impacts. Therefore, any threat to the Indiana bat from operation and maintenance of the 9-Foot Channel Navigation Project would be related to summer habitat loss or modification. Much of the forested land within the project vicinity may meet the criteria for providing potentially suitable habitat for the species.

4.3 PROJECT ACTIONS/POTENTIAL SPECIES IMPACTS

4.3.1 Operation of the 9-Foot Channel Navigation Project

4.3.1.1 Water Level Regulation - Not applicable

4.3.1.2 Impoundment

The construction of navigation dams in the 1930's altered the hydrology of the river system. The lower two-thirds of each navigation pool became more reservoir like, while the upper one-third remains most similar to pre-impoundment. This pooling of the river raised water levels and inundated portions of the floodplain. Impoundment directly impacted floodplain forest and has been implicated in long-term changes. While altered hydrology has contributed to the alteration of species diversity and composition of the floodplain forest, other factors also played important roles. These include extensive logging and conversion to agriculture in the 19th century, as well as urban development. Estimates from 1989 satellite data indicate that approximately 123 000 ha of the Upper Mississippi River floodplain remains forested. This is broken down to bottomland forests covering 18.6% of the land surface of the Upper Mississippi River and 17.6% of the Illinois River. Species composition is estimated to be 80% silver maple, 10% oak-hickory, 5% willow and cottonwood, and 5% other (EMTC 1998).

The effects of water level changes on floodplain forests have been discussed and documented in various publications. Reviews of Government Land Office (GLO) survey records have estimated the presettlement landscape of the floodplain in the area of the confluence of the Illinois and Mississippi Rivers (Nelson *et al.*1994). Estimates indicate that approximately 56% of the floodplain was forested and 41% was prairie. GLO records from Pool 17 indicate that 57% of the floodplain was prairie and 26% was forested. The forest described in the records, however, was less dense than what we know today, and forests were mainly restricted to river banks and islands, with prairies and savanna dominating the floodplain (Nelson *et al.* 1998). Historic surveys of the forest do show that silver maple was a codominant species by 1817 and prior to impoundment in 1938 had become dominant in the area between the Illinois and Mississippi Rivers (Nelson and Sparks 1997). Additionally, Moore (1988) found by reconstructing GLO records from 1837 that silver maple, elm, and ash were dominant species in the Effigy Mounds area in Northeast Iowa and continued to be so in 1983 (Yin *et al.* 1997).

Water levels were most severely altered in the areas immediately upstream from each dam. Yeager (1949) found that after 6 years of completion of Lock and Dam 26 in 1938, the trees on the lowest and thus permanently inundated floodplain were nearly eliminated. Where the groundwater level was raised, only the most flood-tolerant species remained, and on higher elevation areas species such as pin oak showed heavy mortality (Yin and Nelson 1995). Changes in forest composition within the open river reach also occurred. Where oak (*Quercus* spp.), American beech (*Fagus grandifolia*), walnut (*Juglans* spp.), and hickory (*Carya* spp.) were once found adjacent to the river on higher elevation areas, they have largely disappeared and have been replaced by silver maple and willow (*Salix* spp.) (Yin and Nelson 1995). Silver maple and willow were historically found on river fronts, islands, and low-lying floodplain areas and continue to be found there (Yin 1999).

Mississippi River Pools 11-22 (Rock Island District) have been inventoried through stand mapping and entered into a Geographic Information System. That system provides detailed data on the forest resources of the Mississippi River Project. A summary of that data shows an example of species composition change. Table 2 below summarizes the forest composition of areas that had been cruised (8 094-10 117 ha) in 1943. Table 3 shows the percent composition of the roughly 20 000 ha in the current inventory. Though the two tables are not directly comparable, they provide a picture of the change in forest composition and current species composition in Pools 11 through 22. The increase in stands with silver maple and cottonwood as dominant components is clear. What the tables do not show, however, is that the 10 117 ha to 12 141 ha not considered to be merchantable timber in 1943 has all grown to be forest.

TABLE 2. Mississippi River forest composition in 1943, percent of tree species (based on merchantable timber that had been cruised).

Silver Maple	50%
Cottonwood	15%
Elm	15%
Oak	10%
Green Ash	3%
River Birch	2%
Other *	5%

*Other includes Locust, Pecan, Hickory, Sycamore, Hackberry, Willow, Kentucky Coffee Tree, Walnut, and Basswood.

TABLE 3. Mississippi River forest composition in the 1980's-1990's, percent of forest stands with named species as a dominant or codominant component.

Silver Maple	87%
Cottonwood	36%
Green Ash	33%
Black Willow	22%
Hackberry	12%
Elm	20%
River Birch	10%
Pin Oak	8%
Sycamore	3%
Pecan	2%

NOTE: Stands can, and do, include more than one species and therefore this table is not additive.

In addition to and perhaps more significant than the species composition is the size class of existing forest. Generally, Mississippi River forests are aging and not regenerating in a smooth transition. As can be seen from Figure 1 below, approximately 41% of the 21 375 ha (52,818 acres) in the database is 46 cm dbh or greater. Following are 30-46 cm dbh (34%), 12-30 cm (22%), and 2.5-12 cm dbh (3%) size classes. Size class is nearly a direct relationship to age (Gary Swenson, Rock Island District, personal communication) and, therefore, it appears that much of the forest is aging and not regenerating in a smooth transition. Though not extensive, regeneration is occurring in some areas of the floodplain. The Rock Island District has been doing regeneration surveys at clear-cut sites for approximately 10 years. Data show that silver maple, ash, cottonwood, mulberry, willow, and elm are regenerating when there is sufficient light (Casey Kohrt, Rock Island District, personal communication). Regeneration after the flood of 1993 has also been shown on the open river reach. Yin (1999) found that the mortality caused by the flood of 1993 allowed cottonwood and willow to regenerate. He concluded that the composition of the present-day forest will be sustained over the next 50 years (Yin 1999).

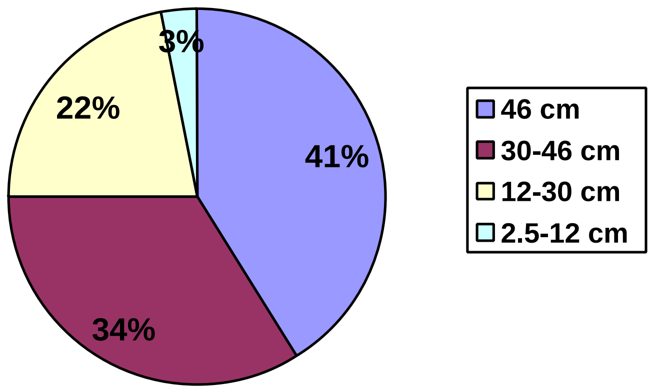

Figure 1. Size class (dbh) distribution, Pools 11-22.

The 9-Foot Channel Navigation Project has contributed to hydrological changes of the river floodplain and initially caused the conversion of some bottomland forest to aquatic and wetland habitat. Many acres of farmed lands were purchased as part of the project and allowed to grow to forest. Therefore, but for the 9-Foot Channel Navigation Project and acquisition of lands by the Federal Government, much of the remaining forest would most likely have been cleared and would not exist today. Much of that remaining bottomland forest is managed for natural resource benefits, and efforts are under way to maintain forest age class and diversity. The areas of floodplain that are frequently inundated and have higher water tables will most likely continue to be comprised of water-tolerant species. The most important disturbance factor will remain flooding for the foreseeable future. This is the same disturbance factor that has shaped the composition of the floodplain forest for centuries. Most likely the floodplain forest will continue to be comprised of a mix of species suitable as Indiana bat summer habitat, as it is now (Gary Swenson, Rock Island District, personal communication).

Though not possible to quantify, it is likely that much of the bottomland forest existing in the project area is of suitable size (dbh and area) and has available roost structure for Indiana bat maternity colonies and summer roost sites. One can assume that the existing bottomland forests in the St. Louis District and along the Illinois River contain suitable habitat. However, as was seen after the flood of 1993, prolonged high water occasionally kills floodplain trees. As regeneration occurs in frequently flooded areas, it is often by silver maple. One can assume that areas frequently inundated will most likely continue to be comprised of water-tolerant species while higher areas will continue to go through various successional stages and species composition may change, especially with management.

It is obvious that inundation has contributed to hydrological changes in the floodplain of the project area and has affected forest composition. Where available, data suggest that the existing forest most likely provides suitable Indiana bat maternity roost habitat. Of the trees listed in Table 3 above, four of the species (silver maple, cottonwood, elm, and green ash) occur on the list of trees most likely to have exfoliating bark when dead (3D/Environmental 1995). In addition, those trees are of suitable size. Flooding will continue to be the most significant factor affecting bottomland hardwood forest, as it has been for centuries. Although flooding will continue to maintain a forest comprised mainly of water-tolerant species, that forest should continue to support Indiana bat summer habitat. Impoundment is not likely to adversely affect the Indiana bat.

4.3.2 Maintenance

4.3.2.1 Dredging - Not applicable

4.3.2.2 Dredged Material Placement

Should clearing of bottomland forest occur for dredged material placement, there is the potential that it may affect roosting or nursery trees. However, dredged material placement does not usually involve forest clearing. In the Rock Island District, when shorepipe is utilized to reach a placement site, large trees are generally avoided while laying out the corridor. In the St. Louis District, terrestrial habitat is not currently impacted by material placement. In the Rock Island District, most dredged material historically was placed in open water, near shore, within bottomland forests, and with periodic beneficial use stockpiles and levee repairs. Preliminary estimates indicate that within the Rock Island District between 75% to 80% of material was placed near shore and open water. In the 1960's stockpiling and inland placement increased, and by the early 1990's as much as 25% was upland behind-the-levee placement. In 1997, the district placed over 85% of dredged material behind levees (Mike Cox, Rock Island District, personal communication). The trend toward upland and levee placement will probably continue into the future if funding is available. Should contaminated substrates be dredged, there would be a potential for resuspension of contaminants. However, sands make up the majority of materials dredged for channel maintenance, and contaminants have a low potential for affinity to sands. With the trend away from placement of material within bottomland forests, dredged material placement will not affect the Indiana bat.

4.3.2.3 Clearing and Snagging - Not applicable

4.3.2.4 Channel Structures/Revetment

There is the potential to affect roosting or nursery trees through bankline grading or placement of stone for bank revetment, wingdams, and closure structures. Maintenance of existing structures could also affect habitat if they require shoreline modification. Current construction practices usually include placing stone from the river without the need for terrestrial staging areas. In cases where shoreline modification is required, it is usually minor, and the long-term effect is preservation of the shoreline and reduction in erosion and tree loss. In most cases, construction of channel structures and revetment will not affect the Indiana bat. In instances where clearing may be required, surveys should be conducted or clearing should occur outside the roosting season. In most cases construction of channel structures/revetment will not include clearing, should clearing be required a Tier II assessment will be conducted. The construction of channel structures or revetment will not adversely affect the Indiana bat.

4.3.2.5 Lock and Dam Rehabilitation - Not applicable

4.3.3 Navigation and Recreation-Related Indirect Effects

4.3.3.1 Tow Traffic - Not applicable

4.3.3.2 Fleeting/Terminal Facilities

Barge fleeting areas are those areas where barges are continuously moved in and out for loading and unloading, or stored. They are generally located in close proximity to terminal facilities. Terminal or port facilities are usually within urban or industrial areas, and since their purpose is to provide river access, they are constructed in areas that were once floodplain habitat. Barge fleeting locations on the system are identified in Appendix E of the *Bank Erosion Field Survey Report of the Upper Mississippi River and Illinois Waterway* (USACE 1997d). The study found that fleeting areas are of high risk for potential bank erosion (USACE 1998d). Existing development may have cleared potential Indiana bat habitat, but it is impossible to determine to what extent or what effect that may have had on the species. The extent to which fleeting contributes to loss of bottomland forest is undetermined. Since the majority of fleeting and terminal facilities are in developed areas, it is likely that the amount of potential habitat affected is small.

Under Section 10 of the Rivers and Harbors Act of March 3, 1899, the placement of any permanent structure below the ordinary high water mark on navigable waterways requires a permit. Where installation involves the discharge of dredged or fill materials, permits are required under Sections 401, 402, and 404 of the Clean Water Act of 1977. Future expansion of fleeting areas or terminals will be subject to regulation and environmental review. Therefore, if expansion should occur in the future, evaluation of potential endangered species impacts will be assessed through the permit process. The State of Iowa regulates barge fleeting activities through their own regulations, and Illinois and Missouri regulate them through review of the Federal permitting process. In addition, trespass laws may be enforced on Federal property should inappropriate fleeting occur there.

Fleeting and terminals may potentially affect the Indiana bat, having contributed along with other types of development to loss of floodplain forest habitat. The extent that erosion may contribute to ongoing loss of habitat has not been quantified. Impacts to the Indiana bat resulting from fleeting or terminals should not be significant.

4.3.3.3 Fleeting - Not applicable

4.3.3.4 Port Facilities - Not applicable

4.3.3.5 Exotic Species - Not applicable

4.3.3.6 Contaminants - See section 4.3.4.5 below

4.3.4 Recreation-Related Indirect Effects

4.3.4.1 Facilities

Recreation facilities are described in section 3.1.2. Operation and management of Corps-operated recreation facilities includes routine maintenance of existing facilities. Additional Corps lands are leased to public and private organizations and individuals as recreation facilities. There is no planned expansion of these areas that may contribute to future loss of suitable habitat. Therefore, future habitat loss from recreation facilities is not likely and will not affect the Indiana bat.

4.3.4.2 Large Vessels - Not applicable

4.3.4.3 Beach Use - Not applicable

4.3.4.4 Exotic Species - Not applicable

4.3.4.5 Contaminants

As described above, studies have implicated pesticides and other chemicals in the decline of bats, but little, if any, has been studied specifically on the Indiana bat. Other than direct application of chemicals to bat colonies as occurred in the 1940's and 1950's, environmental contaminants such as organochlorine insecticides and metals have also been recommended as potential causes of mortality and population decline (Clark 1981). Since Indiana bats are insectivorous and summer in the Midwest, there is a potential that agricultural chemicals may affect the species either directly or through its food source.

Indiana bats will forage over a variety of habitat types but prefer to forage in and around the tree canopy of both upland and bottomland forest. Females in Illinois were found to forage most frequently in areas with canopy cover of >80% (Garner and Gardner 1992). The species feeds on flying insects, both aquatic and terrestrial. Lee (1993) found that reproductively active females consume more aquatic insects than do males (USFWS 1996). 3D/Environmental (1995) summarizes dietary information on the species where they reviewed the known literature. They found that the predominant prey include terrestrial orders such as moths (Lepidoptera) and beetles (Coleoptera). Aquatic insects such as flies (Diptera), caddisflies (Trichoptera), and stoneflies (Plecoptera) are also consumed. As would be expected, in conditions where riparian woodlands are present, more aquatic insects are consumed. Females also have been found to consume higher percentages of aquatic insects. The study area contains a variety of habitats where the species could forage. These include floodplain forests, backwaters, sloughs, and over open water. It is likely that foraging Indiana bats within the project vicinity will forage upon both aquatic and terrestrial insects near the canopy of floodplain forests.

It is possible that insects upon which the species feeds contain environmental contaminants. Meade (1995) describes contaminants in the Mississippi River in detail. Contaminants in the system include heavy metals, pesticides, and synthetic organic compounds with some specific areas known to have contaminated sediments. Mayflies (*Hexagenia* spp.) are considered to be an important species to assess ecosystem contamination and have been studied to document substrate contamination by PCBs, mercury, and cadmium in reaches of the Upper Mississippi River (Steingraeber and Weiner 1995, Steingraeber *et al.* 1994, Beauvais *et al.* 1995). Bioaccumulation of these substances could possibly affect the species; however, without further studies and risk analyses it is impossible to determine the potential or degree of impacts related to sediment contamination.

Agricultural chemicals were suggested in several sources to be a potential cause of population declines in insectivorous bats. Although it is true that the direct application of insecticides could affect the species, this is not of concern here. Chemical use has changed and is continuing to change. First generation insecticides such as DDT or chlordane are insoluble in water and have higher potential to remain attached to sediment particles, thus attributing to their continued persistence (Goolsby and Pereira 1996). Presently, many agricultural insecticides are water soluble and have half lives in the hours, thus making them less likely to impact aquatic insects (Mike Coffey, U.S. Fish and Wildlife Service, personal communication). If they were to affect the Indiana bat or other insectivorous bats, it would most likely be through decreasing the abundance of their food source, not through direct toxic effects. Herbicides also have been documented to be in high concentrations through the river, especially from May through July. With longer half lives, they have higher potential to remain attached to sediments; however, they are also generally less likely to have direct toxic effects to animals.

Though not a direct effect of any operation and maintenance activities, environmental contaminants could potentially affect the Indiana bat. This includes both impacts from spills and from non-point pollution. As discussed in Section 2.3, though possible, the probability of a traffic-related catastrophic spill is rather low. Quantification or determination of specific threats to the species is uncertain at this time.

4.3.5 Interrelated Effects - Management of Corps Lands

4.3.5.1 Forest Management

Forest management was described in section 3.1.3 of this document. Although forest management practices may cause temporary adverse impacts, there will be long-term benefits to the habitat. Prior to carrying out management actions, sites are evaluated for presence of threatened or endangered species and other natural resources of concern, and actions are taken to avoid impacts to these species. This includes designating special management zones, observing seasonal restrictions, and providing buffers. Forest management is carried out through close coordination with State and Federal resource agencies, including the U.S. Fish and Wildlife Service. Forestry practices diversify the habitat and strive to maintain size class diversity. Specific actions are described in the OMP, 5-year plan, and Environmental Assessment prepared for forestry, fish and wildlife management within the Rock Island District (USACE 1992, USACE 1981). Forest management practices that maintain forest age class and diversity contribute to the conservation of the species through providing and maintaining suitable future habitat.

4.3.5.2 Cabin Leases

Private recreational and residential leases within Rock Island District encompass 188 ha. In the St. Louis District, there are approximately 350 recreational cottage leases on 99 ha. New leases are not being issued, but existing sites are maintained. If leased areas are returned to the Corps, natural resource management prescriptions are implemented, which include closure or removal of the access road and conversion to natural habitat. Maintenance actions taken by lessees are subject to review, and therefore impacts to the Indiana bat would be considered at that time. However, this maintenance does not include expansion or additional clearing of forest. Should future clearing be proposed a Tier II assessment would be required. There is little if any tree clearing included in maintenance of lease sites and therefore cabin leases will not affect the Indiana bat.

4.3.5.3 General Plan (Coop Agreement) Lands

As described in Section 2.0, Baseline, a great deal of lands in the project area are managed by the U.S. Fish and Wildlife Service and State natural resource agencies as fish and wildlife refuges and recreation areas. Within the range of the Indiana bat, these include the Illinois River Refuges, the Mark Twain National Fish and Wildlife Refuge, the Upper Mississippi River National Wildlife and Fish Refuge, and various areas managed by the states. Detailed descriptions of the refuges are included in the respective refuge master plans. The Environmental Assessment prepared for the Mark Twain Refuge stated that the Indiana bat potentially occurred on refuge lands but that information on habitat was not understood at the time (USFWS 1979). Therefore, the potential effect of refuge management on the species could not be determined. The Environmental Impact Statement and Master Plan for the Upper Mississippi River National Wildlife and Fish Refuge state that the species may be found on the refuge and that activities that may adversely affect it will be avoided (USFWS 1987).

Maintenance practices on General Plan lands that maintain forest age class and diversity contribute to the conservation of the species; however, management of areas for waterfowl that include water level manipulation or clearing of bottomland forest may affect the species. Maintaining water levels to those required by migratory waterfowl may maintain water tables so high that adjacent forests are affected. This is a potential effect that should be considered in managing refuge lands and in considering future actions to modify water levels.

4.3.5.4 Public Use Sites - Not applicable

4.3.5.5 Corps Port Facilities

Existing Corps port facilities exist in St. Louis, Missouri; Le Claire, Iowa; and Fountain City, Wisconsin. These are part of the baseline condition and there are no plans to expand them; therefore, they will not affect the Indiana bat.

4.3.6 Interdependent Effects

4.3.6.1 Missouri River Navigation - Not applicable

4.3.6.2 USCG Buoy Tending - Not applicable

4.4 ACTIVITIES THAT MAY REQUIRE SURVEYS OR TIER II BIOLOGICAL ASSESSMENT

Actions that include the clearing of trees will be evaluated for potential to impact maternity roost trees. Should clearing of suitable habitat be required or maternity roost trees be located within a project area, they will be addressed in a site-specific Tier II Biological Assessment.

4.5 CONSERVATION MEASURES

1. Any activities that are determined to impact potential Indiana bat habitat will prohibit tree removal/clearing during the period of April 1 to September 30, unless mist net surveys indicate that no bats are present and there is no known roosting at the site. If a site is within a 5-mile radius of hibernacula, the period is April 1 to November 15 (Joyce Collins, USFWS, personal communication).

2. Forest management efforts within the range of the Indiana bat will be carried out to establish and maintain forest species and size class diversity in order to ensure a long-term supply of potential Indiana bat roosting trees.

3. Current Corps of Engineers operations and programs will be evaluated to determine if additional opportunities exist to promote hardwood regeneration and species diversity in floodplain forests.

4.6 CONSERVATION RECOMMENDATION

Conservation guidelines need to be determined to assure that human activities do not adversely affect the species. This follows Recovery Objective 1.2 Protect Indiana Bats and Their Habitat, and minimizes threats from existing and proposed human activities. Habitat assessment guidelines should be established that ensure consistent application throughout the Upper Mississippi River System regardless of the action, responsible agency, or location. These may include assurance that clearing of areas meeting the criteria to provide potential habitat does not take place during the roosting season, uniform habitat assessment criteria, definition of large- and small-scale project criteria, and methods to avoid or minimize tree removal.

4.7 DETERMINATION

Several components of operation and maintenance of the 9-Foot Channel Navigation Project could have site-specific impacts on Indiana bat habitat, but would not individually or cumulatively have an adverse impact on their population. Measures are in place to avoid impacting the species should a project require tree clearing, and forest management efforts are under way to establish and maintain forest species and size class diversity. Future actions that may involve impacts to Indiana bat habitat will be evaluated in a Tier II Biological Assessment. It is our determination that the continued operation and maintenance of the 9-Foot Channel Navigation Project is not likely to adversely affect the Indiana bat.

5.0 DECURRENT FALSE ASTER

The decurrent false aster (*Boltonia decurrens)* (Torr. and Gray) Wood (Asteraceae) is a federally listed, threatened floodplain species (USFWS 1988) that occurs along a 400 km section of the lower Illinois River and nearby parts of the Mississippi River (Schwegman and Nyboer 1985, USFWS 1990). *B. decurrens* is an early successional species that requires either natural or human disturbance to create and maintain suitable habitat. Its natural habitat was wet prairies, shallow marshes, and shores of open rivers, creeks, and lakes (Schwegman and Nyboer 1985). In the past, the annual flood/drought cycle of the Illinois River provided the natural disturbance required by this species. Annual spring flooding created open, high-light habitat and reduced competition by killing other less flood-tolerant, early successional species. Field observations indicate that in "weedy" areas without disturbance, the species is eliminated by competition within 3 to 5 years (USFWS 1990).

Smith *et al.* (1998) found that populations of *B. decurrens* increased in size at three sites studied on the Illinois River following the flood of 1993, with the greatest increase occurring at the two sites which had the most severe flooding. These results suggest that the removal of competing species by flood waters may be an important factor in maintaining populations of *B. decurrens* in the floodplain. *B. decurrens* has high light requirements for growth and achene germination (Smith *et al.* 1993, Smith *et al.* 1995), and shading from other vegetation is thought to contribute to its decline in undisturbed areas.

B. decurrens exhibits a number of morphological adaptations for life on the floodplain. Stoecker *et al.* (1995) found *B. decurrens* to be extremely tolerant when maintained under conditions of root-zone saturation. All plants in the flood treatment survived to study completion at 56 days. The formation of aerenchyma, a common plant adaptation to flooding which allows diffusion of oxygen from aerial shoots to maintain root metabolism, was extensive, increasing in adventitious roots from 26% of root cross-section area in non-flooded plants to 49% in flooded plants (Stoecker *et al.* 1995). Achenes of *B. decurrens* are morphologically structured for flotation and therefore presumably are adapted for dispersal on river currents. Smith and Keevin (1998) found that germination was not significantly reduced in achenes floated for 4 weeks, and 20% of achenes floated under conditions of simulated wave action were still floating after 4 weeks. These data indicate that achenes have the potential for long distance dispersal on water.

Smith and Keevin (1998) found that achenes of *B. decurrens* will not germinate in the dark. Achenes, which were covered with as little as 0.5 cm of sediment, did not germinate; therefore, if achenes are deposited by flood water and subsequently covered by a shallow layer of sediment, it is unlikely they will germinate. Natural or human disturbance of the soil, exposing the achenes to light, would be required for germination. Sediment type may also be an important factor in achene germination and long-term survival of populations. *B. decurrens* has been observed growing on a variety of soil types (Schwegman and Nyboer 1985, Smith 1991); however, laboratory studies (Smith *et al.* 1995) comparing achene germination and growth on two soil types, silty clay (6.7% sand, 53.3% silt, and 40% clay) and loamy sand (80% sand, 16.7% silt, and 3.3% clay) indicate that germination and seedling growth were significantly greater on sand than on clay. These laboratory results suggest that the silt and clay sediment being deposited by flood events on the Illinois River (Lee and Stall 1976) is not ideal for germination and growth. Soil type may thus be important in determining the distribution pattern of this species.

B. decurrens reproduces vegetatively and sexually. Vegetative production of one or more basal rosettes occurs during the fall. Rosettes bolt the following spring; plants flower and set achenes from late August to early October. Field monitoring by Schwegman and Nyboer (1985) suggested prolific achene production. *B. decurrens* produces ca. 50,000 achenes per individual, and, based on achene viability, an average plant is capable of producing ca. 40,000 seedlings under optimal conditions for germination (Smith and Keevin 1998). Fall seedlings overwinter and bolt and flower the following spring and summer. Spring seedlings, however, may either bolt and flower the same year or overwinter as small rosettes which bolt and flower the following year (Smith 1991). In areas where seedling production is low or nonexistent, *B. decurrens* populations can be maintained by basal rosette production. In fact, few seedlings are found in established populations (Moss 1997, Smith 1991). Seedling establishment is expected to be low due to the small achene size, the high light and temperature requirements for germination, and specific soil texture and microtopography requirements for germination and seedling growth (Baskin and Baskin 1988, Smith *et al.* 1995).

5.1 POTENTIAL IMPACT ZONE (RANGE OF DECURRENT FALSE ASTER)

The U.S. Fish and Wildlife Service (1998b) indicated that the species can be considered to occur anywhere in the Illinois River floodplain downstream of La Salle County, Illinois, and the Mississippi River in Jersey, Madison and St. Clair Counties, Illinois, and St. Charles County, Missouri. It occupies disturbed alluvial soils in the floodplains of these rivers. No critical habitat is listed for this species.

5.2 REASONS FOR THREATENED STATUS OF DECURRENT FALSE ASTER

- Habitat destruction and modification (USFWS 1990, Schwegman and Nyboer 1985).

- Wet prairies and natural marshes have been eliminated within the species' range (USFWS 1990, Schwegman and Nyboer 1985). Presettlement wetlands were widespread throughout the Illinois River Valley and counties bordering the Illinois River. Wetlands covered as much as 20%-40% of the land in counties bordering the Illinois River (Suloway and Hubbell 1994). By 1987, the total area in most counties was less than 2% wetlands.

- Natural lakes have been drained and converted to cropland (USFWS 1990, Schwegman and Nyboer 1985).

- Shore habitats have been modified by heavy siltation and altered flooding regimes (USFWS 1990, Schwegman and Nyboer 1985).

- Extensive levee systems prevent small floods that are necessary to reduce competition (Smith *et al.* 1993, Stoecker *et al.* 1995, Smith *et al.* 1998).

- Extensive levee systems prevent flooding and dispersal of seeds to potential habitat (Smith and Keevin 1998).

5.3 PROJECT ACTIONS/POTENTIAL SPECIES IMPACTS

5.3.1 Operation of the 9-Foot Channel Project

5.3.1.1 Water Level Regulation - Habitat loss or modification

Maintenance of navigation pools on the Illinois River has resulted in stable water levels during low-flow periods while the navigation structures have had little effect on water stages during high water events. During low-flow periods prior to lock and dam construction, especially during drought years, the river would have receded, providing additional shoreline habitat for *B. decurrens*. This natural flood/drought process has been eliminated. The magnitude of impact is unknown. It would depend on the timing and duration of shoreline dewatering and availability of a seed bank.

5.3.1.2 Impoundment - Habitat loss or modification

The initial impoundment of the Illinois River by navigation dams (Melvin Price Locks and Dam on the Mississippi River; La Grange Lock and Dam, Peoria Lock and Dam, Starved Rock Lock and Dam, and Marseilles Lock and Dam on the Illinois River) within the historic range of the decurrent false aster created a series of pools. The pooling of the Illinois River resulted in the loss of shoreline habitat. It is known from historic collections that shoreline habitat was utilized by *B. decurrens* (USFWS 1990). The acreage of shoreline habitat lost during the initial inundation by the navigation pools has not been quantified. It should be noted that "new" shoreline habitat was created by the creation of navigation pools.

Historic distribution and abundance records for this species are extremely poor. Historic distribution records are restricted to information provided on museum herbarium sheets as reviewed by Morgan (1980) and Kurz (1981). Populations of this species may have been inundated by the initial impoundment of the Illinois River by navigation dams; however, the magnitude of impact is not known due to the lack of good historic distribution records.

5.3.2 Maintenance of the 9-Foot Channel Project

5.3.2.1 Dredging - Not applicable

5.3.2.2 Placement - Habitat loss or modification

Annual maintenance dredging of the Illinois Waterway 9-Foot Channel Navigation Project by the Rock Island District is generally required at 5 to 15 sites, and the volume of material dredged is approximately 183 493 cubic meters (240,000 cubic yards) per year. Due to the large sediment load carried by the waterway and continually changing flows, specific dredging locations and quantities to be dredged vary from year to year.

The dredged material is usually removed from the navigation channel by a contract 14- to 16-inch hydraulic cutterhead dredge and is discharged to placement sites by floating pipeline. Under optimal conditions, the dredge can pump as much as 270 cubic meters (350 cubic yards) per hour as far as 1 219 m up or downstream and up to 305 m inland. The Government hydraulic cutterhead dredge *William A. Thompson* is occasionally used for large jobs or jobs requiring longer pipeline, up to 1 mile.

Dredged material is usually placed along the shoreline or occasionally in upland sites located in close proximity to the dredging site. Depending upon location, dredged material is placed in the following manner:

1. Shoreline - Material is placed linearly along the shoreline for bankline stabilization or to rejuvenate recreational beaches that have diminished because of erosion.

2. Upland - Material is placed out of the river occasionally in bottomland forest, and usually in industrial sites, on levees, or in beneficial use sites.

The Rock Island District currently has a dredged material placement coordination process in place. Prior to the discharge of any dredged material, representatives of the Rock Island District and the On-

Site Inspection Team (OSIT) meet to determine the preferred placement site for the dredged material. The OSIT is composed of representatives of the appropriate State and Federal agencies. The U.S. Department of the Interior's Fish and Wildlife Service, along with representatives of the State of Illinois, participate in the OSIT. Additionally, appropriate Federal and State agency representatives are coordinated with concerning endangered species. At the end of each dredging season, the OSIT inspects each placement site and makes recommendations to the Rock Island District for future maintenance dredging events. The OSIT also prepares a Post-Placement Evaluation Report and submits this information to each involved agency for review. Although the OSIT tries to reduce potential impacts from dredged material placement, there is a potential that *B. decurrens* may occur in placement areas due to the early successional nature of the species.

In the St. Louis District, placement of dredged material within the range of *B. decurrens* does not involve on-land placement. As such, operation and maintenance dredging will not impact the decurrent false aster within the St. Louis District. The St. Louis District has an interagency dredging team, similar to the Rock Island District's review process, that reviews dredged material placement sites prior to placement.

Previous shoreline and upland placement may have destroyed populations of *B. decurrens*. However, the magnitude of impact, if any, is unknown.

<u>Conservation Measures</u>: Each project that requires bankline or upland dredged material placement along the Illinois River or the Mississippi River (within the known range of the species) will be addressed in a separate site-specific Tier II Biological Assessment to the U.S. Fish and Wildlife Service. An inspection of bankline habitat or upland placement sites will be conducted by Rock Island District personnel, St. Louis District personnel, or an expert contractor prior to habitat modification. If plants are encountered, Section 7 coordination will be completed prior to any habitat disturbance.

5.3.2.3 Clearing and Snagging - Not applicable

5.3.2.4 Channel Structure/Revetment - Habitat loss or modification

There is a potential to adversely affect any decurrent false aster populations that occur on bankline areas where habitat modification would occur. Such modification would include bankline grading and placement of stone (covering habitat) for bank revetment, wingdams, and closure structures. Maintenance of existing structures where shoreline modification would occur could also potentially impact existing populations.

Current construction practices for off-bank revetment, chevron dikes, and bendway weirs do not involve terrestrial habitat destruction. Construction is done from the river without terrestrial staging areas. As such, construction of off-bank revetment, chevron dikes, and bendway weirs will not impact the decurrent false aster. There is also a potential that bank grading and associated activities could create conditions suitable for the establishment of new populations of *B. decurrens* due to habitat disturbance.

Previous construction activities may have destroyed individuals of *B. decurrens;* however, the magnitude of impact, if any, is unknown.

<u>Conservation Measures</u>: Each project that requires bankline habitat modification along the Illinois River or the Mississippi River (within the known range of the species) will be addressed in a separate site-specific Tier II Biological Assessment to the U.S. Fish and Wildlife Service. An inspection of bankline habitat will be conducted by Rock Island District personnel, St. Louis District personnel, or an expert contractor prior to habitat modification. If plants are encountered, Section 7 coordination will be completed prior to any habitat disturbance.

5.3.2.5 Lock and Dam Rehab - Not applicable

5.3.3 Navigation-Related Indirect Effects

5.3.3.1 Tow Traffic - Not applicable

5.3.3.2 Fleeting - Habitat loss or modification

Development of existing fleeting areas required various levels of habitat modification, including placement of on-shore deadmen. The level of impact to *B. decurrens* or potential habitat is unknown. The potential impacts of future development of fleeting areas will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process.

Conservation Measures: All Section 10/404 actions for fleeting projects will be reviewed for potential impacts to federally proposed species and threatened or endangered species. Appropriate Section 7 review will include consideration of habitat potential at the project site by Corps regulatory staff and coordination with the U.S. Fish and Wildlife Service when necessary. Applicants for projects that require bankline or floodplain habitat modification along the Illinois River or Mississippi River within the existing range of the species may be required to conduct a survey for *B. decurrens*. If plants are encountered, Section 7 Consultation will be completed prior to any habitat disturbance.

5.3.3.3 Port Facilities

Currently no Corps of Engineers port facilities are within the range of the *B. decurrens*. Numerous private port and dock facilities may have impacted *B. decurrens* habitat; however, it is impossible to assess the magnitude of impact, if any, due to the lack of historic distribution data.

Conservation Measures: All Section 10/404 actions for port development will be reviewed for potential impacts to federally proposed species and threatened or endangered species. Appropriate Section 7 review will include consideration of habitat potential at the project site by Corps regulatory staff and coordination with the U.S. Fish and Wildlife Service when necessary. Applicants for projects that require bankline or floodplain habitat modification along the Illinois River or Mississippi River within the existing range of the species may be required to conduct a survey for *B. decurrens*. If plants are encountered, Section 7 Consultation will be completed prior to any habitat disturbance.

5.3.3.4 Exotic Species - Not applicable

5.3.3.5 Contaminants - Not applicable

5.3.4 Recreation-Related Indirect Effects

5.3.4.1 Facilities - Habitat loss or modification

Development of existing recreation-related facilities required various levels of habitat modification. The level of impact to *B. decurrens* or potential habitat is unknown. The potential impacts of future development of recreation facilities will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process. The applicant may be required to conduct a survey for *B. decurrens* within the existing range of the species.

<u>Conservation Measures</u>: All Section 10/404 actions for recreation-related facilities will be reviewed for potential impacts to federally proposed species and threatened or endangered species. Appropriate Section 7 review will include consideration of habitat potential at the project site by Corps regulatory staff and coordination with the U.S. Fish and Wildlife Service when necessary. Applicants for projects that require bankline or floodplain habitat modification along the Illinois River or Mississippi River within the existing range of the species may be required to conduct a survey for *B. decurrens*. If plants are encountered, Section 7 Consultation will be completed prior to any habitat disturbance.

5.3.4.2 Large Vessels - Not applicable

5.3.4.3 Beach Use - Not applicable

5.3.4.4 Exotic Species - Not applicable

5.3.4.5 Contaminants - Not applicable

5.3.5 Interrelated Effects - Management of Corps Lands

5.3.5.1 Timber Management - Not applicable

5.3.5.2 Cabin Leases - Not applicable

5.3.5.3 General Plan Lands - Possible to provide benefits

The St. Louis District recently completed an Action Plan for *B. decurrens* on Corps of Engineers General Plan lands within the St. Louis District (USACE 1998a). Development of the Action Plan was a joint effort between the U.S. Fish and Wildlife Service and the Corps of Engineers with participation from Dr. Marian Smith (Southern Illinois University at Edwardsville), an expert on the species.

The Action Plan is provided in Appendix C. Consistent with the Action Plan, the St. Louis District completed Phase 1 (Monitoring Protocol), an initial census of the Environmental Demonstration Area, to determine the locations and general population sizes of *B. decurrens* (USACE 1998b). Similar management possibilities exist on other Corps lands, U.S. Fish and Wildlife Service refuge lands, and management lands owned and/or managed by the Missouri Department of Conservation and the Illinois Department of Natural Resources.

5.3.5.4 Public Use Sites - Not applicable

5.3.5.5 Corps Port Facilities - Not applicable

5.3.6 Interdependent Effects

5.3.6.1 Missouri River Navigation - Not applicable

5.3.6.2 USCG Buoy Tending - Not applicable

5.4 DETERMINATION

Components of operation and maintenance of the 9-Foot Channel Navigation Project that involve terrestrial habitat loss could involve adverse impacts to *Boltonia decurrens* populations due covering of plants (i.e., bankline or upland dredged material placement) or clearing of vegetation (i.e., bankline habitat modification). Each project that requires habitat disturbance in potential decurrent false aster habitat will be addressed in a separate site-specific Tier II Biological Assessment to the U.S. Fish and Wildlife Service. Inspection of potential decurrent false aster habitat (i.e., bankline habitat or upland placement sites) will be conducted by Rock Island District personnel, St. Louis District personnel, or an expert contractor prior to habitat modification. If plants are encountered, Section 7 coordination will be completed prior to any habitat disturbance. It is our determination that the continued operation and maintenance of the 9-Foot Channel Navigation Project is not likely to adversely affect the decurrent false aster.

6.0 FAT POCKETBOOK PEARLY MUSSEL

The U.S. Fish and Wildlife Service (1998a) indicated that the fat pocketbook pearly mussel (*Potamilus capax*), endangered, is "listed for the Mississippi River in Hancock and Pike counties, Illinois and Des Moines County, Iowa where it has been transplanted as experimental populations. The current status of these populations is unknown."

The distribution records for Hancock County and Pike County, Illinois, refer to the Missouri Department of Conservation's fat pocketbook mussel transplant program into Blackbird Island Chute, Pike County, Missouri, and Fox Island, Clark County, Missouri. Clark County, Missouri, is adjacent to Hancock County, Illinois, and Pike County, Missouri, is adjacent to Pike County, Illinois. The Des Moines County, Iowa, record was a mistake (Mr. Gerry Bade - USFWS, Rock Island Field Office, personal communication, November 25, 1998).

During 1989, the Missouri Department of Conservation relocated the fat pocketbook to two sites in the Upper Mississippi River (Koch 1990). One thousand and forty-nine mussels were placed near Blackbird Island (River Mile 291.5, Pike County, Missouri) and 1,252 mussels were placed near Fox Island (River Mile 356.5, Clark County, Missouri).

The transplants were evaluated in 1992 by two divers experienced in collecting mussels (Koch 1993). Only one live fat pocketbook mussel was collected at Blackbird Island. Shells of 28 dead individuals were recovered, but only 11% exhibited post-transplant growth, indicating that most relocated mussels did not survive their first winter. At Fox Island, 13 live fat pocketbook mussels were collected. Shells of 61 dead individuals were recovered, but only 21% exhibited post-transplant growth.

The transplants were again evaluated in 1995 by divers experienced in collecting mussels (Moore 1995). No live fat pocketbooks were collected from Blackbird Island in 1995; however, shells from three relocated specimens were found. None of the shells recovered exhibited growth, suggesting that they died soon after being relocated. No live fat pocketbooks were recovered from Fox Island during 1995; however, dead mussel shells from 17 relocated specimens were recovered. Only five of the 17 fat pocketbook shells exhibited growth. Moore (1995) concluded that the transplants were unsuccessful.

Based on the failure of the Missouri Department of Conservation's transplant program, it is concluded that the experimental population of *Potamilus capax* in the Upper Mississippi River (USFWS 1998b) is no longer extant. As such, it is our determination that the continued operation and maintenance of the 9-Foot Channel Navigation Project is not likely to adversely affect the fat pocketbook pearly mussel.

7.0 BALD EAGLE

The bald eagle (*Haliaeetus leucocephalus*) was listed in 1978 as endangered in 43 states and threatened in five. In recent years, bald eagle numbers have increased dramatically. The bald eagle has expanded its distribution throughout the United States, and its protected status was changed in 1978 from endangered to threatened throughout the lower 48 states. Eagles use the Upper Mississippi River project area year-round and it serves as an important migration corridor. The two basic habitat types defined as being important and having the greatest potential for disturbance in the project area are nesting and wintering habitats. These two important habitat types are the focus of this Biological Assessment.

7.1 NESTING HABITAT

Although eagles occasionally nest on the ground or on cliffs, they prefer larger, prominent trees of a variety of species. The bald eagle prefers to nest in mature timber areas closely associated with water. Although eagle nests along the project area occasionally are located over water, most are found away from the immediate shoreline in large areas of undisturbed mature forest with an open and discontinuous canopy. Preferred nesting sites are usually tall, prominent trees with an open structure and stable limbs that allow easy approach from the air.

Nest densities are highest in areas with minimal human activity. Densities are reduced in areas of moderate human use and are rare in heavy human use areas. Mathisen *et al.* (1977) established three management zones for recommended "activity" levels around bald eagle nest sites. Viewed as concentric rings around the nest site, these zones are defined as follows: (1) in the 100-meter zone there should be no activity any time during the year; (2) in the 200-meter zone no activity from February 15 to October 1 and very little activity the rest of the year; and (3) in the 400 meter zone no activity from February 15 to October 1 but no restrictions on activities the rest of the year. The 400-meter zone can be extended an additional 400 meters if it is justified in the nesting pair plan, which depends on the nest site characteristics, pair behavior, and nesting history.

7.2 WINTERING HABITAT

The majority of bald eagle use within the project area occurs during winter. Winter use is highest where the river is ice-free and adequate perch sites are available. These areas are important, providing stable feeding areas during high caloric demand periods. Large concentrations of eagles often are associated with open water areas bordered by suitable perch trees. High use areas within the project area include many of the tailwaters below the locks and dams, constrictions in the river which remain free of ice, and mouths of large tributary rivers. Of the habitat types used by eagles, toleration of human activity is highest in wintering areas.

There are basically three habitat components to winter management of bald eagles: feeding areas, daytime perching areas, and night roosts. Martell (1992) describes these components and provides management recommendations. The availability of food dictates bald eagle use of an area during winter. They will congregate where open water conditions or other factors provide a food base (i.e., livestock operations). Daytime perching areas are near their foraging areas and are used to hunt from, eat in, or rest on. Trees within 30 m of the shore are preferred.

Winter communal roosting behavior is found in a wide variety of habitats and is important for winter survival. Roost sites probably are selected because they offer bald eagles special advantages such as proximity to feeding areas, protection from the wind and cold, favorable sun exposure, and isolation. Eagles could abandon a wintering area if roost sites are removed or disturbed, thus causing stress during a critical period of the year and potentially affecting survival. Protecting roost sites is therefore important. Communal roosts receive high bald eagle use during the winter, with some sites supporting up to 50 eagles at a time. Roost sites are commonly used during evenings, but may be used during the day in inclement weather. The two types of roosts are critical and secondary. Critical roosts are those used more than 14 nights per season by local breeding eagles, or used more than 14 nights per season by more than 15 eagles per night, or one that has been documented as active for more than 5 years. Secondary roosts do not meet the above criteria and may form temporary foraging areas.

According to the Northern States Bald Eagle Recovery Plan (USFWS 1983a), causes of decline of this population include habitat loss, artificial mortality, and various sources and types of environmental contamination. The Northern States Recovery Plan lists all of the 24 states as probable areas where bald eagles formerly nested to a certain extent. At the time the plan was approved, the bald eagle had been exterminated in seven of the states, and the entire area contained 568 breeding areas producing only 640 young. The recovery plan of the northern range was to re-establish a self-sustaining population and to have 1,200 occupied breeding areas in the region by the year 2000. In 1995, there were nearly 1,900 bald eagle nests in this region, and the other delisting goals were also met. The bald eagle is close to meeting delisting goals in all recovery regions, and the U.S. Fish and Wildlife Service will likely initiate the delisting process in the near future.

Nesting is known to occur within the St. Croix River Valley, the Minnesota River Valley, the Upper Mississippi River Valley, and the Illinois River Valley. In general, nesting activity has increased dramatically. Nest numbers within the Upper Mississippi River Valley are steadily increasing as eagles are nesting in previously unoccupied areas. They can be found throughout the project area during the winter depending upon weather and ice conditions. During extreme cold periods, winter feeding sites are limited to areas immediately downstream of the locks and dams, the confluence of major tributaries, or river constrictions where the river remains ice free. During most winters, winter feeding sites are not limiting, as there is much open water. Known winter roost sites are located in Pools 2, 3, 4, 5, and numerous areas downstream of Lock and Dam 8 (Dunstan 1987).

7.3 PROJECT ACTIONS/POTENTIAL SPECIES IMPACTS

7.3.1 Operation of the 9-Foot Channel Project

7.3.1.1 Water Level Regulation

Since there are no proposed changes in water level regulations in the project, there would be no effect to bald eagles. The tailwater areas will continue to provide open-water feeding areas during the winter.

7.3.1.2 Impoundment

Impoundment of the Upper Mississippi River for navigation has been implicated in contributing to the long-term loss of mature trees and a loss of species diversity. In general, the remaining mature cottonwood and black willow die and are replaced by a different species within stands in upriver reaches (Randy Urich, personal communication, Mississippi River Project Office, Corps of Engineers). A more detailed discussion of general habitat changes is found in the Indiana Bat section (4.0) and will not be repeated here.

The impact of water level regulation is mainly geomorphologic rather than silvicultural. Island habitat has declined since pool habitat was created and will likely continue to decline into the future. In a change assessment of the aquatic guilds in Pools 4 through 26 (USACE Nav. Study Unpub. Data), island habitat would decrease from 43 356 ha in 1998 to 42 467 ha in 2050 (-2%). Of the 888 ha of island habitat lost during this period, 786 ha (88.5%) would be from Pools 4-10. Island habitat in Pools 4-10 is currently estimated at 18 854 ha and would decline by 8.5% over the next 50 years. In Pools 11-26, island habitat is predicted to increase by nearly 3% to 25 218 ha. The general habitat needs for the bald eagle are mature trees for nesting, perch, and roost sites. The best estimate for the prediction of future habitat conditions in the project area is a 2% decline of island area and the accompanying loss of approximately 81 ha of potential bald eagle habitat. Most of the nests on islands are located on the interior of larger islands and would not be impacted by shoreline erosion. The loss of bottomland forest may reduce the amount of bald eagle nesting, perching, and roosting in the project area. However, the Navigation Study prediction is for island habitat, and no estimate is made for the other areas of bottomland forest. These other forested areas are not expected to decline in the next 50 years.

The long-term impact of impoundment upon the bottomland forest and species composition is not yet fully understood. Though impoundment appears to be having some effect, the trees continue to produce seeds so the reproductive potential of the community remains. Yin (1999) predicts that the present-day forest composition of the Upper Mississippi River will be sustained for the next 50 years, and the sustainability of certain communities depends on large flood occurrences (e.g., 1993 flood). The operation of the locks and dams and impoundment of the Upper Mississippi River do not affect the occurrences of large floods. Many species within the bottomland community are shade intolerant, i.e., they need substantial sunlight to grow from seedlings. Ecologically, intolerant plant species need some sort of disturbance in the canopy to survive and grow. Following the floods of 1993, personnel at the Mississippi River Project Office in La Crescent, Minnesota, documented 251,720 seedlings/acre of previously flooded bottomland habitat. Due to the shading caused by the dense overstory canopy, the seedlings at the study site declined steadily to the point that they were eliminated in the understory within 4 years. Ecological catastrophes drive intolerant forest ecosystems, i.e., flooding, fire, tornadoes, wind shears, etc. are needed to open the canopy so the species can regenerate itself. Forestry practices can be developed and implemented to mimic these ecological catastrophes. The Corps is actively taking action to address forest resource problems on fee-owned land and is working towards a better understanding of long-term forest impacts associated with the navigation project (see section 7.3.5).

Overall, impoundment of the Upper Mississippi River would have no effect on the overall population since bald eagle numbers in the project area have increased dramatically in the past two decades despite the continual loss of bottomland forest and island habitat.

7.3.2 Maintenance of the 9-Foot Channel Project

7.3.2.1 Dredging

Dredging primarily affects the main channel of the river, but it can also affect side channels, sloughs, and backwater lakes and ponds through increased turbidity levels and resuspension of pollutants. Dredging can affect bald eagles by impacting their food source. Dredging in the location of a nest could cause nest failure or abandonment depending upon the time of year, duration of dredging, and proximity of the nest to dredging activity. The local fish base is the main staple diet item to bald eagles. Fish are also susceptible to local extermination and can be affected by turbidity, intake of resuspended pollutants, and reduced oxygen levels. Suspended solids and sedimentation from dredging can cause clogging and abrasion of gills and other respiratory surfaces in fish, and can affect spawning beds and feeding. Consequently, bald eagle feeding patterns may be affected during the dredging operations.

Dredging occurs during the open-water season, so bald eagle use of winter feeding and roosting habitat would not be disturbed. Dredging operations can begin in April during the critical nesting period, which could disturb bald eagle nesting activities. However, the average date of first dredging is mid-May, after the most critical nesting period. Dredging occurs in the main navigation channel or within the confines of established boat harbors which are frequently disturbed by recreational and commercial craft use. The dredging operations would add an incremental increase to this disturbance factor. However, dredging operations at a site are typically of short duration, usually lasting only a couple of days. In addition, it is assumed that bald eagles nesting near the main channel are fairly tolerant of human activity. The incremental increase in activity in the main channel or boat harbors from dredging does not add appreciably to the existing disturbance by recreational and commercial craft activities. Therefore, no effects on bald eagle nesting activities are anticipated from dredging.

7.3.2.2 Placement

Placement of dredged material on upland sites could affect bald eagles in two ways: (1) by causing sufficient disturbance during placement activities to have an impact on nesting; or (2) by changing the conditions of bald eagle habitat. The disturbance factor in dredged material placement depends upon the timing of placement, the duration of placement, and the proximal distance to a bald eagle nest. Sediment quality, in terms of contaminants, could also be a factor. In areas with sediment contamination problems, effluent discharge from placement sites could affect the fisheries downstream of the discharge through reduced water quality, both in fish densities and contaminant buildup in fish tissue. This could affect bald eagles by decreasing their food source and bio-accumulation of contaminants in the food chain. Since most of the dredged material contains very little silt and clay, it is extremely unlikely that these types of contaminants would be released at placement areas.

Use of temporary containment sites could affect bald eagles through destruction of habitat, disturbance, and potential contamination. Destruction of habitat could include removal of nesting, perching and roosting trees or changing the habitat conditions of feeding areas, such as precluding the growth of trees along the main channel. Several new containment sites are approved that have not been implemented and several more are currently in the planning phase. The impact of developing new containment sites would have to be evaluated on an individual basis. Disturbance can result from increased human activity within 965 m of an active nest site.

Human disturbance has been shown to negatively affect bald eagle nesting. Eagles are most sensitive to disturbance during the critical nesting period when they are involved with courtship, egg-laying, and incubation. The critical nesting period is generally from March 15 to May 15. The moderately critical period is 1 month before and after the critical nesting period. From February 15 to March 15, the eagles are becoming physiologically conditioned for breeding. From May 15 to June 15, the newly hatched eagles require frequent brooding and feeding. Eagles tolerate moderate amounts of human presence during the low critical period from June 15 to October 1 when young are in the post-fledgling stage.

In-water placement of dredged material could affect bald eagles through disturbance and change of habitat in feeding areas. Although permanent in-water placement of dredged material is not done on the upper portions of the Upper Mississippi River and the Minnesota, St. Croix, Black, or Illinois

Rivers, in some instances a temporary in-water rehandling site is required. In-water placement is a normal method of handling dredged material in lower portions of the Upper Mississippi River. Current dredged material placement would have no effect on bald eagle use of the Upper Mississippi River. Sites not currently used for dredged material placement would have to be evaluated on a case-by-case basis to determine the degree of impact.

7.3.2.3 Clearing and Snagging

Removal of trees or other obstructions from the navigation channel could affect bald eagles by removing nest, perch, or roost trees along the shoreline. The majority of snagging occurs on the Minnesota River and is performed on the St. Croix River upon request of the National Park Service. Both the Minnesota and St. Croix Rivers receive little eagle use. Therefore, clearing and snagging activities would have no effect on bald eagles or their habitat.

7.3.2.4 Channel Structures and Revetments

Channel structure modifications are designed to concentrate flows in the main channel and, therefore, primarily affect flow patterns along with sedimentation patterns. Construction-related impacts of channel control structures could be expected in areas near nesting or roosting sites. Closing dams would be constructed to reduce flows into side channel areas. Primary impacts such as reduced volume of flow, reduced current velocities, reduced sediment input, and increased water residence time in backwaters would occur in these habitats and could affect the local fishery species inhabiting side channel areas. The increased flows in the main channel resulting from side channel closure would affect main channel and channel border habitats as well. Changes in the dynamics of side channels could change the local fisheries, thereby affecting bald eagle feeding opportunities. Placement of stone protection on shoreline areas could affect bald eagles if bank reshaping, including tree removal, is included in the plan, especially if the project is within nesting or roosting zones. In general, structures and revetments would have no effect on the bald eagle.

7.3.2.5 Lock and Dam Rehabilitation

The main impact to future rehabilitation work for the locks and dams within the project area would be mainly through disturbances resulting from increased human activity and associated construction equipment. Depending upon the scope and/or timing of the proposed work, rehabilitation of the locks and dams could effect bald eagle nesting, feeding, or winter roosting. Change of habitat conditions would not result in most construction efforts at locks and dams because rehabilitation entails repair of the existing structures currently in place, not increasing the footprint of the project area. In these cases, there would be negligible disturbance to areas outside the existing disturbed area, so no additional bald eagle habitat would be impacted. Lock and dam rehabilitation efforts that increase the footprint of disturbance (e.g., Lock and Dam 3 spot dikes) would have to be evaluated on an individual basis.

Bald eagle nests are not likely to be located near a lock and dam because of high human activity. Any bald eagle pairs with nests located near the structures may be previously conditioned to disturbances and are probably less apt to be disturbed by the increased activity. Rehabilitation activities during winter may impact feeding activities of eagles downstream of the structure in the open water areas; however, this impact is expected to be minor because eagles are most tolerant of human activity during the winter at feeding areas. Since rehabilitation occurs at a single lock and dam at a time, additional feeding areas would be available at structures upstream and downstream, as well as other open water areas in the vicinity of the lock and dam being rehabilitated. A Programmatic Environmental Impact

Statement on major rehabilitation of Locks and Dams 2-22 was completed by the Rock Island District, Corps of Engineers (USACE 1989b) and is incorporated by reference. The biological opinion rendered by the U.S. Fish and Wildlife Service concluded that rehabilitation would have no effect on the bald eagle.

7.3.3 Navigation-Related Indirect Effects

7.3.3.1 Tow Traffic

The potential impacts to bald eagles through tow traffic effects would result from either increasing the disturbance levels around bald eagle activity areas or destroying bald eagle habitat. Eagles have become accustomed to current levels of tow traffic in the project area, as evidenced by the steady increase in nesting numbers. The impact of any increased tow traffic upon bald eagle nesting within the project area is unknown. Eroding shoreline resulting from propeller wash occurs in areas awaiting lockage in areas downstream of the locks and dams. As a result of this erosion, trees have been toppled and certain backwater habitat has been changed. Both are important bald eagle habitat components. Since the impact of erosion is so localized, the impact to bald eagles or their habitat would be negligible.

7.3.3.2 Fleeting and Port Facilities

Terminal or port facilities are typically within urban or industrial areas, usually built within floodplain habitat. Barge fleeting areas are at high risk for potential bank erosion. However, since the majority of these facilities are in urbanized settings, it is likely that eagle use of these areas would be minimal. Existing fleeting and port facilities have no effect on bald eagles or their habitat. Future expansion of fleeting areas or terminals would be subject to regulation and environmental review, and the evaluation of potential endangered species impacts would be assessed through the permit process. Minnesota, Wisconsin, and Iowa regulate barge-fleeting activities through their own regulations, and Illinois and Missouri regulate through review of the Federal permitting process. In addition, trespass laws may be enforced on Federal property should inappropriate fleeting occur there. Impacts to bald eagles and their habitat by future fleeting and port facility expansion would be evaluated in a separate Section 7 Consultation process.

7.3.3.3 Exotic Species - Not applicable

7.3.3.4 Contaminants

The potential impacts of contaminants from navigation-related effects are potential mortality and reduced nesting success. Numerous studies have linked productivity declines and complete nesting failures with eagle exposure to a range of environmental contaminants. Most of the contaminants responsible for the long-term decline of the bald eagle are no longer used in the U.S. and therefore are not transported or stored by navigation interests. However, due to their widespread use and persistent nature, some contaminants may still be a contributing factor impacting eagle survival and productivity. Many organisms have been shown to be sensitive to a wide range of contaminants, including ammonium, pesticides, and petroleum products, all of which are commonly transported on the Upper Mississippi River. Past practices (i.e., weirs, locks and dams, mooring sites) have made navigation safer on the Upper Mississippi River and have dramatically reduced the potential for a hazardous spill. Persistent contamination in the Upper Mississippi River corridor has dramatically declined from the historic levels that suppressed bald eagle nesting success.

Chemicals of this nature will also continue to decline and will continue to have no effect on bald eagles or their habitat.

7.3.4 Recreation-Related Indirect Effects

7.3.4.1 Facilities

Development of recreational facilities could be responsible for disturbance to bald eagles utilizing nearby habitat. The level of disturbance depends upon the proximity of the recreation area, type and level of human activity at the site, and available eagle habitat. Considering current population trends, human use of these facilities will likely increase, which will increase the potential for conflict. The development of existing facilities requires varying levels of habitat modifications. Most of the development of these areas disturbs upland habitat components and would further add the potential for disturbance to bald eagles by increasing human use of the area or destruction of the habitat. Based upon recent trends of bald eagles using habitat near areas of human disturbances, the overall impact may not have the same consequence as previous research has speculated (i.e., Mathisen *et al.* 1977). It does not appear that current recreational facilities have an effect on bald eagles. Future expansion or new developments need to be assessed on a case-by-case basis to determine the degree of impact.

7.3.4.2 Large Vessels

Large vessel traffic could impact bald eagles through disturbance factors during the nesting season. However, based on current bald eagle numbers present in the Upper Mississippi River and recent increases in the last decade, it appears that disturbance from vessel passage does not affect the species at current levels. It is likely that additional vessel traffic would not impact bald eagle nesting based on the eagle nests being located away from the main navigation channel.

7.3.4.3 Beach Use

Beach use has the potential to disturb bald eagles during the nesting season. The level and degree of disturbance depends upon the proximity of the beach site to the available eagle habitat. Considering current population trends, human use of beach sites will likely increase, thereby increasing the potential for conflict. Additional development and construction of new beach sites require varying levels of habitat modifications, disturbing both upland and wetland habitat components. The disturbance would further add to the potential for disturbance to bald eagles. Based on recent trends of bald eagles and their tolerance levels to human activity, it appears that this impact would not be substantial.

7.3.4.4 Exotic Species - Not applicable

7.3.4.5 Contaminants - Not applicable

7.3.5 Interrelated Effects

7.3.5.1 Forest Management

Forest management is described previously in section 3.1.3. As with most habitat management projects, the prescribed forest management practices may cause temporary adverse impacts but provide long-term benefits to the habitat (i.e., forest regeneration). All forest management prescriptions are evaluated for presence of threatened or endangered species or species of special concern, and actions are taken to avoid impacts to these species. This includes designation of special management zones, observance of seasonal restrictions, and provision of buffers. Forest management practices are carried out through close coordination with State and Federal resource agencies, including the U.S. Fish and Wildlife Service. Forestry practices diversify the habitat and strive to maintain size class diversity. Specific actions are described in the OMP, 5-year plan, and environmental assessment prepared for forestry, fish, and wildlife management within the St. Paul and Rock Island Districts. Forest management practices that maintain forest age class and diversity contribute to the conservation of the species through providing and maintaining suitable habitat into the future. Forestry practices would not negatively impact bald eagle habitat.

7.3.5.2 Cabin Leases

The lease of cabin sites has the potential to impact bald eagle nesting, roosting, and feeding through disturbance and habitat loss in the project area. Private recreational and residential leases affect approximately 283 ha. No new leases will be issued, but those in existence are maintained. All leases returned to the Corps are released and natural resource management prescriptions are implemented. This usually includes closure or removal of the access road and conversion to natural habitat. All new maintenance actions taken by lessees are subject to review; therefore, impacts to bald eagles would be considered at that time.

7.3.5.3 General Plan Lands

Management of General Plan lands by the U.S. Fish and Wildlife Service and state natural resource agencies could result in changes to bald eagle habitat. Within the range of the bald eagle, these areas include the Illinois River refuges, Mark Twain National Fish and Wildlife Refuge, Upper Mississippi River National Wildlife and Fish Refuge, and various areas managed by state agencies. Detailed descriptions of the refuges are included in the respective refuge master plans. No specific practices are listed in these master plans, so no prediction of impact is possible. In general, the management practices on General Plan lands that maintain forest age class and diversity contribute to the conservation of bald eagle habitat. However, those activities that increase human activity near nesting sites during critical periods or clear the bottomland forest may negatively impact the bald eagle.

7.3.5.4 Public Use Sites

The potential general impacts of operating Corps public use sites are disturbance and habitat loss or modification. Operation and management of Corps-operated recreation facilities include routine maintenance of existing facilities, and there is no planned expansion of these areas that may contribute to future loss of suitable habitat. Therefore, future habitat loss from public use sites is not likely and will not affect the bald eagle. Human activity at the public use sites has the potential to disrupt bald eagle nesting, feeding, and roosting behavior depending upon the level and timing of human use and the location of bald eagle use sites. At the present time, it appears that public use sites have no impact on bald eagles, nor is it likely to impact the species in the future.

7.3.5.5 Corps Port Facilities

Two Corps of Engineers port facilities are within the range of the bald eagle: one in the St. Paul District (Fountain City) and one in the Rock Island District (Le Claire Service Base). In general terms, the port facilities impact the bald eagle through disturbance and habitat loss or modification. Neither base has plans for expansion, so no additional habitat would be impacted. Both bases will continue to operate, which could potentially disturb bald eagle nesting, feeding, and roosting behavior. There are no known nests near the bases, which are located within urban areas of high human use. Operation and activity at each service base does not increase human activity at either site substantially; therefore, operation of the bases would not affect the bald eagle. Any future expansion at the facilities would have to be evaluated on a case-by-case basis to determine potential impact upon the bald eagle.

7.3.6 Interdependent Effects

7.3.6.1 Missouri River Navigation - Not applicable

7.3.6.2 USCG Buoy Tending - Not applicable

7.4 DETERMINATION

The Corps of Engineers' operation and maintenance activities of the 9-Foot Channel Navigation Project do have site-specific impacts on the bald eagle, but would not individually or cumulatively have an adverse impact on their populations. In providing the 9-foot channel, there are also indirect effects of the operation and maintenance activities that are addressed. Cumulatively, the direct and indirect effects on the bald eagle and their habitat are both positive and negative. The initial decline of bald eagles in the project area was caused by a number of factors, many of which no longer are present (i.e., bio-accumulation of contaminants, indiscriminant shooting, etc.). Recent population trends in the northern recovery zone of the bald eagle have exhibited dramatic increases, and all recovery goals have been exceeded. It is our determination continued operation and maintenance will not likely adversely affect the bald eagle.

8.0 PALLID STURGEON

Pflieger (1997) indicated that the endangered pallid sturgeon (*Scaphirhynchus albus)* occurs in the Missouri River and the Mississippi River downstream from the mouth of the Missouri. The species formerly occurred in the Mississippi River at least as far upstream as Grafton, Illinois, but there are no recent reports from the Mississippi upstream from the mouth of the Missouri. Smith (1979) indicated that in Illinois the species occurs in the Mississippi River between the mouths of the Missouri and Ohio Rivers.

A published record for the Mississippi River at Keokuk, Iowa, (Coker 1930) was rejected as probably in error by Smith *et al.* (1971). Forbes and Richardson (1905) reported nine specimens from fish markets in Grafton and Alton in their description of the species. Smith (1979) indicated that "The evidence available suggests that this silt-tolerant species enters the Mississippi River from the Missouri River and that the specimens Forbes & Richardson reported from fish markets of Grafton and Alton were captured below the mouth of the Missouri River." Based on this information, Smith (1979) restricted the type-locality of the pallid sturgeon to the Mississippi River at the mouth of the Missouri.

Pallid sturgeon, like shovelnose sturgeon, inhabit comparatively large flowing rivers, but pallid sturgeon occur over a narrower range of conditions. They prefer greater turbidity (Bailey and Cross 1954, Lee 1980a, 1980b), finer substrates, and deeper, wider channels; and they are more likely than shovelnose sturgeon to occur in sinuous reaches and near long-established islands and alluvial bars (Bramblett 1996). Pallid sturgeon typically inhabit thalwegs and channels of relatively low slope (Constant *et al.* 1997). Characteristic depths inhabited by pallid sturgeon vary among populations and with river morphology, but fish typically avoid shallow waters. In the Middle Mississippi River, they were found in locations with water depths ranging from 1.82 to 19.17 m (Sheehan *et al.* 1998). They were found most often (87.7% of all relocations) in water with maximum depths from 6 to 12 m. The study sturgeon were primarily found in the main channel and main channel border habitats, which typically consist of depths in this range. Pallid sturgeon in the Atchafalaya River inhabited depths of 7 m to 21 m (Constant *et al.* 1997), and pallid sturgeon in the Missouri River used areas with depths ranging from 0.6 m to 14.5 m with a mean of 3.30 m, and bottom current velocities ranging between 0 m/s to 1.37 m/s with a mean 0.65 m/s (Bramblett 1996).

The U.S. Fish and Wildlife Service and the St. Louis District, U.S. Army Corps of Engineers, co-funded a study which was principally designed to address the Recovery Plan's Primary Task 3.2.1, Conduct Field Investigations to describe the micro- and macro-habitat components of spawning, feeding, staging, and rearing areas. Sonic telemetry was used to determine the movements, locations, and habitat use of pallid sturgeon (Sheehan *et al.* 1997a, 1997b, 1998).

Sheehan *et al.* (1997a, 1997b, 1998) implanted transmitters in 13 male pallid sturgeon from the Middle Mississippi River. In 157 observations (transmitter contacts) of fish from November 13, 1995, through September 30, 1998, Sheehan *et al.* (1998) found that male pallid sturgeons predominantly used the main channel (43% of the time). The main channel border was used 21% of the time. They were found in depositional areas between wingdams 15% of the time. All other habitats comprised 1% to 9% of all observations.

Habitat associations for the winter season were broken down into two different temperature regimes: below 4^{o} C and between 4^{o} C and 10^{o} C. Below 4^{o} C, the study sturgeon were found in association with current-disrupting habitat features such as the downstream island tip and downstream wingdam tip habitats more often (11% and 11%, respectively). However, the main channel (45%) and the main channel border (14%) were still used most often. Habitat associations below 4^{o} C were as or more diverse than any other season with six of the seven study habitats being used.

Once winter temperatures rose above 4^{o} C, habitat use became more restricted. The study sturgeon were only found in association with the main channel, main channel border, between wingdams, and downstream island tip habitats. The main channel (67%) and the main channel border (20%) together comprised 87% of all relocations in this temperature range.

Habitat associations at temperatures above 10^{o} C but below 20^{o} C during the spring months deviated from those during the rest of the year. The main channel and main channel border habitats which were used heavily during the rest of the year comprised only 7% and 20% of the relocations during the spring, respectively. Use of the between wingdam habitat increased greatly during the spring at 40% of the contacts. The downstream island tip (20%) and wingdam downstream (13%) habitats were also used. However, it should be noted that the number of contacts during this period was low (n = 15) due to spring flooding.

During the fall months at temperatures at or above 10^{o} C but below 20^{o} C, habitat associations were similar to those during the rest of the year. Main channel associations comprised 62% of the contacts, while the main channel border comprised 19%. The downstream island tip, wingdam tip, and between wingdams habitats were also used at 8%, 8%, and 4%, respectively.

During the summer (surface water temperatures over 20^{o} C), habitat associations were diverse and closely resembled the overall habitat associations. The wingdam tip macrohabitat saw its heaviest use during the summer months at 16%. The other major habitats of use during the summer were the main channel (29%), main channel border (27%), island tip downstream (8%), and the between wingdam areas (18%).

These observations support previous studies demonstrating that pallid sturgeon occupy mid-channels and deeper water more frequently than do shovelnose sturgeon, which are more likely to occur in shallower, nearshore waters (Hoover and Killgore 1998, Moos 1978, Bramblett 1996, Constant *et al.* 1997).

Twenty-nine substrate measurements were taken by Sheehan *et al.* (1998) at points where pallid sturgeon were relocated. Eighty-six percent of the time (n = 25) study fish were found over sand substrates. Ten percent of the time sturgeon were found over mud/silt substrates (n = 3). In the Missouri River, pallid sturgeon appeared to utilize sand and avoided gravel-cobble substrates (Bramblett 1996).

Spawning has never been observed (Kallemeyn 1983). Based on the apparent reproductive conditions of adults, the spawning season is believed to be during spring, initiation dependent upon latitude and timing of proximate cues like spring runoff. It is presumed to take place during high water. Spawning probably begins in March in the lower Mississippi and Atchafalaya Rivers, late April or early May in the lower Missouri and Middle Mississippi Rivers, and late May or early June in the Upper Missouri River (Keenlyne and Jenkins 1993). During spring and early summer of both 1993 and 1994, Bramblett (1996) documented aggregations of pallid sturgeon in the lower 12 km of the Yellowstone River, which included a female known to be gravid when tagged. He surmised that these aggregations were related to spawning.

The Pallid Sturgeon Recovery Plan suggested, based on the information from the shovelnose sturgeon, that wingdams may be used as spawning habitat in the main stem of large rivers (USFWS 1993c).

8.1 POTENTIAL IMPACT ZONE (RANGE OF PALLID STURGEON)

The U.S. Fish and Wildlife Service (1998b) indicated that the species "can be considered to occur anywhere in the Mississippi River downstream of its confluence with the Missouri River. There is no critical habitat listed for this species in Illinois."

8.2 REASONS FOR ENDANGERED STATUS OF PALLID STURGEON

The U.S. Fish and Wildlife Service (1993c) listed four reasons for the decline of the pallid sturgeon: (1) habitat loss, (2) commercial harvest, (3) pollution/contaminants, and (4) hybridization. The following discussion is provided to supplement the review provided by the U.S. Fish and Wildlife Service (1993c), with much of the information published after the release of the Pallid Sturgeon Recovery Plan.

Reduced numbers and possible extirpations are indicated in Kansas and in Missouri and are attributed to anthropogenic regulation of river flows (Cross and Moss 1987, Pflieger and Grace 1987). Dams block movements of pallid sturgeon and populations become segregated and fragmented (Keenlyne *et al.* 1994b, Bramblett 1996). Impoundments also create lentic environments which are avoided by pallid sturgeon (Constant *et al.* 1997). Impoundments also reduce discharge, variation in discharge, erosion, turbidity, and presence of fine substrates, habitat factors to which the pallid sturgeon is specifically adapted (Bailey and Cross 1954, Cross and Moss 1987).

Reduced turbidity of water and prevalence of coarse substrates are believed to reduce feeding efficiency of the pallid sturgeon, a turbid water piscivore, and enhance feeding by shovelnose, a clearer water invertivore. Population declines may be attributed to lowland rivers that have become more like upland habitats, favoring shovelnose sturgeon, and possible competition with more adaptable, but biologically similar species (Pflieger and Grace 1987, Ruelle and Keenlyne 1994). Length-weight relationships in the upper Missouri River suggest that fish of a given size were heavier prior to completion of reservoirs than after the reservoirs were established (Keenlyne and Maxwell 1993).

Water pollution also may have impacted pallid sturgeon populations. Long-lived, bottom-feeding fishes can bio-accumulate heavy metals and organic pesticides in their tissues. In the Missouri River, pallid sturgeon with high concentrations of mercury, cadmium and selenium, and of PCBs, DDTs, chlordane, and dieldrin are documented (Ruelle and Keenlyne 1993). These substances accumulate in multiple organ systems including the kidney, liver, and ovaries. High concentrations are associated with lower growth rates and decreased standing crops of fish. Several of these contaminants are concentrated in egg tissues and probably impair successful reproduction. Although there are no data for the pallid sturgeon in the Middle Mississippi River, the Missouri Department of Conservation has collected contaminant data for shovelnose sturgeon eggs (Mr. Alan Buchanan - Missouri Department of Conservation, personal communication, January 4, 1999). Ruelle and Keenlyne (1994) suggested that shovelnose sturgeon are, based on current knowledge, the best surrogate available for study because of their many similarities to the pallid sturgeon. They also suggested that shovelnose sturgeon may have lower concentrations of organochlorine compounds than pallid sturgeon because shovelnose sturgeon may accumulate less body fat.

In the past, the Middle Mississippi River was grossly polluted (Barnickol and Starrett 1951:274-276). For example, in 1947 commercial fishermen in the vicinity of Valmeyer, Illinois, complained that often half of their catches were discarded because of an unpleasant taste resulting from pollution. Starrett and Harth (1950) reported that a serious pollution problem existed on the Mississippi from below Lock and Dam 26 to Cairo, Illinois, and that commercial fishing was almost nonexistent from the St. Louis area to the mouth of the Kaskaskia River. In fact, the conditions remained extremely poor and existed into the 1970's (Thixton Miller - U.S. Army Corps of Engineers, personal communication, January 11, 1998). This section of the river has only recently begun to recover since the enactment of clean water laws. Considering the age at reproduction of both males and especially females, we may be just now seeing the recovery of this species from the effects of pollution.

Altered habitats reduce isolating mechanisms of sympatric species, and abundances of the two sturgeon species are disparate. Both factors reduce likelihood of intrapecific matings of pallid sturgeon and increase the likelihood of interspecific hybridization. Although, some estimates of relative abundance of pallid to shovelnose sturgeon are as high as 1:5 (Etnier and Starnes 1993), most estimates are much lower, 1:20 to 1:400 (Kallemeyn 1983, Carlson *et al.* 1985, Hoover and Killgore 1998).

Hybridization between shovelnose and pallid sturgeon has been well documented and is believed to be a recent phenomenon (Carlson *et al.* 1985). Values for morphological and meristic characters of hybrids are intermediate between those of shovelnose and pallid sturgeon. Hybrids also demonstrate intermediate growth rates and levels of piscivory when compared with those of the parent species. Initially documented percentage of hybrids was low (<0.5% of sturgeon), but more recent estimates have indicated high percentages in the Middle Mississippi River (86.4%) and the Atchafalaya River (43.8%) (Keenlyne *et al.* 1994b). These hybrids are not intermediate in all morphomeristic characters, suggesting that they are not F1 hybrids (first generation offspring of two different species).

Pallid sturgeon may also be impacted by commercial fishing. Historically, river sturgeon were occasionally targeted by commercial fishermen and were frequently obtained as bycatch. Large specimens, including pallid sturgeon, were exploited for caviar, and smaller specimens, including shovelnose sturgeon, were discarded as nuisances (Carlander 1954, Moos 1978). Commercial fishing is believed to have contributed to declines of both species since the early 20th century. Consequently, several states now prohibit fishing for and retention of any river sturgeon. Sheehan *et al.* (1997b) observed four pallid sturgeon among the catch of 179 sturgeon by a commercial fisherman. Although taking pallid sturgeon is illegal, law enforcement appears to be poor.

8.3 PROJECT ACTIONS/POTENTIAL SPECIES IMPACTS

8.3.1 Operation of the 9-Foot Channel Project

8.3.1.1 Water Level Regulation - Not applicable

8.3.1.2 Impoundment

a. Preclusion of upstream movement (Upper Mississippi River, Illinois River, Kaskaskia?).

The U.S. Fish and Wildlife Service (1998a) indicated that the species "can be considered to occur anywhere in the Mississippi River downstream of its confluence with the Missouri River." Pflieger (1997) and Smith (1979) both indicated that the species is found in the Middle Mississippi River below the mouth of the Missouri River. Historical records for the Mississippi River indicate that the species moved short distances above the Missouri River, being caught at Grafton, Illinois, at the mouth of the Illinois River (Forbes and Richardson 1905). Based on this distribution, the construction of locks and dams on the Mississippi, Illinois, and Kaskaskia Rivers would have had minimal impact on upstream movement of the pallid sturgeon.

b. Habitat loss. Loss of riffle habitat which may have provided spawning habitat.

Again, the areas of impoundment and any subsequent loss of riffle habitat by impoundment are outside the known range of the species.

8.3.2 Maintenance of the 9-Foot Channel Project

In the Middle Mississippi River, the St. Louis District uses open-water placement, utilizing historic dredged material placement sites that are located near shore. Use of open-water placement sites is based on two criteria: (1) not more than 20% of the dredged material can consist of fines, and (2) the placement site has to contain similar bed material as the dredged material (e.g., sand has to be placed on sand). A sediment size analysis of both the area to be dredged and the open-water placement site is conducted prior to dredging. The dredged material and placement site bed material in the Middle Mississippi River has never exceeded the 20% fines analysis and consists of sand (Mr. Roger Myhre - St. Louis District, U.S. Army Corps of Engineers, personal communication, January 6, 1999).

8.3.2.1 Dredging - Habitat loss or modification

In the Middle Mississippi River, pallid sturgeons were found in locations with water depths ranging from 1.82 to 19.17 m (Sheehan *et al.* 1998). They were found most often (87.7% of all relocations) in water with maximum depths from 6 to 12 m. The study sturgeon were primarily found in the main channel and main channel border habitats, which typically consist of depths in this range. These data indicate that pallid sturgeon, in the Middle Mississippi River, prefer deeper water. Dredging occurs in depositional areas to maintain a 9-foot navigation channel. As such, it is not expected that dredging will modify habitat that is heavily used by pallid sturgeons—at most marginal habitat will be affected. It should be noted that characteristic depths inhabited by pallid sturgeon vary among populations and with river morphology (Constant *et al.* 1997, Bramblett 1996, Sheehan *et al.* 1998). Considering the plasticity of pallid sturgeon habitat preference, they may be present in main channel and main channel border areas that require periodic dredging. However, this does not appear to be their preferred habitat in the Middle Mississippi River, where they typically avoid shallow waters.

General and project-specific permits issued by the Corps of Engineers in the Memphis, Vicksburg, and New Orleans Districts recognize potential dredging-related risks to spawning pallid sturgeon. Dredging is prohibited during presumed "windows" of pallid sturgeon reproduction: April 1 - June 30 in New Orleans and Vicksburg Districts, April 12 - June 30 in the Memphis District.

The presumed "window" of pallid sturgeon reproduction is currently outside the period when channel maintenance dredging occurs in the St. Louis District. Table 4 presents dredging dates for the Middle Mississippi River for the last five dredging seasons.

TABLE 4. Channel maintenance dredging schedule for the Middle Mississippi River for dredging seasons 1994-1998 (last 5 years).

Dredging Year	Date Dredge Mobilization	Date Dredge Demobilization
1994	08/17/94	08/21/94
	08/30/94	09/22/94
	10/02/94	12/06/94
1995	01/12/95	01/21/95
	09/26/95	01/27/96
1996	09/18/96	09/24/96
	10/07/96	12/06/96
1997	09/02/97	12/20/97
1998	09/26/98	10/05/98
	10/29/98	11/03/98
	11/28/98	01/08/99

Based on the current dredging schedule for the Middle Mississippi River (Table 4), no effect (disturbance or direct impact) is anticipated on spawning pallid sturgeon or their eggs and larvae. The potential effects on young-of-the-year are unknown.

Conservation Measure: The St. Louis District will continue to conduct maintenance dredging outside the presumed "window" of pallid sturgeon reproduction of April 12 - June 30. In cases where emergency dredging is required, the U.S. Fish and Wildlife Service will be contacted.

8.3.2.2 Placement - Habitat loss or modification

In the Middle Mississippi River, the St. Louis District conducts open-water placement, utilizing historic dredged material placement sites that are located near shore. Because these areas are in the main channel border, it is possible that adult pallid sturgeon utilize these sites. Considering the lack of data on this species, it is possible that young-of-the-year pallid sturgeon may utilize these areas. It is also possible that these areas may be utilized for feeding. However, it is not known to what extent placement areas are currently being used by sturgeon. In addition, it is not known what the recovery period is for placement areas after dredged material placement. Given that placement areas represent a small fraction of similar habitat in the Middle Mississippi River, it appears that dredged material placement may have localized effects but is having minimal adverse impacts on the pallid sturgeon.

Currently, thalweg placement is not conducted in the Middle Mississippi River. However, the St. Louis District is currently evaluating the potential for thalweg placement in the Middle Mississippi River. Prior to initiating a thalweg placement program, a hydroacoustic fishery survey will be conducted of potential placement areas during the dredging season to determine if these areas provide usable fishery habitat. These studies will be coordinated with the U.S. Fish and Wildlife Service. If it is shown that these main channel areas provide valuable habitat during the dredging season, thalweg placement in the Middle Mississippi River will not be conducted in designated areas.

8.3.2.3 Clearing and Snagging - Not applicable

8.3.2.4 Channel Structure/Revetment

a. Changes in river processes result in habitat loss or modification.

Sheehan *et al.* (1998) found that in the Middle Mississippi River pallid sturgeons predominantly used the main channel 43% of the time. The main channel border was used 21% of the time. They were found in depositional areas between wingdams 15% of the time, at wingdam tips 8% of the time, downstream of wingdams 4% of the time, and upstream of wingdams 1% of the time. If all wingdam sub-habitat types are summed, they were found in association with wingdams 28% of the time. They were found downstream of island tips 9% of the time.

Even with the work of Sheehan *et al.* (1998), it is impossible to say one way or the other if channel structures/revetment impact the pallid sturgeon. We do know that pallid sturgeon spend nearly equal amounts of time (transmitter contacts) associated with "structure modified" main channel border (28%) habitat and unmodified main channel border (21%) habitat. This indicates that they are not avoiding "structure."

8.3.2.4.1 Wingdams

Dike systems may cause localized flattening of channel slope, increased roughness, vertical accretion of bars, increases in main channel volume, and stage reductions at low discharges (Elliott *et al.* 1991). These structures are designed to direct flow towards the middle of the channel, thus reducing the natural meandering capability of the river. The degree of these effects depends on the geomorphic location, initial channel top bank width, degree of divided flow conditions and braiding, and channel depth.

The U.S. Fish and Wildlife Service has indicated concern that wingdam fields fill with sediment and gradually accrete to land, thus further constricting the channel (Joyce Collins, USFWS, personal communication, January 19, 1999). In the Middle Mississippi River, high wooden dikes were initially constructed to restrict the channel. These were responsible for accretion of land and constriction of the channel (Mr. Robert Davinroy - St. Louis District, personal communication, February 22, 1998). However, dikes are currently constructed to avoid these effects; after an initial period of sandbar accretion, the habitat stabilizes (Shields 1995, Smith 1986). Shields (1995) studied changes in morphology of 26 representative dike fields in the Lower Mississippi River. Dikes in the selected study fields were built between 1957 and 1983, and 23 of the 26 fields were completed prior to 1975. Existing hydrographic survey data were used to compute a time series of dike field pool water areas and volumes for each site. Between 5 and 11 surveys (mean=7) were available for each dike field, and the mean time between surveys was 3 years. Dike pool areas and volumes showed the most rapid change during the first 5 years following construction. Since the dikes were constructed, aquatic volume and area of associated low-velocity habitats have been reduced by 38% and 17%, respectively. However, after initial adjustment, habitat area and volume fluctuated about a condition of dynamic equilibrium. Lower Mississippi River dike fields experience rapid sedimentation and sandbar development during the first few years after construction and then fluctuate about a condition of dynamic equilibrium. Similar behavior has been noted in Middle Mississippi River dike fields (Smith 1986).

It is known that wingdams do have some potentially positive environmental consequences. Wingdams reduce velocities behind them, which provides low water velocity refugia for fish (Maynord 1998). Sheehan *et al.* (1998) found that during March through June (water temperatures above 10^{o} C and below 10^{o} C) pallid sturgeons were found between wingdams 40% of the time and below wingdams 13% of the time. Sheehan *et al.* (1998) suggested that the most likely explanation was that the study fish were using the between wingdam habitats during high spring flows as a velocity refugia. The area may provide lower velocities than the main channel and main channel border areas that were more commonly used than the between wingdam habitats during the other seasons. The St. Louis District's recent hydroacoustic studies conducted in wingdam habitat found the slack water areas to be packed with fish during cold water periods (Brian Johnson - U.S. Army Corps of Engineers, personal communication, January 11, 1999).

8.3.2.4.2 Bendway Weirs

River bends are notorious problem spots for engineers charged with maintaining the navigation channel. Lateral erosion on the outer bend is controlled with revetments, but downcutting (riverbed erosion) can create a very deep channel (10-30 m). Extreme main channel water depths are thought to be of little fisheries value (Baker *et al.* 1991). Dredging on the inner bend is necessary to control point bar expansion into the navigation channel.

Bendway weirs were designed to reduce dredging requirements in river bends by controlling point bar development (Davinroy 1990). They consist of a series of submerged dikes (>3m below the low water reference plane) constructed around the outer edge of a river bend. Each dike is angled 30^{o} upstream of perpendicular to divert flow, in progression, towards the inner bank. The result is hydraulically controlled point bar development and reduced downcutting throughout the bend. The channel bottom affected by the dikes is reduced in depth (3 versus 10 m) and has increased structure and hydraulic variation (Ecological Specialists, Inc. 1997b, 1997c).

Bendway weirs provide benefits for navigation channel maintenance, while at the same time provide complex habitat for macroinvertebrate and fish communities. The weir fields provide a more heterogeneous environment than the surrounding homogenous sand substrate, resulting in greater species richness and diversity of benthic invertebrates (Ecological Specialists, Inc. 1997b, 1997c).

Hydroacoustic surveys of fishes were conducted by Kasul and Baker (1996) in August 1994 and September 1995 in four river bends of the Middle Mississippi River between Cairo, Illinois, and Cape Girardeau, Missouri (River Miles 2-50). In 1994, two of the river bends had bendway weirs. In 1995, all four bends had bendway weirs. An additional bendway without weirs was also sampled in 1995. The bendway weirs added bottom structure in the channel and caused eddies and upwellings nearby.

Density comparisons suggest that bendway weirs increased the local abundance of fishes in affected areas of the river channel approximately two-fold. This was suggested by two experimental comparisons. In one comparison with 1994 data, two bends with weirs had a 2.2x higher density of fishes than two bends without weirs. In another comparison using data from 1994 and 1995 surveys, a 2.4x increase in fish density could be attributed to weir construction at the latter two sites.

Plotting of Sheehan *et al.*'s (1997a, 1997b) pallid sturgeon location data on a map of the of the Middle Mississippi River between River Miles 121-113 showed two fish that were located inside of the bend at the Kaskaskia Island bendway weir field and a large concentration of pallid sturgeon sightings just below the bendway weir field (USACE 1997g).

The U.S. Fish and Wildlife Service has indicated concern that there has been no analysis of the effects of bendway weirs on the inside bend point-bars (Joyce Collins, USFWS, personal communication, January 19, 1999). There is a concern by the Service that sandbar habitat is being lost. Although pallid sturgeon usage of existing sandbars is not known, Table 5 provides data on available sandbar habitat in the Middle Mississippi River (Mr. Steve Cobb - Mississippi Valley Division, U.S. Army Corps of Engineers, personal communication, March 5, 1999).

TABLE 5. Available sandbar habitat (acres) in the Middle Mississippi River at five different river stages referenced to the Low Water Reference Plane (LWRP).

LWRP	Acreage Available Habitat
Cairo, Illinois, to Thebes Gap	
0.0	3,031
5.0	3,800
10.0	4,315
15.0	4,674
20.0	4,735
Thebes Gap to Missouri River	
0.0	8,668
5.0	10,847
10.0	11,858
15.0	12,179
20.0	12,231

The effects of bendway weirs on point-bar fishery habitat were studied on the Lower Mississippi River (Schramm *et al.* 1998) by comparing the changes in late-falling and low-river stage electrofishing catch rates of prevalent fishes before (1994) and after (1996) installation of bendway weirs at Victoria Bend relative to the changes in catch rates of the same fishes at Rosedale Bend, a nearby reference site without bendway weirs. Large interyear variation in catch rates was observed and, for most prevalent species, catch rates declined from 1994 to 1996 in sandbar habitats. However, significant declines in catch rates of prevalent species at Victoria Bend relative to changes in catch rates at the reference site were only noted for gizzard shad. Conversely, catch rates of goldeye, channel catfish, and flathead catfish at sandbar habitat during late-falling river stage significantly declined from 1994 to 1996 at Rosedale Bend while catch rates remained similar at Victoria Bend. Based on this limited study, the bendway weirs appeared to reduce gizzard shad abundance but, at certain river stages, may have improved habitat conditions for threadfin shad, goldeye, channel catfish, and flathead catfish. No data on pallid sturgeon were collected.

<u>Conservation Measure</u>: The St. Louis District's Avoid and Minimize Team will be asked to prioritize physical-biological monitoring of point-bar habitat of bendway weirs in the Middle Mississippi River in FY 2000.

8.3.2.4.3 Bank Revetment/Off-Bank Revetment

Bankline revetments are used to eliminate the tendency for the main channel to migrate within the floodplain because channel movement can disrupt commercial navigation. Revetments serve to alter the sinuosity of the river channel and alter natural alluvial processes, such as erosion. Farabee (1986) studied fish at two revetted and two natural main channel border sites in Pool 26 over a 3-year period. Although number of species at each bankline type were similar, total fish collected was greater on bankline with revetments, especially a site with larger stone. This study and others indicate that rock creates a diversity of habitat types, allowing colonization of macroinvertebrates (Beckett *et al.* 1983, Bingham 1982, Nord and Schmulbach 1973, Payne *et al.* 1989) which in turn attract fish (Farabee 1986, Pennington *et al.* 1983).

An alternative bank stabilization being evaluated in the St. Louis District involves the use of off-bankline revetments (Neimi and Strauser 1991). Off-bankline revetments were designed to reduce bank stabilization costs and increase habitat diversity in main channel environments. They differ from standard revetment in that the riprap is placed several meters away from the bank in areas where there is a gradually sloping river bed. The result is the creation of artificial backwaters adjacent to the main channel. Fish movement is allowed through notches in the revetment. Recent fish work suggests that off-bank revetment provides useful and valuable habitat for a large variety of riverine fishes (Atwood 1996).

8.3.3.4.4 Chevron Dikes

Chevron dikes represent an innovative approach to navigation system management that benefits both navigation and wildlife (Theiling 1995). They were designed to divert flow into a portion of the navigation channel impacted by sediment accumulation on the point bar at a river bend where the river channel splits. The dikes divert flow into the main channel by presenting the hydraulic appearance of a solid object without isolating the side channel with a closing structure. Flow between the structures maintains a permanent side channel connection, which provides important off-channel habitat for fishes. The dikes appear to provide important environmental benefits (Ecological Specialists, Inc. 1997a, Atwood 1997). The rock dike substrate provides habitat for epilithic macroinvertebrates that are capable of colonizing in very high densities and providing an important food source for fish. Chevron dikes are also creating habitat heterogeneity and appear to be increasing invertebrate abundance and diversity (Ecological Specialists, Inc. 1997a) and provide useful and valuable habitat for a large variety of riverine fishes (Atwood 1997).

It should be noted that pallid sturgeon utilize downstream island tips 9% of the time. Considering the rarity of this habitat type, it appears that they are showing a strong habitat preference. The St. Louis District is currently exploring beneficial uses of dredged material in the Middle Mississippi River. If chevron dikes are used to place dredged material, they would in effect be creating islands. Such island creation would possibly benefit the pallid sturgeon by creating preferred habitat.

8.3.2.4.5 Closing Structures

a. Closing structures on the Middle Mississippi River have reduced flows to side channels and have degraded side channel habitat.

Sheehan *et al.* (1998) did not find any pallid sturgeons in side channels during their pallid sturgeon tracking study.

b. Altered habitats in the Middle Mississippi River may have genetically isolated upper Missouri River pallid sturgeon and Lower Mississippi River pallid sturgeon (e.g., there does not appear to be sufficient movement of Middle Mississippi River pallid sturgeon to ensure genetic continuity).

Sheehan *et al.*'s (1998) data indicate that Middle Mississippi River pallid sturgeon home ranges and movement varied greatly. Pallid sturgeon 456 (in two contacts) was located along a 965 m stretch. In contrast, pallid sturgeon 384 was located along a 97 km stretch of river in six contacts. The average home range for the study sturgeon was 34 km. These home ranges represent the minimum range occupied by the study fish as they may have moved out of and back into the range between consecutive relocations.

During the winter months of December through March, every fish except 384 made at least a slight downstream movement. Fish 465 and 339 moved in excess of 32 km downstream during this period.

From March through July, movements were not consistent among sturgeon. Fish 366, 357, and 294 moved slightly upstream (< 8 km), while sturgeon 465, 267, and 375 moved slightly downstream (< 8 km). Large movements were made by study fish 2588 (21 km downstream), 294 (17 km downstream), and 384 (71 km upstream).

During the fall months from July through October, pallid sturgeon 294 and 384 showed marked upstream movements. Study fish 357, 366, 249, and 2237 showed slight upstream movement (<8 km). Fish 2588 exhibited a slight downstream movement during this period.

Based on the above movement data (Sheehan *et al.* 1998) and the fact that pallid sturgeon occupy mid-channels and deep water (Hoover and Killgore 1998, Moos 1978, Bramblett 1996, Constant *et al.* 1997, Sheehan *et. al.* 1998), it is unlikely that altered habitat on the Middle Mississippi River has any effect on isolation of pallid sturgeon populations.

c. Altered habitats may have forced reproduction with shovelnose sturgeon, thus altering the genetic integrity of the species.

Altered habitats may have forced reproduction with shovelnose sturgeon, thus altering the genetic integrity of the species. Campton *et al.* (1995) collected data that support the hypothesis that pallid sturgeon and shovelnose sturgeon are reproductively isolated in less-altered habitats. Presumably, the loss of habitat diversity caused by human-induced environmental changes inhibits naturally occurring reproductive isolating mechanisms.

Bailey and Cross (1954) did not report hybrids, which may indicate that hybridization is a recent phenomenon resulting from environmental changes caused by human-induced reductions in habitat diversity and measurable changes in environmental variables such as turbidity, flow regimes, and substrate types (Carlson *et al.* 1985). A recent study by Keenlyne *et al.* (1994b) concluded that hybridization may be occurring in half of the river reaches within the range of the pallid sturgeon.

It is possible that both the pallid and shovelnose sturgeon are utilizing wingdams as spawning sites as suggested by the U.S. Fish and Wildlife Service (1993c). Sheehan *et al.* (1997b) noted that hybridization points to the fact that similar areas are being used by both species for spawning. Examination of shovelnose sturgeon reproductive biology shows that shovelnose sturgeon typically spawn over rock, rubble, and gravel in the main channel or on riprap wingdams (Moos 1978, Helms 1974). It is possible that cross fertilization at wingdams is occurring. However, spawning sites for the pallid sturgeon in the Middle Mississippi River are not known. In addition, the "natural" spawning habitat for the pallid sturgeon and the potential for pallid-shovelnose hybrids under natural conditions is unknown. It should be noted that hybridization is a controversial issue; Mayden and Kuhajda (1997) contend that there is no empirical evidence indicating that hybridization between the two species is common. Only the development of a genetic technique which definitively discriminates between pallid and shovelnose sturgeon will resolve this controversy with any certainty.

Sheehan *et al.* (1997b) present an alternative hypothesis for hybridization involving the incidental harvest of pallid sturgeon by the shovelnose sturgeon commercial fishery. Pallid sturgeon males mature at 5-7 years of age while female pallid sturgeon first spawn at approximately 15 years (Keenlyne and Jenkins 1993). Once mature, pallid sturgeon may not spawn every year but may take several years between spawning (Keenlyne and Jenkins 1993, Keenlyne *et al.* 1992). Due to its late maturity, pallid sturgeon may be exposed to many years of commercial fishing before they have a chance to spawn. Females may be exposed to over a decade of commercial fishing pressure before contributing to the recruitment of the population. For those that do survive long enough to spawn once, they may have to survive multiple years of commercial fishing danger in order to spawn again. Being at great risk of removal before maturity, incidental commercial harvest of females may skew the sex ratio of the mature sturgeon population. This could indirectly lead to greater hybridization rates as male pallid sturgeon, unable to find mature females to mate with, spawn with the closely related shovelnose sturgeon instead.

Sheehan *et al.* (1997b) indicated that not all commercial fishermen were able to distinguish pallid sturgeon from their close relative the shovelnose sturgeon. As previously noted, Sheehan *et al.* (1997b) observed four pallid sturgeon among the catch of 179 sturgeon by a commercial fisherman. In addition, there may be a black market for pallid sturgeon roe which are used to make caviar. During 5 years of effort to purchase female pallid sturgeon for a habitat preference study in the Middle Mississippi River (Sheehan *et al.* studies), no females were obtained from commercial fishermen. Based on a concern that an illegal black market exists for pallid sturgeon roe, fees paid for females were raised to equal or exceed black market prices. After prices were raised, female sturgeon were obtained. These incidents point to the need for a commercial fishermen education program and better law enforcement.

d. Modifications of structures could result in creation, restoration, or enhancement of habitats.

It is possible that modification of structures could result in creation, restoration, or enhancement of habitats. However, adequate data on pallid sturgeon habitat preference and structure hydraulic properties do not exist to design “pallid sturgeon friendly” structures. It should be noted that pallid sturgeon utilize downstream island tips 9% of the time. Considering the rarity of this habitat type, it appears that they are showing a strong habitat preference. The St. Louis District is currently exploring beneficial uses of dredged material in the Middle Mississippi River. One such use is the creation of off-shore dredged material islands for least terns in the Middle Mississippi River. Chevron dikes create island habitat. Creation of island habitat would possibly benefit the pallid sturgeon.

e. Nutrient cycle disruption due to changes in river processes that inhibit or reduce floodplain inputs into the river.

Sheehan *et al.* (1998) indicated that the “Isolation of the River from its historical floodplain reduces river/floodplain interactions during periods of high water. Many workers believe the so-called flood pulse is crucial to the trophic dynamics and fisheries of large floodplain rivers (see reviews in *Bioscience* Volume 45, 1995). It is not known to what extent Middle Mississippi River pallid sturgeon population size and growth is affected by this reduction in floodplain inundation.”

8.3.2.5 Lock and Dam Rehab - Not applicable

8.3.3 Navigation-Related Indirect Effects

8.3.3.1 Tow Traffic - Direct mortality

Gutreuter *et al.* (1998) found a wounded shovelnose sturgeon in the Mississippi River during ambient sampling with a rockhopper trawl on October 22, 1996. They suggested that the likely cause of the wound was from a propeller. It is not known if the wound was inflicted by a towboat propeller or if the fish was healthy (e.g., not part of drift of fish found during the fall through spring). Bodensteiner and Lewis (1994) and others have found fish at the point of death (moribund) during late fall through spring, which may explain fish with propeller injuries during this period. The potential for direct mortality of pallid sturgeon by tow traffic is unknown.

8.3.3.2 Fleeting

a. Direct mortality.

Towboats maneuver barges in fleeting areas. The potential for direct mortality of pallid sturgeons by tow traffic (i.e., propeller strike) is unknown (see section 8.3.3.1). It is doubtful that barge movement would cause mortality.

b. Habitat loss.

Development of existing fleeting areas required various levels of habitat modification. The level of impact to the pallid sturgeon or potential habitat is unknown. The potential impacts of future development of fleeting areas will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process.

8.3.3.3 Port Facilities - Habitat loss

Development of port facilities required various levels of habitat modification. The level of impact to the pallid sturgeon or potential habitat is unknown. The potential impacts of future development of port facilities will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process.

8.3.3.4 Exotic Species - Not applicable

8.3.3.5 Contaminants

Organic contaminants are partitioned in aquatic systems in fine sediments, organic matter, biota, and the water column. For this analysis, the major concern would be the resuspension of sediments either by commercial navigation passage or by dredging. Organic contaminants are generally associated with the clay component of riverine sediments, both suspended sediments and bed load, on which they attach. A computer model (NAVEFF) was run by the Waterways Experiment Station to determine the potential for increased suspended sediments caused by commercial navigation traffic in the Middle Mississippi River. Preliminary model runs determined that increased suspended sediments resulting from commercial navigation could not be detected above existing suspended sediment (turbidity) levels (Dr. Steve Maynord and Mr. Thomas Pokrefke - Waterways Experiment Station, personal communication, January 6, 1999). The bed load in the main channel of the Middle Mississippi River is sand which has a quick settling time and does not contribute to lateral movement of suspended sediments or increases in turbidity. As such, the movement of commercial navigation traffic within the main channel is not expected to cause significant adverse impacts to the pallid sturgeon.

No analysis of commercial traffic accidents and the potential for spills has been conducted for the Middle Mississippi River.

a. Direct mortality.

There are currently no data available for contaminant body burdens for the pallid sturgeon in the Middle Mississippi River. However, data do exist for the closely related shovelnose sturgeon (Table 5). The values reported for this species are not high enough to cause direct mortality (Mr. Christopher Schmitt - U.S. Geological Survey, Columbia Environmental Research Center, personal communication, January 8, 1998).

b. Chronic effects (e.g., reduced reproduction).

The U.S. Fish and Wildlife Service (1993c) indicated that the prolonged egg maturation cycle of the pallid sturgeon (Conte *et al.* 1988), combined with an inclination for certain contaminants to be concentrated in eggs (Ohlendorf *et al.* 1981), could make contaminants a likely agent adversely affecting developing eggs, development of embryos, or survival of fry and thereby reduce reproductive success (Ruelle and Keenlyne 1991).

There are currently no data available for contaminant concentrations in pallid sturgeon ovaries. However, there are data available for contaminant concentrations in the ovaries of the closely related shovelnose sturgeon (Table 6) from the Middle Mississippi River. The reported values of organic compounds may be of concern for developing embryos, although there are no data available to determine that there is a definite problem. In addition, published toxicity values on the complex of organic chemicals do not exist to conduct a valid risk assessment (Mr. Christopher Schmitt - U.S. Geological Survey, Columbia Environmental Research Center, personal communication, January 8, 1998). Likewise, Ruelle and Keenlyne (1993) suggested that organic compounds (PCBs chlordane, dieldrin, and DDT and its isomers) in Missouri River ovaries where found at concentrations high enough to suggest that contaminants can be affecting pallid sturgeon reproduction in the upper Missouri River. They also noted that little data exist on the effects of multiple insults of contaminants on fish reproduction.

The U.S. Fish and Wildlife Service (1993c) indicated that "Further investigations are needed to identify sources of contaminants in the Missouri and Mississippi Rivers and to assess the role of contaminants in the decline of pallid sturgeon populations." The Columbia Research Center has developed a micro-toxicity egg injection study design which would determine whether current egg organic chemical load is affecting reproduction, development, and larval fish survival (Mr. Christopher Schmitt - U.S. Geological Survey, Columbia Environmental Research Center, personal communication, January 8, 1998).

8.3.4 Recreation-Related Indirect Effects

Unlike the pooled portion of the Upper Mississippi River where the Corps maintains lake-like conditions and recreational facilities that are conducive to boating, no such operation and maintenance of "recreation habitat" occurs on the Middle Mississippi River. The Corps of Engineers does not have boat ramps or other recreational watercraft support facilities on the Middle Mississippi River. The level of recreation would remain approximately the same without the navigation system, except for that fraction of traffic with origin-destinations associated with the pooled portion of the river.

8.3.4.1 Facilities - Not applicable

8.3.4.2 Large Vessels - Direct mortality.

It is possible that large recreation vessels could cause direct mortality from propeller strike. However, it is not known whether this has ever occurred. Considering the low population size of the pallid sturgeon in the Middle Mississippi River and the potential for recreation vessel propeller contact, the probability of mortality is very low.

8.3.4.3 Beach Use - Not applicable

8.3.4.4 Exotic Species - Not applicable

8.3.4.5 Contaminants

The probability of recreational craft resuspending toxic materials in shallow water would be higher than commercial barge traffic that navigates in the main channel where the channel is deep and the bed material is sand.

a. Direct mortality.

There are currently no data available for contaminant body burdens for the pallid sturgeon in the Middle Mississippi River. However, data do exist for the closely related shovelnose sturgeon (Table 6). The values reported for this species are not high enough to cause direct mortality (Mr. Christopher Schmitt - U.S. Geological Survey, Columbia Environmental Research Center, personal communication, January 8, 1998).

b. Chronic effects (e.g., reduced reproduction).

See section 8.3.3.5.b.

8.3.5 Interrelated Effects - Management of Corps Lands

8.3.5.1 Timber Management - Not applicable

8.3.5.2 Cabin Leases - Not applicable

8.3.5.3 General Plan Lands - Not applicable

8.3.5.4 Public Use Sites - Not applicable

8.3.5.5 Corps Port Facilities - Not applicable

8.3.6 Interdependent Effects

8.3.6.1 Missouri River Navigation

The Northwestern Division (Missouri River Region), U.S. Army Corps of Engineers, is currently coordinating with U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act concerning water control on the Missouri River.

a. Water regulation (e.g., when do releases occur and how does this affect the availability of habitat in the Middle Mississippi River).

b. Preclusion of upstream movement may affect the genetic integrity of pallid sturgeon in the Middle Mississippi River.

8.3.6.2 USCG Buoy Tending - Not applicable

TABLE 6. Shovelnose sturgeon egg contaminant concentrations (ppb) for the Missouri and Mississippi Rivers (data provided by Alan Buchanan on January 4, 1999, Missouri Department of Conservation).

Year	Fish Length	Chlordane	DDE	DDT	Dieldrin	Pb	Cd	Hg	PCBs
Missouri River at Nodaway Island (Missouri)									
1996	3FC*	541	143	---	<2	<30	--	--	586
1996	---	726	100	---	<2	--	--	--	698
Missouri River at Easley (Missouri)									
1996	5FC	247	29	---	<2	<30	4	16	354
Mississippi River at Chester (Illinois)									
1996	24.1	1200	135	---	<2	40	41	22	1390
1996	26.6	2450	768	---	<2	10	87	52	5810
1996	24.9	2780	780	---	<2	31	81	37	4520
1996	24.6	1020	200	---	<2	40	21	17	1220
1997	26.6	787	216	15	24	--	--	--	1030
Mississippi River at Caruthersville (Missouri)									
1996	2FC	345	101	---	<2	<30	15	26	747

*3FC indicates that it is a composite sample of sturgeon eggs from three fish.

8.4 DETERMINATION

Components of operation and maintenance of the 9-Foot Channel Navigation Project could involve adverse impacts to the pallid sturgeon. Maintenance dredging and placement of material in the Middle

Mississippi River could affect potential feeding, resting, and spawning habitat. However, based on habitat preference studies, areas requiring dredging are marginal habitat, although they may be utilized by pallid sturgeon to some extent. The U.S. Fish and Wildlife Service has recommended to the Memphis, Vicksburg, and New Orleans Districts a moratorium on dredging during the presumed "windows" of pallid sturgeon spawning to reduce dredging-related risks to the species. The Districts' spawning schedule is currently outside the spawning season. Based on available information, it appears that dredging is having minimal adverse impacts on the pallid sturgeon.

Dredged material placement is in the main channel border, which may provide potential habitat for the pallid sturgeon. However, it is not known to what extent placement areas are currently being used by sturgeon. In addition, it is not known what the recovery period is for placement areas. Given that placement areas represent a small fraction of similar habitat in the Middle Mississippi River, it appears that dredged material placement may have localized effects but is having minimal adverse impacts on the pallid sturgeon.

The St. Louis District is currently evaluating the potential for thalweg placement in the Middle Mississippi River. Prior to initiating a thalweg placement program, a hydroacoustic fishery survey will be conducted of potential placement areas during the dredging season to determine if these areas provide usable fishery habitat. These studies will be coordinated with the U.S. Fish and Wildlife Service. If it is shown that these main channel areas provide valuable habitat during the dredging season, thalweg placement in the Middle Mississippi River will not be conducted in designated areas.

Even with the habitat preference study of Sheehan *et al.* (1998), it is impossible to say one way or the other whether channel structure/revetment impact the pallid sturgeon. We do know that pallid sturgeon spend nearly equal amounts of time (transmitter contacts) associated with "structure modified" main channel border (28%) habitat and unmodified main channel border (21%) habitat. This indicates that they are not avoiding "structure."

Wingdams, revetment, bendway weirs, closing structures, and chevron dikes all cause changes in flow patterns. Even with Sheehan *et al.*'s (1998) habitat preference studies, we do not know if changes in flows adversely impact the pallid sturgeon. We do know that "structure" may provide habitat for fish as well as hard substrate for benthic invertebrates, a main food item for fish. This "structure" may be providing both food and habitat for pallid sturgeon on a seasonal basis.

Tow traffic may be responsible for mortality of larval, juvenile, and adult pallid sturgeon induced by towboat propellers. However, the level of mortality, if any, is probably small (Bartell and Campbell 1998, Gutreuter *et al.* 1998).

There is a potential that components of the navigation project may adversely affect the pallid sturgeon because the navigation project is "sharing" habitat with the pallid sturgeon. There is a lack of adequate data to fully address all the issues raised by the U.S. Fish and Wildlife Service in their impact matrix. The Service requested that the Corps of Engineers use the impact matrix as the outline for this Biological Assessment. The St. Louis District previously acknowledged this lack of impact assessment data and has co-funded a study which was designed to address the Pallid Sturgeon Recovery Plan's "Primary Task 3.2.1 Conduct Field Investigations" to describe the micro- and macro-habitat components of spawning, feeding, staging, and rearing. This is an ongoing study that will hopefully provide additional information to address all of the concerns of the U.S. Fish and Wildlife Service. Based on the best existing scientific and commercial data and professional judgement, it is our determination that the continued operation and maintenance of the 9-Foot Channel Navigation Project may adversely affect the pallid sturgeon to some minor degree but that any adverse effects would not be significant to the population as a whole.

9.0 HIGGINS' EYE PEARLY MUSSEL

The Higgins' eye pearly mussel (*Lampsilis higginsi*) is currently listed as federally endangered. Sparse information is available concerning its specific habitat, but in general terms, Higgins' eye habitat is found in areas of moderate flow (<0.6 m/s), good water quality, and stable substrates consisting of sand/rock cobble. The Higgins' Eye Mussel Recovery Plan (USFWS 1983b) provides a description of the historic and modern distribution of the Higgins' eye. Historically, the Higgins' eye was recorded throughout most of the Upper Mississippi River, ranging as far north as Pool 3 and the Minnesota and St. Croix Rivers. The known distribution of the Higgins' eye is limited to the St. Croix River, Wisconsin River, and on the Upper Mississippi River downstream of Lock and Dam 6 at Trempeleau, Wisconsin to Pool 20 (USFWS 1983b, Havlik 1981, Duncan and Thiel 1983, Thiel 1981, Miller and Payne 1992, Corps of Engineers unpublished survey data).

Seven sites within the project area were identified as "essential" habitat by the Higgins' Eye Recovery Team (USFWS 1983b). In the 1998 Draft Recovery Plan, Hornbach (1998) lists an additional three sites (8-10) as essential habitat areas based on additional studies since the original recovery plan was published. These sites are: (1) St. Croix River opposite Hudson, WI (RM 17.6 - 16.2); (2) Mississippi River at Whiskey Rock, opposite Ferryville, WI, Pool 9 (RM 658.4 - 655.8); (3) Mississippi River at Harpers Slough, Pool 10 (RM 641.4 -639.0); (4) Mississippi River Main and East Channel at Prairie du Chien, WI, and Marquette, IA, Pool 10 (RM 637.0 - 633.4); (5) Mississippi River at McMillan Island, Pool 10 (RM 619.1 - 616.4); (6) Mississippi River at Cordova, Illinois, Pool 14 (RM 505.5 - 503.0); (7) Mississippi River at Sylvan Slough (Quad Cities), Pool 15; (8) St. Croix River at Prescott, Wisconsin; (9) St. Croix River at Franconia, Minnesota; and (10) the Wisconsin River at Muscoda, Wisconsin, commonly known as the Orion mussel assemblage.

Fuller (1980) collected Higgins' eye in the St. Croix River at Hudson, Wisconsin, from a mud-gravel bottom in 3 to 4.5 m of water with moderate current velocity. A more recent survey by Hornbach *et al.* (1995) examined four known Higgins' eye beds on the St. Croix: Prescott, Lakeland, Interstate Park, and Franconia Township. Hornbach *et al.* (1995) were unable to specifically identify strict habitat requirements. They did note that quadrats with Higgins' eye present were deeper and found to be associated with higher species richness and overall mussel densities than to those where Higgins' eye were absent.

Higgins' eye have been collected from wingdam surfaces and those areas immediately downstream of wingdams in Pool 10 during St. Paul District sponsored mussel surveys. A comparison of the broad habitat features found within the Upper Mississippi River "essential" habitats listed above indicates Higgins' eye are generally found in main channel border (including wingdam surfaces) and side channel or slough localities. They are not as common in the deep water of the main navigation channel, especially in frequently dredged areas of the main channel. Dredging operations have a depressing effect upon mussel populations' ability to recolonize an area after the substrate is removed. General habitat conditions described by Miller and Payne (1997) include shallow to moderately deep areas (>1m) with firm gravelly sand substratum free of plants and woody material, wingdams not buried in sand and silt, stable areas immediately downstream of the wingdams, and current velocities less than 0.5 m/s. However, Higgins' eye present in known beds within Pool 10 of the Upper Mississippi River show a poor relationship between sediment size and abundance since they are found in areas with reduced current velocity and fined-grained sediment (Miller and Payne 1997). The authors attribute the presence of Higgins' eye in the "marginal habitat" areas are a result of offspring produced within a dense reproductive stock from mussels in more suitable habitat. Wilcox *et al.* (1993) proposed a list of variables to evaluate potential *L. higginsi* habitat:

- Substrate not firmly packed clay, flocculent silt, organic material, bedrock, concrete, or unstable moving sand.
- Current velocity less than 1 m/s during periods of low discharge.
- Mussel relative abundance: if 2,000 or more mussels are sampled and no Higgins' eye are found, then it is unlikely to be present.
- Density of all mussels should exceed 10/m^2 and any rare species should occur at densities greater than 0.01 individuals/m^2.
- Species richness should exceed 15 when as few as 250 individuals have been collected.

9.1 REASONS FOR LISTING

The major factors for the listing were the decreases in both abundance and range of the species. The Higgins' Eye Recovery Plans (USFWS 1983b, Hornbach 1998) cite several factors responsible for the listing of this species, including commercial harvest, various habitat changes, and channel maintenance activities.

9.2 PRESENT THREATS

The revised draft Higgins' Eye Recovery Plan (Hornbach 1998) lists several threats potentially impacting the species: habitat alteration; water quality; zebra mussels; commercial harvest; non-human predators; and loss of genetic variability. Habitat alteration includes all the physical modifications done to the Upper Mississippi River for navigation since 1878, including the 4½-foot channel, 6-foot channel, and the 9-foot channel. Physical changes in the morphology of the Upper Mississippi River resulting from the alterations have been identified as change in river hydrodynamics, increase in volume of backwater lakes and sloughs, and change in substrate composition, all of which may have impacted the mussel population. The change in mussel habitat is difficult to ascertain, and the impact upon Higgins' eye is impossible to determine at this time. Other types of habitat alteration identified are primarily related to the development of land-based, water-oriented facilities, i.e., barge loading, small boat harbors, dredging access channels, highway bridge construction, and fleeting area establishment. The effects resulting from these activities can be either from direct physical impacts (i.e., destruction of habitat) or the indirect impacts resulting from the areas' development (i.e., fuel spills or mussels being crushed or buried by fleeting activities). Water quality issues encompass a wide variety of point and non-point contaminant and pollutant sources and are thoroughly addressed in the Draft Revised Recovery Plan (Hornbach 1998).

Commercial harvest of mussels is regulated by state resource agencies; however, there is concern over the potential illegal harvest of mussels. Although the harvest is primarily focused on washboard (*Megalonaias nervosa*) and threeridge (*Amblema plicata*), several other species are also legal to collect and sell. The incidental or illegal harvest of Higgins' eye is of such concern that the UMRCC mussel ad hoc committee has recommended that state resource agencies revise the list of commercial species to omit those confused with Higgins' eye (e.g., *Obovaria olivaria*). Although no Higgins' eye are harvested commercially, there may be substantial harvest of the species by illegal take. Mathiak (1979) concluded that hundreds of Higgins' eye were probably harvested in 1975 before the species was listed. A number of predators are known to consume a large quantity of mussels, and Davis and Hart (1995) documented two fresh dead Higgins' eye in muskrat middens in Pool 7. The actual extent and impact of predation are currently unknown. Little research has been completed on mussel genetics other than basic taxonomic investigations. The Higgins' Eye Recovery Team recommends genetic studies be conducted in essential habitat areas in order to assess the population and ensure preservation of the integrity of genetic populations in each essential habitat area.

The latest impact affecting the recovery of the species is the introduction of the zebra mussel (*Dreissena polymorpha*) to the freshwater system of North America. The zebra mussel infestation causes both direct and indirect impacts to native mussels. Their attachment to the shells of the native species impacts feeding and filtering functions, prevents valve closure, and causes shell deformation. Native mussel locomotion can be impacted by zebra mussel attachment to individuals. Zebra mussels can prevent colonization of native mussels in formerly suitable habitats and also prevent their burrowing into substrate by forming a layer preventing the penetration. Indirect impacts of zebra mussels include competition for food resources, unionid glochidia consumption by zebra mussels, and changes in the water chemistry, especially dissolved oxygen levels. Based on previous records of zebra mussel invasion into new habitats, the Higgins' Eye Recovery Team considers the species to be a mortal threat to this species. To date, no reproducing populations of zebra mussels have been found in the St. Croix River (Karns 1998).

9.3 PROJECT ACTIONS/POTENTIAL IMPACTS

9.3.1 Operation of the 9-Foot Channel Project

9.3.1.1 Water Level Regulation

A number of fish species are known to serve as an intermediate host for glochidia. Their development depends on attachment to a proper fish host for an approximate 3-week period. Several fish species have been identified as suitable hosts for Higgins' eye glochidia, including largemouth bass, smallmouth bass, walleye, sauger, and yellow perch (Waller and Holland-Bartels 1988). Although fish movement is somewhat restricted by the locks and dams, the abundance of these host fish increased upon completion of the Upper Mississippi River locks and dams (Fremling and Claflin 1984).

Wilcox *et al.* (1998) examined a number of factors in determining the likelihood that a particular fish species could pass through the Upper Mississippi River locks and dams, such as the hydraulic conditions, dam design, migration behavior, seasonal timing, etc. They found there were two dams that fish could not pass through: Lock and Dam 1 in St. Paul and Lock and Dam 19 in Keokuk. Restriction of fish movement may limit or prevent the dispersal of the glochidia. Coker (1930) discusses the historical movement of skipjack herring, blue sucker, and blue catfish where these species moved upstream in the spring, followed by downstream migrations to overwinter in warmer waters. The extirpation of the ebony shell (*Fusconaia ebena*) and the elephant ear (*Elliptio crassidens*) in the upstream portion of the Upper Mississippi River has been attributed to the inability of the mussels' host fish, skipjack herring (*Alosa chrysochloris*), to navigate past Lock and Dam 19 (Fuller 1980). Water level regulation may indirectly affect the dispersal of certain mussel species. Gene flow within a mussel species may be inhibited by the restricted movements of fish between the pools and on a single fish species serving as the glochidial host (Romano *et al.* 1991). The loss of genetic variability is also listed as a task item in the Higgins' Eye Recovery Plan (Hornbach 1998), but little data exist to support this loss.

9.3.1.2 Impoundment

The impoundment of the Upper Mississippi River created substantially more aquatic habitat area, as well as changed the characteristics of the original habitat. The increased number of shallow-water areas are perceived as beneficial to unionid mussels since they provide suitable nursery habitat for both fish and mussels. Baker and Hornbach (1997) indicated that Higgins' eye are found in areas of low water velocity (<0.3 m/s) but not in areas with no flow. Pre-inundation conditions probably contained less area of low velocity flows habitat that Higgins' eye prefers. Impoundment of the Upper Mississippi River has created more lentic habitat, favoring conditions for certain species. One species of particular concern is the exotic zebra mussel, whose impact upon Higgins' eye will be discussed in section 9.3.3.4.

Impoundment has accelerated sedimentation rates throughout the Upper Mississippi River**,** especially in overbank and backwater areas. Since substrate stability is important to most mussel species, change in substrate composition from sedimentation is likely to impact mussel communities. However, high density and diverse mussel beds are located in stable areas with moderate currents that are the least susceptible to increased sedimentation. Based on the habitat preferences and present locations of Higgins' eye, they are not likely to be impacted by sedimentation.

9.3.2 Maintenance of the 9-Foot Channel Project

9.3.2.1 Dredging

Dredging primarily affects the main channel of the river; however, it also can affect side channels, sloughs, and backwater lakes and ponds through increased turbidity levels. Channel maintenance dredging is normally required and conducted in areas of shifting/shoaling bed load. The unstable substrates typically found in frequently dredged areas are generally inhospitable to mussels. As a result, subsequent dredging usually has little effect on freshwater mussels. However, any mussels within the dredge cut will be killed by either the direct effects of the dredge or by subsequent deposition at a placement site.

Miller and Payne (1992) collected Higgins' eye from a location in the East Channel of the Upper Mississippi River at Prairie du Chien, Wisconsin, which had been previously dredged, indicating that recolonization of dredge cut areas does occur. However, an interval of 8 years had occurred between the dredging operation and their study.

Freshwater mussels are susceptible to extirpation and can also be affected by turbidity, intake of resuspended pollutants, direct coverage by settling sediments produced during the dredging process, and reduced oxygen levels. Suspended solids and sedimentation due to dredging could potentially cause clogging and abrasion of gills and other respiratory surfaces in mussels; however, there is little data documenting this. Miller and Payne (1998) report that mussels tolerate discrete disturbances (i.e., commercial vessel passage, dredging, and extreme high water), but no determination of the long-term effects to mussels could be made from a data set spanning approximately 10 years. Mussels down river from the dredge site possibly may be buried or be exposed to increased turbidity. However, much of the dredged material from the Upper Mississippi River navigation channel is coarse-grained that has very limited suspension and/or associated turbidity. Since contaminants have an affinity for smaller-sized particles and not the coarse-grained material of dredge cuts, dredging main channel areas usually has no impact on contaminant movement.

Dredging will not affect Higgins' eye in any of the dredge cuts with the following conditions:

- Dredging frequency greater than 20% (once every 5 years).
- Substrates in dredge cut are not suitable (i.e., particle size distribution of greater than 10% passing through a U.S. standard mesh 200).
- Areas outside the current range of the Higgins' eye.

Dredging is likely to affect Higgins' eye in areas supporting relatively diverse mussel assemblages, areas where suitable substrate is present, or areas that are infrequently maintained (USACE 1997c). Mussel surveys would be performed in these areas and would require separate coordination with the U.S. Fish and Wildlife Service prior to project implementation.

9.3.2.2 Placement

Dredged material placement sites can be either terrestrial or aquatic deposited on a variety of different habitats. Placement of dredged material on upland sites would desiccate and kill any mussels contained within the dredged material. Hydraulic placement of materials on upland sites normally requires a settling basin from which effluent is discharged. The quality of this effluent would depend largely on the quality, in terms of contaminants, of the sediments placed at the site. In areas with sediment contamination, effluent discharge from placement sites could affect mussel species within a mile downstream of the effluent through reduced water quality. Generally, however, use of upland placement sites would have no effect on freshwater mussels, including threatened or endangered species.

Use of dredged material re-handling sites could affect endangered mussels through direct coverage. However, the likelihood of endangered mussels colonizing open water areas of the re-handling areas is quite low. Generally, the shifting sand substrates in these areas are poor habitat for freshwater mussels and are secluded from the Upper Mississippi River flow. Additionally, these areas are frequently disturbed either through placement of dredged materials or excavation of materials during transfer operations. All sites are surveyed for mussels prior to placing any material.

In-water placement of dredged material (thalweg placement) could affect endangered mussel species through direct burial. Mussels buried by in-water placement of dredged material would likely perish as a result of asphyxiation and/or starvation. Although no permanent in-water placement of dredged material is proposed in the upstream reaches, it is a common practice in lower reaches of the Upper Mississippi River. In addition to the potential for burial, endangered mussels inhabiting re-handling sites could be re-dredged and deposited on upland locations, leading imminently to death. All areas proposed for thalweg placement would require mussel surveys and activities coordinated with the U.S. Fish and Wildlife Service. All dredging activities are previously described in the CMMP and DMMP, and are fully coordinated with district dredging teams in selection and use of placement sites.

9.3.2.3 Clearing and Snagging

Removal of trees or other obstructions from the navigation channel could affect Higgins' eye through disturbance of bottom substrates. However, the majority of snagging occurs on the Minnesota River, which is outside the current known range of the Higgins' eye. Snag removal on the St. Croix River is completed only upon request of the National Park Service. Snag removal has not been requested for the past 20 years and during this time a National Park has been established on the St. Croix. The Corps does not anticipate any snag removal on the St. Croix during the next 50 years. However, prior to any snagging projects, endangered species coordination will be initiated with the U.S. Fish and Wildlife Service.

9.3.2.4 Channel Structures/Revetment

Channel structure modifications are designed to reduce dredging by concentrating flows in the main channel and, therefore, primarily affect flow patterns along with sedimentation patterns. Construction of channel control structures would involve covering benthic habitat and could therefore affect threatened and endangered mussel species. The general impacts of wingdam construction/rehabilitation, closing dam construction/rehabilitation, and shoreline riprapping are described below.

Wingdams could be constructed/rehabilitated in main channel and channel border habitats, areas likely to harbor endangered mussel species. Increased current velocities and thus increased scouring of main channel areas in the vicinity of constructed/rehabilitated wingdams would occur, resulting in increased channel depths and/or widths. Sedimentation patterns would be changed, with sediment transported through rehabilitated river reaches to downstream areas of lower velocity. Since areas of velocity change attract fish species, high mussel densities are often found on or in the vicinity of wingdams near suitable substrate. Placement of riprap often attracts high fish concentrations, hence some contain rich mussel assemblages. Any mussel present in the riprap placement area would be killed by the construction activities. Thorough mussel surveys are performed in the proposed placement areas prior to any work.

Closing dams could be constructed to reduce flows into side channel areas. Primary impacts such as reduced volume of flow, reduced current velocities, reduced sediment input, and increased water residence time in backwaters would occur in these habitats and could affect endangered mussel species inhabiting side channel areas. The increased flows in the main channel resulting from side channel closure would impact on main channel and channel border habitats as well. Placement of stone protection on shoreline areas or wingdams covers benthic habitats and organisms and thus would affect threatened and endangered mussel species present at the site.

Any proposed repair of existing structures and construction of new structures are fully coordinated with the River Resource Forum or the Committee to Assess Regulatory Structures and the U.S. Fish and Wildlife Service in order to avoid or minimize adverse impacts to Higgins' eye.

9.3.2.5 Lock and Dam Rehabilitation

A Programmatic Environmental Impact Statement on major rehabilitation of Locks and Dams 2-22 was completed by the Rock Island District, Corps of Engineers (1989b) and is incorporated by reference. The biological opinion rendered by the U.S. Fish and Wildlife Service at that time concluded the rehabilitation action was likely to cause an incidental take of Higgins' eye. Most construction performed on the lock and dam structures for rehabilitation would not result in the loss or disturbance to aquatic habitat. The work entails the repair or replacement of the existing structures, and very little additional intrusion into aquatic habitat would occur during future rehabilitation. Any lock and dam rehabilitation efforts where activities would disturb aquatic habitats or increase the footprint of the project would have to be evaluated in a separate assessment. During construction activities, there is a possibility for petroleum spills or other hazardous materials to occur. All contractors working on rehabilitation would have an approved Environmental Protection Plan with spill prevention measures and spill response plan that would minimize the likelihood that a spill would occur. Once the structures are rehabilitated, their operation would be more efficient and safer for watercraft, thereby reducing the spill potential. Riprap replacement is occasionally performed in downstream portions of spillway sections. Many of these areas attract high fish concentrations and therefore some contain rich mussel assemblages. Any mussels present in the riprap placement area would be killed by the construction activities. Thorough mussel surveys need to be performed in tailwater areas prior to any work.

9.3.3 Navigation-Related Indirect Effects

9.3.3.1 Tow Traffic

Commercial navigation traffic could impact Higgins' eye by increased turbidity levels and velocity caused by barge propeller action when passing over a mussel bed, by being dislodged from the sediment by propeller wash, or by being buried or destroyed during barge groundings in shallow water conditions. Impacts of increased turbidity levels are minor because of the brevity of tow passing and also the minor contribution of suspended solids in water column caused by tow traffic. In a study in lower Pool 10, Miller and Payne (1997, 1998) found no significant difference in shell morphometrics of common to abundant species in areas where tow traffic occurred and two reference sites. However, at this same location mussel densities ranged from 68.46-149.08 mussels/m^2 in the reference area, while mean densities in the turning basin ranged from 21.96-48.65 mussels/m^2 (Miller and Payne 1992). Miller *et al.* (1996) and Miller and Payne (1998) reported that velocity change from tow passage was not damaging to benthic organisms or their habitat in reasonably straight reaches with more than 0.6 m clearance below the tow. Substantial erosion often results from propeller wash as tows negotiate tight turns in the channel, enter and exit lock chambers, and while they await lockage along certain shoreline areas. These areas are often subjected to severe propeller wash, creating an environment too hostile for mussel colonization. Barges are grounded for a number of reasons, including running into an unknown shoal within the navigation channel, operating outside of the navigation channel in shallow water, or overloading barges past the 9-foot draft. Barge grounding in a newly formed shoal is unlikely to impact any mussels due to the unstable substrate conditions. Substantial local mussel damage could occur if a barge grounded on an off-channel mussel bed. Mussels would be buried, crushed, and/or scoured by propeller wash. Tow traffic has also been implicated in the transport and "reseeding" of zebra mussel populations at upstream locations (Carlton 1993, Keevin *et al.* 1992). The impact of zebra mussels upon Higgins' eye will be discussed in section 9.3.3.4.

9.3.3.2 Fleeting

The general impacts to mussels associated with fleeting areas include direct mortality and disturbance through habitat modification or barge traffic. There are 76 barge fleeting areas in Pools 2-26 with a capacity of 2,950 barges. The majority of these sites are located in Pool 2 which has 30 fleeting areas with a capacity of 742 barges. While development of future fleeting areas would require varying habitat modifications to the area, the prediction of impact is impossible and would have to be evaluated and coordinated during the regulatory process. Prior to development of new fleeting areas, habitat analyses and mussel surveys would be completed to determine the potential impacts. Barge fleeting areas could also serve as upstream sources for zebra mussel colonization. The impact of zebra mussels upon Higgins' eye will be discussed in section 9.3.3.4.

Under Section 10 of the Rivers and Harbors Act of March 3, 1899, the placement of any permanent structure below the ordinary high water mark on navigable waterways requires a permit. Where installation involves discharge of dredged or fill materials, permits under Sections 401 and 404 of the Clean Water Act of 1977 are required. Future expansion of fleeting areas or terminals will be subject to regulation and environmental review. Therefore, if expansion should occur in the future, evaluation of potential endangered species impacts will be assessed through the permit process. Minnesota, Wisconsin, and Iowa regulate barge fleeting activities through their own state regulations, while Illinois regulates through review of the Federal permitting process.

9.3.3.3 Port Facilities

There are approximately 120 commercial port facilities in the range of the Higgins' eye: Upper Mississippi River upstream of Lock and Dam 20; Minnesota River; Black River; and St. Croix River. Port facilities could impact mussels through habitat loss during maintenance or construction of new facilities. Any future expansion or new construction projects would have to follow Section 404 guidelines, and endangered species coordination would occur through the applicants. Port facilities are maintained through occasional dredging. Impacts to mussels from dredging are discussed in general in section 9.3.2.1.

9.3.3.4 Exotic Species

Zebra mussels were first discovered in Lake St. Clair in 1988 and in all the Great Lakes a year later. They were found in the Chicago Sanitary and Ship Canals in June 1989 and the main stem of the Illinois in June 1991. The first zebra mussel collected from the Upper Mississippi River was in September1991 south of La Crosse, Wisconsin. They are known to travel or be transported by land, water, and air, and since their introduction, zebra mussels have impacted the structure and function of natural communities they have invaded. If basic water quality and habitat conditions are suitable, Morton (1997) predicts the zebra mussel will spread to the remaining rivers of North America, the only debate being the timetable.

Naturally occurring substrates are also vulnerable to zebra mussel attachment and even more prone to serious long-term damage. The shells of native unionid mussels provide hard substrates for zebra mussel settlement in lakes and rivers. Dense encrustations such as these will kill native clams since it is impossible for them to open their shell valves to filter feed, respire, and burrow. The attachment on the native bivalves also interferes with basic physiology and growth of individuals (Baker and Hornbach 1997). The effects of a unionid decline on local trophic structure are as yet unknown. High zebra mussel densities have been implicated in unusually low dissolved oxygen levels in parts of the Upper Mississippi River (Sullivan and Endris 1998) and observed substantial increases in water clarity. In western Lake Erie, members of the subfamily Lampsilinae suffered higher reductions in fitness and dramatically higher mortality rates than members of other subfamilies (Haag *et al.* 1993). These authors speculate the different life history strategy and shell morphology of Lampsilinae members may be responsible for the poorer physiological condition and increased mortality rates.

Unlike the Illinois River (via Lake Michigan and the Chicago Sanitary and Ship Canal), the Upper Mississippi River did not have an upriver source from which veligers could spread downriver with the currents. Based on the zebra mussel's current distribution within the Upper Mississippi River, it appears that tow traffic is the main transportation vector responsible for the zebra mussel invading the Upper Mississippi River upstream of the Illinois River (Keevin *et al.* 1992), while river currents are responsible for its downstream spread. Without an abundant upriver source, Upper Mississippi River zebra mussel populations have developed at a much slower pace than those in the Illinois River. This may no longer be the case, since recent reports from Lake Pepin (Pool 4) and Pools 8-10 indicate development of substantial adult zebra mussel populations ($>20,000/m^2$). Studies conducted by Minnesota and Wisconsin resource agencies since 1996 indicate that Lake Pepin is the likely source population for the increasing zebra mussel settlements in Pools 7 and 8. In fact, due to the hydrology and location of Lake Pepin, it will likely serve as a substantial upriver source for the re-supply of zebra mussels to the rest of the Upper Mississippi River. Cope *et al.* (1997) found zebra mussel densities were highest in downstream portions of the Upper Mississippi River and much lower density upstream of Lake Pepin.

Monitoring stations on the St. Croix River have shown no zebra mussel infestation at this time. Since there is no regular commercial tow traffic, recreational boat traffic is the most likely vector present on the St. Croix River. According to a transportation model risk assessment of zebra mussel spread (Schneider *et al.* 1998), the St. Croix River could soon be infested.

The zebra mussel is mainly dioecious. Females release eggs usually when water temperatures reach 11-12° C. Males release sperm into the water column and the eggs are fertilized externally. Veligers are free floating for 10-14 days after hatching and are capable of only vertical movements in the water column. They are unable to swim horizontally and therefore can only colonize new areas passively via water currents. Upstream colonization of zebra mussels in the Upper Mississippi River, as well as other rivers, is therefore dependent upon a vector or upstream currents. Using the average weekly water temperatures at Locks and Dams 4 through 15 from 1984-1997, the temperature minimum required for sexual activity (11° C) is achieved from May 1 through mid-October. However, water temperature by itself may not be sufficient to trigger spawning (Garton and Haag 1993). Starr *et al.* (1990) linked spawning activities of marine invertebrates with the increased phytoplankton abundance.

Lock chambers provide excellent habitat for colonization by zebra mussels. Yager *et al.* (1994) provided estimates of zebra mussels in lock chambers ranging up to 68.4/m². Recent maintenance work at Lock and Dam 5A revealed a much higher density than this earlier estimate.

Zebra mussels will attach to nearly all available hard substrates and may also colonize soft substrates such as aquatic vegetation or soft mud (Whitney *et al.* 1997). Once firmly attached, adult zebra mussels are able to withstand water velocity up to approximately 1.5 m/s (Claudi and Mackie 1994). In this sense, they appear to be highly adapted to lotic conditions. However, when the complete life history of zebra mussels is considered, adaptability to lotic life is much more doubtful. Successful riverine bivalves hold eggs in marsupial chambers of the gill, are fertilized, and development proceeds to the production of glochidia larvae. The larvae are released, attach to fish fins, skin, or gills, undergo metamorphosis, and drop from the fish to the river bottom. Reliance on external fertilization and planktonic larvae has not been a successful design for bivalves in lotic habitat with relentless downstream flow. Native mussels have certain ecological advantages over zebra mussels such as the ability to bury into the substratum, possess a much longer life span, possibly greater energy reserves, thicker shells, and a reproductive strategy more suitable for lotic habitats. There is a possibility that the negative effects of zebra mussels on native riverine mussels has been overstated, as was the case with the Asian clam (Miller and Payne 1994).

Strayer (1991) concluded that zebra mussels do not exist in rivers less than 30 m wide. Lakes and run-of-river reservoirs along large rivers are the primary habitats of zebra mussels. Hunter *et al.* (1997 and references within) showed zebra mussel settlement is restricted by water velocity. Settlement is most successful in slow-moving water (<10 cm/s) and within velocity refuges from even such slow-moving water. Successful colonization of smaller river systems by zebra mussels may greatly depend on lakes, large pools, and impoundments along the river's course (Hunter *et al.* 1997). Even then, density of zebra mussels downstream of the lentic portions of the system tends to be markedly lower. Although impoundments along a smaller river enhance conditions for successful zebra mussel colonization, the overall susceptibility of such river systems to heavy infestation by zebra mussels is certainly much lower than for lakes and long, low-velocity sections of large rivers.

Zebra mussel dispersal is by three natural (water currents, birds, and other animals) and 20 human-related mechanisms (Carlton 1993). Many of these mechanisms accommodate upstream and/or overland transport of zebra mussels or their larvae. Carlton (1993) suggests inadvertent movement of zebra mussels on boats and other substrates leads to rapid "hopscotching" over suitable habitat, with "backfilling" likely to occur later. It is uncertain that these introductions lead to infestation. Johnson and Carlton (1992) state: (1) the introduction of only a few zebra mussels creates a very low probability a self-sustaining population will develop; (2) many repeated introductions into a water body could be required before there is an outbreak; (3) overland transport requiring survival of mussels out of water is rarely successful; and (4) high likelihood of an eventually successful invasion of most water bodies nonetheless allows little in the way of predicting when that invasion will occur—it could require decades or longer.

At Prairie du Chien, Wisconsin, total density of freshwater mussels declined substantially between 1996 and 1998 (Table 7). Unionid densities have always varied among years since studies were initiated in 1984. During those years, density fluctuations were typically less than 50% of mean values and were likely the result of natural mortality, recent recruitment, and patchiness within the bed. However, the marked decline between 1996 and 1998 is likely the result of the extremely high zebra mussel density during both years. Virtually all native mussels were heavily covered by thousands of zebra mussels, and many had zebra mussels inside the shell and were unable to move their valves (Miller and Payne, unpublished data).

Based upon data collected in the Upper Mississippi River, there is no obvious relationship between unionid recruitment rate, expressed as percentage of young individuals or species, and the introduction and spread of zebra mussels (Table 8). The 2 years with the greatest number of native mussels less than 30 mm total shell length were 1987 before zebra mussels were present and in 1996, when the infestation may have been at its peak. It is certainly possible that the decline in evidence of recruitment noted in 1998 could be the result of the extremely high densities of zebra mussels. However, values are within the range of normal variation for this location (note the values for 1990 and 1995 before zebra mussels reached extremely high densities). Examination of size structure of zebra mussels during 1998 revealed recent recruits did not make up a large component of the population and many of the larger zebra mussels were dead or dying. Based on these data, zebra mussel density in the East Channel is expected to be low in 1999. In spite of the dramatic unionid density declines between 1996 and 1998, there is evidence of their recruitment, indicating that the unionid population could still recover. As of February 1999, Waterways Experiment Station scientists are still analyzing data from the 1998 survey.

TABLE 7. Mean density of freshwater mussels at three locations in the Upper Mississippi River near Prairie du Chien, WI, 1996. Sixty samples were collected at each location.

Location	1996		1998	
	Mean Density	**Standard Deviation**	**Mean Density**	**Standard Deviation**
Turning Basin	25.13	31.34	11.13	16.15
Reference Site	59.20	18.73	10.07	8.70
Below Bridge	78.07	48.40	16.93	13.66
Overall	54.13	41.16	12.71	13.44

TABLE 8. Percent of native mussel species and individuals less than 30-mm total shell length at the reference site, Prairie du Chien, Wisconsin.

Year	Individuals	Species
1987	34.4	75.0
1988	24.5	52.0
1990	14.8	42.1
1995	11.3	54.2
1996	32.5	66.7
1998	25.8	45.0

Species and sizes of native mussels can vary in their susceptibility to mortality and stress from zebra mussels, but these distinctions probably do not matter at extremely high infestations. Higgins' eye is probably no more susceptible to extremely high zebra mussel infestations than most other unionid species. The major concern with any type of stress and this endangered species is its low abundance. On average, Higgins' eye represents about 0.5% of the community. Therefore, in a bed with a mean total density of 100 individuals/m², it is unlikely to find more than one Higgins' eye every several square meters. If the total mussel community were reduced 50% by zebra mussels, Higgins' eye density could drop so low that successful reproduction and subsequent recruitment would not occur.

Dense zebra mussel colonization on native mussels has been shown to have severe impacts upon unionid communities. The likelihood for another exotic species invasion into the Upper Mississippi River is very high, and the degree of impact upon the native fauna is impossible to determine. One potential species that could impact Higgins' eye in the same fashion as the zebra mussel is the quagga mussel (*Dreissena bugensis*). Other species of concern for potential invasion to the Upper Mississippi River are the round goby (*Neogobius melanostomus),* black carp, or a number of pathogens (bacterial or viral). Invasion of another exotic species into the Upper Mississippi River could have detrimental effects to an already stressed Higgins' eye population.

9.3.3.5 Contaminants

Contaminants from navigation traffic can impact Higgins' eye by direct mortality and other chronic effects. Benthic organisms have been shown to be sensitive to a wide range of contaminants including ammonium, pesticides, and petroleum products, all of which are commonly transported on the Upper Mississippi River. Although past practices (i.e., weirs, locks and dams, mooring sites, etc.) have made navigation safer on the Upper Mississippi River and have reduced the potential for a hazardous spill, accidents are still occurring which may result in a spill. A spill of hazardous material could have disastrous effects on the mussel population of the Upper Mississippi River. A large spill of salt or fertilizer could destroy a large number of mussels. The overall consequence, however, can not be predicted, but would depend upon the amount and type of substance spilled, the effectiveness of spill containment and cleanup, the river stage, and on additional unquantifiable factors (USFWS 1993d).

9.3.4 Recreation-Related Indirect Effects

9.3.4.1 Facilities

Development of recreational facilities could be responsible for loss of Higgins' eye habitat. The development of existing facilities does require varying levels of habitat modifications, but most of these disturb upland habitat components. Construction activities such as sand fill placed at recreational facilities for beach or swimming areas as well as riprap placement for shoreline protection have the potential to cover and permanently change Higgins' eye habitat. Disturbances to the aquatic system would require the Corps to go through the Section 404(b)(1) evaluation process where coordination with other Federal and State agencies would occur.

9.3.4.2 Large Vessels

Large vessel traffic could impact mussels through abortion, direct mortality, or other disturbance factors. Miller *et al.* (1996) indicated velocity changes created by tow passage did not impact benthic organisms or their habitat. Although tow passage affect water conditions much differently than recreational craft, it is unlikely that large recreational craft would impact similar habitat. Recreational craft are more capable of navigating shallower habitats and consequently have a higher potential to impact more habitat. These vessels have also been implicated in the transport and spread of zebra mussels. The impacts of zebra mussels are discussed in section 9.3.4.4.

9.3.4.3 Beach Use - Not applicable

9.3.4.4 Exotic Species

The general impact of zebra mussels upon Higgins' eye is found in section 9.3.3.4. Exotic species infestation resulting from recreation-related effects has the potential to impact Higgins' eye by direct mortality and chronic impacts. Based on the current distribution of the zebra mussel in the Upper Mississippi River basin, it appears that recreational boat traffic has not been responsible for its spread to the degree that commercial tow traffic has. The Upper Mississippi River tributaries with no commercial tow traffic, yet support recreational craft traffic, have not been infested by zebra mussels. Schneider *et al.* (1998) provide evidence of zebra mussel spread from recreational boats between lakes in close proximal distance to the other. Based on the dramatic increase in spatial distribution of the zebra mussel from earlier records, recreational craft are undoubtedly partially responsible for the spread of the species within the Upper Mississippi River system. Large recreation vessels are less likely to transport as many zebra mussels as barges do for a number of reasons. The majority of large vessels in the upper reaches of the river are dry-docked during the winter months, which kills any zebra mussels attached. Barges usually remain in the water year-round. The exposed surface area of large vessels is also much lower than the area of a barge hull. The location where vessels have been moored also influences zebra mussel attachment.

9.3.4.5 Contaminants

Recreation-related petroleum spills have the potential to impact mussels through direct mortality and long-term chronic effects. The likelihood of recreational contaminant spills is higher due to a number of factors. A large number of craft operate on the Upper Mississippi River, many with inexperienced operators. The number of accidents of recreational traffic compared to commercial traffic is much higher. Although recreational craft deal with smaller amounts of petroleum products, most have no spill prevention plan and are not prepared when one occurs. Since most of these spills are comparatively small and petroleum products rarely reach below the water surface, the impacts would be negligible to Higgins' eye.

9.3.5 Interrelated Effects

9.3.5.1 Timber Management - Not applicable

9.3.5.2 Cabin Leases - Not applicable

9.3.5.3 General Plan Lands - Not applicable

9.3.5.4 Public Use Sites - Not applicable

9.3.5.5 Corps Port Facilities

Two Corps of Engineers port facilities are within the range of the Higgins' eye: one in the St. Paul District (Fountain City) and one in the Rock Island District (Le Claire Service Base, Iowa). In general terms, the port facilities impact the mussel population through habitat loss. Higgins' eye have not been found recently near the Fountain City port, and future expansion would probably have no impact. The Le Claire Service Base is located downstream of a known mussel bed of high quality. Any additional expansion in this vicinity would have to be coordinated regarding the rich mussel fauna. Future expansion at the facilities would have to be determined on a case-by-case basis.

9.3.6 Interdependent Effects

9.3.6.1 Missouri River Navigation - Not applicable

9.3.6.2 USCG Buoy Tending

A potential impact of buoy placement by the U.S. Coast Guard is zebra mussel infestation into previously unoccupied habitat. Since zebra mussels are found throughout the Upper Mississippi

River downstream from the head of navigation, buoy placement would not substantially add to the spread of zebra mussels considering the population densities within the river. Buoys removed from contaminated waters may have attached zebra mussels on the anchor, chain and buoy. Placement of contaminated equipment into the St. Croix could lead to an established population. See section 9.3.3.4 for general zebra mussel impacts to mussels.

9.3.7 Summary

The Corps of Engineers operation and maintenance activities of the 9-Foot Channel Navigation Project could have site-specific impacts on Higgins' eye pearly mussels, but would not individually or cumulatively have an adverse impact on their populations. In providing the 9-foot channel, potential indirect effects of the operation and maintenance activities must be addressed. All navigation effects can be considered as interrelated or secondary effects of the 9-Foot Channel Navigation Project, but are not regulated by the Corps of Engineers. Commercial navigation is a secondary interdependent activity of the 9-Foot Channel Navigation Project. Most recreational traffic could occur whether or not there is continued operations and maintenance because only the very largest recreational craft depend on the project's 9-foot channel draft for safe vessel passage. Navigation traffic has been shown to be an upstream dispersal mode for the zebra mussel, a species already firmly established in suitable habitats in the Upper Mississippi River. The Mississippi River is hydraulically a very dynamic water body with many backwaters, eddies, etc., and it has many niches conducive to the establishment and maintenance of zebra mussel populations. These established populations will continue to provide a source of veligers for many years into the future.

It is doubtful whether barge transport is as important to the maintenance of zebra mussel populations as it was in the initial spread of this exotic species. Commercial tow traffic could be adversely impacting Higgins' eye pearly mussel, but the magnitude of this impact is unknown. Zebra mussels and the potential introduction of other exotics impose a serious threat to native unionids. Recent work in the East Channel area near Prairie du Chien discovered dramatic declines in unionid populations which can probably be attributed to zebra mussel infestation. The Higgins' Eye Recovery Team believes this bed is of such importance to the overall Higgins' eye population that its demise would be a very serious threat to the continued existence of the species.

Three project-related indirect effects may be exacerbating the impact of zebra mussels and other exotics on Higgins' eye. Impoundment of the Upper Mississippi River has created more favorable habitat for the zebra mussels, a species that is ecologically developed and thrives in lentic conditions. Second, navigation traffic in the Upper Mississippi River has been shown to be an upstream dispersal vector for the zebra mussel. Third, the likelihood is still present of additional exotic species, such as the quagga mussel, to invade the Upper Mississippi River by using this same vector. The impact of another exotic species invasion to the Upper Mississippi River upon the currently stressed Higgins' eye is unknown.

9.3.8 Determination

It is our determination that continued operation and maintenance of the 9-Foot Channel Navigation Project will likely adversely affect the recovery of the Higgins' eye pearly mussel. However, even in the absence of the above three project-related indirect or secondary effects, the ultimate fate of the Higgins' eye pearly mussel remains uncertain.

10.0 WINGED MAPLELEAF

The Winged Mapleleaf Mussel Recovery Plan (USFWS 1997) describes the historic and present distribution of the federally endangered winged mapleleaf mussel (*Quadrula fragosa*). The present known distribution of the winged mapleleaf mussel is limited to a 20 km stretch of the St. Croix River below Taylors Falls, Minnesota. This species is not known to occur within the lower 40 km (9-foot channel area) of the St. Croix River or anywhere else in the Upper Mississippi River.

The specific habitat requirements of the winged mapleleaf mussel are not known. However, in the St. Croix River, winged mapleleaf mussels have been found in riffles with clean gravel, sand, or rubble substrates. Winged mapleleaf mussels were most abundant in shallow areas with fast current. Hornbach *et al.* (1996) reports "typical" winged mapleleaf habitat in the St. Croix River has an average water depth of 0.98 m with an average bottom current 0.19 m/s. In a mussel community survey by Hornbach *et al.* (1996), the winged mapleleaf was found to be significantly associated with *Truncilla truncata*, *T. donaciformis,* and *Q. metanerva*, and they concluded it is found only in "high quality habitat" for other mussel species.

The reproductive biology of the winged mapleleaf is even less clear than its habitat requirements. During biweekly examinations since May 1997, approximately 250 *Q. fragosa* were examined, revealing only a single gravid individual on September 24, 1997 (David Heath, personal communication). The glochidia were immature, suggesting it was the beginning of their brooding period. This would be quite unusual since almost all other members of the winged mapleleaf's subfamily brood in spring and early summer. The host fish for glochidia attachment is also unknown, but is likely a centrarchid member based on information known from other *Quadrula* species (USFWS 1997) or the flathead catfish.

The Winged Mapleleaf Mussel Recovery Plan (USFWS 1997) provides a description of the historic and modern distribution of the species. Historically, the winged mapleleaf was recorded from 34 rivers in 12 states, all either the Mississippi River or tributaries of the Mississippi. This species is probably extirpated from the entire historic range except for a remnant population on the St. Croix River. All recent collections of the winged mapleleaf have been limited to a 20 km stretch of the St. Croix River below Taylors Falls, Minnesota. However, the full distribution of this population in the St. Croix has not been identified.

10.1 REASONS FOR LISTING

The reasons that the winged mapleleaf was listed in the final ruling (USFWS 1991a) as endangered are:

- This species has been eliminated from nearly all of its original 11-state range and is now known from a single extant population along one 20 km reach of the St. Croix River.
- The remnant population is thought to be small and therefore vulnerable to stochastic disturbances, such as toxic substance spills or low water levels.
- Reproductive success is also jeopardized by the small population size. Surveys in 1988 and 1989 (Heath and Rasmussen 1990) failed to collect any individuals brooding young or less than 4 years old, even though congeneric individuals collected in the same survey showed evidence of successful reproduction. Additionally, small

populations are known to be vulnerable to various genetic constraints that can independently threaten a species (Allendorf and Leary 1986).

- Changes in land use practices in the watershed are anticipated because the watershed is close to a major and growing metropolitan area. These changes will probably affect the habitat quality of *Q. fragosa*. Also, recreational boat use in the vicinity of the population is heavy and potentially damaging.

10.2 PRESENT THREATS

The Winged Mapleleaf Mussel Recovery Plan (USFWS 1997) lists several threats potentially impacting the species, including habitat alteration, water quality, zebra mussels, predators, disturbance, development, competition, and parasites and disease.

Habitat alteration includes all past development in the river corridor that has changed its characteristics (i.e., hydroelectric dam at St. Croix Falls). Water quality issues encompass a wide variety of point and non-point contaminant and pollutant sources and are discussed in the Recovery Plan (USFWS 1997). The latest, and potentially the greatest, impact preventing the recovery of the species is the introduction of the zebra mussel (*Dreissena polymorpha*) to the freshwater system of North America. The zebra mussel infestation causes both direct and indirect impacts to native mussels. Their attachment to the shells of the native species impacts feeding and filtering functions, prevents valve closure, and causes shell deformation. Native mussel locomotion can be impacted by zebra mussel attachment to individuals. Zebra mussels can prevent colonization of native mussels in formerly suitable habitats and also prevent their burrowing into substrate by forming an impenetrable layer. Indirect impacts of zebra mussels include competition for food resources, unionid glochidia consumption by zebra mussels, and changes in the water chemistry, especially dissolved oxygen levels. Despite several findings of zebra mussels on boat hulls and other substrates in the St. Croix, no reproducing populations of zebra mussels have been found in the St. Croix River (Karns 1998).

A number of predators are known to consume a large quantity of mussels. There is also evidence that the winged mapleleaf has been harvested indiscriminately with other mussels for either human consumption or fish bait (Doolittle 1988). The actual extent and impact of predation upon this species is currently unknown. Little research has been completed on mussel genetics other than basic taxonomic investigations.

10.3 POTENTIAL IMPACTS TO WINGED MAPLELEAF

10.3.1 Operation of the 9-Foot Channel Project

10.3.1.1 Water Level Regulation - Not applicable

10.3.1.2 Impoundment - Not applicable

10.3.2 Maintenance of the 9-Foot Channel Project

10.3.2.1 Dredging - Not applicable

10.3.2.2 Placement - Not applicable

10.3.2.3 Clearing and Snagging

Removal of trees or other obstructions from the navigation channel could affect the winged mapleleaf through disturbance of bottom substrates, where a loss of habitat or modification of the existing habitats could occur. However, the majority of snagging occurs on the Minnesota River, which is outside the known range of the winged mapleleaf. Snag removal on the St. Croix River is completed only upon the National Park Service's request. No requests for clearing and snagging have been made for the past 20 years, and during this time a National Park has been established on the St. Croix. The Corps does not anticipate any snag removal on the St. Croix during the next 50 years. All clearing and snagging operations on the upper St. Croix River would have to be coordinated with numerous agencies and a Tier II Biological Assessment would be prepared.

10.3.2.4 Channel Structures/Revetment - Not applicable

10.3.2.5 Lock and Dam Rehabilitation - Not applicable

10.3.3 Navigation-Related Indirect Effects

10.3.3.1 Tow Traffic

The head of the 9-foot channel on the St. Croix River is located at Stillwater, Minnesota, St. Croix River Mile 24.5. The known population of the winged mapleleaf is located at least 30 km upstream from the head of navigation. At the current time, no commercial tow traffic uses the St. Croix River for transport; however, that use and the operation and maintenance of the 9-foot channel is still authorized. Tow traffic has been implicated in the transport and "reseeding" of zebra mussel populations at upstream locations (Carlton 1993, Keevin *et al.* 1992). The impact of zebra mussels upon the winged mapleleaf is discussed in section 10.3.3.4.

10.3.3.2 Fleeting - Not applicable

10.3.3.3 Port Facilities - Not applicable

10.3.3.4 Exotic Species

The greatest exotic species concern for the winged mapleleaf is presently the zebra mussel. Based on the zebra mussel's current distribution within the Upper Mississippi River, it appears that tow traffic has been the main transportation vector responsible for the zebra mussel invading the Upper Mississippi River upstream of the Illinois River (Keevin *et al*. 1992). However, this is not the case on the St. Croix River. Since there is no regular commercial tow traffic, recreational boat traffic would be the most likely vector present on the St. Croix River. Commercial navigation will likely continue to transport zebra mussels in the Mississippi River. Zebra mussels are already firmly established in suitable habitats in the Mississippi River and it is doubtful whether barge transport is as important to the maintenance of zebra mussel populations as it was in the initial spread of this exotic species. Presently, the St. Croix River is not infested with zebra mussels.

Potential impacts of exotic species have been covered in section 9.3.3.4. Generally, dense zebra mussel colonization on native mussels has been shown to have severe effects upon unionid communities. The likelihood for another exotic species invasion into the Upper Mississippi River basin is possible, but the degree of impact upon the native fauna is impossible to determine at this time. One potential species that could impact unionids is the quagga mussel (*Dreissena bugensis*), a deep-water member of the same genus as the zebra mussel.

10.3.3.5 **Contaminants** - Not applicable

10.3.4 Recreation-Related Indirect Effects

10.3.4.1 Facilities

Development of recreational facilities could be responsible for loss of winged mapleleaf habitat. The development of existing facilities requires varying levels of habitat modifications. Most of the development of these areas disturbs upland habitat components; however, aquatic systems could be impacted as well. Disturbances to the aquatic system would require project review under the Section 404(b)(1) evaluation process where coordination with other Federal and State agencies would occur. The Wild and Scenic River designation for the St. Croix River further protects any modifications to critical mussel habitat.

10.3.4.2 Large Vessels

Large vessel traffic could impact mussels through abortion, direct mortality, or other disturbance factors. Paddleboat groundings occur occasionally in winged mapleleaf habitat. Miller *et al.* (1996) studied mussel habitat and indicated that the velocity changes created by tow passage did not impact benthic organisms or their habitat. Recreational craft are more capable of navigating shallower habitats and therefore have a higher potential to impact more habitat.

10.3.4.3 Beach Use

Human activity at St. Croix River beaches has the potential to impact the winged mapleleaf by causing abortion, direct mortality, or through other types of disturbances. Human traffic in winged mapleleaf habitat during periods of gravidity could lead to premature glochidia release by females if disturbed. Winged mapleleaf reproduction may be disrupted and glochidia aborted due to human wading and swimming activity at one of the most important mussel beds (Heath 1991). High human activity at beach sites has the potential to modify habitat by substrate changes through swimming and wading action, and the modifications to the substrate by craft use. Direct mortality could be caused by crushing, burial, or intentional vandalism by the recreationists.

10.3.4.4 Exotic Species

Exotic species infestation resulting from recreation-related effects has the potential to impact winged mapleleaf by direct mortality and chronic impacts (see section 9.3.3.4). Based on the current distribution of the zebra mussel in the Upper Mississippi River basin, it appears that recreational boat traffic has not been responsible for its spread to the degree that commercial tow traffic has. Zebra mussels have not infested the Upper Mississippi River tributaries that have no commercial traffic yet support recreational craft traffic. Schneider *et al.* (1998) provide evidence of zebra mussel spread from recreational boats between lakes in close proximal distance to the other. Based on the dramatic increase in spatial distribution of the zebra mussel from earlier records, recreational craft are undoubtedly partially responsible for the spread of the species within the Upper Mississippi River System. The explanation that commercial traffic seems to be more effective in spreading zebra mussels is really quite simple: there is more square footage of wetted hull on commercial vessels, they tend to be left in the water longer than recreational vessels, and they travel greater distances. Monitoring stations on the St. Croix River have shown no established zebra mussel infestation at this time. There may be several reasons for this, including habitat less conducive to zebra mussel infestations, a near lack of commercial vessels, the public awareness of the zebra mussel problem provided by the resource agencies, and the quarantine above Arcola Bar by the U.S. Park Service. Because there is very little commercial tow traffic on the St. Croix River, recreational boat traffic will be the most likely vector for the future spread of zebra mussels in the St. Croix.

10.3.4.5 Contaminants

Recreation-related petroleum spills have the potential to impact mussels through direct mortality and long-term chronic effects. The likelihood of recreational contaminant spills is higher due to a number of factors. A large number of craft operate on the St. Croix River, many with inexperienced operators. The number of accidents of recreational traffic compared to commercial traffic is much higher. Although recreational craft deal with smaller amounts of petroleum products, most have no spill prevention plan and are not prepared when one occurs. Since most of these spills are comparatively small and petroleum products rarely reach below the water surface, the impacts would be negligible to winged mapleleaf.

10.3.5 Interrelated Effects

10.3.5.1 Timber Management - Not applicable

10.3.5.2 Cabin Leases - Not applicable

10.3.5.3 General Plan Lands - Not applicable

10.3.5.4 Public Use Sites - Not applicable

10.3.5.5 Corps Port Facilities - Not applicable

10.3.6 Interdependent Effects

10.3.6.1 Missouri River Navigation - Not applicable

10.3.6.2 USCG Buoy Tending

A potential impact of buoy placement by the U.S. Coast Guard is zebra mussel infestation into previously unoccupied habitat. Since zebra mussels are found throughout the Upper Mississippi River downstream from the head of navigation, buoy placement would not substantially add to the spread of zebra mussels considering the population densities within the river. Buoys removed from contaminated waters may have attached zebra mussels on the anchor, chain, and buoy. Placement of contaminated equipment into the St. Croix could lead to an established population. See section 10.3.4.4 for additional discussion of impacts.

10.3.7 Summary

The Corps of Engineers operation and maintenance activities of the 9-Foot Channel Navigation Project would have no direct effect upon the winged mapleleaf or its habitat. In providing the 9-foot channel, there are potential indirect effects of the operation and maintenance activities that must be addressed. All navigation effects can be considered as interrelated or secondary effects of the 9-Foot Channel Navigation Project, but are not regulated by the Corps of Engineers. Commercial navigation is a secondary interdependent activity of the 9-Foot Channel Navigation Project. Recreational traffic could occur whether or not there is continued operations and maintenance. Only the very largest recreational craft depend on the project's 9-foot channel draft for safe vessel passage, and Lake St. Croix would provide adequate depths for even these vessels. Navigation traffic has been shown to be an upstream dispersal mode for the zebra mussel. However, based on habitats currently used by the zebra mussel, it does not appear that this species would thrive in the habitat where the winged mapleleaf is currently found.

It should be pointed out that zebra mussels are probably already firmly established in suitable habitats in the Upper Mississippi River. The Mississippi River is hydraulically a very dynamic water body with many backwaters, eddies, etc., and it has many niches that are conducive to the establishment and maintenance of zebra mussel populations. These established populations will continue to provide a source of veligers for many years into the future.

It is doubtful whether barge transport is as important to the maintenance of zebra mussel populations as it was in the initial spread of this exotic species. Presently, the St. Croix River is not infested with zebra mussels. Commercial navigation will likely continue to transport zebra mussels in the Mississippi River. Since there is no regular commercial St. Croix tow traffic, recreational boat traffic would be the most likely vector on the St. Croix River. The possibility exists that an additional exotic species could invade the St. Croix River via the Upper Mississippi River from the Chicago Ship and Sanitary Canal, as the zebra mussel did. The most likely candidate would be the quagga mussel (*Dreissena bugensis*), a deep-water relative to the zebra mussel. The differing habitat preferences of this species from that of zebra mussel cast some doubt as to its ability to successfully invade the Upper Mississippi River; however, this yet remains to be seen.

10.3.8 Determination

It is our determination that the continued operation and maintenance of the 9-Foot Channel Navigation Project is not likely to adversely affect the present populations of winged mapleleaf mussel. The following arguments are offered in support of this determination:

(1) The potential impacts are secondary, interrelated effects of the proposed action from potential zebra mussel infestation. Although these effects are identified, their relationship to the continued operation and maintenance of the 9-Foot Channel Navigation Project is quite tenuous and is not dependent on the proposed action. Recreation traffic represents secondary interrelated, but not dependent effects of continued operation and maintenance. All but the very largest recreation craft would be able to navigate into the St. Croix River whether or not there would be continued operation and maintenance. Commercial navigation is nearly non-existent, and this is not likely to change in the near future. However, if this fact does change in the future, this consultation would have to be reinitiated.

(2) Recreational vessels are relatively inefficient in transporting zebra mussels as compared to commercial vessels.

(3) The habitat in the area where *Q. fragosa* are found is more lotic and not necessarily conducive for zebra mussels. The St. Croix River has not yet established a sustainable population of zebra mussels even though there have been several instances of isolated adult zebra mussels found in these waters. The reasons for this are not known.

(4) Zebra mussels are probably already firmly established in suitable habitats in the Mississippi River. The Mississippi River is hydraulically a very dynamic water body with many backwaters, eddies, etc., and has many niches that are conducive to the establishment and maintenance of zebra mussel populations. These established populations would continue to

provide a source of veligers for many years into the future. It is doubtful whether barge transport is as important to the maintenance of zebra mussel populations as it was in the initial spread of zebra mussels.

(5) There is a separation of about 65 river km between the mouth of the St. Croix and the populations of *Q. fragosa*. Further, there is an established quarantine check station provided by the U.S. Park Service that prevents contaminated vessels from navigating beyond Arcola Bar. The States of Minnesota and Wisconsin as well as the U.S. Park Service have established effective public education programs regarding transportation of zebra mussels. All of these activities will reduce the opportunity for zebra mussel infestation of the St. Croix River.

11.0 SICKLEFIN CHUB AND STURGEON CHUB - CATEGORY 1 SPECIES

11.1 SICKLEFIN CHUB (*Macrhybopsis meeki*)

11.1.1 General Life History Data (from USFWS 1993a, Piller *et al.* 1996, Gebwick 1996)

Sicklefin chub require turbid, free-flowing riverine habitats. They are typically found in the main channels of large rivers over sand or fine gravel. Pflieger (1971) reported that sicklefin chub were more abundant in the lower Missouri River due to a preference or requirement for sand or fine gravel substrate. Pflieger (1997) noted that mainstream reservoirs on the Missouri River appear to favor the sicklefin chub in the lower river by functioning as a sediment trap, thus increasing the extent of firm, silt-free substrate.

Collections of the sicklefin chub made at Grand Tower on the Middle Mississippi River by Piller *et al.* (1996) were in strong current at depths of 0.3 m to 1.5 m over a substrate of firm, clean sand. Like the sturgeon chub, the sicklefin chub is found in strong currents in turbid water, but is more commonly found over substrates of sand with some gravel (Bailey and Allum 1962, Reigh and Elsen 1979, Smith 1979, Klutho 1983, Etnier and Starnes 1993).

On the Missouri River (Gebwick 1996), sicklefin chubs were present in at least one collection at 13 of the 16 channel bars sampled. They were present in collections at the head, channel side, bank side, and between bars (chute side) and were collected most frequently from the channel side of these bars. Sicklefin chubs were also collected on 5 of 10 connected bars sampled. They were present in collections at the head and channel side and were collected most frequently at the head of these bars. Sicklefin chubs were present in at least one collection at one of 29 channel margin habitats sampled. They were collected at channel margin habitats upstream of notched revetments, upstream and downstream of wing dikes, downstream of chutes, downstream of small tributaries, and over flooded sandbars.

Sicklefin chubs were collected over substrates dominated by silt, sand, gravel, and flooded vegetation but were collected most frequently over sand and gravel substrates (Table 9). Average bottom water velocities where sicklefin chubs were collected ranged from 0.02 m/s to 0.34 m/s. Sicklefin chubs were collected most frequently from areas with average velocities between 0.15 m/s and 0.199 m/s and between 0.30 m/s and 0.349 m/s (Gebwick 1996).

TABLE 9. Percent frequency of occurrence of sicklefin and sturgeon chubs in collections over dominant substrates present during November 1994 sampling on the Missouri River, Missouri (Gebwick 1996).

Dominant Substrate	Number of Collections	% of Collections with Sicklefin Chubs	% of Collections with Sturgeon Chubs
Silt	17	29	29
Sand	43	53	35
Gravel	19	53	53
Flooded Veg.	9	22	11

The reproductive biology of sicklefin chub is unknown, but is likely similar to that of other *Macrhybopis* species. Lopinot and Smith (1973) reported that sicklefin chub reproduce at 1 year of age and spawn annually. The sexes are similar in color and size. Spawning is believed to occur in the spring as young-of-the-year have been collected in July from the Missouri River (Pflieger 1997).

The sicklefin chub is specially adapted for life in turbid waters. The eyes and optic lobes of sicklefin chub are reduced and the eyes are partially covered with a flap of skin. These physical characteristics further limit vision. The species exhibits a greater development of other sensory structures to compensate for diminished visual acuity. Sicklefin chub have a single pair of maxillary barbels. However, sensory papillae are abundant in the gular region and within the buccal cavity (Davis and Miller 1967). Lateral line neuromasts are abundant and canal pores are specialized to prevent suspended particles from entering (Reno 1969).

11.1.2 General Life History Data for the Middle Mississippi River

Smith (1979) indicated that the sicklefin chub occurs in fast water of large rivers over a bottom of firm sand or fine gravel. In Illinois, the species is restricted to the Mississippi River below the mouth of the Missouri River (Smith 1979). Smith noted that "this chub is known from several sites, but it is, and probably always has been, quite rare." Pflieger (1997) indicated that in Missouri the sicklefin chub is restricted to the Missouri River and the Mississippi River downstream from the Missouri's mouth. Based on museum specimens, the species has been previously collected above the mouth of the Missouri River to the Lower Illinois River and other smaller tributaries of the Mississippi River (Joyce Collins, USFWS, personal communication, February 1, 1999).

After little success in collecting sicklefin chubs and sturgeon chubs using conventional seining methods and lack of success by others using seines in the Middle Mississippi River (Piller *et al.* 1996), the Missouri Department of Conservation began trawling in 1997 using 3/16-inch mesh nets. Approximately 120 sites have been surveyed in the Cape Girardeau area. During 1997-1998 trawling, 131 sicklefin chub and 66 sturgeon chub were collected (Table 10). Trawling allows collection of fish in deeper water that otherwise can not be seined. Sicklefin chub appear to be less habitat (bottom type) specific, using hard sand or firm sand with dunes. They are also found in side channels. They are not found in straight sections of the river where there appears to be only low dunes. Suggested habitat preference is based solely on observation. No substrate collections have been made to associate sturgeon chub catch with actual bottom type (Dave Herzog - Open River LTRM Field Station, Missouri Department of Conservation, personal communication, January 8, 1998). Qualitative data indicate that approximately 80% of sicklefin chub were caught in areas classified as sand/mostly sand. Approximately 70% of the trawl surveys which caught sicklefin chub and sturgeon chub had gravel ("pea" sized) associated with the bottom substrates (Dave Herzog - personal communication to Joyce Collins - USFWS).

TABLE 10. Collection of sicklefin chubs and sturgeon chubs by trawling on the Middle Mississippi River in the vicinity of Cape Girardeau, Missouri (Missouri Department of Conservation, unpublished data).

Year	Number Sicklefin Chub	Number Sturgeon Chub
1997	60	3
1998	71	63

11.1.3 Reasons for Category 1 Status of the Sicklefin Chub

The U.S. Fish and Wildlife Service (1993a) lists the following "threats to survival" for the species:

Present or threatened destruction, modification, or curtailment of habitat or range.

1. **Past Threats.** "Water development projects on the Missouri and lower Mississippi Rivers likely impacted sicklefin chub populations. Reservoirs flooded riverine habitat, altered temperature and flow regimes, and reduced turbidity. Channelization straightened and narrowed the river, reduced habitat diversity, and reduced overbank flooding. Additional pressure on the species likely resulted from stocking high densities of piscivorous fish into the reservoirs and remaining riverine sections. Pollution from industry and agriculture may have also deteriorated water quality. Sand and gravel extraction operations have removed habitat and restricted fish movements.

2. **Existing Threats.** Water manipulation through dams and irrigation diversions continues to threaten the species. The lack of sediment transport contributes to reduced turbidity. Average annual sediment loading in the lower Missouri River decreased by 81% after closure of the main stem dams (Slizeski *et al.* 1982).

The seasonal hydroperiod and water temperature have also been disrupted. Sicklefin chub entering the main stem reservoirs are likely especially vulnerable to walleye, sauger, and other predators. Pollution from industry and agriculture may continue to be a threat. Sand and gravel extraction continues on the Missouri River and is especially prevalent on the Kansas River.

3. **Potential Threats.** Water manipulation, habitat loss, and possibly predation are the greatest threats facing sicklefin chub populations. Also, power plant and water supply intakes may entrain or impinge

sicklefin chub. Fragmentation of sicklefin chub populations due to dam construction and channelization are potential threats to the species, reducing genetic variability. Dredging for channel maintenance and sand/gravel extraction may be especially detrimental. Future introductions of exotic fish and other organisms may threaten sicklefin chub through predation or competition."

11.2 STURGEON CHUB (*Macrhybopsis gelida*)

11.2.1 General Life History Data (from USFWS 1993b, Piller *et al.* 1996, Gebwick 1996)

Sturgeon chub require turbid, free-flowing riverine habitat with a combination of rock, gravel, and/or sand substrate. They are found in greatest abundance in gravel riffles (Stewart 1981, Werdon 1992).

Collections of the sturgeon chub made at Grand Tower on the Middle Mississippi River by Piller *et al.* (1996) were in strong current at depths of 0.3 m to 1.5 m over a substrate of firm, clean sand. In the western part of the range of the sturgeon chub, the species is strongly associated with coarse substrates of rock and gravel, strong current, and shallow, turbid water (Bailey and Allum 1962, Cross 1967, Reigh and Elsen 1979, Stewart 1980, Rowe 1992, Cross and Collins 1995). In the Mississippi River and lower Missouri River where gravel substrates are rare, the sturgeon chub has been collected over firm sand (Pflieger 1997, Smith 1979, Klutho 1983, Etnier and Starnes 1993).

Pflieger (1997) suggested that "The recent increase in abundance of this species in the lower Missouri River may be attributable to construction of several large reservoirs on the river upstream from Missouri. These function as huge sediment traps, substantially reducing the quantities of silt carried by the lower river. As silt was flushed out and not replaced the prevalence of gravel substrate markedly increased. Affinity of the sturgeon chub for gravel substrate has been noted (Bailey and Allum 1962)."

On the Missouri River (Gebwick 1996), sturgeon chubs were present in at least one collection at 10 of 16 channel bars sampled. They were present in collections at the head, channel side, bank side, and between bars (chute side) and were collected most frequently from the chute side and bank side of these bars. They were collected from 4 of 10 connected bars sampled, but only from the channel side of these bars. Sturgeon chubs occurred in at least one collection at nine of 29 channel margin habitats sampled. They were collected at channel margin habitats upstream of notched revetments, upstream and downstream of wing dikes, downstream of chutes, and along channel margins with no distinguishing characteristics.

Sturgeon chubs were collected over substrates dominated by silt, sand, gravel, and flooded vegetation (Table 10). Average bottom water velocities where sturgeon chubs were collected ranged from 0.11 m/s to 0.36 m/s. Sturgeon chubs were collected most frequently from areas with average velocities ranging between 0.25 m/s and 0.30 m/s (Gebwick 1996).

The reproductive biology of the sturgeon chub is unknown but is likely similar to that of the speckled chub with which it has been reported to hybridize. Speckled chub spawn at midday in deep water where the current is fast (Botrell *et al.* 1964). Fertilized speckled chub eggs drift downstream and hatch in about a day (Botrell *et al.* 1964). Ripe female sturgeon chub contain approximately 5,000 previtellogenic, vitellogenic, and mature oocytes (Werdon 1992).

Breeding male sturgeon chub have tubercles along the edges of the pectoral fins (Pflieger 1997). However, there are no other secondary sex characteristics, and the sexes are similar in color and size. Sturgeon chub mature at 2 years of age and annual growth slows as the fish mature (Stewart 1981, Werdon 1992). Mature females are approximately 76 mm to 81 mm total length; mature males are approximately 78 mm to 79 mm total length (Werdon 1992).

Sturgeon chub are ripe from mid-June until later July in Wyoming and in mid-July in South Dakota (Jenkins 1980, Stewart 1981, Werdon 1992). Tuberculate male sturgeon chub have been collected in the Kansas River in May and June and tubercles disappear by July and August (Cross 1967). Spawning is likely influenced by water temperature. Sturgeon chub in the Powder River, Wyoming, were ripe at water temperatures of 18.3^{o}C to 22.2^{o}C (Werdon 1992). Ripe males were collected at 23^{o}C in Kansas (Cross 1967). Spawning may also be regulated by increasing flows due to snowmelt or precipitation events.

11.2.2 General Life History Data for the Middle Mississippi River

Smith (1979) indicated that the sturgeon chub occurred on shallow fast riffles over fine gravel or coarse sand in large rivers. Smith indicated that the sturgeon chub occurs in Illinois only in the Mississippi River below the mouth of the Missouri River. At the time of his publication, he considered the species to be one of the rarest of Illinois fishes. At the time it was known from a few specimens from single localities in Madison and Union Counties. Smith suggested that the reason for its rarity in the Illinois portion of the Mississippi River was probably that nearly all shallow riffles in the Middle Mississippi River flow over fine sand rather than gravel.

Based on the trawling work of the Missouri Department of Conservation, the sturgeon chub appears to prefer the inside of bends and shoals with hard, firm substrate and dunes. They are not found in straight sections of the river where there appears to be only low dunes. Suggested habitat preference is based solely on observation. No quantitative substrate collections have been made to associate sturgeon chub catch with actual bottom type (Dave Herzog - Open River LTRM Field Station, Missouri Department of Conservation, personal communication, January 8, 1998). Qualitative data indicate that approximately 93% of sturgeon chub were caught in areas classified as sand/mostly sand. Approximately 70% of the trawl surveys which caught sicklefin chub and sturgeon chub had gravel ("pea" sized) associated with the bottom substrates (Dave Herzog - personal communication to Joyce Collins - USFWS).

11.2.3 Reasons for Category 1 Status of the Sturgeon Chub

The U.S. Fish and Wildlife Service (1993b) lists the following "threats to survival" for the species:

A. Present or threatened destruction, modification, or curtailment of habitat or range.

1. **Past Threats.** "Water development projects on the Missouri and lower Mississippi Rivers and Missouri River tributaries likely impacted sturgeon chub populations. Reservoirs flooded riffle habitat, altered temperature and flow regimes, and reduced turbidity. Channelization straightened and narrowed the river, reduced habitat diversity, and reduced overbank flooding. Additional pressure on the species likely resulted from stocking high densities of piscivorous fish into the reservoirs and remaining riverine sections. Pollution from industry and agriculture may have also altered water quality. Sand and gravel extraction operations have removed habitat and restricted fish movements.

2. **Existing Threats.** Water manipulation through dams and irrigation diversions continues to threaten the species. Threats from water depletion are greatest for tributary populations. Average annual sediment loading in the lower Missouri River decreased by 81% after closure of the main stem dams (Slizeski *et al.* 1982). The seasonal hydroperiod and water temperature have also been disrupted. Sedimentation occurring under continued low-flow conditions may be threatening the species' riffle habitat. Sturgeon chub forced into pool habitat on the smaller tributaries or into main

stem reservoirs are likely especially vulnerable to walleye (*S. vitreum*), sauger, and other predators. Pollution from industry and agriculture may continue to be a threat.

3. **Potential Threats.** Water depletion, water manipulation, habitat loss, and possibly predation are the greatest threats facing sturgeon chub populations. Future water depletions are likely to result from energy development (coal mining) in the upper Missouri River Basin. Other water losses may result from inter-basin diversions and increased municipal, industrial, and irrigation usage. Also, power and water supply intakes may entrain and impinge sturgeon chub. Further fragmentation of sturgeon chub populations due to dam construction and channelization are a potential threat to the specie, reducing genetic variability and preventing repopulation of genetic variability and preventing repopulation of tributaries after severe drought conditions. Dredging for channel maintenance and sand/gravel extraction may be an obstacle to fish movement. As sturgeon chub populations are isolated and numbers decline, the potential for hybridization with speckled chub will increase. Water pollution associated with nutrient enrichment and chemical contaminants may be especially detrimental to populations in small tributaries and under low water conditions where pollutants would be concentrated. Future introductions of exotic fish and other organisms may threaten sturgeon chub through predation or competition."

11.3 PROJECT ACTIONS/POTENTIAL IMPACTS

11.3.1 Operation of the 9-Foot Channel Project

11.3.1.1 Water Level Regulation - Not applicable

11.3.1.2 Impoundment - Reduced turbidity may affect abundance and distribution in the Middle Mississippi River.

Depending on stage and precipitation events, 75% to 95% of the suspended solids entering the Middle Mississippi River comes from the Missouri River. The navigation impoundments are having little effect on the suspended sediments (turbidity levels) on the Middle Mississippi River (Claude Strauser - St. Louis District, personal communication, January 8, 1998). As such, they are having minimal impact on the sicklefin and sturgeon chubs that require turbid water.

11.3.2 Maintenance of the 9-Foot Channel Project

11.3.2.1 Dredging - Habitat loss or modification. See the Pallid Sturgeon, section 8.3.2, for current dredging and placement practices in the Middle Mississippi River.

It is known that both species use bars on the Missouri River (Gebwick 1996) which are depositional areas, and Herzog (personal communication) indicated that both species were found on shoaling areas on the insides of bends on the Middle Mississippi River which are also depositional areas. Sicklefin chubs have been found in water depths ranging from 1.0 m to 8.1 m and sturgeon chubs have been found in water depths ranging from 1.0 m to 5.8 m (Dave Herzog - personal communication to Joyce Collins - USFWS). If these species are in dredging areas, there is a potential to adversely affect both species.

What are not known are the current range of the species in the Middle Mississippi River, the macrohabitat and microhabitat preference, and the occurrence within dredged areas. Without adequate macrohabitat data for the sicklefin and sturgeon chub, it is impossible to say even if the species are using potential dredge sites, let alone make an impact assessment. However, if the species are using these areas, it is likely that they would be impacted by dredging activities.

11.3.2.2 **Placement -** Habitat loss or modification

Again, without adequate macrohabitat data it is impossible to say even if the species are using potential dredge sites, let alone make an impact assessment. However, if the species are using these areas, it is likely that they would be impacted by dredged material placement.

11.3.2.3 **Clearing and Snagging -** Not applicable

11.3.3.4 Channel Structure/Revetment

a. Changes in river processes result in habitat loss or modification.

Piller *et al.* (1996) suggested that "The extensive modifications to the middle Mississippi River have left little remaining shoreline habitat for *M. gelida* and *M. meeki*. Wing dikes, present throughout the river, direct the current to the middle of the river, eliminating flow along the shore. This results in silting in of sand and gravel bars, eliminating critical habitat for these species and other big-river chubs (Etnier and Starnes 1993). Much of the rest of the shoreline areas of the river have been stabilized by rock rip-rap."

Gebwick (1996) reported that sicklefin chubs and sturgeon chubs were collected from a variety of habitat types, including wingdams on the Missouri River. It appears that on the Missouri River, if a combination of appropriate habitat characteristics (substrate and velocity) are available, "structures" have no effect on the occurrence of the species. Existing velocity profiles behind wingdams on the Middle Mississippi River (Maynord 1998) have velocity ranges that both sicklefin and sturgeon chubs utilized in the Missouri River (Gebwick 1996). Substrates conducive to both species are also available (Table 9) and bars associated with wingdams (which were used on the Missouri River) are also available in association with wingdam structures.

Contrary to the suggestions of Piller *et al.* (1996), the data from the Missouri River (Gebwick 1996) suggest that navigation structures may not be impacting either species. However, there are no habitat usage data (microhabitat: bottom type, velocity, depth; macrohabitat: sandbars, channel location, usage of revetted versus natural banklines, use of side channels, use of wingdam habitat, etc.) for either the sicklefin or sturgeon chub on the Middle Mississippi River. Without such data, it is impossible to say one way or the other if channel structures/revetment impact either species.

Closing structures on the Middle Mississippi River have reduced flows to side channels and have degraded side channel habitat. A 122 mm sicklefin chub was found in Schenimann Chute in the Middle Mississippi River during February of 1998. It is not known if side channels are important habitat, especially during winter months, or if the individual captured represents an isolated use of a chute. Again, without adequate macrohabitat data it is impossible to say even if the species are using this habitat type, let alone make an impact assessment.

b. Reduced turbidity may affect abundance and distribution.

The existing structures are having no effect on the turbidity levels of the Middle Mississippi River (Claude Strauser - St. Louis District, personal communication, January 8, 1998).

c. Modifications to existing structures could result in creation, restoration, or enhancement of habitat.

It is possible that modification of structures could result in creation, restoration, or enhancement of habitats. However, adequate data on sicklefin and sturgeon chub habitat preference and structure hydraulic properties do not exist to design "chub friendly" structures.

d. Nutrient cycle disruption due to changes in river processes that inhabit or reduce floodplain inputs into the river.

Many workers believe the flood pulse is crucial to the trophic dynamics and fisheries of large floodplain rivers (see reviews in *Bioscience* Volume 45, 1995). The loss of floodplain connectivity and the connection of the river to off-channel habitats have resulted in fewer nutrient inputs into the river, affecting productivity of many large river fish. It is not known to what extent, if any, Middle Mississippi River sicklefin and sturgeon chub population size, growth, and reproductive potential are affected by this reduction in floodplain inundation and connectivity of off-channel habitats.

11.3.2.5 Lock and Dam Rehab - Not applicable

11.3.3 Navigation-Related Indirect Effects

11.3.3.1 Tow Traffic - Direct mortality

11.3.3.2 Fleeting

a. Direct mortality.

Towboats maneuver barges in fleeting areas. The potential for direct mortality of sicklefin chub or sturgeon chub by tow traffic (i.e., propeller strike) is unknown. It is doubtful that barge movement would cause mortality.

b. Habitat loss.

Development of existing fleeting areas required various levels of habitat modification. The level of impact to the sicklefin chub or sturgeon chub or potential habitat is unknown. The potential impacts of future development of fleeting areas will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process.

11.3.3.3 Port Facilities - Habitat loss

Development of port facilities required various levels of habitat modification. The level of impact to the sicklefin chub or sturgeon chub or potential habitat is unknown. The potential impacts of future development of port facilities will be evaluated and coordinated with appropriate natural resource agencies during the Clean Water Act (Section 404) and Rivers and Harbors Act (Section 10) regulatory process.

11.3.3.4 Exotic Species - Not applicable

11.3.3.5 Contaminants

Organic contaminants are associated with the clay component of riverine sediments, both suspended sediments and bed load, on which they attach. A computer model (NAVEFF) was run by the Waterways Experiment Station to determine the potential for increased suspended sediments caused by commercial navigation traffic in the Middle Mississippi River. Preliminary model runs determined that increased suspended sediments resulting from commercial navigation could not be detected above existing suspended sediment (turbidity) levels (Dr. Steve Maynord and Mr. Thomas Pokrefke - Waterways Experiment Station, personal communication, January 6, 1999). The bed load in the main channel of the Middle Mississippi River is sand that has a quick settling time and does not contribute to lateral movement of suspended sediments or increases in turbidity. As such, the movement of commercial navigation traffic within the main channel is not expected to cause significant adverse impacts to the sicklefin or sturgeon chub.

a. Direct mortality.

There are currently no data available for contaminant body burdens for either the sicklefin chub or sturgeon chub in the Middle Mississippi River. As such, it is impossible to determine if any potential non-navigation related problems exist.

b. Chronic effects (e.g., reduced reproduction).

No data are currently available for contaminant body burdens for either the sicklefin chub or sturgeon chub in the Middle Mississippi River. As such, it is impossible to determine if any potential non-navigation related problems exist.

11.3.4 Recreation-Related Indirect Effects

Unlike the pooled portion of the Upper Mississippi River where the Corps maintains lake-like conditions and recreational facilities that are conducive to boating, no such operation and maintenance of "recreation habitat" occurs on the Middle Mississippi River. The Corps of Engineers does not have boat ramps or other recreational watercraft support facilities on the Middle Mississippi River. The level of recreation would remain approximately the same without the navigation system, except for that fraction of traffic with origin-destinations associated with the pooled portion of the river.

11.3.4.1 Facilities - Not applicable

11.3.4.2 Large Vessels - Direct mortality

It is possible that large recreation vessels could cause direct mortality from propeller strike; however, it is not known whether this has ever occurred. Considering the low population size of sicklefin chub and sturgeon chub in the Middle Mississippi River and the potential for recreation vessel propeller contact, the probability of mortality is very low.

11.3.4.3 Beach Use - Not applicable

11.3.4.4 Exotic Species - Not applicable

11.3.4.5 Contaminants - Direct mortality

a. Direct mortality

There are currently no data available for contaminant body burdens for either the sicklefin chub or sturgeon chub in the Middle Mississippi River. As such, it is impossible to determine if any potential non-navigation related problems exist.

b. Chronic effects (e.g., reduced reproduction)

There are currently no data available for contaminant body burdens for either the sicklefin chub or sturgeon chub in the Middle Mississippi River. As such, it is impossible to determine if any potential non-navigation related problems exist.

11.3.5 Interrelated Effects-Management of Corps Lands

11.3.5.1 Timber Management - Not applicable

11.3.5.2 Cabin Leases - Not applicable

11.3.5.3 General Plan Lands - Not applicable

11.3.5.4 Public Use Sites - Not applicable

11.3.5.5 Corps Port Facilities - Not applicable

11.3.6 Interdependent Effects

The Northwestern Division (Missouri River Region), U.S. Army Corps of Engineers, is currently coordinating with U.S. Fish and Wildlife Service under Section 7 of the Endangered Species Act concerning water control on the Missouri River.

11.3.6.1 Missouri River Navigation

a. Water level regulation - When do releases occur and how does this affect the available habitat in the Middle Mississippi River?

b. Preclusion of upstream movement due to impoundment

c. Reduced turbidity in the Middle Mississippi River due to impoundment

11.3.6.2 USCG Buoy Tending - Not applicable

11.4 DETERMINATION

Components of operation and maintenance of the 9-Foot Channel Navigation Project could potentially involve adverse impacts to the sturgeon chub and sicklefin chub. However, without adequate basic life history information it is difficult to make impact assessments for many of the items included in the Service's impact matrix. Basic life history data such as the range of the species in the Middle Mississippi River, macrohabitat (i.e., sandbars, channel location, usage of revetted versus natural banklines, use of side channels, use of wingdam habitat, etc.) preference, and microhabitat (i.e., bottom type, velocity, depth) preference are lacking.

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APPENDIX A

CORRESPONDENCE FROM THE U.S. FISH AND WILDLIFE SERVICE

APPENDIX B

"GROUND RULES" FOR INTERAGENCY COORDINATION DURING PREPARATION OF THE BIOLOGICAL ASSESSMENT AND BIOLOGICAL OPINION

APPENDIX C

ACTION PLAN FOR MANAGING AND PROTECTING POPULATIONS OF BOLTONIA DECURRENS ON U.S. ARMY CORPS OF ENGINEERS, ST. LOUIS DISTRICT LANDS