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U.S. Army Corps
of Engineers
Missouri River Division

Draft Environmental Impact Statement Executive Summary

Master Water Control Manual

MISSOURI RIVER

Review and Update

July 1994

United States Department of the Interior

NATIONAL PARK SERVICE
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Missouri River
Master Water Control Manual

Review and Update Study

Draft Environmental Impact Statement
Executive Summary

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PURPOSE AND NEED FOR ACTION

The Federal action considered in this environmental impact statement (EIS) is the operation of the Missouri River Mainstem Reservoir System and the downstream Navigation and Bank Stabilization Project (Mainstem System). The Mainstem System is operated under the guidelines of the Master Water Control Manual (Master Manual), which identifies the current Water Control Plan.

In October 1989, the Missouri River Division of the U.S. Army Corps of Engineers (Corps) was directed to initiate a study to search for Master Manual operating criteria that better serve the contemporary uses of the Missouri River system. The study was called the Missouri River Master Water Control Manual Review and Update. The study solicited input from interested parties, identified alternatives to the current Water Control Plan, evaluated impacts of the alternatives, and identified the best plan for operation of the Mainstem System. Included in this study was the preparation of an EIS.

Background

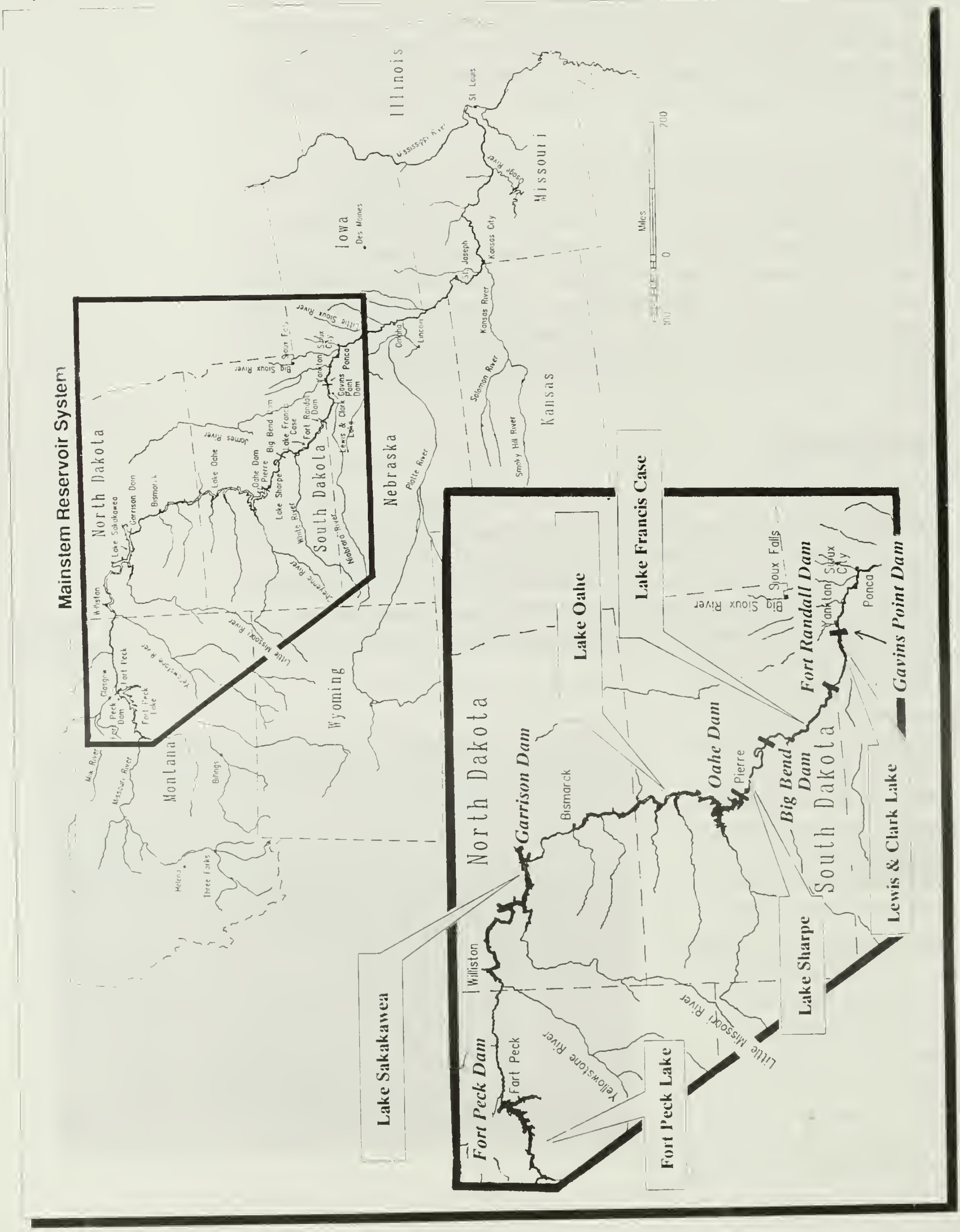
The Mainstem System consists of six dams and lakes constructed, operated, and maintained by the Corps (Figure 1). Water flowing down the Missouri River is stored in the six lakes and released as needed for downstream purposes. Released water flows downstream through the Navigation and Bank Stabilization Project from Sioux City to St. Louis. These Mainstem System projects were originally authorized under various Congressional acts from 1912 to 1945 and later modified in subsequent acts. The Corps operates the Mainstem System to balance the needs of the system's many uses, including flood control, navigation, irrigation, hydropower, water supply, water quality control, recreation, and fish and wildlife.

Wetlands bordering river

The Master Manual describes the current Water Control Plan for operating these projects. It was first published in 1960 and later revised in 1973, 1975, and 1979. Because of numerous changes in the Missouri River Basin since earlier versions of

Figure 1

Project area map.



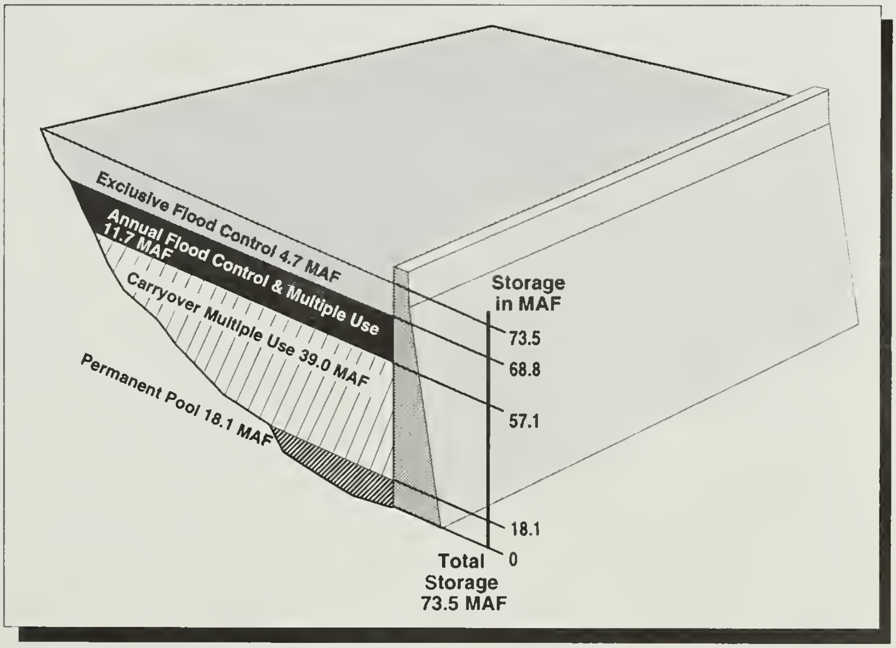
the Master Manual and the significant effects on all project purposes during the recent drought (1987 to 1992), the Corps began the latest review of the Master Manual in November 1989.

As required by the National Environmental Policy Act (NEPA) and other environmental laws for major Federal actions, the Corps' review of the Master Manual includes technical studies; alternatives development; and economic, environmental, and social impact assessments. As part of the review process, the Corps prepared a draft environmental impact statement (DEIS), and supporting appendices, to evaluate the potential social and environmental effects from proposed changes to system operation.

Current Water Control Plan

The existing Master Manual prescribes operation of the Mainstem System for the multiple project purposes of flood control, hydropower, water supply, water quality, irrigation, navigation, recreation, and fish and wildlife. For planning purposes, the Master Manual separates the total available storage volume in the mainstem lakes into four zones: (1) storing flood waters (the exclusive flood control zone); (2) storing flood waters and water for other uses (the annual flood control and multiple use zone); (3) storing water for multiple uses (the carryover multiple use zone); and (4) retaining water permanently (the permanent pool). Figure 2 shows this division in volumes expressed in millions of acre-feet (MAF) (an acre-foot is equivalent to an acre covered by one foot of water) for the total system. Figure 3 shows the allocation of three parts (the first two for flood control are combined) for each of the lakes.

Figure 2
Mainstem System total storage by zone.

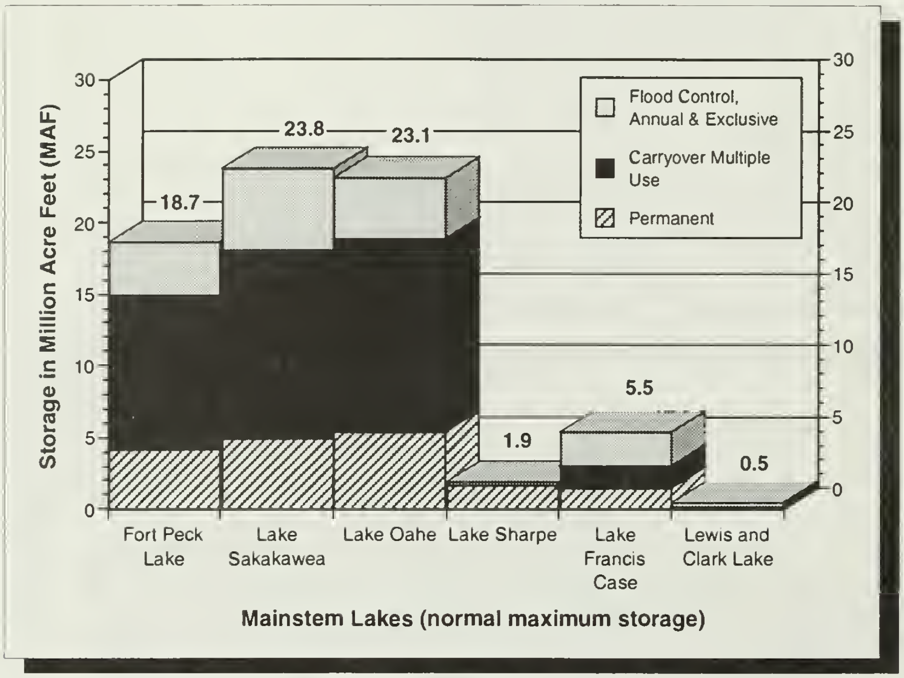


The exclusive flood control zone is the total upper volume of the mainstem reservoirs maintained exclusively for flood control. Water is released from this zone as quickly as downstream channel conditions permit so that sufficient space remains for capturing future incoming flood waters.

The annual flood control and multiple use zone is used to capture high spring and summer river flows into the lakes. Later in the year, water stored in this zone is released for downstream uses so that the zone is emptied by the beginning of the next flood season on March 1. This zone provides benefits for navigation, water supply, hydropower, water quality control, recreation, and fish and wildlife. As with the exclusive flood control zone, most of the water is released from the lakes during the summer and fall navigation season.

Figure 3

Mainstem System storage allocation for the current Water Control Plan.



The largest zone of storage, the carryover multiple use zone (Figure 3), remains full in most years but is gradually drawn down in multiyear droughts. Release of water from this zone is controlled by demands for navigation and nonnavigation services in the river below Sioux City.

The remaining storage capacity, the permanent pool, is the minimum water level necessary to operate the hydropower plants at the dams. The permanent pool also provides a minimum amount of water necessary for recreation, fish and wildlife, and the water supply for towns and irrigators located around the lakes.

The Master Manual specifies the criteria for releasing water from the four zones. The release criteria relate to the total amount of water stored in the lakes. When the amount of stored water declines during droughts, cutbacks in releases are made to conserve water. The criteria were originally designed so that the water stored would be sufficient to sustain navigation through a drought like that of the 1930s and early 1940s. The current Water Control Plan contains guidelines for reducing navigation service (the depth of water in the navigation channel) and shortening the navigation season during droughts. It also specifies minimum releases to the lower Missouri River during droughts when navigation is suspended.

The Master Manual provides specific rules for water releases from Fort Randall and Gavins Point Dams, and general water release criteria for the other four dams. Internal regulation of the system to meet the needs of power generation follows a seasonal pattern at each of these dams. Demands for water releases for navigation generally set the seasonal intrasystem regulation patterns. In general, the movement of water in storage from one reservoir to another follows a basic pattern each year. Occasionally, short-term adjustments in intrasystem regulation are necessary.

Fort Randall Dam and Lake Francis Case

Big Bend Dam and Lake Sharpe

ALTERNATIVES TO THE CURRENT WATER CONTROL PLAN

The search for a water control plan that better serves the present day needs of the basin has focused on two primary features of the Master Manual:

- The amount of water stored in the permanent pool and the carryover multiple use zones of the lakes; and
- The allocation of water in storage for downstream needs (i.e., navigation, water supply, irrigation, power production, water quality, flood control, recreation, and fish and wildlife).

Other features of the operations of the Mainstem System are not being considered for change. The allocation of reservoir storage for flood control was reviewed, but not changed. Structural changes in the reservoir system and navigation channels are not being considered. Also not being considered are temporary system unbalances, daily and weekly release patterns, and other intrasystem, short-term variations. The vast array of intrasystem details and daily operating specifics are appropriately evaluated in the context of the annual operating plan. Tributary projects are also not within the scope of the review.

Alternatives to the current Water Control Plan considered in the DEIS have varying system storage and release criteria. Overall, there are seven features of the Water Control Plan being evaluated for change:

1. Modified navigation service criteria for service level and season length in periods of drought.
2. Reduction in navigation season length in nondrought periods.
3. Addition of a spring rise in river flow through higher spring service levels.
4. Increases in seasonal nonnavigation service levels.
5. Reduced flood control constraints on system releases.
6. Modified intrasystem regulation of stored water among the upper three lakes.
7. Higher permanent pool levels.

Modified Navigation Service Criteria

Navigation service criteria for drought periods are a key feature of the Master Manual that is being evaluated. The navigation service level (the amount of river flow required to provide specific depths in the navigation channel) and the navigation season length are major factors that govern the release of water in droughts. Navigation service level and season length are necessarily cut back in droughts to conserve water for upstream and downstream uses.

The amount of water in system storage required for providing full navigation service under the current Water Control Plan on March 15 is 54.5 MAF. A total of 59.0 MAF on July 1 is also required to continue the full service level to the end of the season. As the stored water declines below these levels, navigation service is reduced towards minimum service until the levels reach 46.0 and 50.5 MAF on March 15 and July 1, respectively. At lower stored water levels, only minimum navigation service is supported by Mainstem System releases. The current and the modified navigation service level criteria are presented in Table 1 for an 18-MAF permanent pool. These values go up slightly for higher permanent pool alternatives. The modification would lower the amount of stored water released in support of navigation in drought periods. A new season length criteria that would reduce the navigation season length as the amount of stored water falls in drought periods is also being considered. Navigation season lengths are currently shortened when total stored water levels drop below 41 MAF on July 1, and the 8-month full season is reduced proportionately as stored water levels decline to 25 MAF on July 1. If the amount of stored water is less than 25 MAF, a 6-month season is supported unless this support would release the amount of water stored during the minimum season to less than 18 MAF (top of the permanent pool). Table 1 also presents current and modified season length criteria for the 18-MAF permanent pool option.

Table 1

Navigation service criteria for current and modified water control plans.

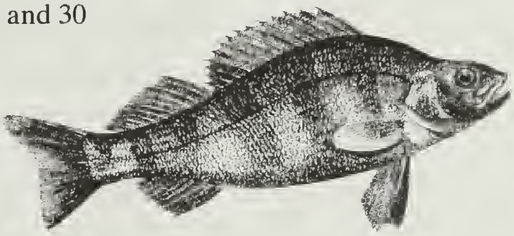
	March 15 (MAF)		July 1 (MAF)	
Service Level	**Current**	**Modified**	**Current**	**Modified**
Reduced Service	<54.5	<57.5	<59.0	<62.5
Minimum Service	<46.0	<54.5	<50.5	<60.5
Season Length			**Current**	**Modified**
Shortened Season			<41.0	<60.0
Minimum Season			<25.0	<52.0

Reduced Navigation Season Length

Reducing the navigation season length from 8 to 7 or 6 months in nondrought years is also being evaluated as a means of conserving stored water. Two forms of the 6-month navigation season are being evaluated. In addition to an April through September shortened season, a split season with two periods of navigation (April to July and October to November) is being evaluated.

Higher Spring Service Levels

Higher spring service levels are also being evaluated to provide a more natural spring rise in river flows to benefit native fish of the river. Additions to the spring navigation full service level of 10, 20, and 30 thousand cubic feet per second (kcfs) are being evaluated.



Increasing Nonnavigation Service Levels

Increasing the minimum flows in the river below the dams during drought periods is also being evaluated in the DEIS. Because navigation service is not always supported in drought periods, releases of stored water are necessary to maintain sufficient river flow to protect water supply and other downstream uses. Increasing the winter nonnavigation service level from the present 12 kcfs to as high as 18 kcfs is being evaluated. Increasing the spring and fall nonnavigation service level from the present 9 kcfs to as high as 25 kcfs is being evaluated. An increase in the summer nonnavigation service level from 9 kcfs to as high as 25 kcfs is being evaluated.

Reduced Flood Control Constraints

Constraints on releases during downstream flooding are also being evaluated. Current constraints provide a cutback in system releases to the normal full navigation service (35 kcfs) or minimum navigation service (29 kcfs) levels whenever flows exceed specified target levels in the lower river from Omaha to Kansas City. Two alternative criteria are being evaluated in the DEIS: (1) cutting system releases to provide only the minimum navigation service level; and (2) not cutting back releases regardless of the severity of downstream flooding. These changes would allow spring flows to remain higher in the river below Gavins Point Dam for the benefit of fish and wildlife while increasing the potential for downstream flooding.

Modified Intrasystem Regulation

The regulation of stored water among the mainstem lakes is also being evaluated in the DEIS. The current method of intrasystem regulation of stored water provides for an annual balanced regulation of storage among the upper three lakes. Although storage among these lakes is unbalanced seasonally, an effort is made to follow a consistent pattern for the balance of stored water among the lakes on an annual basis. An alternative to this scheme was developed that unbalances annual stored water on a scheduled basis among the three lakes to provide more optimal conditions for fish production. At least once in every three years, the level of each lake is allowed to rise in spring to enhance fish production.

Higher Permanent Pool Levels

The final feature of the Master Manual being evaluated for change is allocation of system storage between the permanent pool and carryover multiple use zones. Changes to the amount of storage designated as permanent pool would have an effect on lake levels and water releases from dams during drought periods. An increase in the current permanent pool of 18 MAF would reduce the amount of stored water in the carryover multiple use zone for release during drought periods for downstream needs. Of the total possible range of 0 to 57 MAF for the permanent pool, only the range from 18 to 48 MAF is considered in the DEIS. Levels below 18 MAF are not considered because the hydroelectric generators at the three largest lakes could not be operated effectively at lower levels. Permanent pools above 48 MAF are not considered, because there would be insufficient water in the remaining (less than 9 MAF) carryover multiple use zone to provide adequate water releases for downstream needs in many drought years.

Interior least tern—an endangered species

EFFECTS OF CHANGES ON KEY RESOURCES

Changes in the current Water Control Plan would affect important economic uses (flood control, water supply, hydropower, recreation, and navigation) and environmental resources (water quality, wetland and riparian habitat, wildlife, fish, socioeconomics, and historic properties) in the Missouri River Basin. Effects on key uses and resources are summarized below.

Flood Control

Agricultural lands, residential areas, business districts, and navigation benefit from flood control on the Missouri River. Approximately 1.1 million acres of farmland is subject to flooding along the Mainstem System. There are approximately 22,500 residential and 3,300 nonresidential buildings with an approximate worth of $10.8 billion located within identified flood zones. The navigation industry located below Sioux City is valued at $18 million per year and is subject to losses resulting from interrupted service during floods.

Under the current Water Control Plan, long-term average annual flood control benefits (reductions in flood losses) are estimated at $44 million, while benefits in an extended drought like that of the 1930s and early 1940s would average about $57 million. Changes in the current Water Control Plan would have the following effects on flood control benefits:

- Modified navigation service criteria would reduce benefits by less than 1 percent.
- Shortening the navigation season would reduce benefits by less than 1 percent.
- Higher spring service levels would reduce benefits by 1 to 2 percent for each 10 kcfs rise in service level.
- Higher nonnavigation service levels would increase benefits by no more than 1 percent.
- Reduced flood control constraints would reduce average benefits 10 percent and extended drought benefits 2 percent.
- The modified intrasystem regulation would reduce the benefits by less than 1 percent.
- Higher permanent pool levels would reduce average benefits up to 3 percent and extended drought benefits up to 5 percent.

Water Supply

The Missouri River and its mainstem lakes are a source of water for municipal water supply; irrigation; cooling water; and commercial, industrial, and domestic uses. There are approximately 1,600 water intakes of widely varying size on the Mainstem System. Access to water is a key concern because low water levels increase the cost of getting water from the lakes or river. Twenty-five coal-fired and nuclear powerplants with a combined generating capacity of 15,084 megawatts draw cooling water from the Mainstem System. The flow in the river and the river's water temperature affect a powerplant's ability to operate within discharge permit requirements. Low flows in the river may therefore force cutbacks in power production.

Under the current Water Control Plan, long-term average annual water supply benefits are valued at $546 million, while the average annual benefits in extended droughts like that of the 1930s and early 1940s would be about $550 million. Changes in the current Water Control Plan would have the following effects on water supply benefits:

- The modified navigation criteria, through higher lake levels in droughts, would improve the water supply benefits by less than 1 percent, with slightly more than 1 percent improvement during droughts.
- Shortening the navigation seasons by eliminating support for navigation in August and September in nondrought periods would reduce water supply benefits approximately 2 percent and drought period benefits by 3 percent. Eliminating navigation support in October and November, or November alone, would have little effect on water supply benefits.
- The spring rise in service levels of 10 to 30 kcfs would reduce the water supply benefits by less than 1 percent.
- Higher winter minimum nonnavigation service levels would reduce overall water supply benefits by less than 1 percent in nondrought years and approximately 2 percent during extended droughts because of reduced lake levels. Higher spring/fall and summer nonnavigation service levels would produce little or no reductions to water supply benefits in either nondrought or drought periods.
- Modified intrasystem regulation would have little or no effect on water supply benefits.
- Reduced flood control constraints would have little or no effect on water supply benefits.
- Higher permanent pool levels would reduce long-term water supply benefits by up to 2 percent and extended drought benefits up to 8 percent.

Hydropower

The six mainstem dams support 35 hydropower units with a combined capacity of 2,409 megawatts (MW) of potential power generation. These units provide an average 10 million megawatt-hours (MWh) of energy per year, or approximately 9 percent of the combined energy used in the Mid-continent Area Power Pool (MAPP), which includes Iowa, Minnesota, Nebraska, North Dakota, South Dakota, and portions of Illinois, Montana, and Wisconsin. Nearly all the water that flows into the Missouri River passes through these hydroelectric turbines. Energy is lost if releases of lake water are not passed through turbines. The value of the energy produced varies from season to season depending on power demand. Power generation at the six mainstem dams generally must follow the seasonal pattern of water movement through the system; however, adjustments have been made (when possible) to provide maximum power production during summer and winter when demand is high.

Gavins Point Dam

Under the current Water Control Plan, long-term average hydropower benefits are valued at $620 million per year, while average benefits in extended droughts would be about $548 million. Changes in the current Water Control Plan would have the following effects on hydropower benefits:

- The modified navigation service criteria would improve the long-term hydropower benefits by about 1 percent, with a 3 percent improvement in extended droughts.
- Shortening the navigation seasons would have little effect on benefits.
- A spring rise in the service level of 10 to 30 kcfs would reduce hydropower benefits by 1 to 2 percent over the long term and in droughts.
- Higher minimum nonnavigation service levels would reduce hydropower benefits less than 1 percent.
- Modified intrasystem regulation would reduce hydropower benefits less than 1 percent.
- Reducing flood control constraints would reduce hydropower benefits less than 1 percent.
- Higher permanent pool levels would increase long-term hydropower benefits up to 2 percent while extended drought period benefits would increase up to 6 percent.

Recreation

The six large lakes of the Mainstem System and the reaches of the Missouri River between and below the lakes provide considerable recreation opportunities to residents of the States through which the river flows, as well as neighboring States. These opportunities include boating, fishing, hunting, camping, sight-seeing, and swimming. Sport fishing is a major source of recreation along the entire system. The wetlands along the river corridor provide waterfowl habitat, and waterfowl hunting is popular.

Most of the recreation opportunities are in the mainstem lakes. There are over 80,000 acres of recreational lands along the nearly 6,000 miles of lake shoreline. There is an extensive network of roads, boat ramps, and campgrounds, and additional facilities are being developed.

River recreation, like lake recreation, is predominantly water-based, with boating and fishing as major activities. Portions of the river above Fort Peck Lake, below Fort Randall Dam, and below Gavins Point Dam have been designated "National Recreational River Reaches," as a part of the National Wild and Scenic Rivers System.

Water levels are a key factor in recreational use of the lakes and river reaches. At low lake levels, some boat ramps are unusable and recreational areas at the upper ends of the lakes may not provide access to the lakes. Low river flows affect boat access and maneuverability. Certain kinds of fishing and hunting depend upon adequate lake levels and river flow. Visitors are also less likely to frequent lakes and river reaches at low water for aesthetic reasons. In the recent drought (1987 to 1992), there was reduced access and many recreational areas were closed. Many boat ramps had to be extended and facilities had to be improved at open recreation sites to minimize overcrowding. Overall, the quality of recreation on the Mainstem System suffered.

Under the current Water Control Plan, long-term average recreation benefits are valued at $76 million, while benefits during extended droughts would average about $60 million. Changes in the current Water Control Plan would have the following effects on recreation benefits:

- The modified navigation service criteria, through higher lake levels in droughts, would improve long-term average recreation benefits by 4 percent, with a 14 percent average increase in extended droughts. Lake recreation would benefit the most because the upper three mainstem lakes would be drawn down less during droughts, while river recreation would be relatively unaffected because spring through fall river flows would not be affected.
- Eliminating support for navigation in late summer would reduce the long-term average benefits by 2 percent and the extended drought benefits by 7 percent. Eliminating navigation support in the fall would have little effect on benefits.
- The spring rise in service level of 10 to 30 kcfs would reduce long-term average recreation benefits a maximum of 1 percent by decreasing spring and summer lake levels in non-drought years.
- Higher winter minimum nonnavigation service levels would reduce long-term average benefits about 1 percent, while drought period benefits would decline about 8 percent because of reduced lake levels. Higher spring/fall and summer nonnavigation service levels would have minimal overall effect because they are less frequently activated in droughts.
- Modified intrasystem regulation would have minimal overall effect on recreation benefits, but would measurably improve drought period benefits in the upper mainstem lakes by allowing increased spring and summer lake levels in some years and provide for greater fishing opportunities.
- Reduced flood control constraints would have little or no effect on recreation value.

- Higher permanent pool levels would reduce the effects of drought on recreation by limiting the decline in lake levels in extended droughts. With an increase in permanent pool from 18 MAF to 48 MAF, long-term average recreation benefits would improve by up to 4 percent, while average extended drought benefits would improve by up to 18 percent.

Navigation

Navigation on the Missouri River occurs from Sioux City to the mouth at St. Louis. In normal years, total commodity tonnage barged on the river averages 2.5 million tons. Approximately 140 docks and terminals operate on the river. The Missouri River Navigation and Bank Stabilization Project provides a 9-foot-deep, 300-foot-wide navigation channel at full navigation service. Navigation service is provided by the release of stored water to maintain a 7.5- to 8.5-foot navigation draft (minimum and full service, respectively) in the navigation channel depending on the amount of water stored in the mainstem lakes. Navigation is limited to the normal ice-free season, with a full-length season of 8 months that generally extends from April 1 to December 1 near St. Louis. With above-normal stored water in the system, the season may be extended 10 days. The amount of stored water in the mainstem lakes needed to support navigation during the season varies depending on the amount of inflow from tributary rivers. In drought years service is reduced (less than 8.5 feet of draft is provided) or even eliminated in some months or years according to the navigation service criteria in the current Water Control Plan. In flood years such as 1993, service may be reduced or eliminated at the upper end of the navigation reach near Sioux City to limit downstream flooding.

Under the current Water Control Plan, long-term navigation benefits would average approximately $18 million per year, while benefits would average $12 million in an extended drought. Changes in the current Water Control Plan would have the following effects on navigation benefits:

- The modified navigation criteria would reduce average long-term and extended drought benefits by about 5 percent.
- Elimination of August and September navigation support would reduce long-term benefits about 20 percent and extended drought benefits by 37 percent. Eliminating October and November support would reduce long-term benefits by 13 percent and extended drought benefits by 10 percent. Reducing support only one month (November) would reduce the benefit 5 to 10 percent.
- The spring rise in service level of 10 to 30 kcfs would reduce navigation benefits from 1 to 2 percent for each 10-kcfs increase in service level.
- Higher winter nonnavigation service levels would decrease long-term average navigation benefits up to 6 percent, with an average reduction of

up to 30 percent in extended droughts. Higher fall nonnavigation service levels would decrease long-term benefits up to 4 percent and extended drought benefits up to 35 percent. Higher spring and summer nonnavigation service levels would have little or no effect because navigation service would be provided in most drought years.

Navigation—barge on the river

- Eliminating flood control constraints would reduce long-term navigation benefits up to 3 percent, because extra releases of stored water would not benefit navigation and less stored water would reduce subsequent navigation service.
- Modified intrasystem regulation would have no effect on navigation benefits because releases to the navigation reach would be minimally affected.
- Higher permanent pool levels would lead to reduced service, shortened seasons, and fewer navigation years in extended drought periods. Long-term benefits would be reduced up to 10 percent, while extended drought benefits would be reduced up to 40 percent.

Water Quality

Water quality in the Mainstem System is generally good with only minor suspected problems. In the upper lakes, summer oxygen levels in the deeper colder waters are a potential problem, especially in droughts when the volume of the deeper coldwater layer is reduced. Water temperature is a consideration in the river reaches, particularly in the lower river where the discharge of water used for cooling by many powerplants is controlled under discharge permits. Lower river flows provide less dilution for the warmwater discharges from the powerplants, and thus lead to higher river water temperatures. In extreme cases water temperature increases would be limited by cutbacks in power production to meet discharge permit requirements.

Changes in the current Water Control Plan would affect water quality in the following ways:

- The modified navigation service criteria would improve dissolved oxygen levels in summer in the upper mainstem lakes during droughts by providing higher water levels. Reduced navigation service in drought periods would lower river flows and increase water temperature considerations in the lower river.
- Shortening the navigation season by eliminating late summer or fall navigation support would improve water quality in the upper lakes, particularly in droughts. A shortened navigation season and its associated lower river flows, particularly during droughts, is a consideration in the lower river only in the summer when water temperature is highest.
- Higher spring navigation service levels would have little effect on water quality because they would not affect water levels or river flows appreciably in drought periods.
- Higher nonnavigation service levels would improve water quality in drought periods in the lower river, but aggravate dissolved oxygen problems in the upper lakes by further lowering lake levels in droughts.
- Reduced flood control constraints would have little effect on water quality because changes in lake levels and river flows would be confined primarily to nondrought periods.
- Modified intrasystem regulation would improve water quality in the upper lakes by increasing upper mainstem lake levels in at least one of three years in droughts, but would have minimal effect on the lower river.
- A higher permanent pool level would improve water quality in the upper lakes by increasing lake levels in droughts; however, lower river water temperature considerations would increase in droughts because of reduced navigation service.

Wetland and Riparian Habitat

The floodplain of the Mainstem System has approximately 113,000 acres of wetlands, 60,000 acres of exposed shoreline, and 913,000 acres of riparian vegetation. The deltas of the mainstem lakes support varying amounts of wetlands depending on lake level. Near the end of the 1991 drought, there were 59,000 acres of wetlands in the deltas of the mainstem lakes. After the floods in 1993 and a return to near normal lake levels, most of the wetlands in the upper three lakes were flooded and new wetlands began forming at higher elevations in the deltas. The floods also changed the character of the wetland and riparian vegetation in the lower river. Mature woody riparian habitat in the river reaches between the mainstem lakes is limited because cottonwoods have not regenerated under the controlled flow regimes. In the lower river, wetland and riparian habitats are limited by channelization and bank stabilization. Wetlands are concentrated in remaining oxbows (isolated bends in the river) and backwaters. The lower channelized portion of the river supports much lower densities of wetland and exposed shoreline habitat than the upper unchannelized portions near the mainstem lakes.

Under the current Water Control Plan, long-term wetland habitat would average approximately 155,000 acres per year, while in extended droughts the average would be approximately 144,000 acres. Riparian habitat would average 108,000 acres over the long term and 122,000 acres in extended droughts. Changes to the current Water Control Plan would have the following effects on wetland and riparian habitat:

- The modified navigation service criteria would increase long-term mean annual wetland habitat less than 1 percent and decrease riparian habitat about 2 percent.
- Shortening the navigation season by eliminating support in August and September would increase long-term and extended drought wetland habitat by about 2 percent and decrease riparian habitat about 3 percent. Shortening the season in October and November, or only in November, would increase wetland habitat less than 1 percent and decrease riparian habitat about 3 to 4 percent.
- A spring rise in service levels of 10 to 30 kcfs would increase average long-term wetland habitat up to 7 percent and extended drought habitat by up to 5 percent. Riparian habitat would be reduced up to 8 percent over the long term and up to 6 percent in extended droughts.
- Higher nonnavigation service levels would have a minimal effect on wetland and riparian habitat.
- Reduced flood control constraints would increase long-term average wetland habitat up to 1 percent and average extended drought habitat by up to 2 percent. Riparian habitat would decline by up to 2 percent over the long term and in extended droughts.

Island nesting habitat for terns and plovers

- Modified intrasystem regulation would reduce wetland habitat by up to 1 percent and reduce riparian habitat up to 3 percent.
- Higher permanent pools would increase long-term average wetland habitat up to 2 percent and average extended drought wetland habitat up to 6 percent. Riparian habitat would decline up to 3 percent over the long term and up to 6 percent in extended droughts.

Wildlife

The Missouri River supports important forest and wetland habitat for a wide variety of wildlife including at least 60 species of mammals, 301 species of birds, and 52 species of reptiles or amphibians. Of these, 6 birds and 2 bat species are listed as threatened and endangered under the Endangered Species Act. The combination of open water, wetlands, and riparian habitat is particularly important for the large number of waterfowl that stop along the river during the spring and fall. Of the threatened and endangered bird species, of particular importance are the endangered interior least tern and threatened piping plover because they depend on the river for nesting and are directly affected by water level changes. These birds typically nest in colonies on river sandbars, sandy shorelines of lakes, or in sandpits along the river. Important nesting reaches are below Fort Peck, Garrison, Fort Randall, and Gavins Point Dams.

River hydrology and channel characteristics influence the composition and distribution of wildlife habitat along the river. Seasonal river flow and water level patterns dictate the frequency and duration of habitat flooding. Bank erosion and sediment movement in the riverbed also play an important part in creating and destroying sandbar and island habitat and scouring sandbar vegetation.

Under the current Water Control Plan, the long-term average amount of tern and plover nesting habitat along the Missouri River is 432 acres, while the average in an extended drought would be about 390 acres. Changes to the current Water Control Plan would have the following effects on tern and plover habitat:

- Modified navigation service would reduce the long-term average habitat by approximately 11 percent and the extended drought average by 16 percent. The effects would be concentrated in the Garrison reach.
- Shortening the navigation season by eliminating navigation support in August and September would increase long-term habitat by about

4 percent, but would reduce extended drought habitat by 7 percent. Eliminating navigation support in October and November would reduce long-long term habitat about 5 percent, while not affecting the amount of habitat during an extended drought.

- A spring rise in service level of 10 to 30 kcfs would increase the long-term average habitat by up to 11 percent, and the extended drought average up to 30 percent.
- Higher nonnavigation service levels would have minimal effect on nesting habitat.
- Reductions in flood control constraints would reduce nesting habitat by 1 to 3 percent.
- Modified intrasystem regulation would improve the long-term average nesting habitat by 25 percent and the extended drought average by 44 percent. The improvement would occur in drought and nondrought years and would be concentrated in the reaches below Fort Peck and Garrison Dams.
- Higher permanent pool levels would reduce long-term average habitat up to 6 percent, but increase the extended drought average up to 30 percent.

Fish

Currently, 156 fish species are known to occur in the Missouri River and mainstem lakes. These include native species and many that have been introduced over the years. In the river reaches, the most important sportfish are walleye, sauger, white bass, yellow perch, channel catfish, paddlefish, shovelnose sturgeon, and northern pike. Rainbow and brown trout, chinook salmon, and smallmouth bass are locally abundant in cold tailwaters of the upper three dams. Past commercial fisheries targeted channel catfish, bigmouth buffalo, smallmouth buffalo, flathead catfish, goldeye, and suckers. The native river fishes, including the catfish, sturgeon, sauger, suckers, and paddlefish, have declined because of migration obstruction, loss of habitat, change in habitat, and competition from new species. The pallid sturgeon is listed as an endangered species. Other rare native fish such as the paddlefish, blue sucker, sturgeon chub, and sicklefin chub are being considered for listing under the Endangered Species Act.

The six mainstem lakes of the Missouri River contain a diverse community of coldwater, coolwater, and warmwater fishes. The upper three lakes have been stocked with coldwater game and forage species to take advantage of the coldwater retained through the summer and fall in the deeper waters of the lakes. Chinook salmon, rainbow and brown trout, and rainbow smelt have been stocked in the three lakes. Lake trout have been stocked in Fort Peck Lake along with lake cisco for forage, and both are reproducing naturally. Fish in the lower three lakes and the warmer waters of the upper three lakes include native and non-native species that have adapted to the lake habitat. These include walleye, sauger, smallmouth and largemouth bass, goldeye, carp, channel catfish, shovelnose sturgeon, river carpsucker, white and black crappie, gizzard shad, and many forage species such as emerald shiner. Coldwater fish are raised in hatcheries and stocked in the lakes. The only exception is lake trout in Fort Peck Lake, which in addition to stocking are supported by some natural reproduction in deeper waters along the face of the dam. Most of the warmwater and coolwater species spawn in lake shallows or in tributary streams. Because appropriate natural spawning and rearing habitat is limited, especially in low-water years, some warmwater and coolwater fish such as walleye are stocked.

The success of the fish in the Mainstem System depends on habitat conditions. Water levels, inflow, and outflow are important factors in the lakes. In the upper three lakes, low water levels in droughts limit coldwater fish habitat and shallow spawning and rearing habitat of warmwater and coolwater species. In the lower three lakes, high inflow and outflow reduce lake productivity and cause young fish to be flushed from the lakes. Native fish in the river reaches are naturally adapted to the high, warm, and muddy spring and early summer flows, and lower late summer and fall flows characteristic of the historic Missouri River. Cold, clear tailwaters of the upper three dams are more conducive to trout and salmon, but not the native paddlefish, sturgeon, and other fishes.

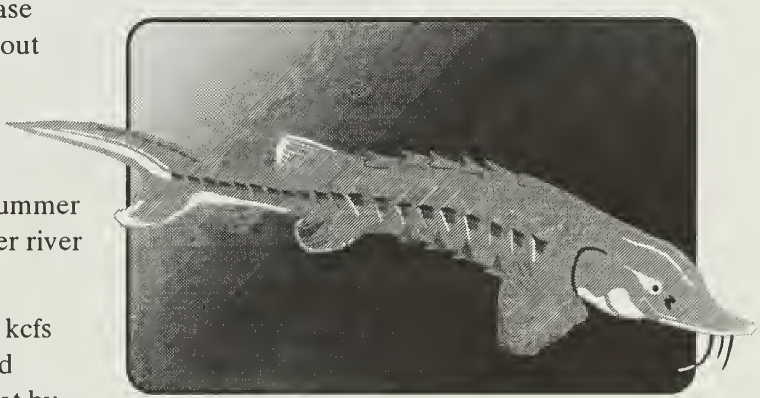
Coldwater lake habitat under the current Water Control Plan would average about 10 MAF over the long term and 5 MAF in extended droughts. Changes in the current Water Control Plan would have the following effects on coldwater lake habitat:

- Modified navigation service criteria, through higher drought lake levels, would increase long-term average coldwater habitat about 10 percent, and extended drought average habitat about 20 percent.
- Shortening the navigation seasons by eliminating navigation support in late summer would increase long-term coldwater lake habitat by 10 percent and extended drought habitat by 17 percent. Shortening the navigation season by eliminating support in October and November, or November, would have minimal effect on coldwater lake habitat.
- A spring rise in service level of 10 to 30 kcfs would reduce the average long-term and extended drought coldwater lake habitat by up to 8 percent.
- Higher winter nonnavigation service levels would decrease coldwater lake habitat by 3 percent over the long term and 2 percent in extended droughts. Higher spring/fall nonnavigation service levels would reduce coldwater lake habitat by 2 percent over the long term and 3 percent in extended droughts.

- Reductions in flood control constraints would reduce coldwater lake habitat by up to 3 percent on average over the long term and 5 percent in extended droughts.
- Modified intrasystem regulation would improve the long-term average coldwater lake habitat by 2 percent, but have a minimal effect in extended droughts.
- Higher permanent pool levels would increase long-term average habitat up to 15 percent, and increase the extended drought average up to 82 percent.

Coldwater river habitat below the upper two lakes under the current Water Control Plan would cover approximately 187 miles over the long term and 161 miles in extended droughts. Changes in the current Water Control Plan would have the following effects on coldwater river habitat:

- Modified navigation service criteria, through higher drought lake levels, would increase long-term average coldwater habitat about 4 percent and extended drought average habitat about 7 percent.



- Shortening the navigation seasons by eliminating navigation support in late summer or fall would have no effect on coldwater river habitat.
- A spring rise in service level of 10 to 30 kcfs would reduce the average long-term and extended drought coldwater river habitat by up to 3 percent.
- Higher winter nonnavigation service levels would decrease coldwater river habitat by 1 percent over the long term and 2 percent in extended droughts. Higher spring/fall nonnavigation service levels would reduce coldwater river habitat by less than 1 percent over the long term and 3 percent in extended droughts.
- Reductions in flood control constraints would reduce coldwater river habitat by up to 1 percent over the long term and in extended droughts.
- Modified intrasystem regulation would reduce the long-term average coldwater river habitat by 3 percent, and by 4 percent in extended droughts.
- Higher permanent pool levels would increase long-term average habitat up to 5 percent, and increase the extended drought average up to 15 percent.

Warmwater river habitat below Fort Peck, Garrison, and Fort Randall Dams under the current Water Control Plan would cover approximately 49 miles over the long term and 68 miles in extended droughts. Changes in the current Water Control Plan would have the following effects on warmwater river habitat:

- Modified navigation service criteria, through higher drought lake levels, would decrease long-term and extended drought average warmwater habitat about 4 percent.
- Shortening the navigation seasons by eliminating navigation support in late summer would reduce warmwater river habitat by 3 percent over the long term and 14 percent in extended droughts. Elimination of navigation support in fall would reduce warmwater river habitat about 1 percent or less.
- A spring rise in service level of 10 to 30 kcfs would increase the average long-term warmwater river habitat by up to 13 percent and extended drought habitat by up to 8 percent.
- Higher winter nonnavigation service levels would increase warmwater river habitat by 3 percent over the long term and 4 percent in extended droughts. Higher spring/fall nonnavigation service levels would increase warmwater river habitat by 2 to 3 percent over the long term and in extended droughts.
- Reductions in flood control constraints would reduce warmwater river habitat by up to 1 percent over the long term and up to 3 percent in extended droughts.
- Modified intrasystem regulation would increase the long-term average warmwater river habitat by 3 percent, and by 4 percent in extended droughts.
- Higher permanent pool levels would decrease long-term average warmwater habitat up to 12 percent, and decrease the extended drought average up to 28 percent.

The index of young fish production in the mainstem lakes under the current Water Control Plan would average about 1.96 units over the long term and 1.66 units in extended droughts. Young fish production is expressed as an index derived from survey catch statistics. Changes in the current Water Control Plan would have the following effects on young fish production:

- Modified navigation service criteria, through higher drought lake levels, would increase long-term average young fish production about 1 percent and reduce extended drought average production about 4 percent.
- Shortening the navigation seasons by eliminating navigation support in late summer would increase long-term young fish production by 1 percent and increase production in extended drought habitat by 9 percent.

Shortening the season by eliminating support in the fall would have minimal effect on young fish production.

- A spring rise in service level of 10 to 30 kcfs would reduce the average long-term and extended drought young fish production by up to 1 percent.
- Higher winter nonnavigation service levels would not change young fish production over the long term, but would increase it by 5 percent in extended droughts. Higher spring/fall and summer nonnavigation service levels would not affect young fish production.
- Reductions in flood control constraints would reduce young fish production by up to 3 percent over the long term and 2 percent in extended droughts.
- Modified intrasystem regulation would improve the long-term average young fish production by 2 percent, and 6 percent in extended droughts.
- Higher permanent pool levels would increase long-term average young fish production up to 10 percent and increase the extended drought average up to 38 percent.

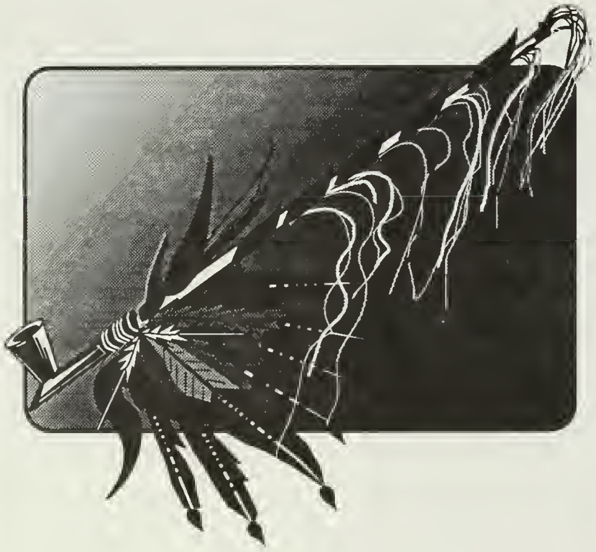
Physical habitat for native river fish below Fort Peck, Garrison, Fort Randall, and Gavins Point Dams under the current Water Control Plan would average 59.0 index units over the long term and 60.6 units in extended droughts. Changes in the current Water Control Plan would have the following effects on physical river habitat:

- Modified navigation service criteria would increase long-term and extended drought average physical habitat about 1 to 2 percent.
- Shortening navigation seasons by eliminating navigation support in late summer would increase physical river habitat by 2 to 3 percent over the long term and in extended droughts. Elimination of navigation support in fall would increase physical river habitat about 1 to 2 percent.
- A spring rise in service level of 10 to 30 kcfs would increase the average long-term and extended drought physical river habitat by up to 2 to 3 percent.
- Higher winter nonnavigation service levels would increase physical river habitat by less than 1 percent over the long term and in extended droughts. Higher spring/fall nonnavigation service levels would increase physical river habitat by 1 percent over the long term and 3 percent in extended droughts.
- Reductions in flood control constraints would increase physical river habitat by up to 1 to 2 percent over the long term and in extended droughts.
- Modified intrasystem regulation would increase average physical river habitat by less than 1 percent.

- Higher permanent pool levels would decrease long-term average physical habitat up to 1 percent, and decrease the extended drought average up to 3 percent.

Historic Properties

Historic properties include historic and prehistoric archaeological sites, historic architectural and engineering features and structures, and resources of traditional cultural or heritage significance to Native Americans and other social or cultural groups. Paleontological resources include fossils of prehistoric plants and animals. Significant paleontological resources are found in the Fort Peck region. A variety of archeological sites, including historic forts and homesteads, are found within the lakes, along their shorelines, along the river reaches, and adjacent uplands. Archaeological surveys have discovered nearly 3,000 sites along the Mainstem System. Shoreline and bluff erosion is a constant threat to many of these sites. Some sites within the lakes are threatened by exposure during low water periods.



Changes to the current Water Control Plan would have the following effects on historic properties:

- Modified navigation service criteria would increase effects on historic properties by 7 percent.
- Shortening the navigation season would increase effects on historic properties by less than 1 one percent.
- Higher spring service levels would decrease effects by about 2 percent for each 10 kcfs rise in service level.
- Higher winter nonnavigation service levels would decrease effects by 2 percent.
- Reduced flood control constraints would not change effects on historic properties.
- The modified intrasystem regulation would reduce effects by less than 1 percent.
- Higher permanent pool levels would increase effects up to 14 percent.

Socioeconomic Resources

Seven States—Montana, North Dakota, South Dakota, Nebraska, Iowa, Kansas, and Missouri—border on the Missouri River Mainstem System and benefit directly from the presence of the river and lakes. Benefits are derived from employment and income generated from recreation, hydropower production, transportation of goods, and water supply for powerplants, domestic use, and crop irrigation. Population and economic growth in these States have remained stable. Counties adjacent to the river and lakes account for 32 percent of the population and 27 percent of the economic growth in the States along the Mainstem System portion of the Missouri River. There are 13 Indian reservations along the Mainstem System:

- Fort Peck Indian Reservation (Montana)
- Fort Bertold Indian Reservation (North Dakota)
- Standing Rock Indian Reservation (North and South Dakota)
- Cheyenne River Indian Reservation (South Dakota)
- Lower Brule Indian Reservation (South Dakota)
- Crow Creek Indian Reservation (South Dakota)
- Yankton Indian Reservation (South Dakota)
- Santee Indian Reservation (Nebraska)
- Winnebago Indian Reservation (Nebraska)
- Omaha Indian Reservation (Nebraska)
- Iowa Indian Reservation (Nebraska and Kansas)
- Sac Indian Reservation (Nebraska and Kansas)
- Fox Indian Reservation (Nebraska and Kansas)

Changes to the current Water Control Plan would have the following socioeconomic effects:

- The combination of modified navigation service criteria and modified intrasystem regulation would increase long-term average employment in the counties adjacent and near the Mainstem System approximately 1 to 2 percent, while increasing long-term average total income about 1 percent. The improvement would be higher at 2 to 3 percent for employment and income in the upper portion of the system from Fort Peck Lake downstream to Lake Oahe. Benefits would decline to about 1 percent between Lake Oahe to Lewis and Clark Lake. From Lewis and Clark Lake downstream to Kansas City benefit improvements would be between 0.5 to 1.0 percent. Downstream of Kansas City to St. Louis there would be little or no change in benefits from the modified navigation service criteria and intrasystem regulation.

- The combination of a spring rise in service level by 20 kcfs and elimination of navigation support in the fall would reduce employment opportunities and total income in the counties adjacent and near the Mainstem System about 1 percent. The loss would be less than 1 percent in each of the various reaches of the upper portion of the system between Fort Peck Lake and Gavins Point Dam. Below Gavins Point Dam the loss would be about 1 percent to Kansas City. From Kansas City to St. Louis the loss in employment and total income would approach 2 percent.

- An increase in the permanent pool level from 18 MAF to 48 MAF would increase long-term average employment and total income in the region about 1 percent. The increase would be 2 to 3 percent in the area of the upper three lakes, 1 to 2 percent in the area of the lower three lakes, 0.5 to 1.0 percent from Gavins Point Dam to Kansas City, and near zero below Kansas City to St. Louis. An increase to the intermediate level of 31 MAF would derive benefits about one-third to one-half the benefits of the 48 MAF level.
- Effects on employment and income from reductions in flood control constraints and increases in the nonnavigation service levels in winter, spring/fall, and summer are unknown but believed to be minimal (less than 1 percent change) based on the relative difference caused by the other factors and relative effects on water levels in the lakes and flows in the river.

SELECTION OF THE PREFERRED ALTERNATIVE

The selection of the preferred alternative involved varying the water control plan criteria and comparing the effects to the environmental resources and economic uses. Wetland habitat, tern and plover habitat, and physical habitat for native river fish were considered primary environmental resources for the selection process. This decision was based on information regarding the biological significance of the various environmental resource categories provided by the U.S. Fish and Wildlife Service during formal consultation under Section 7 of the Endangered Species Act.

Navigation Service Criteria

The navigation service criteria prescribe the navigation service level and the season length in drought periods. Two criteria were compared—the current criteria and a more conservative modified criteria. The modified navigation service criteria results in reduced releases from mainstem lakes at higher total storage levels which in turn reduces navigation service earlier in droughts. Figures 4 and 5 show the effects of changing the navigation service

Figure 4

Changes in economic use and environmental resource values resulting from a change from the current to the modified navigation service criteria. Based on simulations for the period 1898 to 1993.

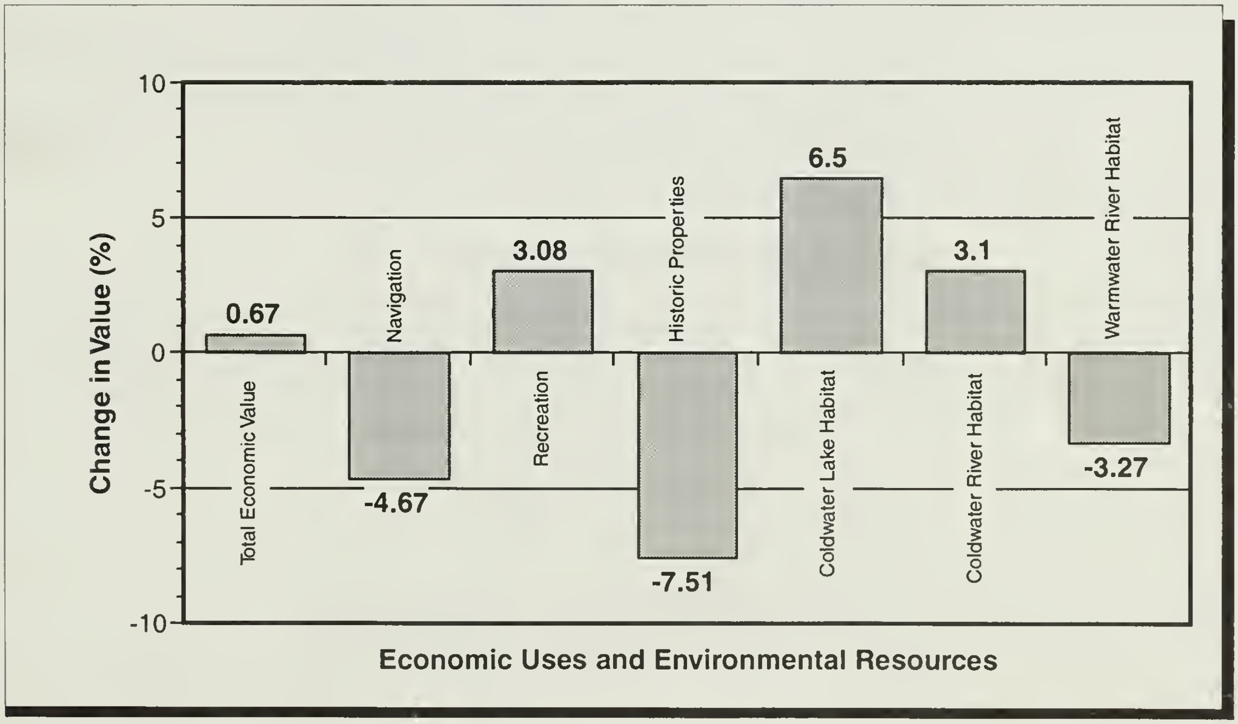
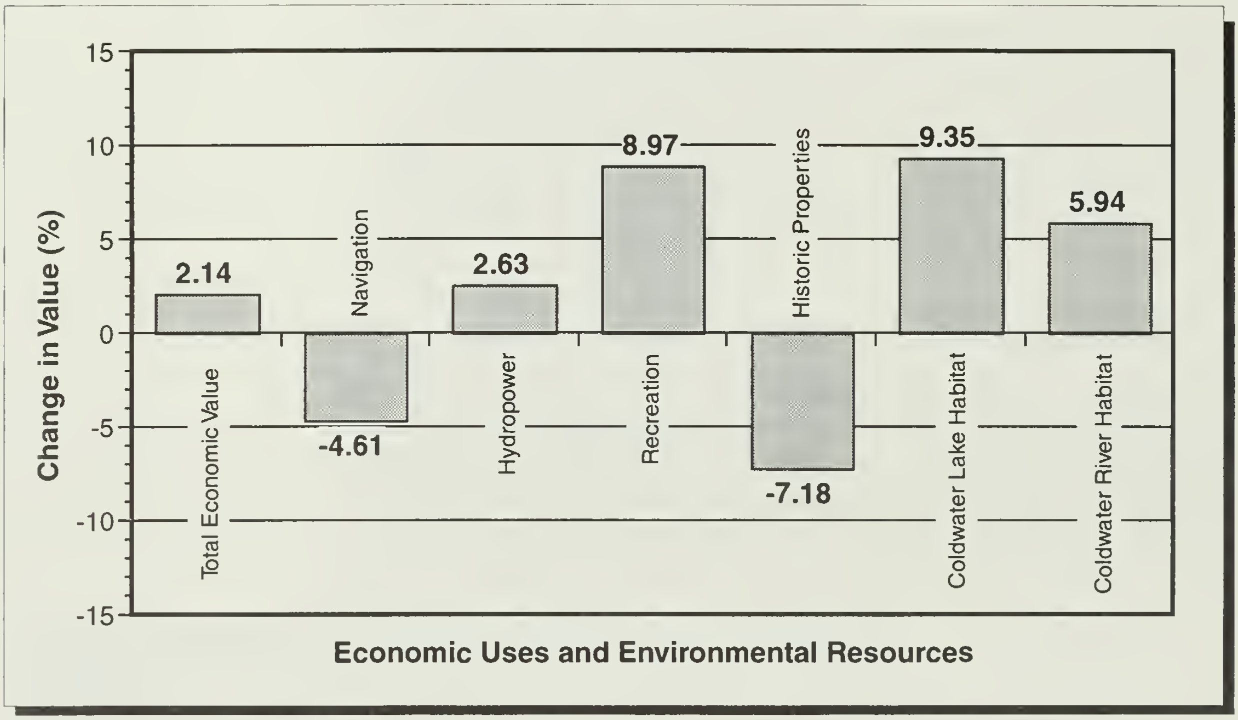


Figure 5

Changes in economic use and environmental resource values resulting from a change from the current to the modified navigation service criteria. Based on simulations for the period 1930 to 1950.



criteria over the 96-year period of record and the 21-year drought period, respectively. The modified navigation service criteria were selected because total National Economic Development (NED) value would increase, as shown on Figure 4, particularly during drought periods, as shown on Figure 5, without affecting primary environmental resources.

Normal Navigation Season

Currently, the normal navigation season is 8 months long— from April 1 to December 1 at the mouth of the Missouri River near St. Louis. When there is excess water in storage at the end of the season, a 10-day extension is provided. Four normal season lengths were considered as shown below.

8-Month Season — April 1 through December 1

7-Month Season — April 1 through November 1

6-Month Season — April 1 through October 1

6-Month Season — April 1 through August 1 and October 1 through December 1

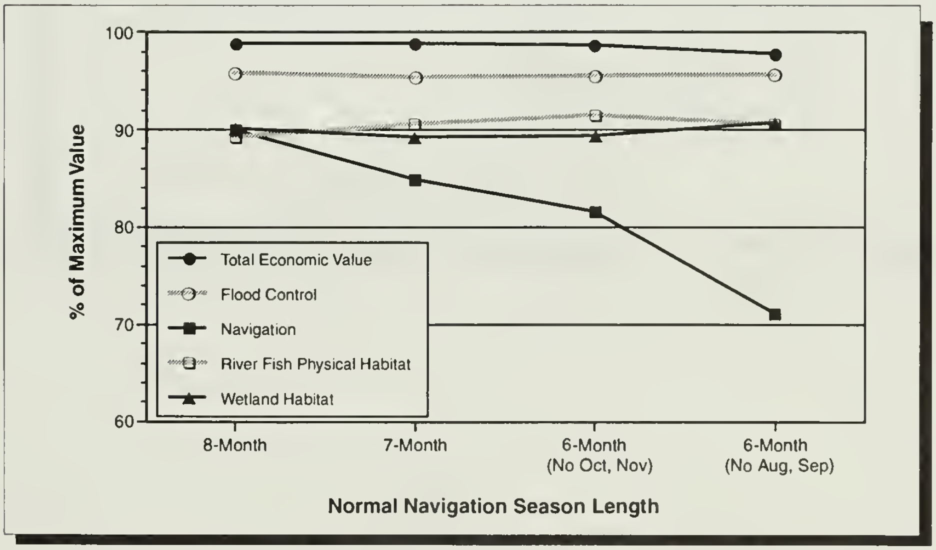
Figure 6 shows the effects of these alternative normal season lengths. The U.S. Fish and Wildlife Service recommended adopting the 6-month, split navigation season with no navigation support in August and September. A 7-month navigation season was selected as best representing a balance between navigation, flood control, physical habitat for native river fish, and wetland habitat.

Spring Rise in River Flow

Fishery resource experts have stated that the decline in some of the native river fish species has been influenced by the controlled flows being very different from the "natural" annual flow pattern of high flows in the spring and early summer and lower flows the remainder of the year. The U.S. Fish and Wildlife Service advised that "some semblance of a natural hydrograph is key to the restoration of the river ecosystem." An effort was made to develop alternatives that resulted in a more "natural" flow pattern. This flow pattern would be accomplished by increasing the releases above that needed to meet normal navigation targets during the first 3 months (April to June) of full-service navigation seasons. When releases from the reservoirs are reduced during droughts, corresponding reductions would be made to the size of the spring rise with no spring rise provided when navigation service is

Figure 6

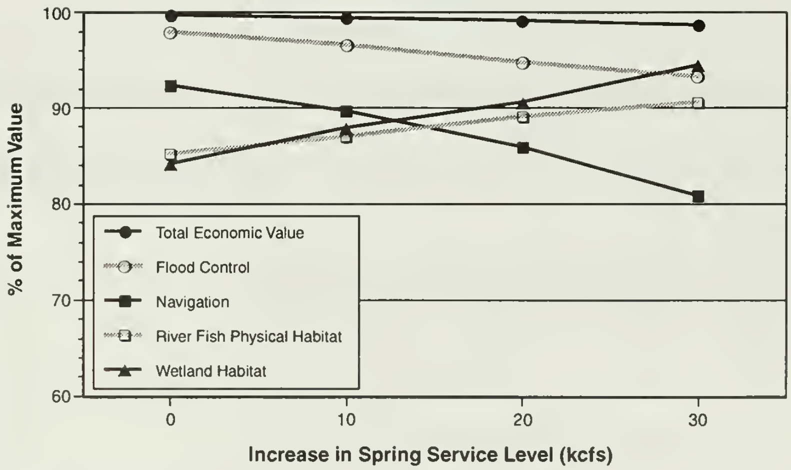
Average annual percent of maximum economic use and environmental resource value for four navigation season options. Based on simulations for the period 1898 to 1993.



at the minimum level. July service level would be based on the modified July 1 service level criteria; the remaining navigation season would be at the minimum navigation service level. Three spring rise options were considered: adding 10, 20, and 30 kcfs to the normal full-service levels. Figure 7 shows the effects, as a percent of maximum attainable, of changing the amount of the spring rise. Increasing the spring rise would cause an increase in physical habitat for native river fish and wetland habitat, and a loss in flood control, navigation, and total NED value. A balance in percent of maximum attainable value between the two primary environmental resources and navigation would occur with a spring rise of slightly more than 10 kcfs, and a balance between the two primary environmental resources and flood control would occur at about 30 kcfs. Therefore, a spring rise of 20 kcfs (about halfway between) was selected.

Figure 7

Average annual percent of maximum economic use and environmental resource value for increases in spring service level. Based on simulations for the period 1898 to 1993.



Nonnavigation Service Level

Flows downstream from Gavins Point Dam during periods of nonnavigation are established by the nonnavigation service levels. Target flow levels at Sioux City, Omaha, and Kansas City for three seasons—winter, spring/fall, and summer—were evaluated. Minimum winter nonnavigation service levels of 9, 12, 15, and 18 kcfs were evaluated. The winter season extends from December through February. A minimum winter service level of 12 kcfs was selected because total NED value would decline by decreasing to 9 kcfs and not improve by increasing the service level to 15 or 18 kcfs. The spring season includes March and April. Fall includes September, October, and November. Nonnavigation service levels of 9, 12, 15, 18, and 25 kcfs were considered for the spring/fall seasons. Actual operating experience and previous economic studies found that flows lower than 9 kcfs significantly increases water supply costs. The 9-kcfs level was selected for the minimum spring/fall nonnavigation service level because it provides the best overall balance among economic and environmental resource values. Summer season includes May, June, July, and August. Service levels of 9, 12, 15, 18, and 25 kcfs were considered. A summer nonnavigation service level of 9 kcfs was selected because total economic value did not significantly improve with increased service level while wetland and tern and plover habitat declined.

Flood Control Constraints

Under the current Water Control Plan, when river flows are predicted to exceed established flows at Omaha, Nebraska City, or Kansas City by specified amounts, releases from Gavins Point Dam are reduced. The current plan calls for two levels of reductions which are termed the "full service" and "minimum service" constraints. Three options were considered:

- No flood control constraints
- Minimum service constraint only
- Retain both the full and minimum service flood control constraints

None of the resources would increase significantly as a result of reducing the number of flood control constraints; therefore, it was decided to retain both constraints.

Intrasystem Regulation

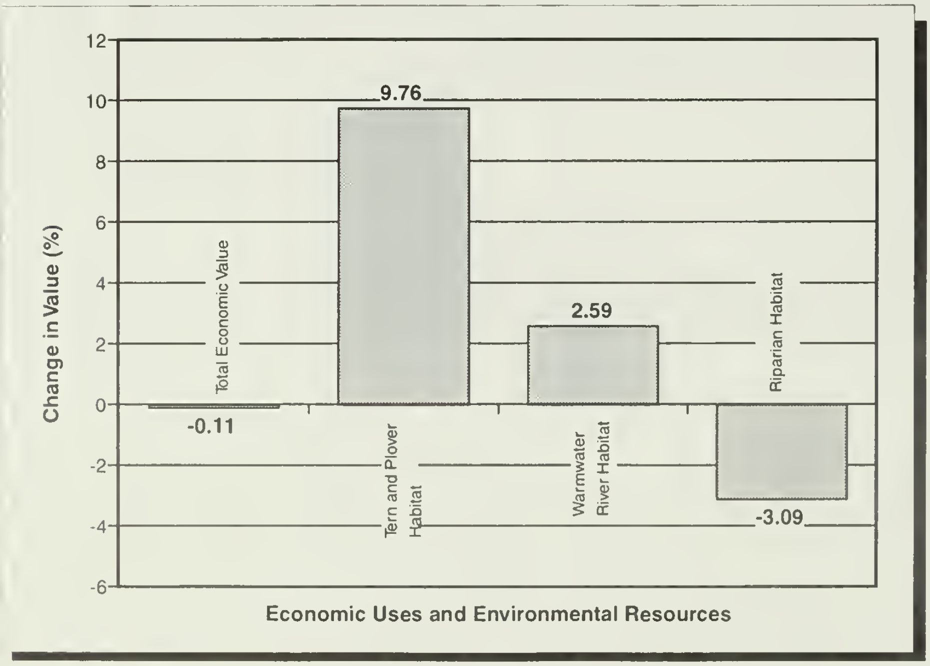
Intrasystem regulation refers to the movement of stored water among the upper three lakes (Fort Peck Lake, Lake Sakakawea, and Lake Oahe). Two options for intrasystem regulation were evaluated: (1) the current method of maintaining a relative balance in the amount of stored water in these reservoirs, and (2) a modified method with a 3-year cycle of purposely causing rising pools in each of these three reservoirs. This would provide a rising pool during fish spawning season at each reservoir at least 1 out of every 3 years. Figure 8 shows the significant effects of changing to the modified intrasystem regulation. Modified intrasystem regulation was selected because of the increase in the tern and plover and warmwater river fish habitat.

Permanent Pool

The current Water Control Plan reserves 18 MAF in the combined permanent pools of the six mainstem lakes as the lowest level to which water will be withdrawn. Permanent pools of 18, 26, 31, 38, and 44 MAF were considered. An 18-MAF permanent pool was selected based on slight economic loss and a decline of physical habitat for native river fish at higher permanent pools.

Figure 8

Changes in total economic use and resource values resulting from a change from the current to the modified intrasystem regulation. Based on simulations for the period 1898 to 1993.



Summary of Preferred Alternative

Table 2 lists the nine water control plan criteria being reviewed for the current Water Control Plan and the preferred alternative. Of the nine variables, five remained unchanged after review:

- winter nonnavigation service level
- spring/fall nonnavigation service level
- summer nonnavigation service level
- flood control constraints
- permanent pool level

Four variables were changed:

- navigation service criteria
- intrasystem regulation
- normal navigation season length
- spring service level

Table 2

Comparison of criteria for the current Water Control Plan and preferred alternative.

Water Control Plan Criteria	Current Water Control Plan	Preferred Alternative
Navigation Service Criteria	Current	Modified
Intrasystem Regulation	Current	Modified
Nonnavigation Service Level		
Winter	12 kcfs	12 kcfs
Spring/Fall	9 kcfs	9 kcfs
Summer	9 kcfs	9 kcfs
Flood Control Constraints	2 Constraints	2 Constraints
Normal Navigation Season	8 Months	7 Months
Spring Rise in Service Level	Navigation Target	Navigation Target + 20 kcfs
Permanent Pool	18 MAF	18 MAF

EFFECTS OF THE PREFERRED ALTERNATIVE

The impacts of the current Water Control Plan and the preferred alternative on environmental resources and economic uses were compared to portray the consequences of adopting the preferred alternative. Average annual values for the 96-year simulation period for both water control plans are shown in Table 3. The impacts identified in this table are discussed in the remainder of this section.

Total Water in Storage and River Flow

The total amount of water in Mainstem System storage is affected by two components of the preferred alternative. In non-drought periods, the total amount of water in storage would be drawn down earlier by the higher spring flow requirements from mid-March through mid-June. Reduced releases of water in storage over the remainder of the navigation season would recover some of the water in storage. In drought periods, releases of stored water are curtailed earlier, which reduces the drawdown of the mainstem lakes in these water-short periods. Both the navigation service level and season length are reduced earlier in the drought periods. If the drought is severe enough, releases and the associated declines in stored water are similar for both water control plans because both are providing a minimum navigation service level with a 6-month season length. Figure 9 shows a comparison of water in mainstem storage for both water control plans during the recent drought.

The amount of stored water in each of the upper three reservoirs does not follow the general overall pattern of the total amount of stored water. Modified intrasystem regulation under the preferred alternative causes a 3-year cycle of declining and rising pools at these three reservoirs. For example, Fort Peck Lake can decline in a high inflow year because it is supplying the water needed for a rising pool at either of the two downstream reservoirs, which have releases that are meeting potential high flow needs in the lower river.

Intrasystem reservoir releases and river flows are impacted primarily by two components of the preferred alternative. First, modified intrasystem regulation causes a 3-year pattern in lower and higher releases from the upper three lakes. For example, in the year of a rising pool at Fort Peck Lake, releases are lower than the subsequent 2 years when higher releases are required to ensure rising pools at either Lake Sakakawea or Lake Oahe. Second, spring releases are higher in non-drought years to achieve the spring rise in the lower river. Correspondingly, summer and fall flows would be lower. Overall, the net differences over the 96-year period are not very great.

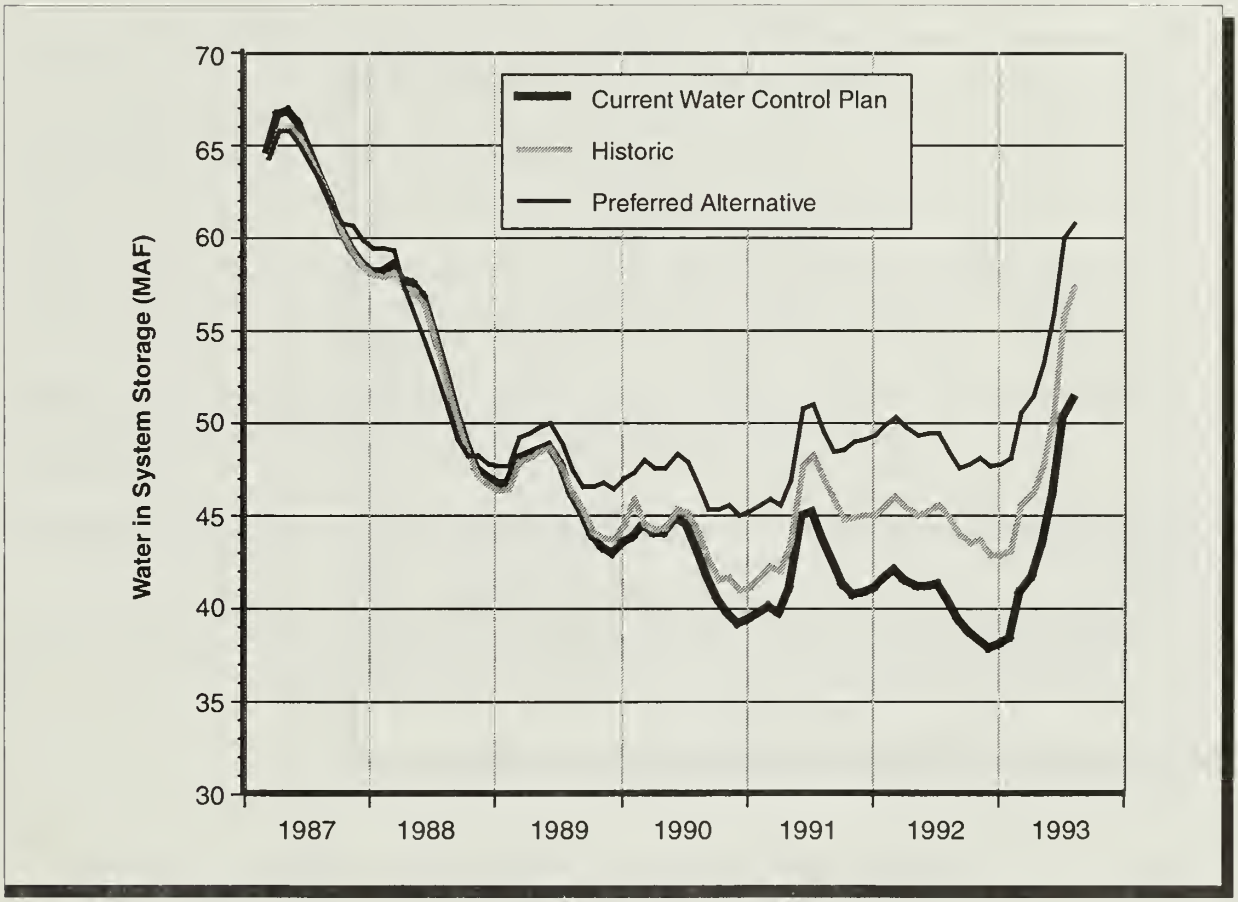
Table 3

Comparison of the Preferred Alternative to the current Water Control Plan and Maximum Values.
Based on data for the period 1898 to 1993.

	Flood Control	Navi-gation	Hydro-power	Water Supply	Recre-ation	Total NED	Physical Habitat	Tern/ Plover	Wetland Habitat	Warm River	Cold River	Young-of-Year	Cold Lake	Riparian Habitat	Historic Properties
	($ millions)						(Index)	(acres)	(1,000's acres)	(miles)	(miles)	(index)	(MAF)	(1,000's acres)	(Index)
Maximum Attainable Values	44.7	17.7	643.8	549.2	81.3	1,321	70.8	1,450	186	62.3	201	2.23	13.2	108	4,743
Current Water Control Plan	44.4	17.7	619.8	546.2	75.7	1,304	59.0	432	155	49.4	187	1.96	9.9	108	4,689
Preferred Alternative	42.6	15.0	620.6	546.7	77.7	1,303	64.1	587	166	58.8	187	2.03	10.6	96	4,484
Preferred Alternative % of Maximum Attainable	95%	85%	96%	100%	96%	99%	90%	41%	89%	94%	93%	91%	80%	89%	95%
Preferred Alternative % of Current Water Control Plan	96%	85%	100%	100%	103%	100%	108%	136%	107%	119%	100%	104%	107%	89%	96%

Figure 9

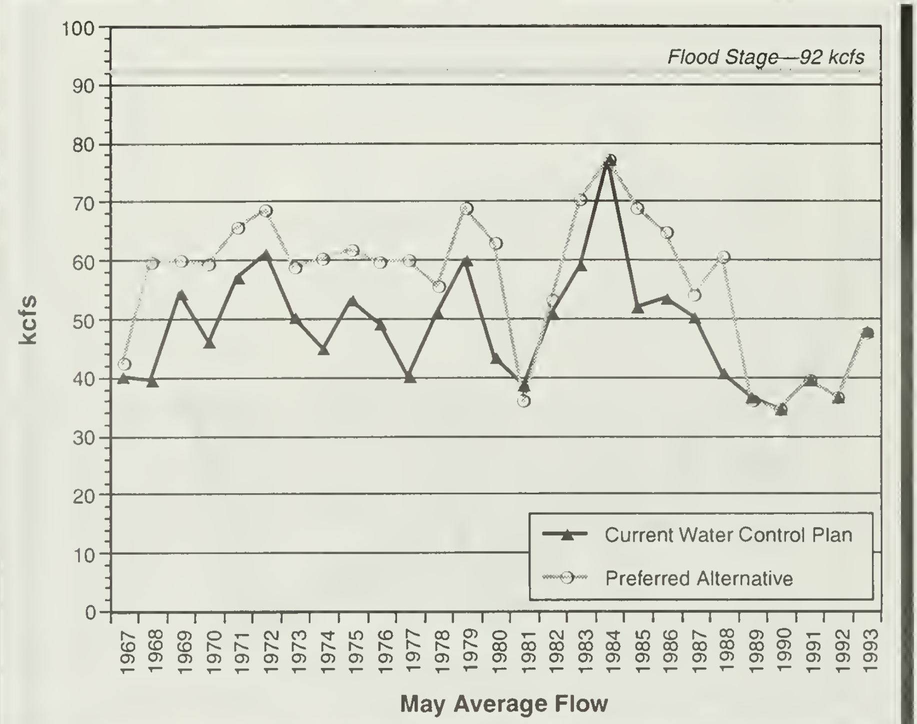
Monthly average Mainstem System water in storage for current Water Control Plan and preferred alternative for the period March 1987 through August 1993.



Lower river flows are affected primarily by the spring rise and subsequent reduction in navigation service and season length in most years. Spring flows in over half of the 96 years are increased to mimic a more natural flow pattern. The effects of the spring rise are shown in Figure 10 for Nebraska City. Mainstem System releases continue to be constrained in some months by flood control criteria when downstream flooding is a problem; however, flooding is not a problem in many of the months with the spring rise. The impacts of the spring rise become less noticeable farther downstream from Gavins Point Dam because of the increasing influence of tributary inflows into the lower Missouri River. The modified navigation service criteria impacts lower river flows by reducing the Mainstem System releases in even minor droughts. This saves water should a drought persists, and this effect is most noticeable in 1937 when the preferred alternative has a navigation year and there is no navigation under the current Water Control Plan.

Figure 10

Simulated monthly average May Missouri River flow at Nebraska City (1967 to 1993).



Changes in Missouri River flows affect Mississippi River flows. Mississippi River navigation is impacted if flow at St. Louis falls below 90 kcfs. At 44 kcfs or less, the Mississippi River is closed to commercial navigation. The preferred alternative generally provides lower flows in November than the current Water Control Plan, and this effect is shown for the Mississippi River in Figure 11.

Sedimentation, Erosion, and Ice Processes

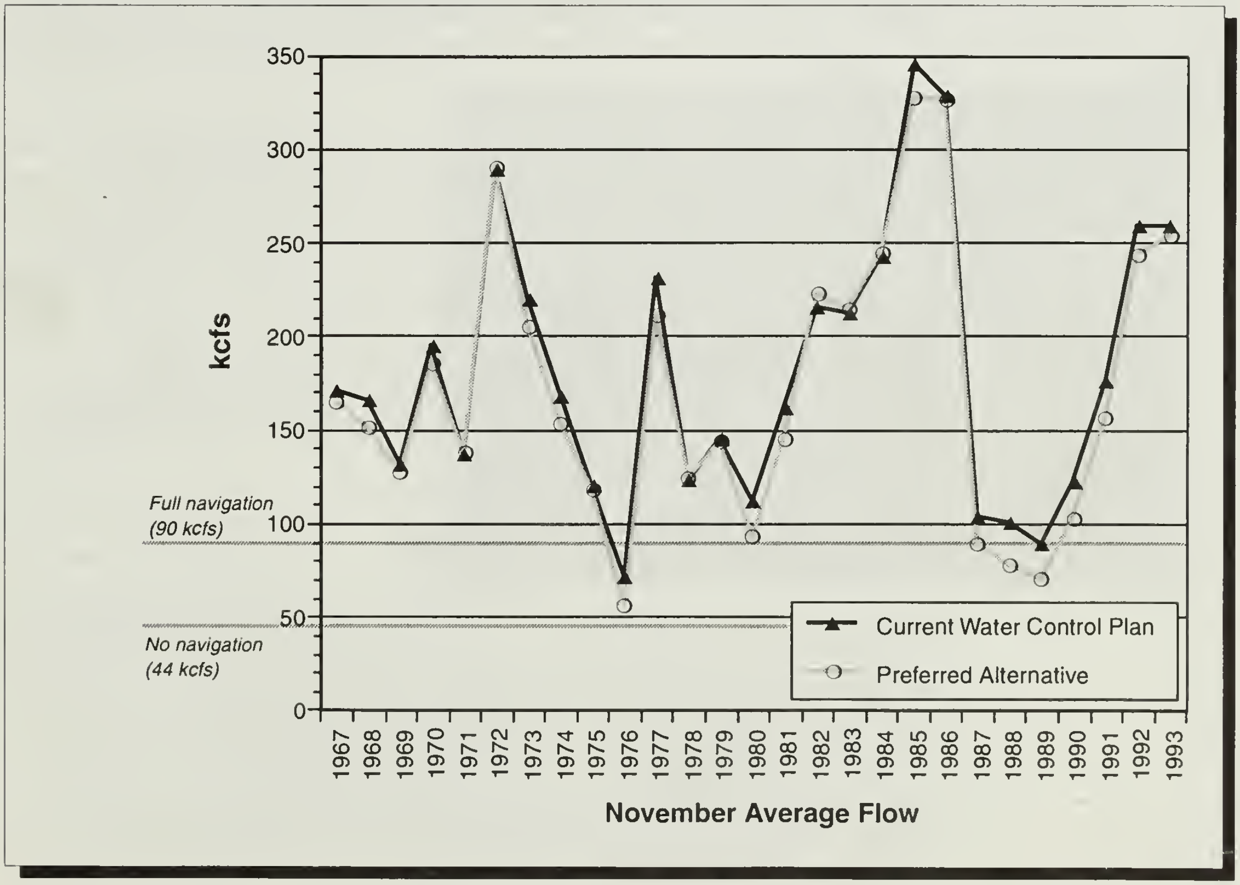
Significant changes in lake levels and river flow would occur in specific months as a result of a change to the preferred alternative, and these changes could have short-term impacts on sedimentation, erosion, and ice processes. Because these changes are generally short term (i.e., a high May flow replaces a comparable high September flow in a given year), changes in these processes are expected to be limited. Changes in precipitation patterns are more likely to impact these processes.

Reservoir storage losses due to sedimentation would continue at historic rates irrespective of how the Mainstem System is operated because this process is primarily a function of upstream watershed conditions and the rainfall/runoff process and not system operations. The preferred alternative would result in the upper three lakes averaging about 10 feet higher 30 percent of the time during the 96-year period. Sedimentation would, therefore, occur at somewhat higher elevations and further upstream in the lakes than under the current Water Control Plan. This would increase both surface and groundwater levels in the open river reaches immediately upstream from the lakes and exasperate existing problems in these areas. Within the lakes, the more consistent water surface levels over the entire period would minimize the redistribution of previously eroded sediments residing immediately below the waterline and provide some stability to the underwater slopes for the preferred alternative.

Sedimentation and erosion in the river reaches are also potentially affected by a change to the preferred alternative. Downstream from Fort Peck Dam, small changes in the flows would have a minor impact on the overall channel

Figure 11

Simulated monthly average November Mississippi River flow at St. Louis (1967 to 1993).



erosion or sediment deposition processes. Changes in flows are somewhat greater downstream from Garrison Dam, and increases of this magnitude could increase the bankline and bed erosion processes in this reach. Sediment movement changes in the reaches downstream from Fort Randall and Gavins Point Dams are expected to increase over present rates; however, the increases would not be substantial because of the minor differences in flows between the two plans. From Sioux City downstream, no change in bank erosion is expected in this well-controlled river reach. The slight increase in stage and velocity may slightly increase the bed degradation process in the Sioux City area and in the reach downstream.

Ice formation and movement processes are expected to be nearly identical under both plans because there is no basic difference in the operation of the Mainstem System during the winter months.

Water Quality

Differences in the amount of water in storage and river flow affect water quality of the Mainstem System. Increased amounts of water in storage reduce the potential for water quality problems via the resuspension of exposed sediments. Because there is some potential for one of the three upstream lakes to undergo an extreme drawdown in a year with the modified intrasystem regulation and a significant reduction in inflow, water quality in one of these lakes is more likely to be adversely impacted by even a single-year drought.

Water quality impacts were not a problem during the recent drought in any of the river reaches, and the lowest flows provided by both alternatives in most reaches are similar to those experienced in this drought. There are no data to verify whether there could be water quality problems in the summer months in the reach downstream from Sioux City; however, simulations indicate that the water quality standards for the lower river are met even at flows as low as 9 kcfs. Because the preferred alternative never has a nonnavigation year in the 96-year period and the resulting low nonnavigation service flows in the summer, the potential for water quality problems in this lower river reach is reduced for this plan.

Wetland and Riparian Habitat

The preferred alternative improves the average annual acreage of wetland habitat over the 96-year period by 7 percent over the 155,000 acres of the current Water Control Plan while reducing the riparian habitat by 11 percent from 108,000 acres. Gains in wetland habitat and loss of riparian habitat are greatest for the intrasystem river reaches (+12 and -14 percent, respectively) and lowest for the lake deltas (+2 and -6 percent, respectively). Increased wetland habitat acreage would occur in almost every year of the 96-year period. Wetland habitat acreage would decline and riparian habitat acreage would increase during the three major drought periods under both water control plans; however, the return to pre-drought values would be delayed for the preferred alternative.

The ratio of wetland to riparian habitat increased under the preferred alternative. It was 1.4 to 1 for the current Water Control Plan and increased to 1.7 to 1 under the preferred alternative. An increase in the ratio is a move toward a more natural mix, which is characterized by a ratio of 2.4 to 1 for a run-of-river alternative.

Cottonwood stands are expected to continue to diminish under both plans; however, the decline may be greater under the preferred alternative because of the anticipated increased bankline erosion of the river reaches. Also, the early growth of cottonwoods that colonizes exposed sediment during lower flow years is removed when high flows occur, and overall increase of the high flows are expected to increase this removal for all river reaches upstream from Sioux City.

Wildlife Resources

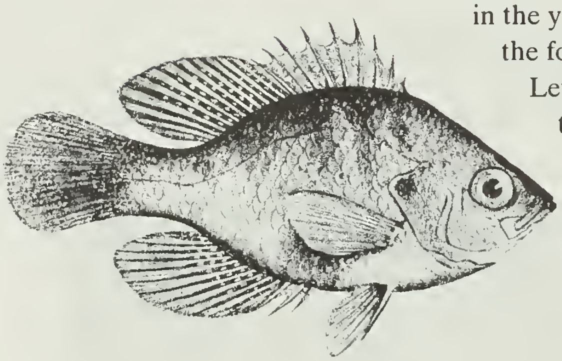
Diverse species of wildlife depend on Missouri River floodplain habitats. The endangered interior least tern and threatened piping plover nest on exposed sandbars and are consequently directly affected by river flows. Periodic high flows are required to remove encroaching vegetation, but stable or declining flows are needed during the nesting season to avoid nest flooding. Other wildlife occurring in the floodplain rely more on the productive mix of wetland and riparian habitat maintained by river hydrology.

Piping plover—threatened species

Operation under the preferred alternative increases the amount of available tern and plover island nesting habitat from 432 acres to 587 acres, an increase of 36 percent. This increase occurs for all four river reaches currently used by terns and plovers for nesting with the greatest percentage increase in habitat occurring downstream from Gavins Point Dam (+285 percent) and the greatest absolute change occurring downstream from Garrison Dam (+61 acres). Year-to-year data show a distinct pattern of improved habitat every third year for the preferred alternative. This distinctive pattern can be traced back to the improved habitat in the reach downstream from Garrison Dam. Reduced releases combined with the vegetation scouring effects of the high flows 2 years earlier result in a dramatic increase in habitat in this reach every 3 years. The spring rise of the preferred alternative improves tern and plover habitat downstream from Fort Randall and Gavins Point Dams via the island vegetation scouring effect of the higher spring flows followed by the lower summer flows. Improved habitat occurs in 68 years downstream from Fort Randall Dam and in 93 of the 96 years downstream from Gavins Point Dam.

Young Fish Production in Mainstem Lakes

Young fish production was estimated for each of the six Mainstem System lakes. Modeling was based on relationships between various hydrologic variables and measured production of several species felt to be indicative of the variety of fish predominant in each lake. Comparison of the average annual values of the combined young fish production indices for both plans shows that the preferred alternative provides a 4 percent increase in the young fish production index. Production increases at the four larger lakes and decreases at Lake Sharpe and Lewis and Clark Lake. The year-to-year variation in the total annual values shows a distinctive increase every third year. This corresponds to the increased value at Lake Oahe, which has a dominant increase in these years corresponding to a rising pool in the modified intrasystem regulation component of the preferred alternative. Lake Sakakawea also has a noticeable but much smaller increase in 25 of the 32 years it has a rising pool; however, Fort Peck Lake does not exhibit this characteristic. Production would be lower in Lake Sharpe because of an increase in the flushing rate through the lake in response to the spring rise. Increased values for this lake occur in years with reduced releases in response to downstream flooding. Values for Lake Francis Case increase in years with higher releases. Finally, changes at Lewis and Clark Lake are very small.



Coldwater Fish Habitat in Mainstem Lakes

The annual minimum amount of coldwater habitat with a specified combination of dissolved oxygen and temperature was estimated for the four larger lakes for both plans. The total average annual value for the preferred alternative is 7 percent higher than that of the current Water Control Plan. The increase is due to higher average annual amounts of water in storage resulting from higher pool levels in the major drought periods. Results indicate that only the upper three lakes have coldwater habitat on a consistent basis, and Fort Peck Lake and Lake Sakakawea have the largest and similar increases in the average annual habitat volume for the preferred alternative. Lake Oahe has a relatively small average annual increase. The most notable difference in the annual values for a change to the preferred alternative occurs in the three major drought periods in response to the modified navigation service criteria. Higher pool levels early in the 1930s and early 1940s drought and in the subsequent droughts beginning in the mid-1950s and late 1980s result in higher minimum levels of coldwater reservoir fish habitat in all three lakes. Modified intrasystem regulation does not predominantly impact the amount of coldwater stored in the individual lakes on a year-to-year basis.

Coldwater Fish Habitat in River Reaches

The number of miles of coldwater river fish habitat (combination of dissolved oxygen levels and temperature that varies from month-to-month) for the 6 months from April through September was modeled for the two reaches downstream from Fort Peck and Garrison Dams. Higher and colder lake releases result in more miles of coldwater river fish habitat. A change to the preferred alternative results in no change in the total amount of coldwater river fish habitat. An increase in the average annual value occurs downstream from Fort Peck Dam for a change to the preferred alternative, and coldwater habitat decreases downstream from Garrison Dam. Droughts have a negative effect on both the temperature and the amount of water released from these lakes; therefore, the river coldwater habitat decreases in droughts. In general, the amount of coldwater river fish habitat is higher in droughts for the preferred alternative with its higher amounts of (and colder) water in storage in both lakes and more variable rate of release from the lakes.

Warmwater Fish Habitat in River Reaches

Total warmwater river fish habitat downstream from Fort Peck, Garrison, and Fort Randall Dams meeting variable temperature and dissolved oxygen requirements was computed for both plans. Warmwater river fish habitat increases significantly under the preferred alternative. A 20 percent increase occurs in the average annual value (49 miles for the current Water Control Plan to 59 miles for the preferred alternative) for the change in the water control plan. None of the increase occurs downstream from Fort Peck Dam. Major increases of 52 and 42 percent occur for the reaches downstream from Garrison and Fort Randall Dams, respectively. Year-to-year changes occur in differing ways downstream from the three dams. The reach downstream from Fort Peck Dam shows noticeable increases in the number of miles of habitat in the three major drought periods. Downstream from Garrison Dam, the third-year pattern is predominant with the highest values occurring in the lower release years. No specific pattern occurs downstream from Fort Randall Dam except high values occur consistently for the preferred alternative in most of the years of the 1930s and early 1940s drought.

Physical Habitat for Native River Fish

Habitat diversity is considered to be essential for the continued existence of many native riverine fish species, which include the endangered pallid sturgeon and other candidate species. For four reaches upstream from Sioux City (three intrasystem and one lower river), velocity distributions were used as an estimate for this diversity. Downstream from Sioux City, estimates of optimal flows were developed for five contiguous river reaches. The model computes higher values for alternatives that have an annual flow pattern that approximates the historic natural flow pattern of higher spring flows and lower flows the remainder of the year. The preferred alternative provides an 8 percent increase in the combined average annual physical habitat index value for the nine river reaches.

Improvements in physical habitat occur in all nine river reaches with the greater improvements occurring downstream from Sioux City. The improvements are significant (16 to 25 percent) for the reaches from Sioux City to downstream from Boonville for a change to the preferred alternative. The preferred alternative increases the total annual average river fish physical habitat value in 79 of the 96 years analyzed. Differences between the two plans diminish in the most severe drought of the 1930s and early 1940s except in the one nonnavigation year of the current Water Control Plan (1937). Lower values generally occur in the years of increased summer and fall releases for flood storage evacuation and extended droughts. Improved values occur in the individual reaches in half to three-fourths of the 96 years modeled for a change to the preferred alternative with the exception of the Hermann reach where the flows are more "natural" because tributary inflows increase in the downstream reaches and are more "natural" than the Mainstem System lake releases. This reach has 38 years in which the values were the same for both plans and 23 years of reduced values for a change to the preferred alternative. Values increase in six or more of the nine river reaches in nine of the months for a change to the preferred alternative. Fewer reaches increase in value in January (4), February (3), and July (1). July is generally a poor performance month in terms of physical habitat because the increased releases to create the spring rise result in a cutback to the minimum navigation service level instead of full service in this month in many years. Optimal flows for July river fish physical habitat are generally greater than required for even the full navigation service level.

Historic Properties

Historic properties located within the Mainstem System lakes and immediately adjacent zones are subject to the adverse effects of shoreline erosion and inundation. Of these two factors, the long-term potential for erosion at each known site was evaluated based on the monthly water level in each of the three upstream lakes. An index value was computed that converts the number of "hits" by erosional forces to a value that is indirectly proportional to this number to allow the index to provide higher values for "better" effects on known historic properties at these lakes. A change from the current Water Control Plan to the preferred alternative decreases the average annual index value by 4 percent from 4,689 units to 4,484. This loss occurs primarily at Lake Oahe. Essentially, no change occurs at Fort Peck Lake to known sites, which are extremely limited; therefore, the remainder of the lost units occurs at Lake Sakakawea. These two losses translate to a loss of 4 percent at Lake Sakakawea and 8 percent at Lake Oahe, both having a significant number of known sites compared to Fort Peck Lake.

Flood Control

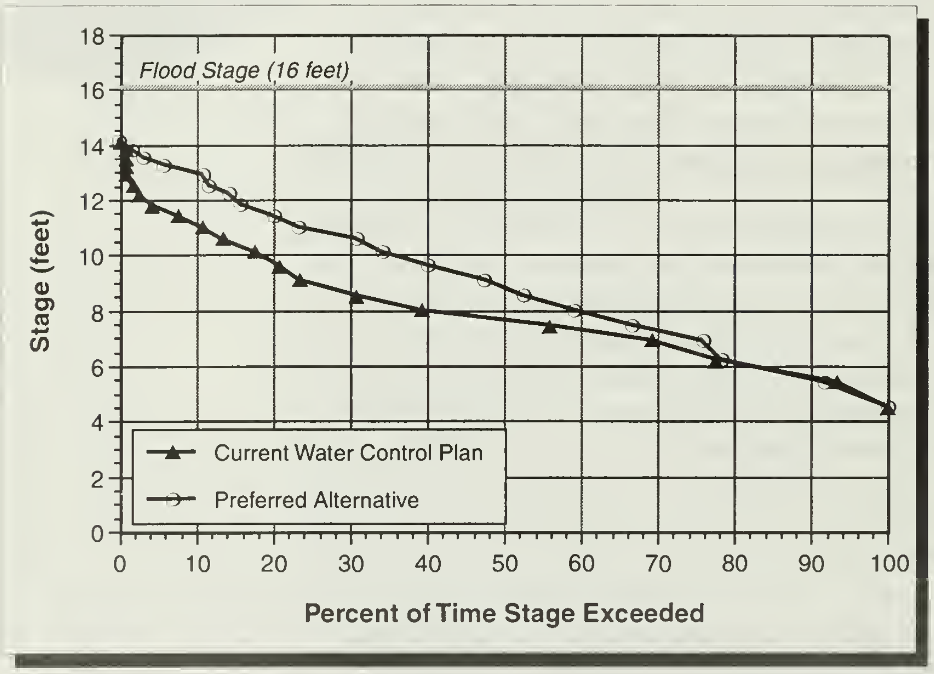
Flood control benefits were computed for the river reaches downstream from five of the dams (not Big Bend Dam). The reach downstream from Gavins Point Dam to the mouth was subdivided into eight reaches. A change to the preferred alternative results in a 4 percent decrease of the total average annual flood control benefits for all twelve reaches.

A detailed analysis was done for the reach at Bismarck because increased flooding at this location is the primary cause for increased damages downstream from Garrison Dam. Damaging flood events (consecutive months of flooding are just one event) since October 1953 increase from 10 under the current Water Control Plan to 16 under the preferred alternative. The months with increased flood events are the spring months, the result of the spring rise and modified intrasystem regulation. Figure 12 shows a frequency distribution of peak monthly stages at Bismarck for April, May, and June for the two water control plans. Peak stages at Bismarck are about 2 feet higher with the preferred alternative about 40 percent of the time for the period of peak flow records since 1953.

Expressed concern for the impacts of the spring rise on lower river farmland flooding resulted in a detailed analysis for the Nebraska City reach. This analysis determined that the number of flood events since October 1928 stays the same at 65 events. These events occur in 47 years under the current Water Control Plan and in 49 years under the preferred alternative. This increase in the number of years is a redistribution of the flood events, which results in an increase in the number of flood events in the spring months. Changes in the spring flood events include 2 fewer events in March, 4 more in April, 3 more in May, and 2 less in June. Total flood damages for all 65

Figure 12

Frequency plot of peak stage for spring (April through June) in Missouri River at Bismarck, North Dakota. Based on simulations for the period 1953 to 1993.



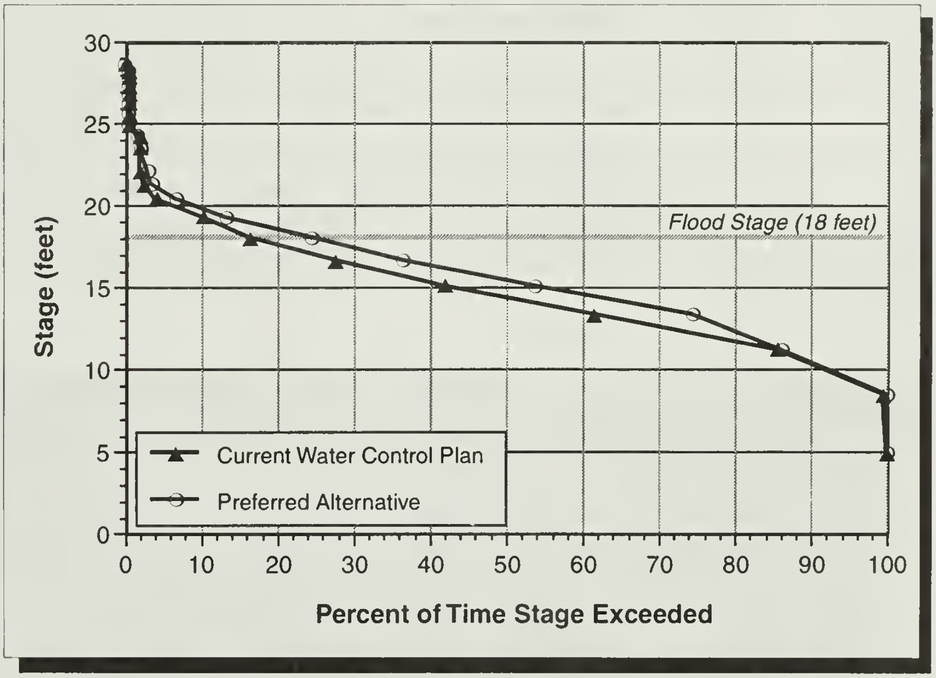
events increases from $146 million to $151 million for the change to the preferred alternative. Figure 13 shows a frequency distribution of peak river stages at Nebraska City for April, May, and June for the two water control plans for the 66 years of historic peak flow records. River stages at Nebraska City are about 1 foot higher with the preferred alternative about 60 percent of the time.

One factor that was not modeled is the effect of river flows on interior drainage problems which can cause flood damages. The Nebraska City reach is about 5 days downstream from Gavins Point Dam in terms of flow time. If reductions in releases to either full or minimum service to navigation can eliminate the interior drainage problem, interior drainage may be a problem for a maximum of 5 days. If it is due to continued high tributary flows, the problem would be identical under both plans.

A concern was also raised regarding the potential impact of higher Missouri River flows on the evacuation of stored flood waters in the Kansas River and Osage River basins. In the case of the Kansas River projects, releases are curtailed when flows at Waverly, Missouri (near Kansas City) exceed 100 kcfs. During the spring rise months, the number of months averaging 90 kcfs or more is 44 for the current Water Control Plan at Kansas City and 65 for the preferred alternative. This increase of 21 months out of a possible 384 months during the 4-month spring rise period (March through June) is an increase of 5 percent of the time that evacuation could be limited for potential long periods. (The higher the average monthly flow the longer the potential period of flows greater than 100 kcfs.) A similar analysis of the Hermann data, which dictates constraints on evacuation from the Osage River basin, determined that there are almost no months in which evacuation is limited for a long period and there is essentially no difference between the two plans.

Figure 13

Frequency plot of peak stage for spring (April through June) in Missouri River at Nebraska City, Nebraska. Based on simulations for the period 1928 to 1993.



Water Supply

Water supply benefits were determined for the intake facilities along the Mainstem System for all of the lake and river reaches between the headwaters of Fort Peck Lake and the mouth of the Missouri River at St. Louis. Total benefits are the same for both plans. For many reaches there is also very little, if any, difference in benefits between the two plans. In some reaches, however, there are noticeable differences, but they are not very great. Under the preferred alternative, benefits would increase 4 percent at Fort Peck Lake and Lake Oahe while declining 2 percent at Lake Francis Case. Examination of the differences between the two plans in terms of the various types of use (power, municipal, commercial/industrial, irrigation, and domestic) also shows no difference. Subtle differences occur in differing years for the two plans. The most notable is the effects on the lower river in 1937 under the current Water Control Plan. This is a nonnavigation year under this plan; therefore, the summer nonnavigation service level criteria were followed. The 9-kcfs target does not provide adequate flows for some major powerplants. Also, two powerplant intakes had to be lowered. An increase in the water supply benefits for the preferred alternative relative to the current Water Control Plan result in the June through October 1937 period totaling $166 million. This amounts to less than $2 million per year over the 96-year period of analysis, and there are offsetting decreased benefits in some other periods as well as other periods of increased benefits for the preferred alternative.

Hydropower

Total average annual Mainstem System hydropower benefits are essentially the same for both plans. This results in essentially no differences in the hydropower benefits provided by the individual dams or to the States receiving this hydropower. The largest reduction in annual average benefits occurs in the most extreme drought modeled, the drought of the 1930s and early 1940s. The preferred alternative provided greater benefits during all three

Generators in a dam powerhouse

major droughts. These beneficial differences are offset by a reduction in benefits in most non-drought periods. In general, the increase in benefits in a major drought year is greater than the reduction in benefits in each non-drought year. The preferred alternative provides less variability over the entire period with the range in annual benefits being smaller for the preferred alternative ($451 million to $724 million) than it is for the current Water Control Plan ($389 million to $730 million).

Review of the capacity and energy data shows major differences between the two plans. The preferred alternative increased the average annual capacity in every month with the increases ranging from 23 to 80 MW. A critical factor from a power marketing standpoint is the marketable capacity available. This is currently determined by the minimum summer and winter values in 1961. The current Water Control Plan reduces the amount currently marketed in the summer from 2,070 MW to 1,960 MW while the preferred alternative increases this value to 2,130 MW. Both plans have higher winter values than the current value of 2,010 MW—2,044 MW for the current Water Control Plan and 2,208 MW for the preferred alternative. The month-to-month distribution of energy generated by the Mainstem System hydropower units was altered by a change to the preferred alternative. The largest changes consisted of moving energy generated from the fall months to the spring months.

Recreation

Water recreation

Recreation benefits were computed for all of the lake and river reaches. Under the current Water Control Plan, the lakes provide 73 percent of the over $75 million of average annual benefits for the 96-year period. The combined average annual benefits for all reaches increase by $1.9 million (+3 percent) for a change to the preferred alternative. This increase occurs for the three upstream lakes with Lake Sakakawea having the greatest improvement in benefits, +$1.8 million (+15 percent). The preferred alternative improves lake recreation benefits significantly in the major droughts. For example, the preferred alternative provides an additional $34.0 million of benefits at the upper three lakes in

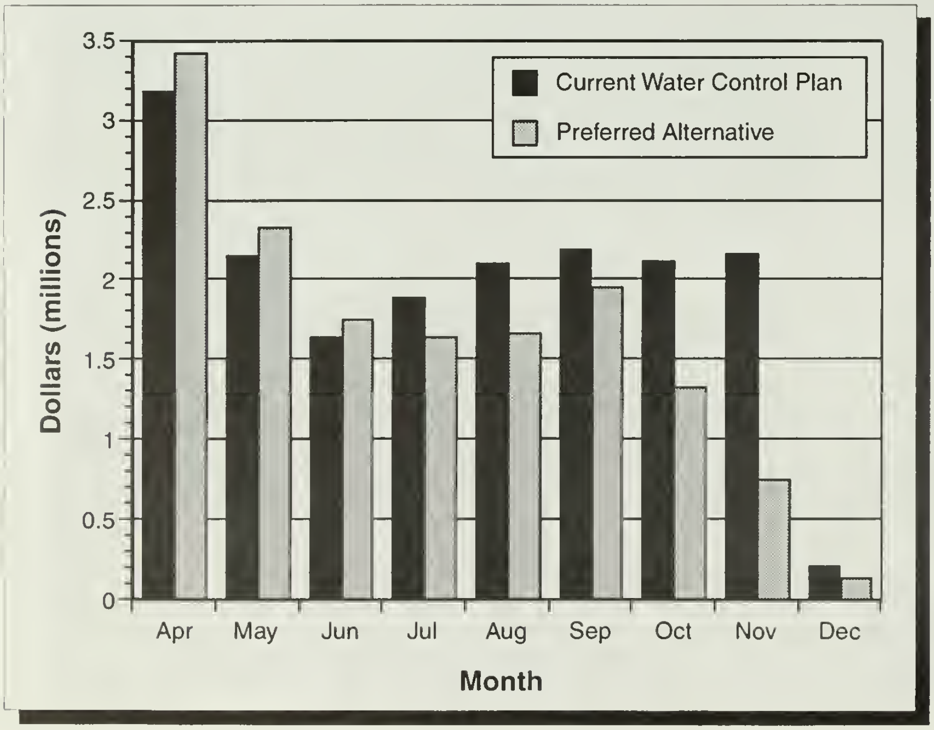
1936, which was the year in which these lakes declined to their lowest levels. Intrasystem and lower river recreation losses are very small on an average annual basis. By eliminating the subsequent nonnavigation year of the current Water Control Plan, the preferred alternative even improves benefits for lower river recreation. These increases total $1.0 million (+29 percent compared to the value for the current Water Control Plan) for the reach downstream from Gavins Point Dam and $2.3 million (+31 percent) for the Sioux City reach in 1937.

Navigation

Average annual benefits for Missouri River navigation are reduced by 15 percent under the preferred alternative. Figure 14 shows a monthly distribution of the average annual benefits. Reduced service levels in the latter half of the navigation season in many years is a factor in this loss of benefits. Full service seasons are reduced from 39 to 14 and partial service years are increased from 56 to 82. The preferred alternative provides service in all 96 years while the current Water Control Plan has a nonnavigation year in 1937. A reduction of the normal navigation season length is also a factor. The number of 8-month or longer navigation seasons is cut from 89 under the

Figure 14

Average annual navigations benefits by month (April through December). Based on simulations for the period 1898 through 1993).



current Water Control Plan to 33 under the preferred alternative. This is a primary factor for the reduction of average annual November benefits under the preferred alternative, as shown in Figure 14. The modified navigation service criteria of the preferred alternative also reduce benefits in the drought periods. Even though they are a factor in eliminating the complete loss of benefits in 1937, their effects on navigation service level and season length outweigh this improvement.

Missouri River flows also affect Mississippi River navigation. Modeling results of both plans demonstrate that Mississippi River navigation is relatively unaffected (less than 1 percent in terms of average annual benefits) over the 96-year period of analysis.

Total NED Economics

All of the economic use benefits discussed above are NED benefits. When the average annual benefits for the five uses are totaled, the net result is no change in total NED benefits between the two plans. The preferred alternative increases the benefits in the drought periods and this improvement is offset by reduced benefits in the non-drought periods. This results is a reduction in the range of economic benefits provided in each of the 96 years by the Mainstem System. The minimum benefits provided by the current Water Control Plan in the most severe of the three droughts is $982 million, and the minimum value for the preferred alternative is $1,214 million. Maximum numbers for the two plans occur in 1975 and are very similar at $1,564 and $1,560 million, with the lower value being for the preferred alternative. The distribution of the total NED benefits among eight basin States is presented in Table 4. This table also includes the economic benefits for each use to show the makeup of the total value for each State. Also shown is the distribution of the benefits for the alternative that maximizes the total benefits for each use.

Table 4.

Benefits by states (in $Millions)

(MAX = Maximum attainable; CWCP = Current Water Control Plan; PA = Preferred Alternative)

		Montana	Wyoming	North Dakota	South Dakota	Nebraska	Iowa	Kansas	Missouri
NAVIGATION	**MAX**	0	0	0	0.2	4.4	4.2	2.8	6.2
	CWCP	0	0	0	0.2	4.4	4.2	2.8	6.2
	PA	0	0	0	0.1	3.7	3.5	2.3	5.3
FLOOD	**MAX**	0.5	0	1.3	5.6	13.0	10.7	3.8	9.9
CONTROL	**CWCP**	0.5	0	1.4	5.6	12.8	10.5	3.8	9.9
	PA	0.5	0	1.2	5.6	12.1	9.8	3.7	9.7
HYDROPOWER	**MAX**	46.9	0	83.1	119.5	177.5	81.3	0	0
	CWCP	45.6	0	80.3	115.3	168.9	78.9	0	0
	PA	45.4	0	80.3	115.3	170.1	78.8	0	0
RECREATION	**MAX**	3.3	0	23.9	28.2	11.3	4.0	0.6	2.5
	CWCP	2.7	0	20.0	27.3	11.7	4.2	0.6	2.5
	PA	3.0	0	21.7	27.5	11.4	4.1	0.6	2.5
WATER SUPPLY	**MAX**	3.2	4.4	29.7	24.8	245.6	89.8	12.9	87.0
	CWCP	3.1	4.4	28.5	24.0	245.2	89.7	12.6	86.7
	PA	3.2	4.4	28.5	24.0	245.5	90.0	12.6	86.6
TOTAL	**CWCP**	52	4	130	172	443	188	20	105
	PA	52	4	132	173	443	186	19	104