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ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER--ETC(U)
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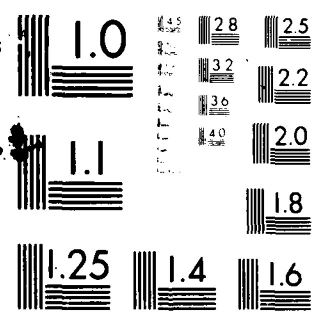

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REPORT DOCUMENTATION PAGE — READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
2. GOVT ACCESSION NO. AD-A110 151
3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): ENVIRONMENTAL IMPACT STUDY OF THE NORTHERN SECTION OF THE UPPER MISSISSIPPI RIVER, POOL 7.
5. TYPE OF REPORT & PERIOD COVERED: Final Report
6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Thomas O. Claflin, Barbara J.R. Gudmundson
8. CONTRACT OR GRANT NUMBER(s): DACW37-73-C-0059
9. PERFORMING ORGANIZATION NAME AND ADDRESS: North Star Research Institute, Environmental Services Division, 3100 38th Avenue S. Minneapolis, MN 55406
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Army Engineer District, St. Paul, Corps of Engineers, 1135 USPO & Custom House St. Paul, MN 55101
12. REPORT DATE: November 1973
13. NUMBER OF PAGES: 193
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)
18. SUPPLEMENTARY NOTES
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
    Navigation
    Barges
    Inland Waterways
    Environmental assessment
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps of Engineers' activites on Pool 7 (LaCrosse, Wisconsin) on the Upper Mississippi River. These activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and dredging of the navigation channel.

An analysis of natural and socioeconomic systems is included, such as impact of river transportation on economy, wildlife habitat, effects of dredge spoil on natural ecosystem, and recreational activities.

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FINAL REPORT

ENVIRONMENTAL IMPACT ASSESSMENT STUDY

POOL 7

of the Northern Section of the
UPPER MISSISSIPPI RIVER

for the

ST. PAUL DISTRICT CORPS OF ENGINEERS
under Contract No. DACW37-73-C-0059

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La Crosse, Wisconsin
November 1973

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FOREWORD

Purpose of the Environmental Studies

The National Environmental Policy Act of 1969 directs that all agencies of the Federal Government "include in every report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement ... on the environmental impact of the proposed action." The Act deals only with proposed actions. However, in keeping with the spirit of the Act, the U.S. Army Corps of Engineers has developed its own policy that requires such reports on projects it has completed and for which continuing operational and maintenance support are required.

In keeping with its policy, on January 15, 1973, the St. Paul District of the U.S. Army Corps of Engineers contracted with the North Star Research and Development Institute to prepare a report assessing the environmental impact of the Corps of Engineers' operations and maintenance activities on the Mississippi River from the head of navigation in the Minneapolis, Minnesota, to Guttenberg, Iowa. Included also are the Minnesota and St Croix Rivers from their respective heads of navigation at Shakopee and Stillwater, Minnesota to the Mississippi River. This portion of the Mississippi River basin will subsequently be termed the "Northern Section" of the upper Mississippi River, the "study area", or the St. Paul District.

The Corps of Engineers has been active in the Northern Section since the 1820's, when they first removed brush and snags from the river to permit navigation as far north as Fort Snelling. Later in the 1870's, further improvements were made, primarily through construction of wing dams, to deepen and maintain the channel. Presently, the river in the study area consists of a series of pools, which were created by the construction of navigation locks and dams in the 1930's. Several recreation areas along the river were also built by the Corps.

The purpose of the environmental impact study is to assess the impacts, both positive and negative, of the Corps' activities on the Northern Section. These activities are defined as operations and maintenance activities and mainly include operations of facilities (locks and dams) and maintenance of the navigation channel (dredging). Actually, the impacts on the environment of the earliest operations are also being sought, but most of the information will concern those of the present navigation system.

The studies are designed not only to identify the impacts, but to assess their effects on both the natural and social environment. Such impacts may include effects of river transportation on the area economy, effects of creation of the pools on recreational activities and wildlife habitat, effects of dredge spoil disposal on the natural ecosystem and on recreation, and many others. As a result of identification and assessment of the impacts, it may be possible to suggest ways of operating the facilities and maintaining the navigation and recreation system to amplify the positive and minimize the negative results of the Corps' activities. The study will provide a comprehensive basis for the St. Paul District to prepare an environmental impact statement consistent with the National Environmental Policy Act of 1969 and the policy of the U. S. Army Corps of Engineers.

Scope of Current Report

The present report covers the entire study program only from January, 1973 through November, 1973. The report contains both historical information and data collected in the field from activities such as water sampling and wildlife observation.

Research Approach

Three aspects of the research approach used in the study are: (1) the benchmark point in time, (2) data collection and analysis on the natural systems, and (3) data collection and analysis on the socioeconomic activities.

Benchmark Time Period

In order to analyze the impact of the activities of the Corps of Engineers on the Northern Section of the Upper Mississippi River, it is necessary to select a time period that can serve as a benchmark. This benchmark represents the state of the Mississippi River prior to the time activities related to the nine-foot channel were initiated. As the nine-foot channel project was constructed in the 1930's, the preconstruction benchmark was taken as 1930. Wing-dams were built and other Corps' activities took place prior to 1930, however, and earlier data were also used where they were readily available. The preconstruction benchmark data were obtained from available reports and from a variety of other sources cited at the end of each section.

Project Description

Lock and Dam No. 7 is located 702.5 miles above the mouth of the Ohio River and is the tenth of 13 like structures downstream from the head of navigation in the canalized section of the Mississippi River in the St. Paul District. The structure is 11.8 miles below lock and dam No. 6 and 23.3 river miles above lock and dam No. 8.

From the riverward wall of the auxiliary lock, a movable dam section 940 feet long, extends across the main channel to island 98. The movable dam consists of 5 roller gates and 11 tainter gates which regulate the pool elevation. An earth dike extends across the island and French Slough and meets high ground on the west side of French Island. A fixed concrete spillway is located in this section of the dike. Another section of dike extends eastward from French Island and connects to a submersable dam section with a culvert spillway, which extends across the main channel of the Black River, three miles above its confluence with the Mississippi River.

The closure of Lock and Dam No. 7 and the subsequent filling of Navigation Pool No. 7 inundated the floodplain formed at the point where the Black River enters the Mississippi River gorge, approximately 8 miles above its actual confluence with the Mississippi River. (Figures 1-4).

The principal features of the pool are summarized below:

a. Length of pool — 11.8 river miles

b. River miles — 702.5 to 714.3

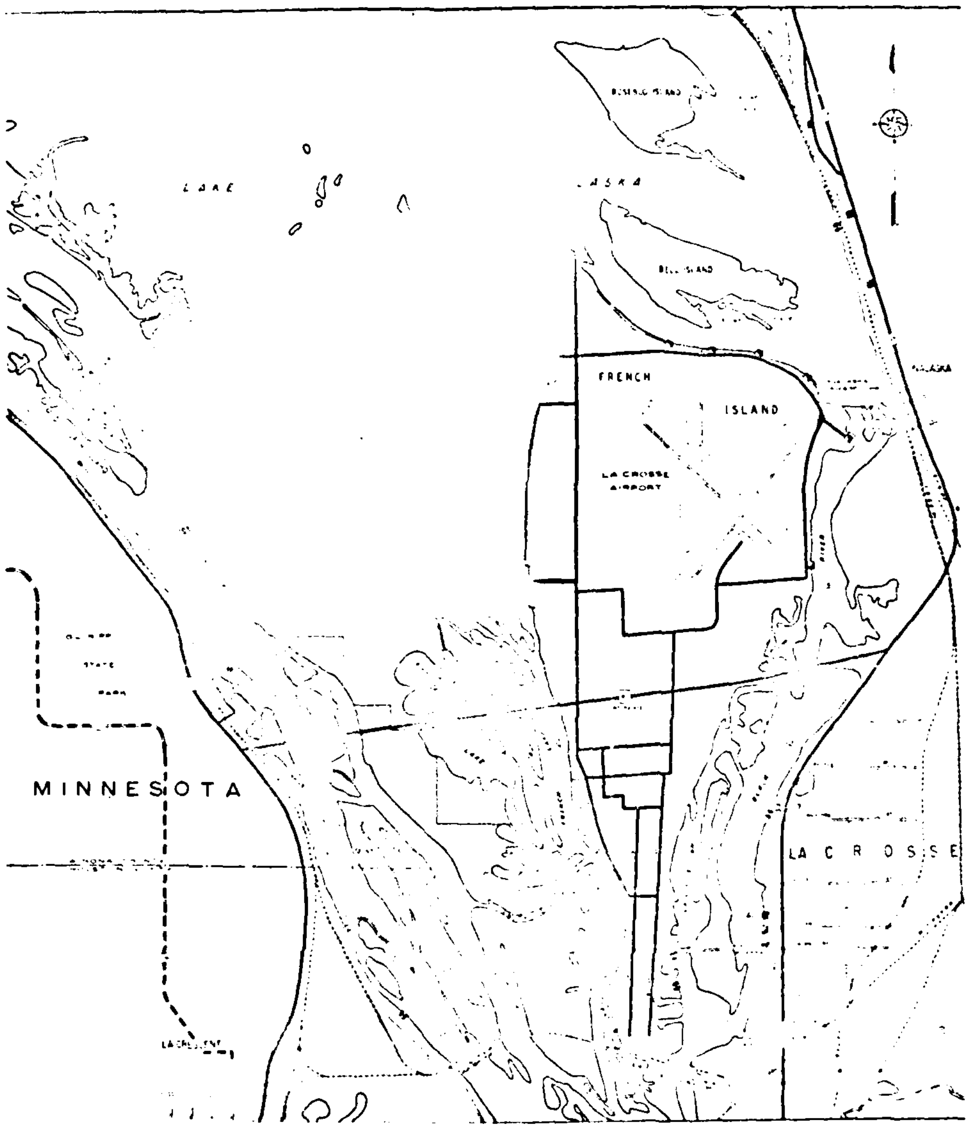


Figure 1. Navigation Pool No. 7, 1967, Mile 702-704

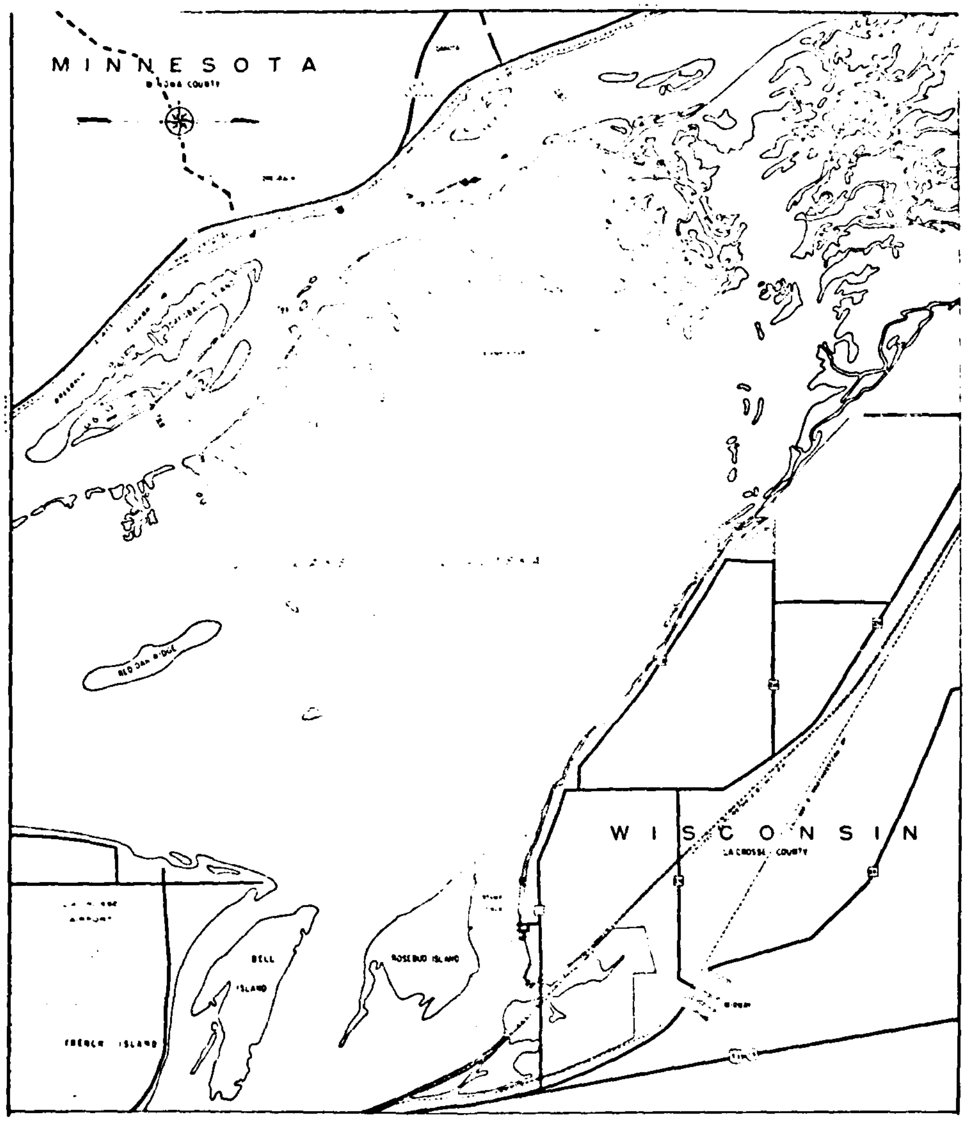


Figure 2. Navigation Pool No. 7, Mile 704-707

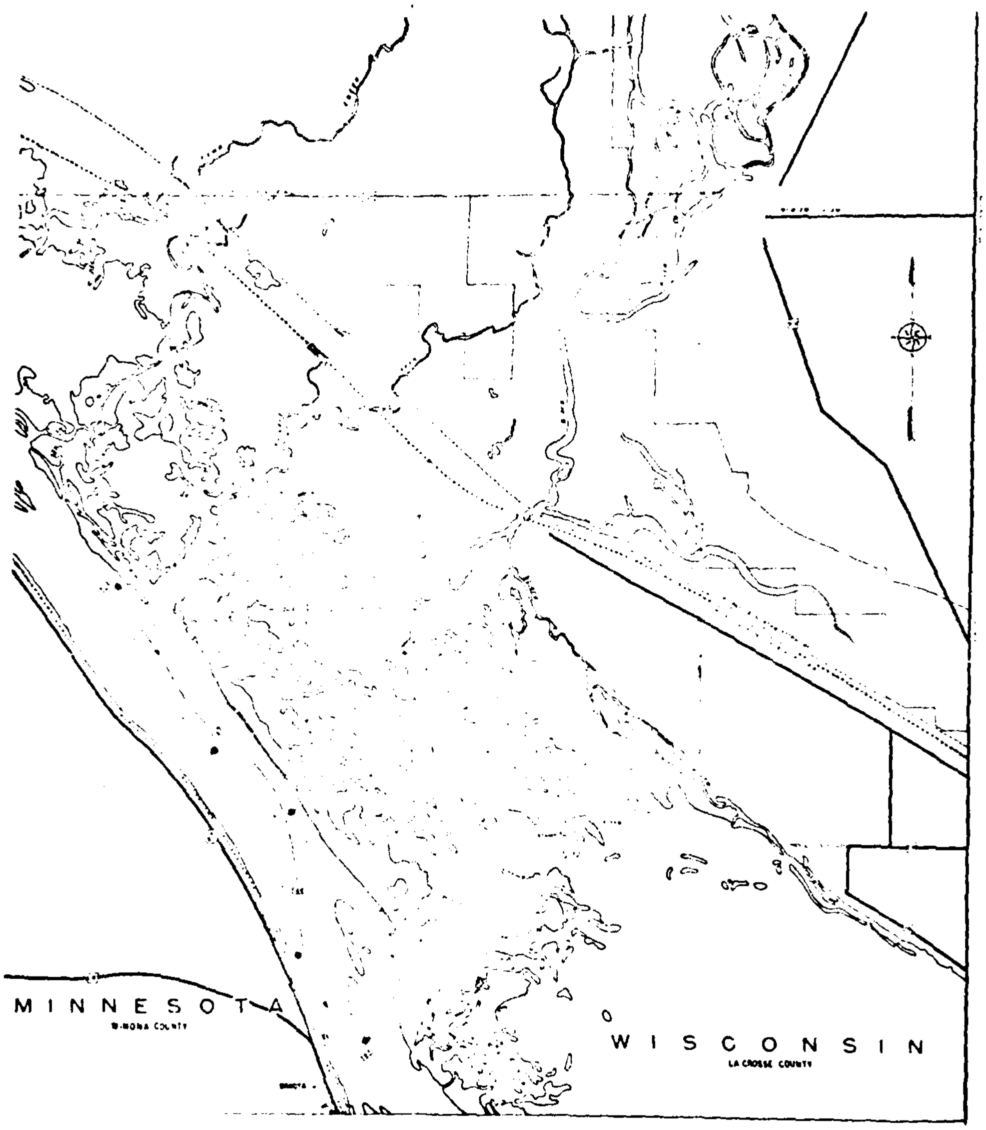


Figure 3. Navigation Pool No. 7, Mile 707-710

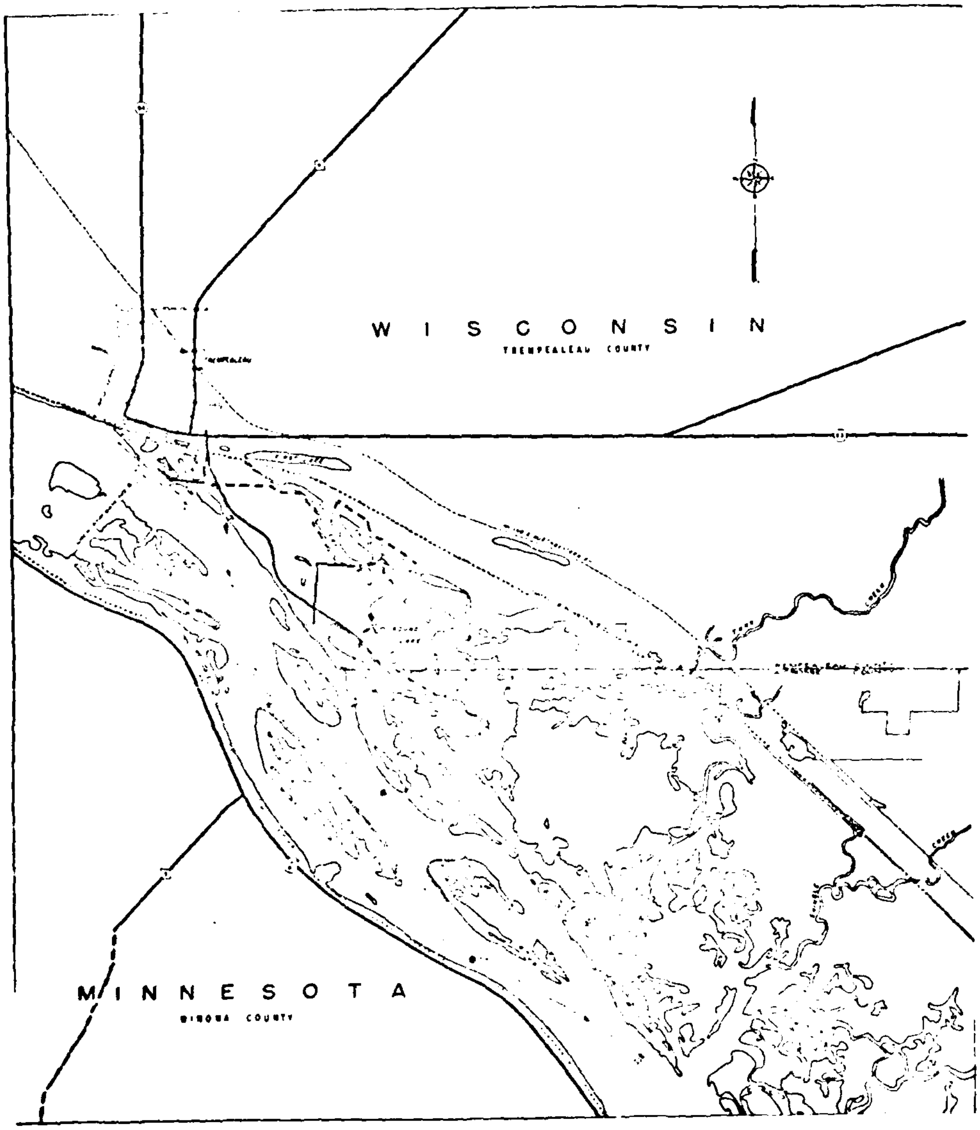


Figure 4. Navigation Pool No. 7, Mile 710-714

c. Pool elevation (flat pool) 639.0

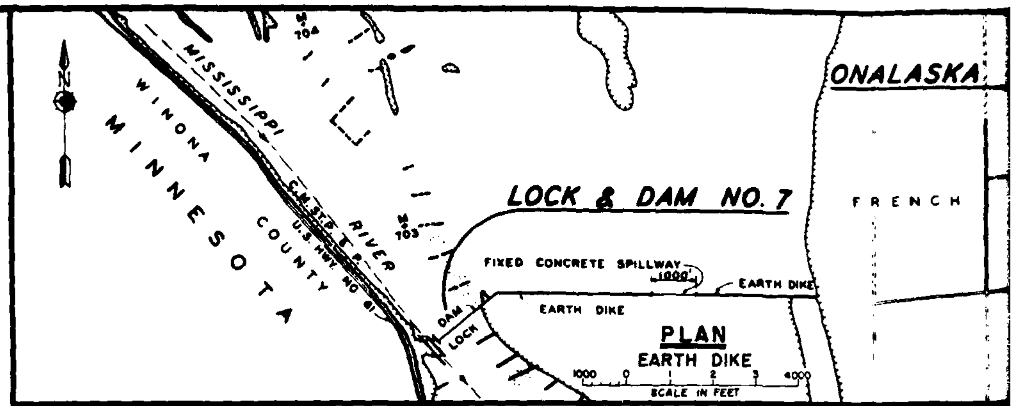
d. area of pool (water) 13440 acres

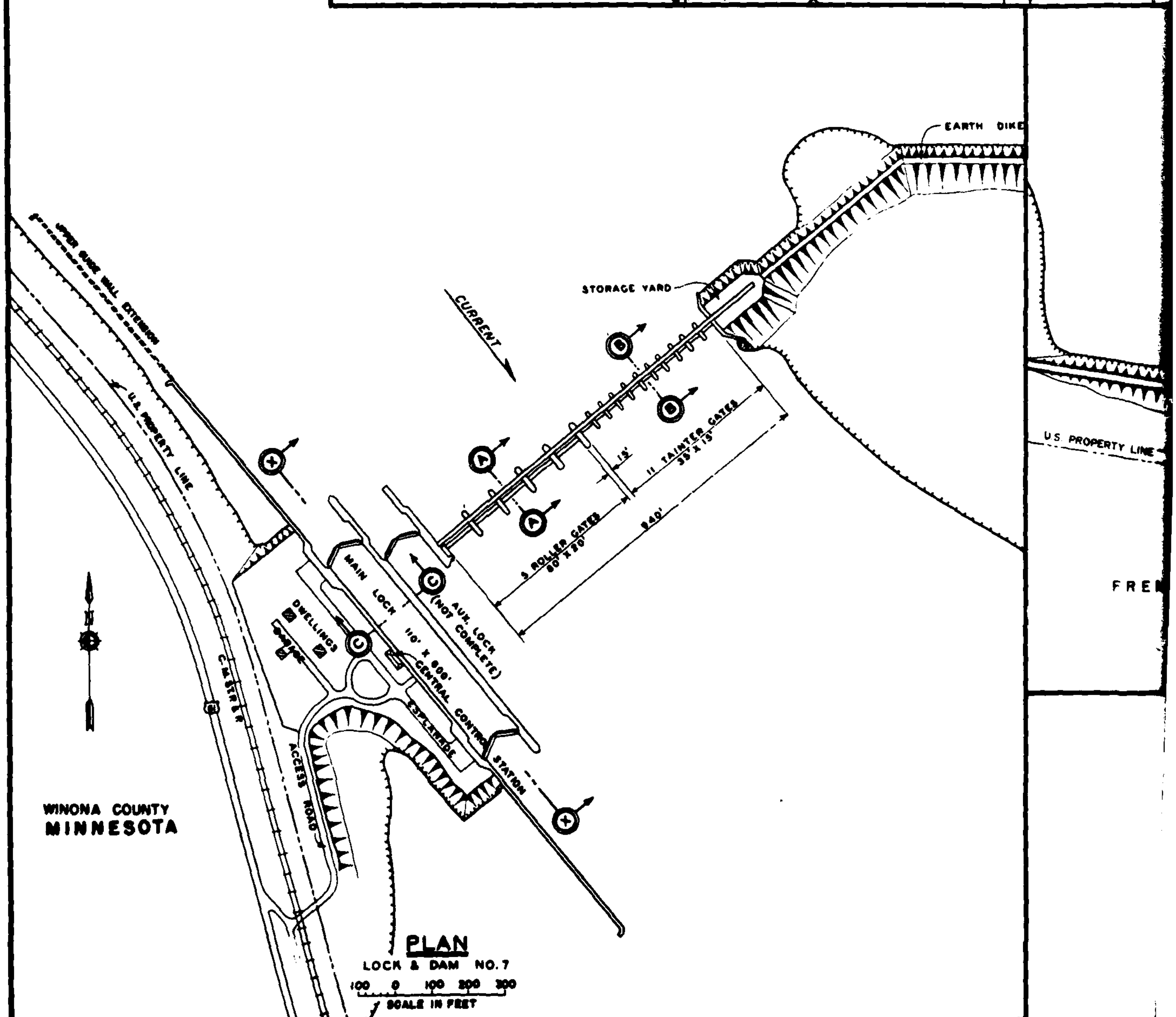
e. shoreline (perimeter) 37.1 miles

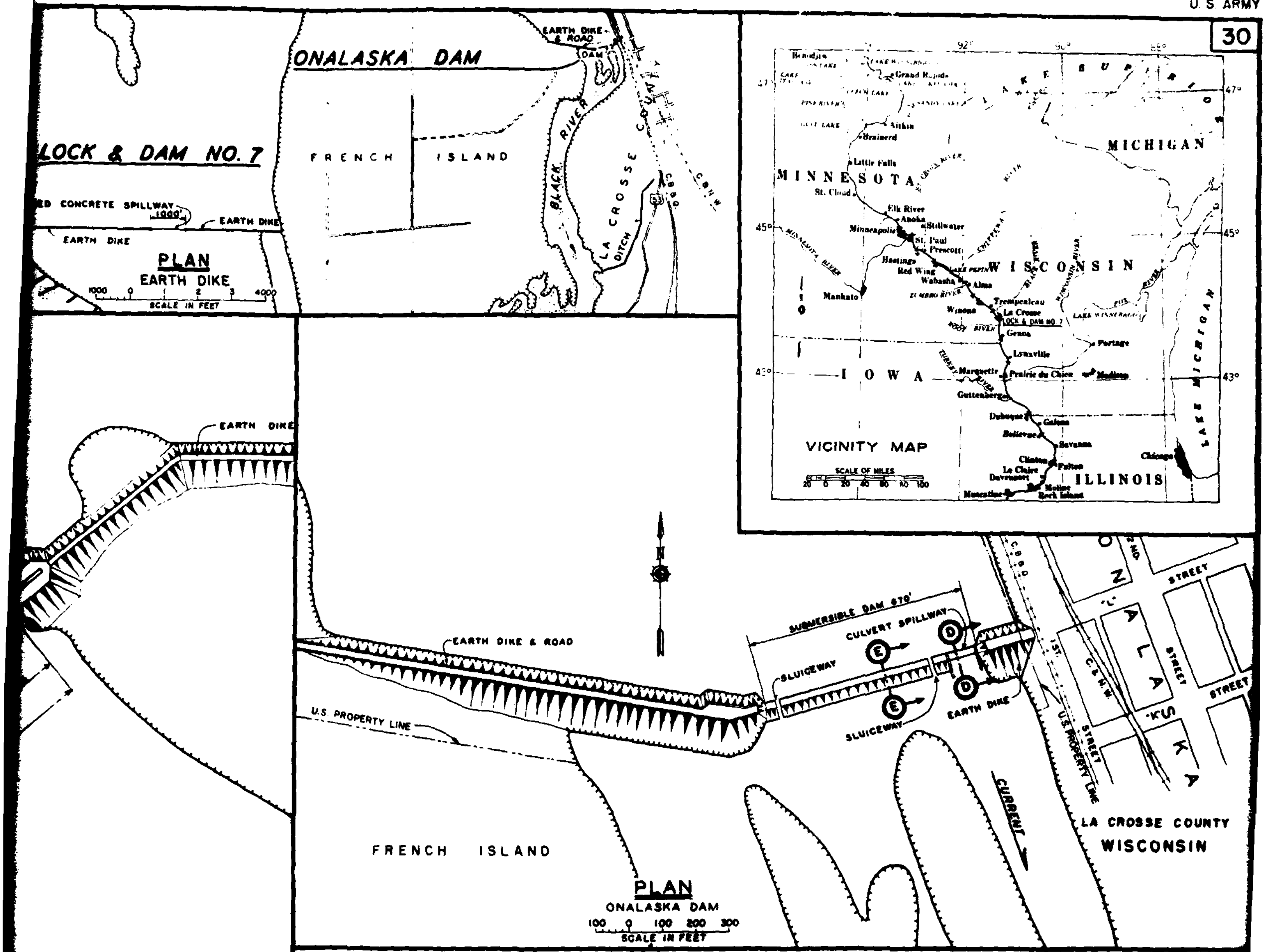
f. total above water lands 7070 acres

Pool No. 7 is the sixth largest of the 13 pools by acreage. It is one of the most heavily used pools (by visitation statistics) as it serves the people living in LaCrosse and the immediate environs.

Prior to the construction of Lock and Dam No. 7 a four and one half foot channel was maintained with wing dams and closing dam structures. These structures were constructed from Limestone and brush (predominantly willow) in a sandwich fashion to increase their stability under flowing water conditions. In Navigation Pool No. 7 there are approximately 88 wing dams and 6 closing dams between Lock and Dam No. 6 and Lock and Dam No. 7. (Figures 5, 6, (maps).


ONALASKA
LOCK & DAM NO. 7
FRENCH
MISSISSIPPI
RIVER
WINONA
COUNTY
MINNESOTA
C.M.St.P. & P. R.R.
U.S. HWY NO. 61
FIXED CONCRETE SPILLWAY
EARTH DIKE
EARTH DIKE
DAM
LOCK
PLAN
EARTH DIKE
SCALE IN FEET
N


EARTH DIKE
STORAGE YARD
CURRENT
UPPER GUIDE WALL EXTENSION
U.S. PROPERTY LINE
U.S. PROPERTY LINE
11 TAINTER GATES
35' X 15'
5 ROLLER GATES
80' X 20'
940'
MAIN LOCK
110' X 600'
AUX. LOCK
(NOT COMPLETE)
DWELLINGS
GARAGE
CENTRAL CONTROL STATION
ESPLANADE
ACCESS ROAD
C.M.St.P.& P. R.R.
FRENCH
WINONA COUNTY
MINNESOTA
PLAN
LOCK & DAM NO. 7
100 0 100 200 300
SCALE IN FEET



TOTAL LENGTH OF EARTH DIKE - 9003.0 FT.
DEPTH ON UPPER GATE SILL - 18.0 FT. (U.P.EL. 639.0)
DEPTH ON LOWER GATE SILL - 12.0 FT. (L.P.EL. 631.0)
ELEVATION UPPER GATE SILL - 621.0
ELEVATION LOWER GATE SILL - 619.0

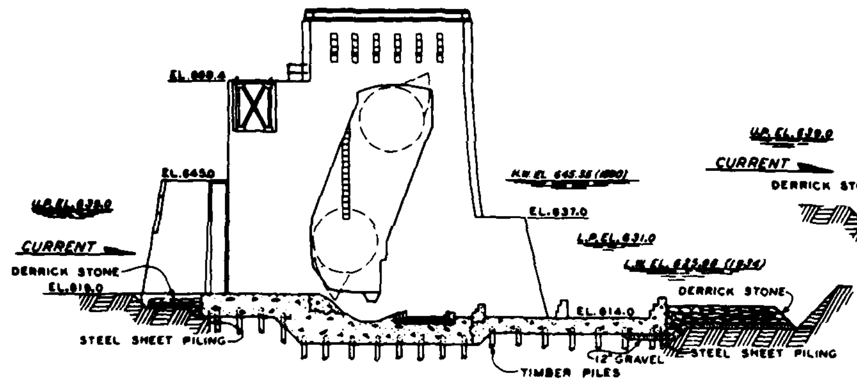
ELEVATIONS ARE REFERRED TO M.S.L. (1912 ADJ.)

Figure 5.

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN

LOCK & DAM NO. 7

IN 2 SHEETS — SHEET NO. 1
SCALE: AS SHOWN
CORPS OF ENGINEERS — U. S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT — ST. PAUL, MINN
JUNE 1961

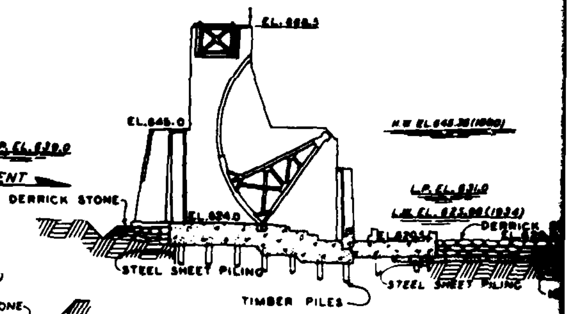


SECTION A-A

ROLLER GATE

10 0 10 20 30

SCALE IN FEET



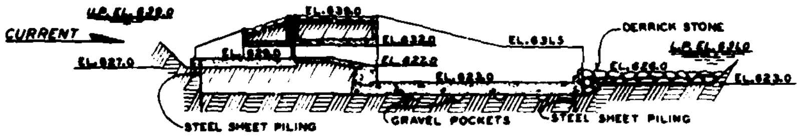
SECTION B-B

TAINTER GATE

NON-SUBMERGIBLE TYPE SHOWN

10 0 10 20 30

SCALE IN FEET



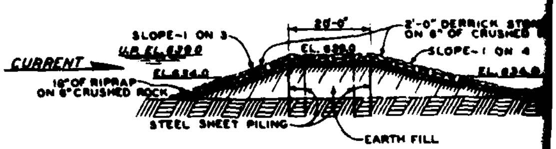
SECTION D-D

CULVERT - SPILLWAY

ONALASKA DAM

10 0 10 20 30

SCALE IN FEET



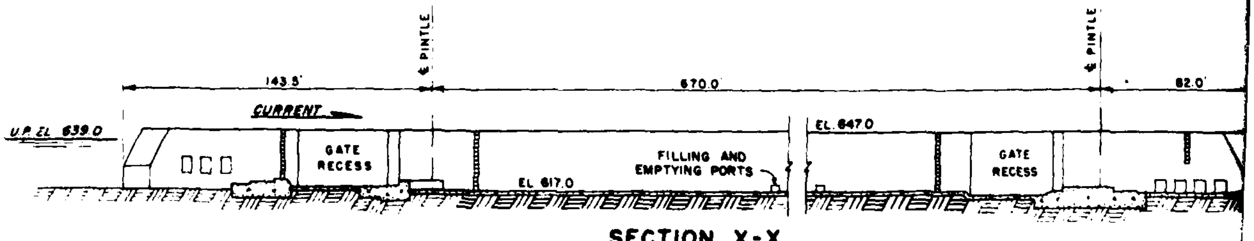
SECTION E-E

SUBMERSIBLE DAM

ONALASKA DAM

10 0 10 20 30

SCALE IN FEET

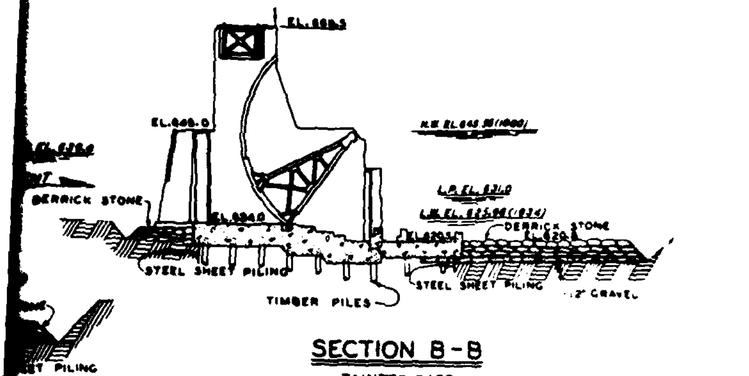


SECTION X-X

MAIN LOCK

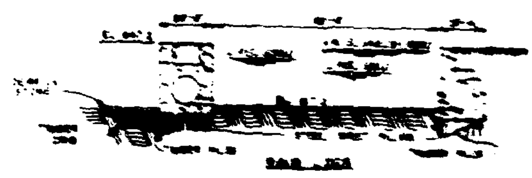
20 0 20 40 60

SCALE IN FEET

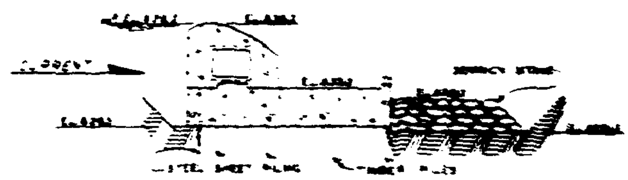


SECTION B-B

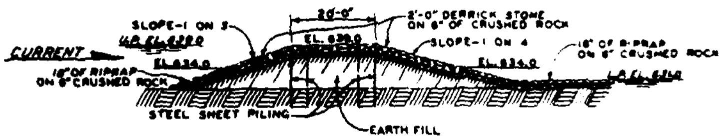
TAINTER GATE
NON-SUBMERGIBLE TYPE SHOWN
10 0 10 20 30
SCALE IN FEET



SECTION C-C

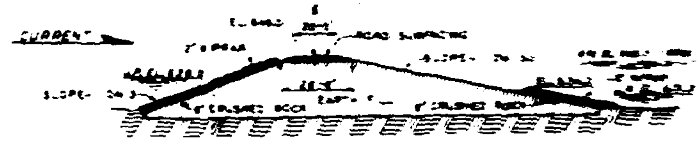


SPILLWAY SECTION

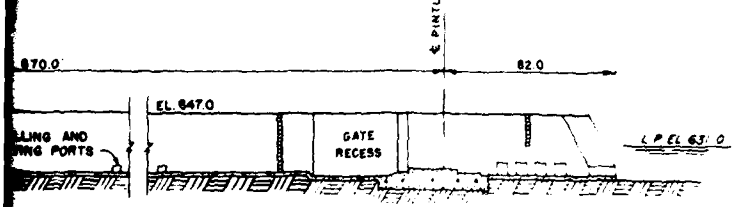


SECTION E-E

SUBMERSIBLE DAM
ONALASKA DAM
10 0 10 20 30
SCALE IN FEET



EARTH DIKE SECTION



ION X-X

20 40 60
LE IN FEET

ELEVATIONS ARE REFERRED TO M.S.L.

Figure 6.

RIVER & HARBOR PROJECT
MISSISSIPPI RIVER
MISSOURI RIVER TO MINNEAPOLIS, MINN.
LOCK & DAM NO. 7
IN 2 SHEETS SCALE AS SHOWN SHEET NO. 2
CORPS OF ENGINEERS U.S. ARMY
OFFICE OF THE DISTRICT ENGINEER
ST. PAUL DISTRICT ST. PAUL, MINN.
JUNE 1961

2. ENVIRONMENTAL SETTING

INTRODUCTION

The environmental setting of the project covered in this section is divided into (1) the natural setting and (2) the socioeconomic setting and includes a description of the study area from prior to the authorization of the nine-foot channel (1930) up to the present time. Lock and Dam No. 7 was opened to navigation in 1937. Thus, because the project under consideration was initiated about 40 years ago, it is difficult to reconstruct accurately the natural and socioeconomic setting existed prior to lock and dam construction. There are three reasons for this difficulty:

1) lack of precise data on the environmental setting prior to 1930;
2) the difficulty in isolating some changes in the river environment due to the nine-foot channel from those caused by the earlier 4-½-and 6-foot channels or by increased population and industrialization along the river; and,

3) the practical emphasis on reducing the environmental settings in this section were reconstructed from available published information and are of necessity brief and not complete.

In the discussion of the environmental impact of the project later in Section 3 an attempt has been made to identify changes in the study area occurring in the past four decades that are attributable to the nine-foot channel project.

History of the River Basin

The exact age of the Mississippi River is not known. The existing gorge was probably cut prior to the Wisconsin stage of the glacial period. In fact it appears that the gorge may be preglacial. The gorge was partially filled with glacial outwash during the drift period. Terrace formation occurred, depositing the first terrace at a height of over 100 feet above the present floodplain. Following the filling of the river gorge, a period of terrace cutting occurred, leaving remnants of terrace along the lower borders of the bluffs. Many of these terraces have since been cut by tributary streams. This change from deposition to erosion is related to the large volume of water from the southward flow from Lake Agassiz. The water being derived from an extremely large lake carried little or no sediment for deposition in the river basin. The third stage in the development of the Mississippi River is a period of floodplain deposition. With the pronounced decrease in flow due to the lack of glacial melt water, the river became dependent upon rainfall and runoff from its own basin. Since it could not carry the sediment load delivered by its tributaries and the head water, depostion resumed and is occurring at the present time.

The same processes probably occurred in the tributary streams, particularly those that enter the Mississippi River in the driftless area.

Navigation Pool No. 7 now occupies an area that was once low lying marsh and meadow. The Black River, having risen east of the Western Upland of Wisconsin, and flowing completely across it, entered the Mississippi River valley upstream from Lock and Dam No. 7. It then paralleled the Mississippi River for approximately 15 miles in the Mississippi River Basin, having its confluence at La-Crosse.

This river carried vast quantities of water from glacial melt, and deposited a large delta at its mouth, forming the raised flood plain that is now lower Navigation Pool No. 7.

Physical Description

The Floodplain

Where the Mississippi River is contained within a gorge as in the areas of Pools 7 and 8, the floor of the gorge shows two conspicuous features; a. the floodplain of the river, which occupies most of the bottomland, and b. the terraces, which are narrow and discontinuous. The floodplain slopes southward from an elevation of about 675 feet at Prescott, Wisconsin to 592 feet at Dubuque, Iowa. The distance between these points being 260 river miles thus the grade of the river is slightly less than 4 inches per mile. The floodplain material is clay, silt and loam, sometimes sandy, and often dark with organic matter. This topsoil is underlain by several feet of sand, which often grades into coarse gravel 3 to 6 feet below the surface. The basin abounds with pools and small lakes where decaying vegetation constitute the floodplain material. This surface material however, is extremely thin compared with the great thickness of glacial outwash below.

Climate

The climate in the area of Pool No. 7 is a humid-continental type, marked by wide extremes of temperature. The yearly average temperature is 46 degrees with the average degree days of 7650. The annual average rainfall is 29.9 inches.

Geology

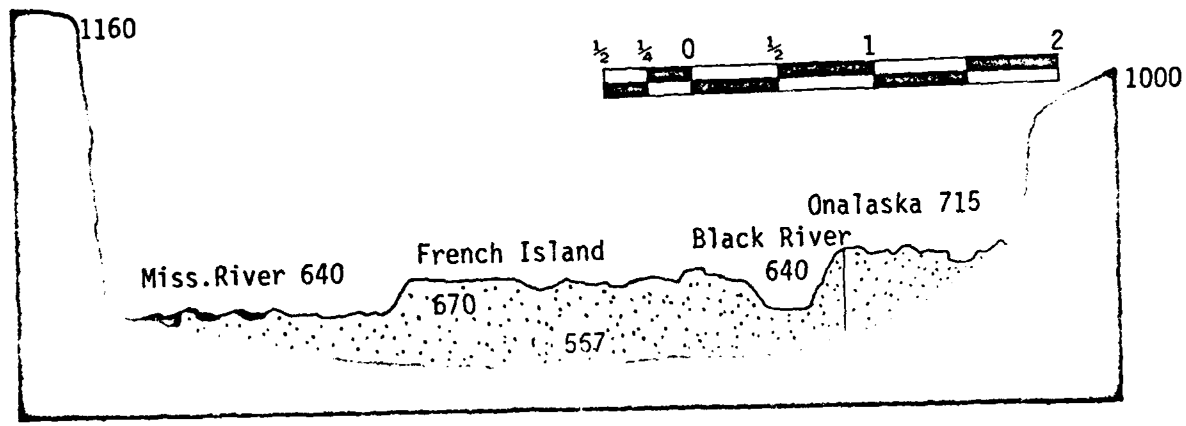
Whereas there are many descriptions of the geological events affecting the western Wisconsin and southeastern Minnesota, several specific events become important in the discussion of the formation of the Navigation Pools on the upper Mississippi. The area of Pool No. 7 was not glaciated and is thus located in the "Driftless" area, but the basin in this area was greatly affected by glacial activity. Pool 7, being located at the confluence of the Black and Mississippi Rivers, was subject to great flooding during the period of glacial melt. Subsequently many large terraces were formed.

These terraces do not usually occupy the whole width of the bottomland outside the actual channel of the river. One notable exception to this however, is the Trempeleau terrace. (The LaCrosse terrace occupies approximately one-half of the width of the basin.) More frequently they are restricted to a narrow area at the bases of the bluffs. At La Crosse, the floodplain occupies the western side of the bottomland and there is no terrace at the base of the

Minnesota bluff, except in the valley mouth at LaCrescent. The present channel of the river is about half way between the bluffs. At the city of LaCrosse the terrace is bordered by a steep west facing scarp 30 feet high. The surface of the terrace rises less than 10 feet more in the city. It ends in a low, east facing scarp where the abandoned valley of the LaCrosse River lies within the terrace near the base of the Wisconsin bluff. The northern end of this terrace is cut into several parts between the LaCrosse River, the Black River and the French Slough on the Mississippi River. Whereas there is only one terrace preserved at LaCrosse, one of the lower of the Mississippi River series, there are three or four located north of Onalaska. The levels represented are 1. the 20-35 foot terrace of Brices Prairie, French Island, North LaCrosse, and Onalaska, 2. the 50 foot terrace east of North LaCrosse, and 3. the 80 foot terrace upon which rests Onalaska. Irregularities can be seen on this terrace due to sand dune formation. (Figure7).

These terraces provide a suitable place for people to settle and populate. However, outwash from these terraces tends to create uniformity in the floodplain by filling small channels. Since terraces are formed form relatively unstable materials, this tendency can be observed within the floodplain of the Mississippi River. Thus an elevation in water level of only a few feet has resulted in the inundation of thousands of acres of low land.

Figure 7. Profile of the Mississippi River gorge with terraces and elevations of the river bed at Lock and Dam No. 7, Dresbach, Minnesota.



Soils

The soils in the area of Pool 7 have been derived from a variety of parent materials. In a few places, particularly on the steep slopes in the Driftless areas, on the escarpments overlooking the Mississippi River, the soils are derived directly from weathering of the bedrock materials. In the majority of the watershed, however, the soils are derived from the covering materials. This is most commonly glacial till, but in some areas, alluvium and loess predominate. The weathering of this till, however, has taken place under a vegetative covering on one kind or another, and has resulted in the predominance of the following soil types:

Gray-Brown Podzolic soils, Brunizems, Bog soils, Alluvial soils and Regosols. The Podzolic soils consist of loess or alluvial silts, sand, weathered products of sand stone, or red clay. These soils have formed under deciduous trees in a temperate continental climate. The Brunizems have formed in a temperate humid-continental climate. under a cover of tall grasses. The Bog soils are represented in this area by muck and peat. This type of soil predominates on the lower edges of terraces in the river basins. Alluvial soils are forming from material recently deposited on floodplains. The Regosols are made up of deep soft mineral deposits in which few or no clearly expressed soil characteristics have developed.

The loess cap which covers the southern one half of the state, lies as a blanket over the other parent soil types and can be found as deep as 16 feet in some areas of the Mississippi River floodplain. Composed of silt size particles, it is uniform in distribution and chemical composition. Whereas one might expect to find different vegetational patterns in the driftless area because of exposure and weathering of ancient rocks, as opposed to glacial till, the loess cap provides a constant substrate of recent origin for vegetation to develop on, thus obscuring any effect of the original rock type (Figures 8 and 9).

Water Quality

Natural

The term natural water quality will be used to describe the natural, unaltered characteristics of the water received by navigation pool No. 7 from the Mississippi and Black Rivers; characteristics that are affected by geological and topological features of the watershed.

Since most of the watershed of the upper Mississippi River is forested, and the geological features in the uppermost portion of the watershed are extremely old Cambrial formations the water in this part of the river is quite soft. Total hardness rarely exceeds 175 mg/L in Navigation Pool No. 7 and does only where emergent ground water is concentrated in the pool. The alkalinity of the water varies slightly around 175 meq/L $CaCO_3$, and the water has a characteristic brown color, from organic substances leached from forest floor areas. Aeration processes maintain the disolved oxygen in excess of 60%

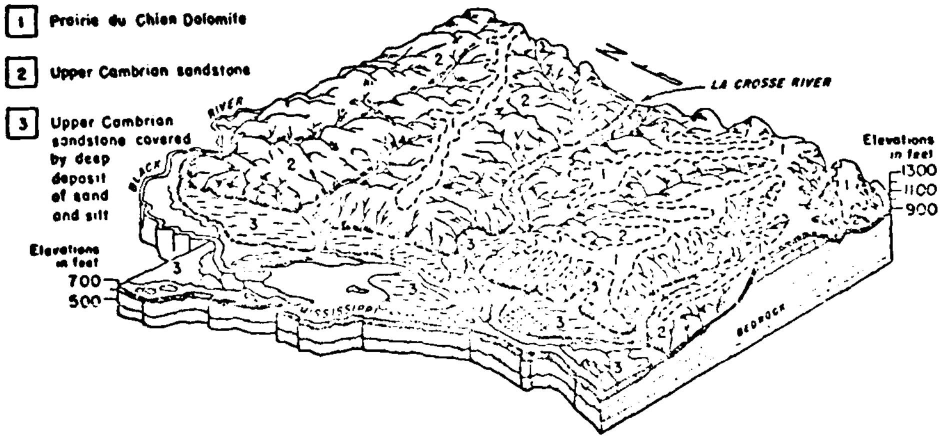


Figure 8. Dolomite and sandstone formations and covering material, with elevations, at the confluence of the Black, LaCrosse, and Mississippi Rivers.

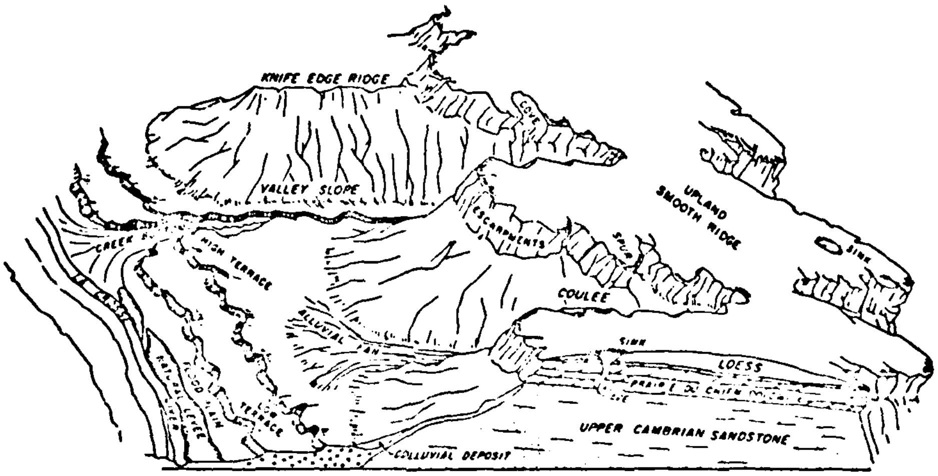


Figure 9. Topological and geological formations of the bluffs and the Mississippi River gorge floor at LaCrosse, Wisconsin.

saturation at all times. Whereas the water is not well buffered, the pH seldom varies from 7.5-7.8.

The water received form the Black River is essentially the same as upper Mississippi River water except that the color is more pronounced. This is because the Black River derives much of its water from the boggy areas in the old lowest portions of the geological Lake Wisconsin basin, which is rich in soluble organic material. A small percentage of the water in navigation pool #7 is derived from ground water emerging in the immediate vicinity. This water flows through limestone and sandstone aquifers and differs considerably from the surface derived water in the river. It is extremely hard (250-300 mg. L total hardness) and is well buffered (alkalinity ≈190-260 meq/L $CaCO_3$). This probably represents an insignificant addition to the water flow through the pool due to the large dilution with surface derived water. The turbidity of the water is quite low during most parts of the year (0-18 JTU). However during periods of high flow the turbidities increase considerably to a range of from 20-60 JTU.

Groundwater

The ground water table in the floodplain of the Mississippi River ranges from 10 to 30 feet, depending upon topography. This highly productive aquifer is open to and in direct connection with the Mississippi River. Groundwater from a maximum depth of approximately 100 feet is largely natural filtered river water and is of excellent quality. The water from depths below 100 feet is typically native groundwater for the LaCrosse area, is harder, and has an iron content of 0.1-1.0 mg./L. This water comes from Cambrian sandstone formations, and it appears that there are many layered aquifers in this formation.

Terrestrial Vegetation

The vegetation in the watershed adjacent to Navigation Pool No. 7 can be divided into two general groups; the upland xeric southern forests of Wisconsin and Minnesota, and the southern lowland vegetation of the floodplain.

The upland xeric forests are predominately oak forests. They are located on well drained sites on either sandy and porous flat lands, on south and west slopes of hills, or on thin soils on hilltops and ridges. In a study of 127 forest located south and somewhat west of the tension zone in Wisconsin (the southern 1/3 of Wisconsin including 80% of the Mississippi River bordering Wisconsin), 29 species of trees were found (Table A1). An analysis of the groundlayer species indicate that more than one half of the species are included in nine families. The Compositae comprise 10% of the total species in the dry mesic stands and ferns are dominant. Other families in the group of nine are the Gramineae, Ranunculaceae, Rosaceae, Umbelliferae, and Caprifoliaceae. (Table A2)

Lowland vegetation

The valley forests are commonly known as bottomland or floodplain forests and the lake border types are usually termed hardwood swamps. They are similar because the soil moisture supply is in excess of that falling as rain. The floodplain forests are present along all the rivers tributary to the Mississippi and on the Mississippi floodplain. The composition of the forest differs greatly from the upland forests and groundlayers. (Table A3). Of the 37 species listed, 21 were found in the initial or wet segment and 36 in the intermediate wet mesic segment. The lowland forest thus have more species of trees than any other community in the area. In large part this is due to a number of species of southern derivation which have progressed northward in river valleys. These include the buckeye, (Aesculus glabra), the honey locust (Gleditsia triacanthos), the sycamore (Platanus occidentalis), and the river birch (Betula nigra). The average values tend to obscure the fact that several different combinations of species are included within the wet segment. In the pioneer sites along sand bars, mud flats and other open places of recent soil disturbance the usual forest is dominated by black willow (Salix nigra) and cottonwood (Populus deltoides). On open sites near the upland edge of the wet ground, river birch or swamp oak (Quercus bicolor) are the usual dominants. As both of these types mature, they are invaded by silver maple (Acer saccharinum) and American Elm (Ulmus americana). The moist forests, particularly the riverine stands, tend to have a high total basal area per acre, with an average of 14, 300 square inches per acre. This is due to the large size of the trees rather than high densities. This can be substantiated by examining the size of the stumps remaining from the timber clearing activities in the navigation pool areas prior to inundation.

The prevalent groundlayer species of the lowland forest are reported in Table A4. The floristic homogeneities as shown by the ratio of prevalent species sum of presence to total species sum of presence are low. Analysis of the total flora reveal that the same seven families include 50% of the total species. The main change in family representation as compared to the upland forests, is the prominent role of the sedge and mint families and the increase importance of the nettle and carrot families. The low values of average presence for the prevalent species of the wet stands are an indication fo the great variation to be found from stand to stand. This is due to the frequency of flooding.

Succession

The pioneer stages of the lowland forests occur on two differnet sites. Toward the rivers edge on wet newly deposited banks, conditions are favorable for the establishment of cottonwood and willows. As these mature they tend to be replaced by the silver maple and American elm in the absence of further distrubance by the river. Toward the upper side of the floodplain soil conditions are more stable and favor the invasion by the river birch or the swamp white oak.

Aquatic Vegetation

The composition of the aquatic vegetation communities prior to navigation lock and dam construction is virtually unrecorded. However, based on data available for similar communities at these latitudes and the vicinity of Navigation Pool No. 7 a probable species list of the most important plants by occurrence can be constructed. Tables A5 and A6 list the most impartant species for similar communities. The percent occurence shown are not for the Mississippi River Basin but are for similar community situations in Western Wisconsin (Curtis, 1971).

Algae

Members of all classes and virtually all common orders of algae are found in the water of navigation pool No. 7 (Table A7) (Cary, 1972).

Total population fluctuations in the Mississippi River are similar to those found in smaller streams and generally are similar to those found in lakes located that these latitudes. (Figure 8). Whereas these data describe the present situation, data prior to the construction of locks and dams are unavailable. However, there is no reason to conclude that the general patterns were not similar.

The construciton of locks and dams probable has an indirect effect on phytoplankton populations, in that new habitats were created and are conducive for the growth of certain species. Nutrient

Figure 8. Annual fluctuations of total phytoplankton populations in Navigation Pool No. 7, 1971.

cycles were probably altered in some areas, and presumably have an effect on the population responses of certain species. This will be discussed in the impact section.

Wildlife

There are many wildlife species that provide hunting and trapping in the upper Mississippi River Basin (Table A8). Of the huntable species, the white tailed deer is the most popular big game animal. Small game mammals that are hunted include the gray squirrel and the cottontail rabbit. The majority of the hunting however, is for migratory waterfowl. The Mississippi Flyway provides a suitable habitat for in-route migratory rest areas, and in locally nesting species, marshalling areas during pre-migratory periods. Not only does the area of Navigation Pool #7 provide these areas for north-south migratory corridors for mallards, pintail, gadwall and teal, but is situated such that it lies in the east-west corridors utilized by canvasbacks and redheads.

Whereas, the principal goose migratory corridors lie east and west of the upper Mississippi River basin in southwestern Wisconsin, there is quite extensive use of these areas, particularly by snow geese (Figure 9).

Fish

Commercial and sport fishing have been popular on the Mississippi River for the entire period of history of man's development of the river basin. The river has long been a source of fish flesh for man. (Table A9)

Statistics of commercial fish catches have been recorded for navigation pool No. 7 since 1953. The data indicate that during the period from 1953 to the present, the catch per unit effort and the total

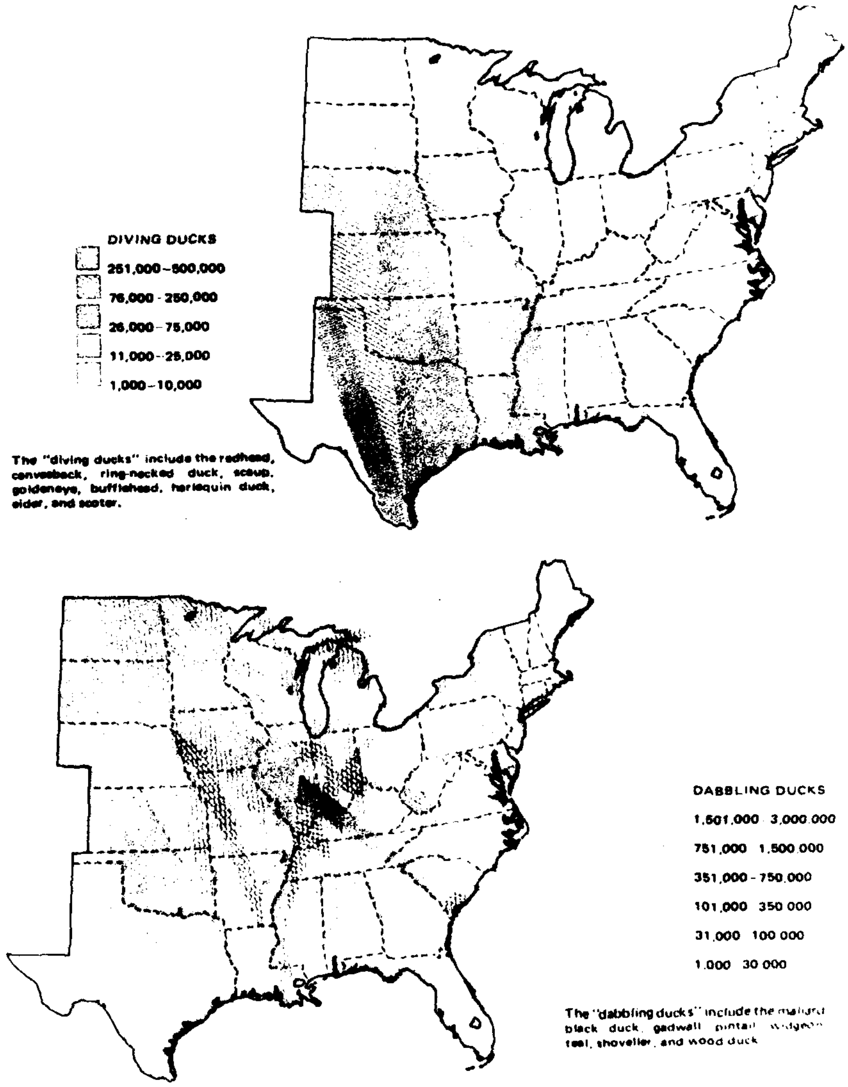


Figure 9. Migratory corridors of major species groups of waterfowl in the Mississippi River flyway (from Comp. Basin Rept).

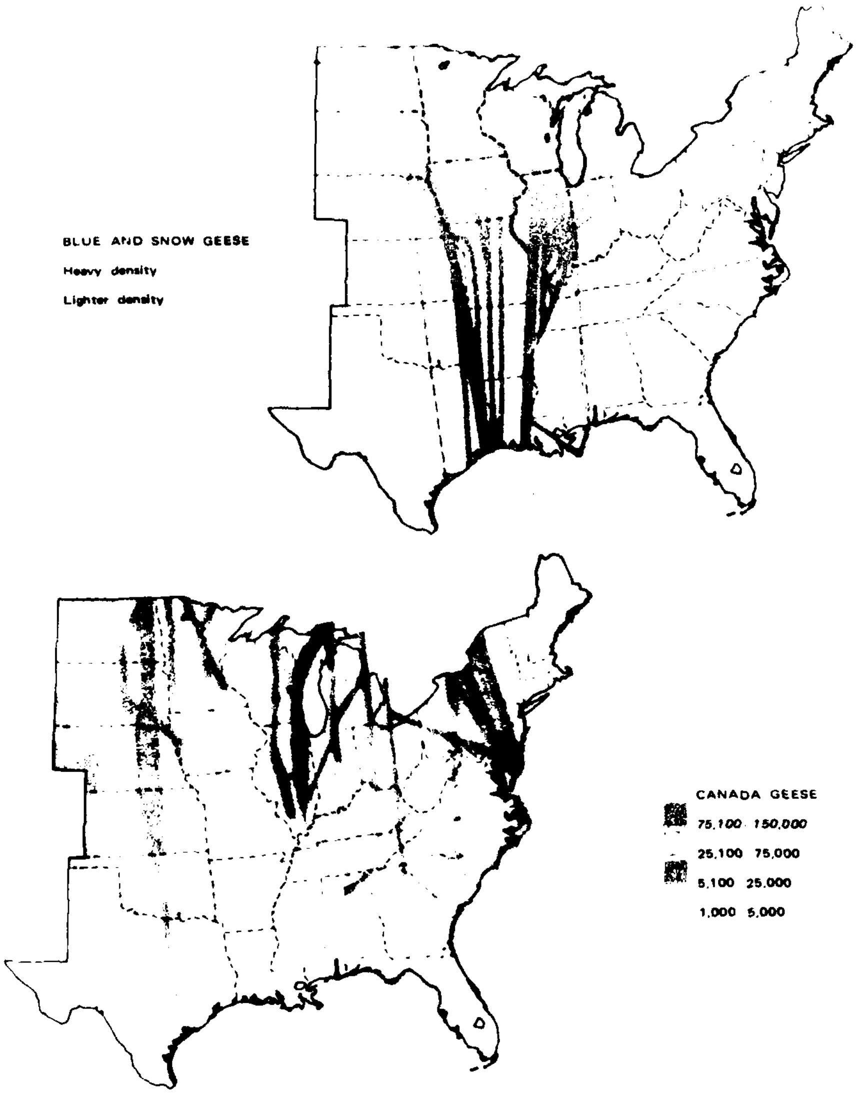


Figure 9. Continued...

catch in pounds for Pool 7 has increased steadily. (Table A9). Fluctuations in the data are probably due to local conditions during periods of high water, and presumably reflect the accessability of the waters for fishermen. The highest single recorded catch in Navigation Pool 7 occurred in 1970 with a total catch of 820,816 pounds. This was also the year with the highest combined catch per unit effort for all year types. The data indicates that a trend exists with increased total poundage caught and increased catch per unit effort. The possible causes of this will be discussed in a later section of this statement. (Figure 10).

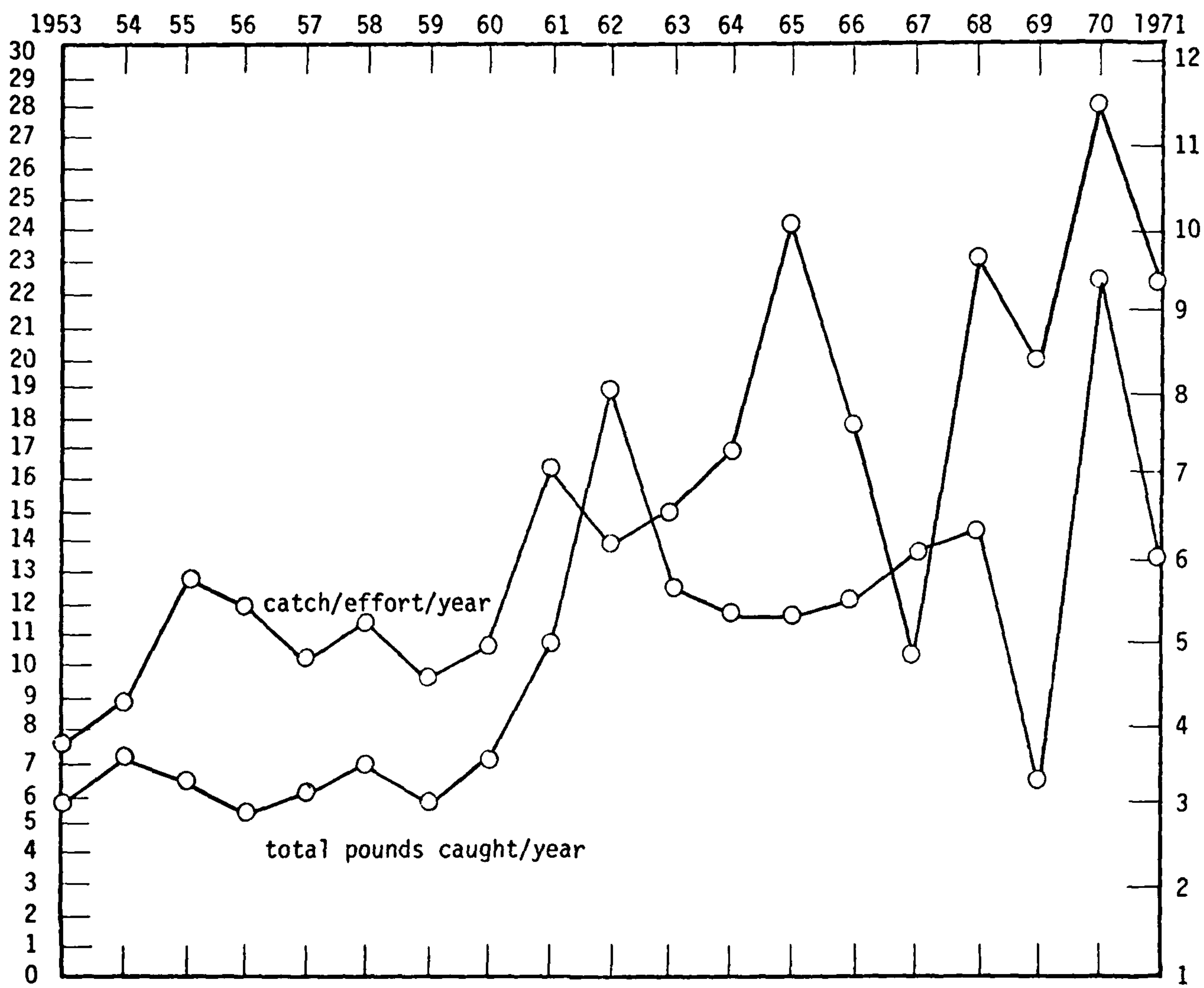


Figure 10. Total catch per unit effort, commercial species of fish, and total no. pounds caught per year, Nav. Pool 7, 1953-1971

SOCIOECONOMIC SETTING

The socioeconomic aspects of the environmental setting are discussed (1) by identifying the three-way subdivision of socioeconomic activities used in this report and (2) by presenting an overview of these activities in Pool 7 as they also relate to the Northern Section of the Upper Mississippi River.

Three Subdivisions of Socioeconomic Activities

It is useful to divide a discussion of the socioeconomic setting of the study area of the Upper Mississippi River into (1) industrial activity, (2) recreational activity, and (3) cultural considerations.

Industrial Activity

Industrial activity includes agricultural, manufacturing, transportation, and related pursuits that affect employment and income in the study area directly; this includes employment on farms, in barge operations, commercial dock facilities, lock and dam operations, and commerical fishing. While it is probably most desirable to measure industrial activity in terms of jobs or dollars generated, lack of available data makes this impossible in the present study. As a result indices of this industrial activity -- such as tons of commodities moved, industrial facilities constructed, or pounds of fish caught -- are generally used.

Recreational Activity

Recreational activity has two effects of interest. One is the psychological value to the users themselves of being near or on the Mississippi River for leisure activities. A second effect is the impact of the recreational activity on employment and income. Recreational activity is more indirect in its effect on employment and income than is industrial activity and relates mainly to leisure-time activities of people using the Mississippi River for recreational purposes; examples include boating, sport fishing, hunting, sightseeing, camping, and picnicking. Recreational activities frequently use units of measurement like number of boaters or fishermen using a lake or river, fishing licenses sold, or visitor-days. It is often very difficult to find such measures for a particular pool on the Mississippi River. Where such data are available -- such as pleasure boat lockages -- they are used. Where they are not available -- such as fishermen using a specific pool -- proxy measurements are used; for example, number of sport fishermen observed annually by lock and dam attendants are taken as a measure of fishing activity in the pools -- even though this is not as precise a measure as desired. Problems involved with placing dollar values on these recreational activities are discussed in Section 6.

Cultural Considerations

Cultural consideration are the third component of the socio-economic setting. These considerations include three kinds of sites of value to society: archaeological sites, historic sites, and comtemporary sites. These sites can include such diverse physical assets as burial mounds, historical battlegrounds or buildings, or existing settlements of ethnic groups such as Amish communities. Because of the difficulty of placing any kind of value on such sites, they are simply inventoried in the present study.

Overview of Socioeconomic Activities in the Study Area

The industrial, recreational, and cultural aspects of Pool 7 are discussed below in relation to the entire Northern Section of the Upper Mississippi River to provide a background with which to analyze the impact of operating and maintaining the nine-foot channel in Section 3 of this report.

Industrial Activity

The existence of the Mississippi River and its tributaries has had a profound effect on the industrial development of the American Middle West. It has served as a route of easy access for transportation and communication tying together the industrialized East with the agricultural Middle West as well as the varied economies of the North and South.

Historical Development of the Waterway. The development of the Northern Section of the Upper Mississippi as a waterway for shipment has paralleled the rise of the American economy, keeping pace with the need to move bulk raw materials and heavy, high-volume commodities over the wide geographical areas served by the river network. This has allowed barge transportation to remain competitive with other forms of transportation. It is noteworthy that competing systems of land transportation such as railroads and highway trucking utilize the relatively gentle river valley terrain in order to simplify both engineering design and fuel energy demands. Thus, the Mississippi River Valley is intensively utilized to meet the transprotation needs of the Midwest.

Long before the coming of the first white settlers, the Mississippi River was a transportation corridor for the Indians. It was used to facilitate the primitive barter economy and as a route for other forms of social and cultural communication and contact.

In its primitive condition, the Upper Mississippi was characterized by numerous rapids and rock obstructions. Fluctuations in water flow during various seasons of the year were minor inconveniences to the Indian canoe, but demanded modification before substantial commercial use of the river could take place. Prior to improvements, such traffic was limited to periods of high water when log rafts and small boats sould pass between the Falls of St. Anthony and the mouth of the Ohio River.

The necessity of modifying the natural course of the river to make it suitable for commercial navigation gradually became apparent as the size of the river boats and barges grew. Since the first river steamboat arrived at Fort Snelling in 1823 and steamboat transportation for freight and passenger use grew to a peak in the decade 1850 to 1860 when over 1000 steamboats were active on the entire length of the river. By 1880 the growth of the railroad system in the U.S. and the lack of a channel of sufficient depth marked a decline in the use of the river for transportation. However, on the upper reaches of the Mississippi, growth in freight traffic continued. A peak was reached in 1903 with 4.5 million tons moved between St. Paul and the mouth of the Missouri River. A subsequent rapid decline coincided with a drop in river use for moving logs and lumber. In 1916 only 0.5 million tons were shipped on this section of the river.

As the population and industry of the Upper Midwest region grew, there was a corresponding growth in the need for cheap coal for power generation. A technological consequence of this need was the development of the barge and towboat which gradually replaced the steamboat on the river. The barge and towboat required a deeper channel than the earlier steamboats. The need for coal in the upper Midwest was complemented by the need to ship large quantities of grain south to other centers of population. Thus, economies were realized by having at least partially compensating cargoes going both directions on the upper reaches of the river. In the later 1920's large grain shipments from Minneapolis began.

Although 4½-foot and 6-foot channels had been authorized in recognition of the increasing role of the river in the transportation network of the U. S., technological developments in barges and tugs led to the authorization of a 9-foot channel to Minneapolis in 1930. By 1940 the channel and the requisite locks and dams were essentially complete.

When figures for tonnages shipped at various times on the Mississippi River are examined, it is difficult to make comparisons that relate to Corps activities. For example, the following factors complicate the problem of data analysis during the period prior to 1940:

1. Statistical data collected by the Corps of Engineers covered different segments of the Upper Mississippi River during these years. Some of the reasons for this appear to be changes in the administration of river segments during that time, as well as some experimentation with better methods of statistical collection.

2. Shipping in the Upper Mississippi was distorted during the decade of the 1930's due to the construction of locks and dams in the St. Paul District.

3. From 1941 to 1945 all forms of transportation were utilized for the war effort without regard to maximizing economic return. Therefore, data for these years (as with the 1930's) does not necessarily reflect a normal period of transportation on the Upper Mississippi.

Barge Shipments. Table 1 - shows tonnage information available for selected years from 1920 through 1945 for the river segment identified in the third column of the table.

Table 1: River Shipment from 1920 through 1945

Year	Total Tonnage (short tons) Shipments and Receipts*	River Segment
1920	630,951	Mpls. to Mouth of Missouri River
1925	908,005	Mpls. to Mouth of Missouri River
1926	691,637	Mpls. to Mouth of Missouri River
1927	715,110	Mpls. to Mouth of Missouri River
1928	21,632	Mpls. to Mouth of Wisconsin River
1929	1,390,262	Mpls. to Mouth of Ohio River
1930	1,395,855	Mpls. to Mouth of Ohio River
1935	188,613	St. Paul District
1940	1,097,971	St. Paul District
1945	1,263,993	St. Paul District

*Tonnages exclude ferry freight (cars and other) and certain cargoes-transit.

Source: Annual Report of the Chief of Engineers, U. S. Army, Part 2 "Commercial Statistics: Table , by selected year.

In more recent years, data are available for the St. Paul District. Table 2 - shows the movement of tonnages through the St. Paul District for the years from 1962 through 1971.

Table 2:

Year	Total Traffic St. Paul District*
1962	8,168,594
1963	9,266,361
1964	9,621,336
1965	9,205,538
1966	11,346,457
1967	11,618,849
1968	10,736,350
1969	12,647,428
1970	15,423,713
1971	15,070,082
1972**	16,361,174

Sources:
*Comparative Statement of Barge Traffic on Mississippi River and Tributaries in St. Paul District, U. S. Army Engineer District, St. Paul, St. Paul, Minnesota
**Estimated

When this table is compared with the previous one, the growth of shipping on the Upper Mississippi becomes readily apparent. Thus, the total traffic for the St. Paul District in 1962 was about six times the traffic in 1945, which was a war year. In fact, traffic in the St. Paul District for 1962 was more than five times greater than all of the traffic on the Upper Mississippi between Minneapolis and the Mouth of the Ohio River in 1930. Traffic about doubled in the St. Paul District between 1962 and 1971. This was due to a large degree to grain shipments from the District and to an increase in receipts of coal.

In 1928 data was collected on receipts and shipments for the river segment from Minneapolis to the mouth of the Wisconsin River. This approximates the navigable segment of the Upper Mississippi within the St. Paul District, and the data for this segment can be equated with data for the St. Paul District with little difficulty. In that year, 21,600 ton were received and shipped. By 1940, tonnages handled reached 1,000,000 tons annually, when the lock and dam system and the 9-foot channel were virtually complete. Tonnages reached 2,000,000 by 1946, and 3,000,000 by 1953. By 1962 over 8,000,000 tons were shipped and received in the St. Paul District. In the decade between 1962 and 1972 this had doubled to 16,000,000 tons.

Table 3 - shows the number of trips made on the Mississippi between Minneapolis and the mouth of the Missouri River in 1971.

River Trips in 1971

Transportation Mode	Upbound	Downbound
Self Propelled		
Passenger and dry cargo	1,900	1,875
Tanker	3	2
Towboat or Tugboat	8,433	8,419
Non-Self Propelled (barge)		
Dry cargo	25,250	25,237
Tanker	7,312	7,311
Total	42,898	42,844

Source: Waterborne Commerce of the United States Calendar Year 1971, Part 2; Department of the Army U. S. Corps of Engineers, p. 165.

Pool 7 contains no commercial docks, however, so that it serves only as a thoroughfare for the river traffic shown in Table between the river south of Pool 7 and the Twin Cities. An indication of the "thoroughfare" function that Pool 9 provides for barge traffic in the study are the commercial lockages through all locks in the Northern Section that is shown in Figure 11 . These also provide another indication of the recent increase in barge traffic. From 1960 to 1972 the number of lockages in the portion of the River between Lock and Dam 2 and Lock and Dam 10 increased by about 600, commercial lockages through Lock and Dam increased by about 1100, the increase that was also present in Pool 9 during the period -- about twice the level of adjacent locks and dams.

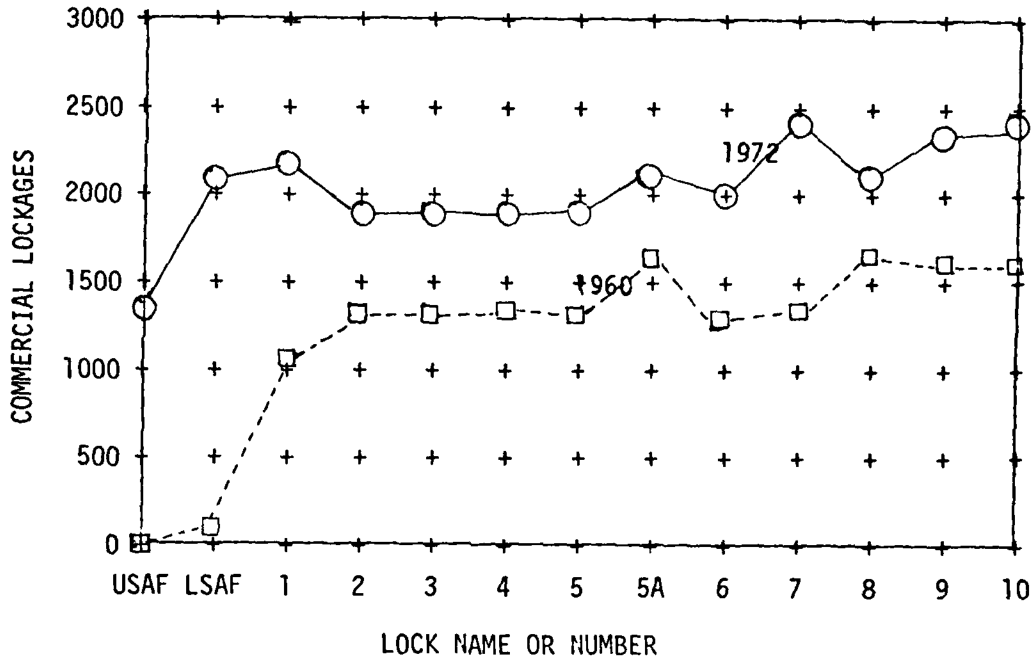


Figure 11. Commercial lockages 1960, 1972; all locks Upper River Segment

Recreational Activity

In addition to the industrial activity described above, the Northern Section of the Upper Mississippi River has provided innumerable recreational opportunities for the entire region it serves. Even prior to Congressional authorization of the 4½-foot channel in 1878 -- the first comprehensive project on the Upper Mississippi, from the mouth of the Ohio River to St. Paul -- settlers used the river extensively. The Upper Mississippi provided settlers the opportunity to boat, fish, hunt, and sightsee. However, the need for these settlers to carve out an existence in the Minnesota wilderness of the early nineteenth century meant that recreational uses of the upper River were few. Thus, boating then was not for recreational purposes; it was essential for the settlers' continuing existence to move people and supplies to where they were needed. Similarly hunting and fishing were not for sport; they provided the food needed to feed the settlers' families; surplus fish or game were sold or traded for other necessities required for daily living.

As the twentieth century dawned, leisure time accompanying the settlers' higher standard of living led to recreational uses for the Upper Mississippi River. Segregating present-day recreational uses of the study area due to Corps' operations from those existing in 1930, prior to the 9-foot channel, presents problems. These arise because of the difficulty of isolating the increased recreational uses of the river caused by more people in the region, higher standards of living, and increased leisure from those caused by improved navigational and other recreational opportunities.

A significant portion of the recreational activity on the Upper Mississippi is due (1) to the improved navigation opportunities for large pleasure craft on the river, and (2) to improved fish and game habitat resulting from higher water levels in the river. The potential for improved fishing and hunting is not always realized because increased industrialization along the river has polluted the river and has reduced the available hunting areas, which often more than offset the increased habitat.

Boating Activity and Related Facilities. As noted above, much of the increased boating in the study area of the river -- and virtually all of it for the deeper-draft pleasure boats -- is made possible by the improved navigational opportunities provided by the system of locks and dams. Figure 1? - illustrates the dramatic growth in pleasure boating in the study area from 1960 to 1972. The figure shows that number of pleasure boats moving through each lock in the study area increased by an average of about 1,500 boats during the twelve-year period. It can be seen that the number of pleasure boats moving through Lock 6 and 7, those at each end of Pool 7, increased by about the average for the District during this period.

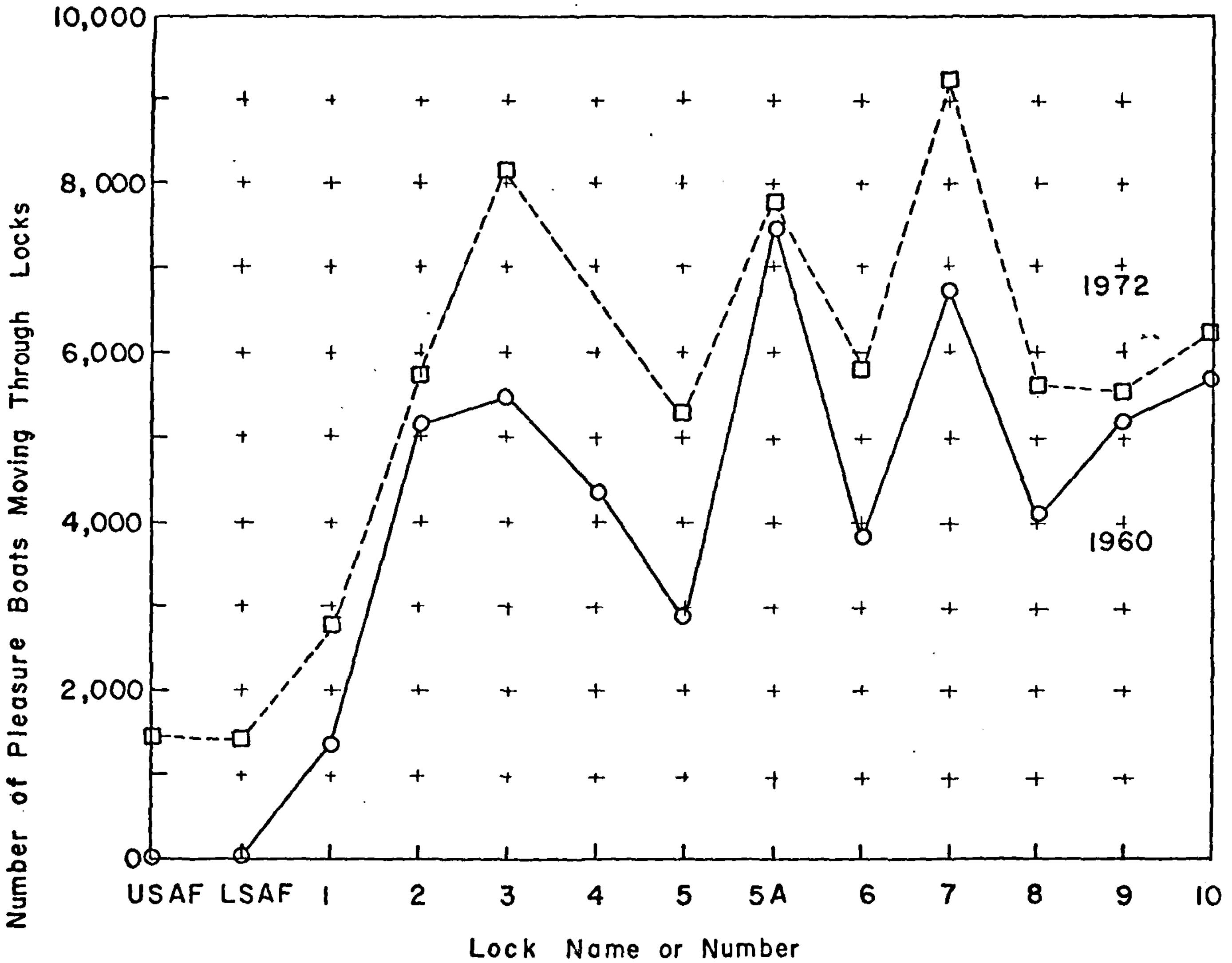


Figure 12. Lockages, Pleasure Craft 1960, 1972; all locks Upper River Segment

Sport Fishing and Hunting. Precise measures of the number of sport fishermen using each specific pool in the study area are not available. Perhaps the only comparable data for all pools are the number of sport fishermen observed annually by attendants at lock and dam sites. Attendants to each lock and dam observe the river pool areas above and below their site at 3:00 p.m. each day and record the number of sport fishermen seen; the annual data are simply a sum of these daily estimates.

The number of sport fishermen observed by attendants at each lock and dam in the study area are shown in Figure 13 for the years 1960 and 1970. There has been little change during the ten-year period of the number of sport fishermen observed. Because fish tend to seek water with a high concentration of dissolved oxygen and the dams tend to aerate the water, the bulk of the sport fishermen tabulated in Figure 13 are probably in the pool downstream from the lock and dam cited on the horizontal axis of the figure. The figure shows that in 1970 slightly over 5,000 fishermen were observed form Lock and Dam 6, most of them fishing in Pool 7.

Sport fishery survey data for two years, 1962-63 and 1967-68, are also available for Pool 7. These are summarized in Table 4 and show that the number of fish caught in Pool 7 declined by about 40 percent from 1962-63 to 1967-68. A portion of the decline in the sport catch during the period is related to the 20 percent decline in fishing trips observed in Pool 7 during the period.

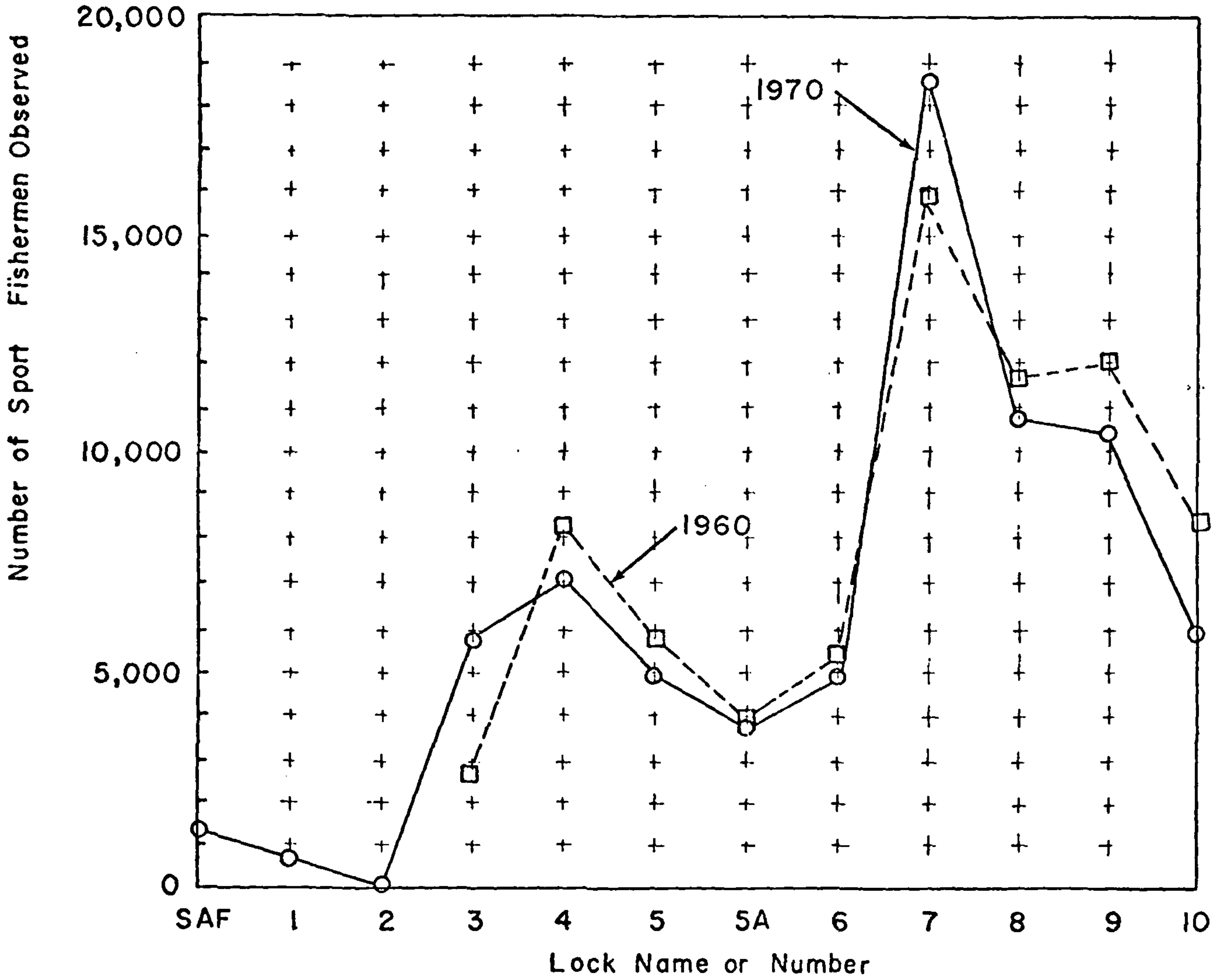


Figure 13. Number of Sport Fishermen observed at locks in 1960 and 1970; Upper River Segment

Table 4: Results of Two Sport Fishery Surveys on Pool 7, 1962-63 and 1967-68.

Measure of Comparison	1962-63	1967-68
Projected number of fishing hours annually	308,741	233,973
Percent breakdown of fishing hours:		
a. Boat	48%	36%
b. Bank	18	10
c. Barge	6	6
d. Ice	28	48
Total	100%	100%
Percent breakdown of fish cheifly sought		
a. Bluegill, crappie, and sunfish	78%	40%
b. Walleye and sauger	15	17
c. Largemouth bass	5	5
d. Other	2	2
Total	100%	100%
Projected breakdown of fish caught annually (in fish)		
a. Bluegill, crappie, and sunfish	354,000 fish	182,000 fish
b. Walleye and sauger	14,000	21,000
c. Largemouth bass	14,000	14,000
d. Other	63,000	42,000
Total	445,000 fish	259,000 fish
Catch rates (Fish caught per man-hour)		
a. Boat	1.333	0.750
b. Bank	1.318	0.817
c. Barge	0.637	0.496
d. Ice	1.896	1.444
Annual Average	1.441	1.105
Estimated annual recreational value:		
a. Fishing trips	79,030	63,238
b. Value at $1.50 per trip	$118,545	$94,857

Sources: The 1962-63 data are from Robert C. Nord, The 1962-63 Sport Fishery Survey of the Upper Mississippi River (LaCrosse, Wisconsin: Upper Mississippi Conservation Committee; October 6, 1964). The 1967-68 data are from Kenneth J. Wright, The 1967-68 Sport Fishery Survey of the Upper Mississippi River (LaCrosse, Wisconsin: Upper Mississippi Conservation Committee; October 1, 1970).

Sport hunting of waterfowl along the Mississippi River study area is large. It is estimated that in 1963, the year for which the most presice data is available, hunters made about 6,400 visits to Pool 7. The LaCrosse District of the Upper Mississippi River Wildlife and Fish Refuge (which covers both Pools 7 and 8) estimates that for the ten years from 1961 to 1970 an average of 26,800 hunters in the District bagged an average of 49,750 waterfowl annually.

Sightseeing and Picnicking. Studies in general indicate that a body of water is often essential for most recreation activities. People want this water not only to boat on or to fish or swim in, but also simply to look at, picnic beside, and walk along. The study area of the Upper Mississippi has served this purpose for settlers for two centuries. Again, because precise data is lacking, it is generally difficult to isolate the effect of Corps' operations on recreational activities such as sightseeing, picnicking, and hiking. To assist sightseers, the Corps of Engineers operates eight overlooks at locks and dams in the study area. In addition, a variety of parks exist along the river that are available for sightseeing and other recreational activities.

Cultural Considerations

A number of archaeological, historical, and contemporary sites exist in the study area. No such sites in Pool 7 are known to have been affected by operations of the Corps of Engineers.

<u>Commercial Fishing and Trapping</u>. As population along the Northern Section of the Mississippi River increased, industrial specialization also took place. The result was the development and growth of commercial fishing and trapping along the Upper Mississippi in the last half of the nineteenth century and during the twentieth century.

Limited data is available on the extent of commercial fishing and trapping prior to 1930. However, the rise in the water level behind the newly-constructed locks and dams in the Upper Mississippi River after 1930 increased marsh development and provided more fish and fur-animal habitat over that existing prior to the construction.

Data on commercial fishing in the 1960's in the pools in the study area are shown in Figure 14 . In 1969 the Northern Section of the Upper Mississippi River produced about 5.5 million pounds of fish that were sold commercially; this was an increase of about 9 percent from the 1960 total. The commercial value of the fish caught in 1969 was about $400,000.

Trapping data has been collected for the past three decades by the Upper Mississippi River Wildlife and Fish Refuge, which is managed by the Bureau of Sport Fisheries and Wildlife of the U.S. Department of the Interior. This refuge was established by Congress in 1924 and runs for 284 miles along the Upper Mississippi River from about Wabasha, Minnesota, to above Rock Island, Illinois -- or from approximately Lock and Dam 4 to Lock and Dam 13. Between 1940 and 1970 an average of 748 trappers per year obtained trapping permits. Between 1940 and 1970 25,000 beavers and

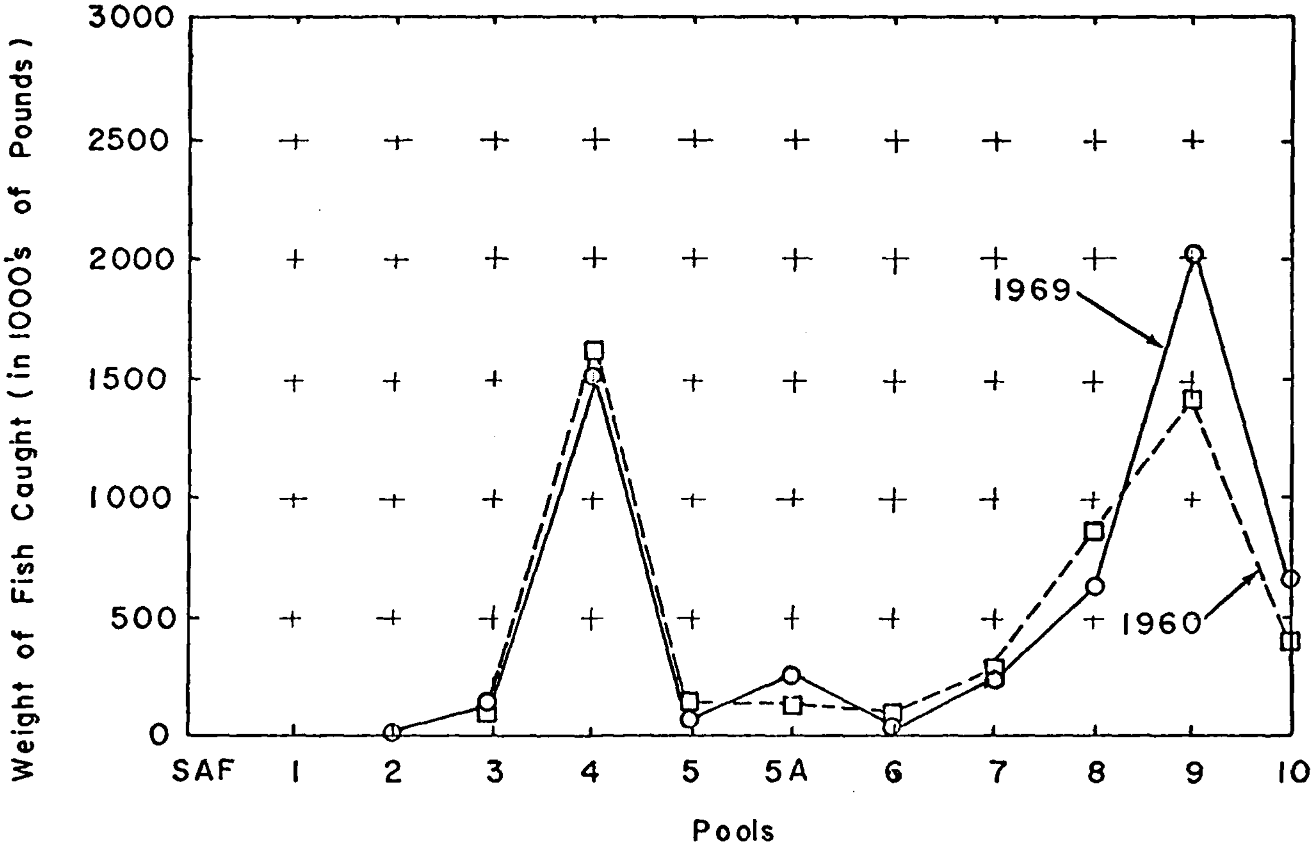


Figure 14. Weight (pounds) of fish caught by commercial methods; all pools Upper River Segment

over 2.25 million muskrats were trapped whose furs averaged nearly $100,000 annually (Green, 1970). By the 1971-72 season, the price of muskrat pelts was over $1.00 and the annual harvest was valued at about $200,000.

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3. ENVIRONMENTAL IMPACT OF THE PROJECT

INTRODUCTION

The major changes in the river systems that have been effected by the Corps of Engineers with the construction of the 9-foot navigation channel are as follows:

1. The construction of a dam across the Mississippi and Black Rivers to elevate the Pool a total of 8-feet.

2. The construction of a 600-foot lock to accomodate the passage of commercial and recreational boats.

3. The construction of auxiliary structures to protect the shorelines adjacent to the channel, for the maintenance of a 9-foot channel.

4. Maintenance dredging in the navigation pool to maintain a minimum 9-foot deep channel.

Whereas the specific assignment of cause and effect with regard to impacts due to the above components of the project is difficult, the actual construction and subsequent raising of the water levels and maintenance dredging are probably responsible for the major changes in the pool area. Operation of the locks and dams has an impact upon the biological systems in the pools with regard to water level fluctuations during normal and high water flows, and will be discussed separately.

NATURAL SYSTEMS

Lock and Dam Construction

The closure of Lock and Dam #7 resulted in the immediate eight foot rise in water elevation upstream from the dam. The changes incurred by this elevation were profound, and resulted in large scale changes in the habitats within the area affected.

A comparative tabulation of the acreage of various habitats lost and gained are shown in Table 5 . These figures are derived from a planimetric comparison of the 1970 navigation charts and the circa 1930 flowage survey charts. The terminology on the flowage charts and the navigation charts was different and resulted in some slight problems in resolving the comparability of the habitats.

Consequently, a few of the categories were combined where doubt existed as to their nature of the habitat. An attempt was made, however, to measure the same areas. On both charts the rise in pool elevation expanded the area of main channel from 1471 acres to 3495 acres, an increase of 135% in area. The most striking change was the inundation and subsequent loss of approximately 10,000 acres of meadow and/or timber, and the resultant creation of 8,700 acres of open pool and related habitats. The impact of these changes is immeasurable but can be described simply as loss of terrestrial habitat and gain of shallow aquatic habitat. The low meadows that were inundated were not widely used by man. The areas that were four feet or more higher than normal river levels were occasionally used for cattle grazing where accessable. The forested areas were typical lowland forests as described in Section 2.

The closure of Dam No. 7 created a pool that is easily divisible into three portions:

1. the uppermost portion or tailwater area just downstream from dam No. 6;
2. the middle portion, typified by narrow parallel channels and islands;

1930		1970
1,471	MAIN CHANNEL	3,495
-0-	OPEN POOL	8,700
354	FEEDER CHANNEL	605
	RUNNING SLOUGH	783
137	CLOSED SLOUGH	
	POND	40
1,866	MARSH	-
10,149	MEADOW-TIMBER	-

Table 5. Acreages of ecotypes prior to and after closure of Dam No. 7. (determined planimetrically from Flowage Survey charts and Navigation Charts).

3. the lower portion or open pool (Lake Onalaska).

The latter portion of the pool accounts for the majority of the area of the total pool and includes most of the greatly affected areas of the original river floodplain prior to closure of Dam No. 7.

HYDROLOGY

The upper part of the pool is the least affected hydrologically. The water flows in this area are probably similar to those that occured prior to dam construction. The middle part of the pool was affected much more. Water levels displaced the lateral channels typical of the area.

The general ecotypes in this area have not changed drastically but have been displaced laterally. This is particularly true just upstream from and at the original point where the Black River makes its entrance into the Mississippi River floodplain. The most drastic changes in the pool area, however, can be seen in the lower or open pool (Lake Onalaska). Here the large stand of timber and the meadows that once predominated were completely inundated and remain so.

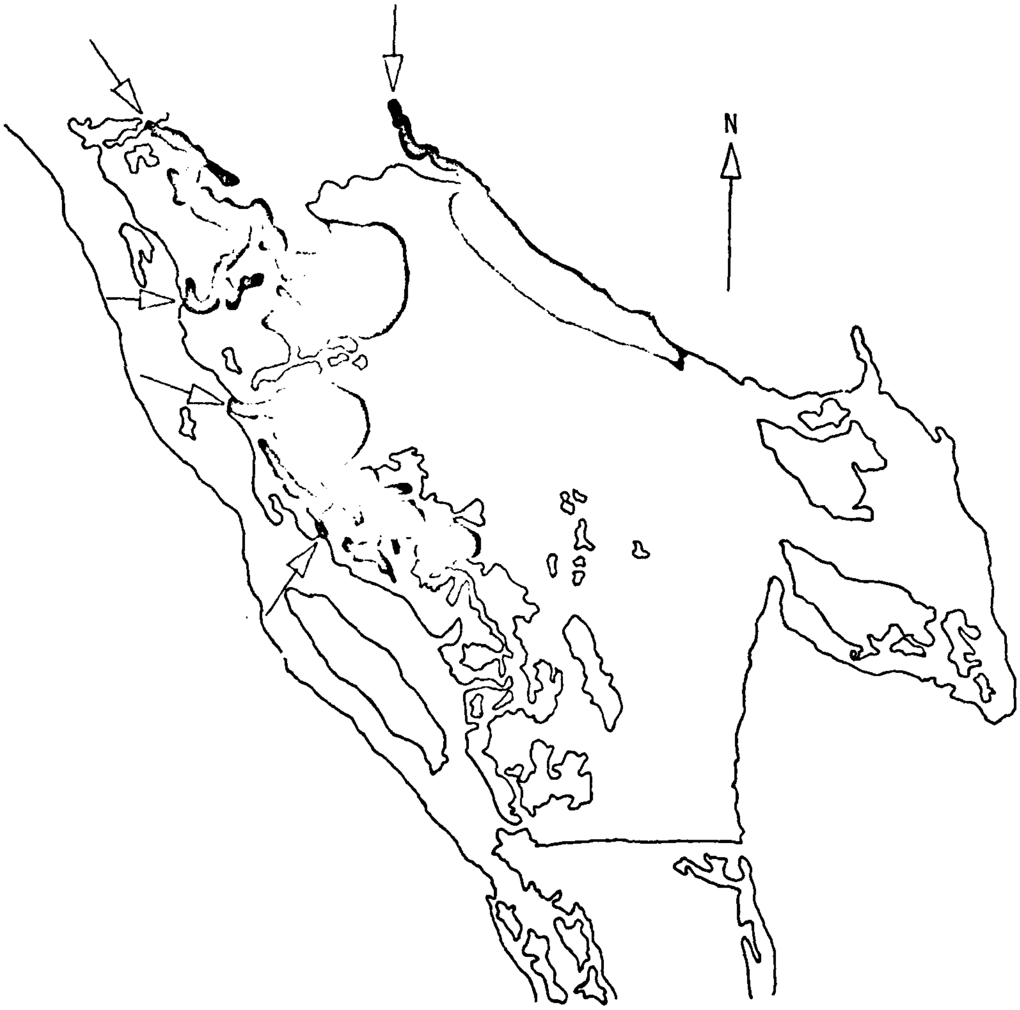
Hydrologically the flow patterns into Lake Onalaska are reduced due to the almost complete chain of islands separating the main body of the lake from the main channel of the Mississippi River. The Black River contributes its flow into upper Lake Onalaska, but the sum of both sources is not adequate to supply the lake basin with large quantities of water. The result is the presence of an actual lake that is hydrologically, chemically, and biologically similar to a natural lake basin. The influence of detectable water currents is restricted to a small area in the upstream portion of the lake basin (Figure 15). Rhodamine B released in the small feeder channels travelled a short distance in the pool. The data indicates that there is little or no current influence in the middle and lower parts of the Lake Onalaska during the periods of normal water levels. (Figure 15). However, water from the Black River is supplied to all parts of the pool, even though actual currents cannot be detected.

WATER QUALITY

The changes in water quality of Pool 7 are difficult to quantify due to the lack of baseline data.

The introduction of allochthonous nutrients has increased during the past seven years (Table A10). This increase can probably be extrapolated back to some normal level, prior to man's increased activities in the watershed. However, there is no available data for Navigation Pool 7. Probably as significant, however, are the internal changes that have occurred in the pool with regard to nutrient levels. With the formation of a lake situation due to closure of dam No. 7 follows the normal nutrient accumulation and cycling that typifies a eutrophic lake. Water chemistry data indicate that nitrogen and phosphate levels increase drastically in the autumn, corresponding with the autumnal turnover in the dimictic lake. A closer examination of the processes occurring in Lake Onalaska reveal that stratification does not occur and the nutrient releases coincide approximately with the

Figure 15. Dispersion patterns of Rhodamine B dye released at four points (arrows) after 12 hours. Navigation Pool No. 7, (upper Lake Onalaska), Summer, 1970, (Fluorometric determinations).



decay of vegetation in the pool. (Figure 16 & 17). Therefore, Navigation Pool No. 7 behaves like a lake and contributes nutrient materials to the river system. The ultimate fate of the nutrients is unknown, but they are probably incorporated into living systems in the downstream pools. Whereas, the nutrient data prior to dam closure is unavailable, it is assumed that the river system cycled nutrients in much the same fashion that open reaches of the river does at the present time. If this is true, the open pool areas that resemble lakes in many ways represent a totally new habitat type for the upper Mississippi River.

The data collected on the four transects in Navigation Pool No. 7 during the summer of 1973 appear to support this. The sampling sites on the transects were subgrouped according to their general ecological habitat type, whereas, the selection of the stations for subgrouping was somewhat subjective; depth, current velocity, sediment type, and distance from the main channel were used as criteria for classification in every case.

The means for each parameter within each subgroup on the transects were calculated. Analyses of variance were computed for each parameter within each subgroup. Significance in differences between means was calculated by computing the F-statistic. The 99% and 95% levels of significance were determined from the F-distribution table.

TRANSECT AA (River Mile 714.2)

Eight stations were located on this transect. They were divided into the following subgroups for statistical analysis:

1. Stations 1-4 (Backwater, Minnesota side)
2. Stations 5-8 (Channel)

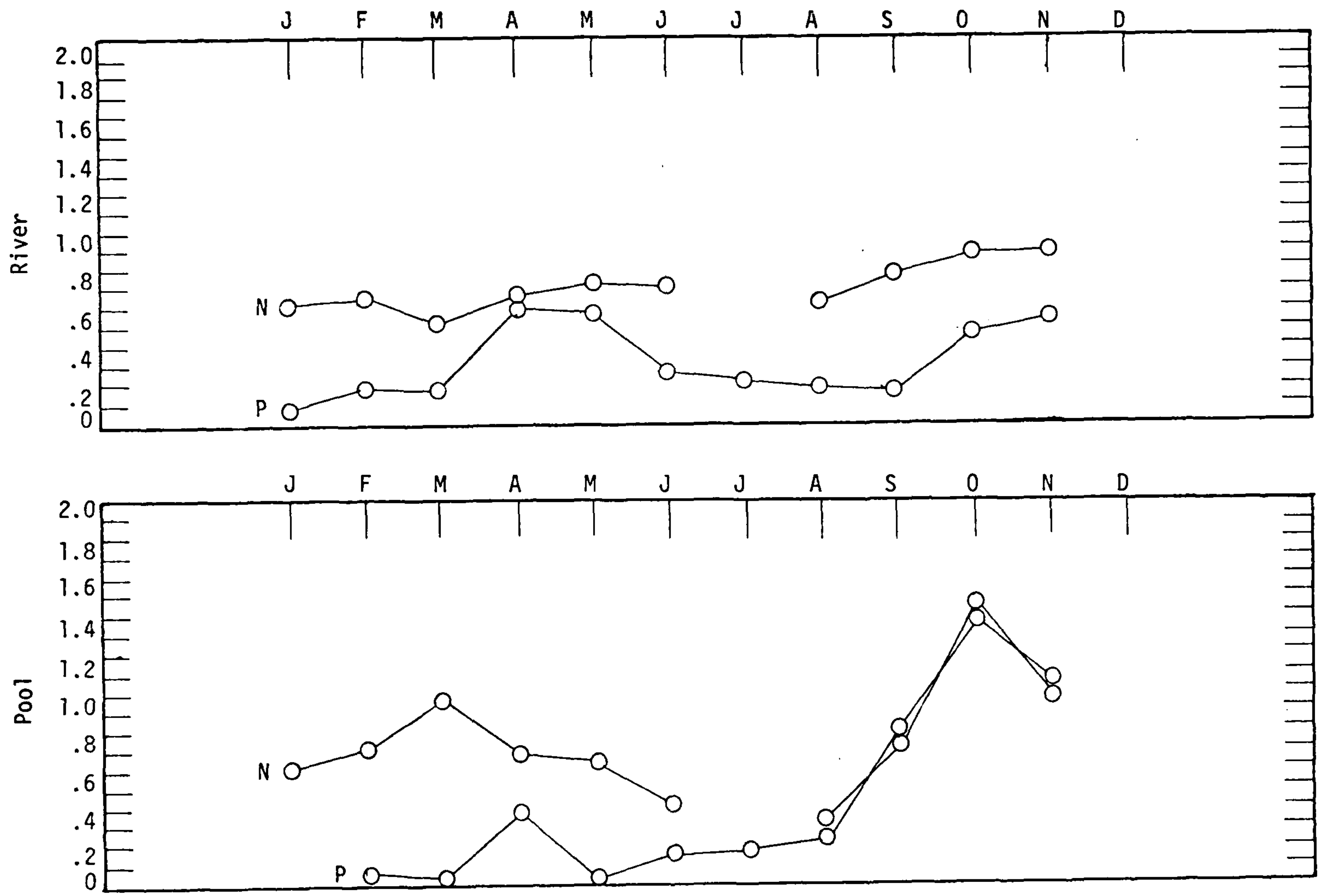


Figure 16. Nitrogen (NO_2, NO_3) and Phosphorus (total) levels, Navigation Pool No. 7 (pool) and in the main channel (river), 1967.

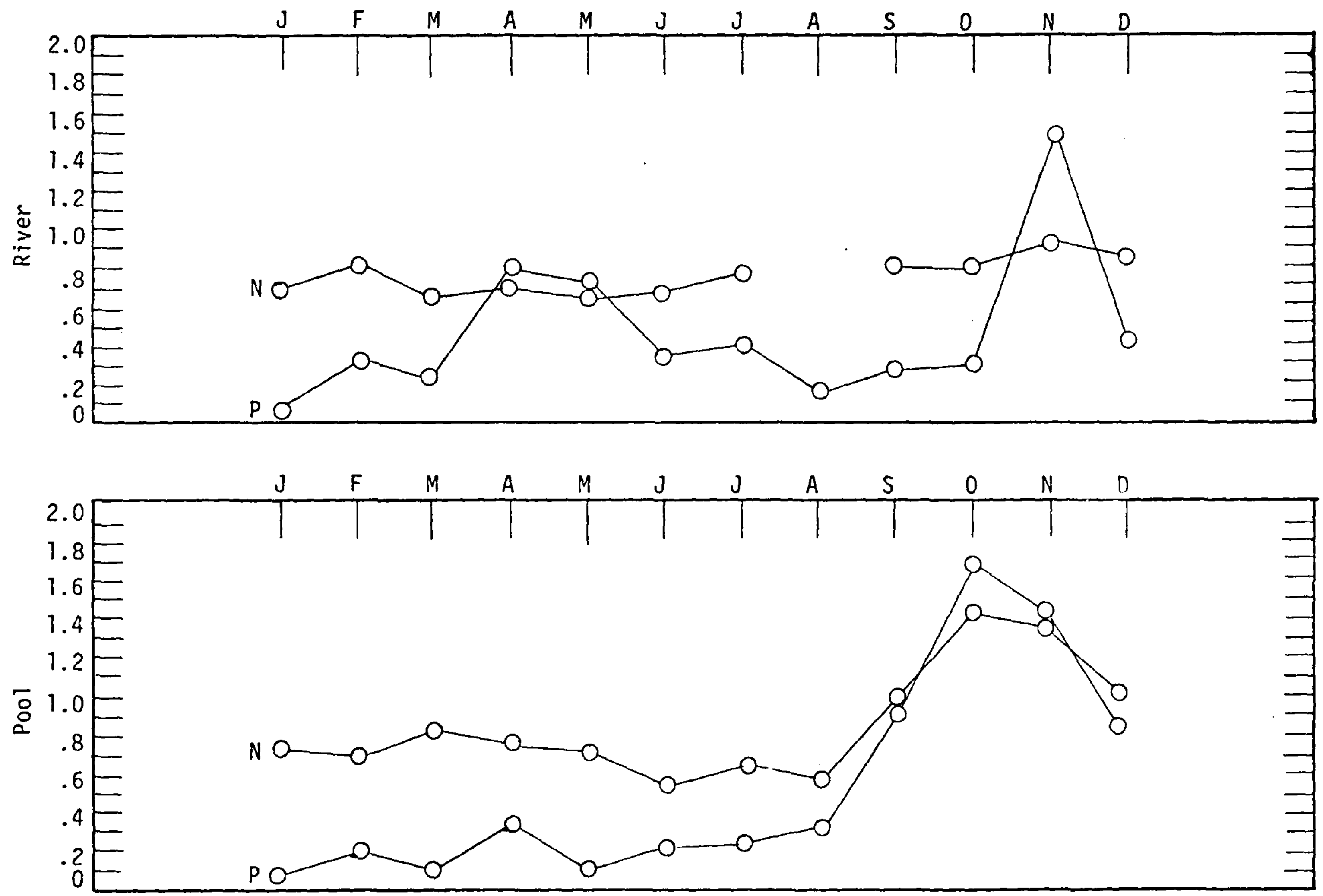


Figure 17. Nitrogen (NO_2, NO_3) and phosphorus (total) levels, Navigation Pool No. 7 (pool) and in the main channel (river), 1971.

Significant differences were noted between the turbidity, nitrate nitrogen, and dissolved oxygen in the two areas. (Table A11) The turbidity was slightly higher in the back water area which was not expected. However, water was passing over the spillway just upstream from the sampling stations below Dam No. 6, and probably accounted for this slight elevation. The nitrate nitrogen in the back water area was also higher than in the channel. This is probably a reflection of the total amount of biological activity occurring in the two areas. The nitrogen levels in the sediments of the back water areas are no doubt higher than in the channel and this material subsequently enters the column of water in these areas. The differences in dissolved oxygen were attributed to diurnal changes due to the differences in sampling times.

TRANSECT BB (River Mile 708.3)

The seventeen stations located along transect BB were subdivided into three groups:

1. Stations 1-5 (Channel)
2. Stations 6-11 (Running sloughs and Pools)
3. Stations 12-17 (Upper Black River channels)

There were few striking differences between the means of the parameters measured within these subgroups (Table A12). Significant differences were noted between temperature, conductivity, nitrate nitrogen, and nitrite nitrogen. Differences in temperature were attributed to diurnal differences due to sampling times during the day. The conductivity of the Black River water is characteristically higher than that of the Mississippi River and is indicated by the data. The nitrogen levels were significantly higher in the channel areas than along the remainder of the transect. This was the only instance where this occurred. All other transects demonstrated higher nutrient levels in the shallow pool areas. A plausible explanation at this time is tenuous. However, since the nitrite levels were also higher, it could be accounted for by the introduction of allochthonous nitrogenous material from a point source upstream. However, no data is available in this study to support this.

TRANSECT CC (River Mile 702.8)

Transect CC was established to sample the large open expanse of lower Lake Onalaska. The stations along this transect were divided into two groups:

1. Stations 1-12 (Open Pool)
2. Stations 13-17 (Channel)

There were few significant differences between the means of the parameters sampled in the channel and those collected in the open pool (Table A13). Differences were noted between the means of: temperature, turbidity, conductivity, nitrite nitrogen, and phosphate. The differences in temperature were attributed to diurnal differences due to the time of day of sampling. The higher conductivity in the pool again reflects in part, the source of water for the pool (Black River and associated group water supplies). The higher nitrite and phosphate levels in the middle portion of the pool reflects the release of these substances in the pool area. The phenomenon of nutrient release is common to the open navigation pools on the upper Mississippi River.

TRANSECT DD (River Mile 706.4)

This transect was established to sample the upper portion of the open pool area (Lake Onalaska). The sampling stations were divided into the following subgroups:

1. Stations 1-5 (Channel)
2. Stations 6-17 (Open Pool)
3. Stations 18-22 (Black River Backwaters)

Significant differences between the means of the parameters sampled were found in: turbidity, nitrate nitrogen, nitrite nitrogen, and orthophosphate (Table A14). The differences in turbidity at the stations along the transect were attributed to localized anomalies, and no ecological significance is placed on these deviations. However, where differences occurred between the means of nitrogen and phosphorus, the levels were always higher in the pool area. This is ecologically significant, in that a pattern appears to have been developed in Navigation Pool No. 7. Nutrient levels (nitrogen and phosphorus) were always higher in the areas of the pool exclusive of the channel, and no doubt, are a measure of the total amount of biological activity occurring there.

The data developed during the summer of 1973 concur with those data gathered during previous years. The new data appears to support the thesis that nutrient cycles with independent rates of uptake and release, are operating in the areas adjacent to the main channel system. This must be interpreted as a long term impact of the 9-foot channel project, as it is a measure of a trend of nutrient accumulation. There is no demonstrable reason why these phenomena of nutrient accumulation cannot be extrapolated into the future to possibly predict what the levels will be at some future date.

Sedimentation

The rates of sedimentation in the open pool portion of Navigation Pool No. & vary considerably from one part of the pool to another (Figure 18). Whereas, the rates of sedimentation are highest in the main channel lying lateral to the open pool, high sedimentation rates also occur in the upper part of the pool. The particles collected in the samplers in the channel area consist of fine to medium sand, whereas, the particulate material in the open pool consist of silt and clay size particles. From the data presented, the following conclusions can be drawn:

1. The main channel possesses an unstable bottom type, with sand moving steadily downstream. The source of the sand has not been determined at this time.

2. The highest sedimentation rates that occur in the open part of the pool (Lake Onalaska), occur at the upstream end of the pool. This is no doubt due to the reduction in current velocity in this area.

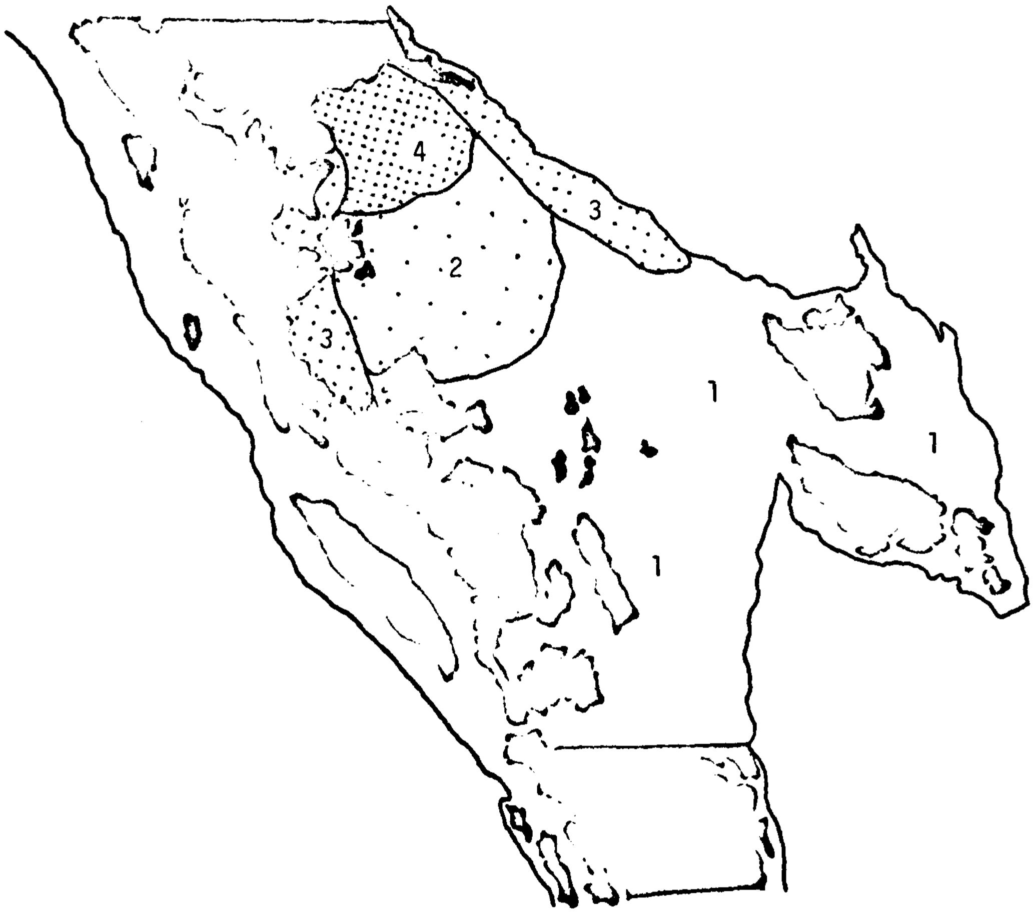
3. The particulate material being deposited in the upper part of the lake remains there for longer periods of time. The only mechanism for removal of this material is the scouring activity provided by occasional flooding.

4. Much of the material depositing in the open pool does in fact remain for long periods of time. A comparison of soundings recorded in 1969 and 1970 with the original topographic maps of the area indicate that the volume loss of Lake Onalaska is as high as 25-30% over a 26 year period.

5. The sediments accruing in Lake Onalaska support biological systems much better than do the unstable shifting sand bottoms of active channel areas.

Figure 18. Areas of high total sedimentation rates, Navigation Pool No. 7, 1969.

1. Low
2. Medium low
3. Medium high
4. High

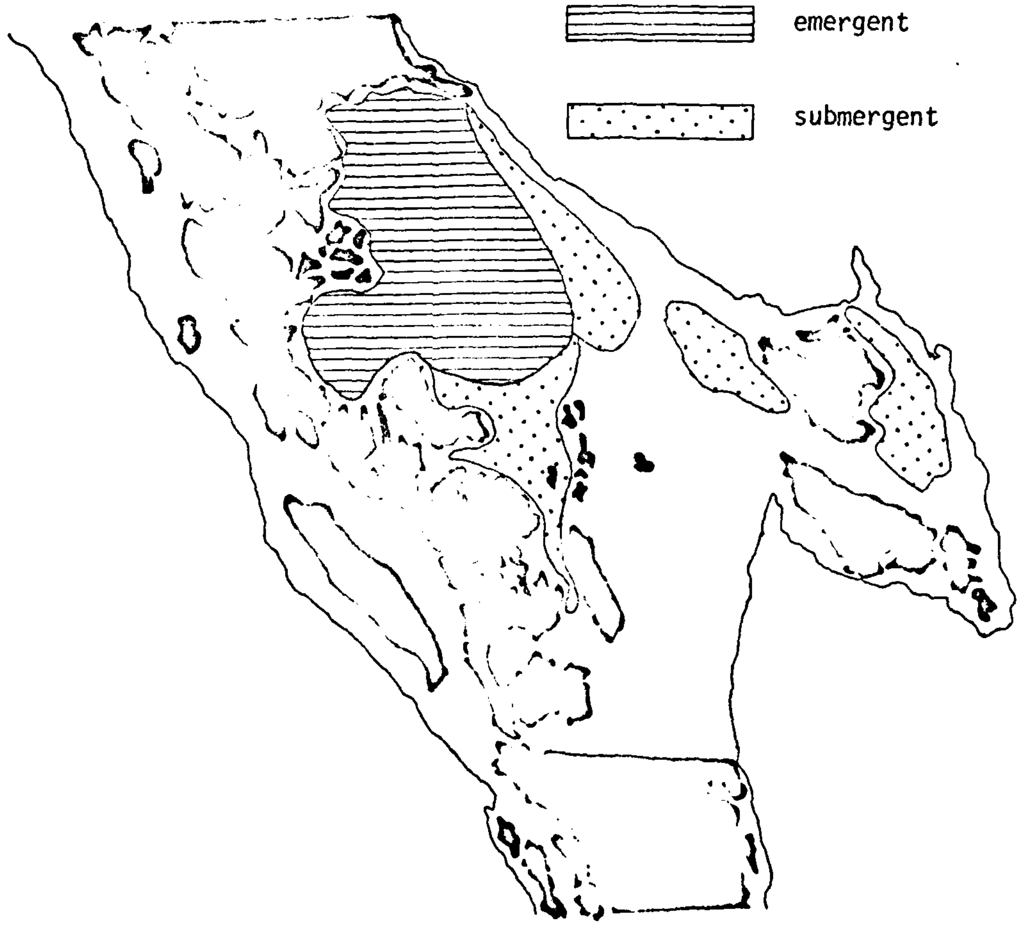


BIOLOGICAL

Acquatic Vegetation

It is unknown whether the inundation of bast areas due to closure of the Dam No. 7 effected the removal from or introduction of new species into the areas. The creation of new habitat did however create new areas to accomodate the growth of rooted aquatic vegetation. A comparison of the flowage survey charts to the present situation indicates that there is a new gain of approximately 4500 acres that are suitable for the growth of one or more species of aquatic vegetation (Figure 19). The areas east of Rosebud and Bell Islands also accomodate emergent rooted vegetation (Figure 19). The 1973 summer data confirm this. A separate discussion section on rooted vegetation follows inmediately.

Figure 19. Areas presently supporting emergent rooted vegetation, and submergent rooted vegetation, Navigation Pool No. 7 1970.



BOTANICAL SURVEY OF THE B TRANSECT, POOL 7

This survey attempts to characterize precisely the vascular flora of the B transects established by the River Studies Center of the University of Wisconsin-La Crosse on Pool 7 of the Mississippi River. The locations of the transects are shown in figure 3. I have personally identified all specimens collected. All specimens collected have been assigned collection numbers in the manner and fashion practiced by most professional taxonomists. A collection number refers to the specimens gathered from an individual plant. Obviously many duplicate specimens, all bearing the same number, can be gathered from a tree or shrub. The first set of all duplicate collections and all unicates are deposited in the herbarium of the University of Wisconsin-La Crosse, where they will vouch for the data reported here, as well as be utilized in continuing studies. All of the specimens retained have been appropriately mounted on standard 100% rag herbarium sheets. Duplicate sets of the collection will be distributed to other institutions to assure the saftey of the collection and maximize its potential value. The nomenclature utilized follows that of Hartley (1966).

METHODS AND MATERIALS

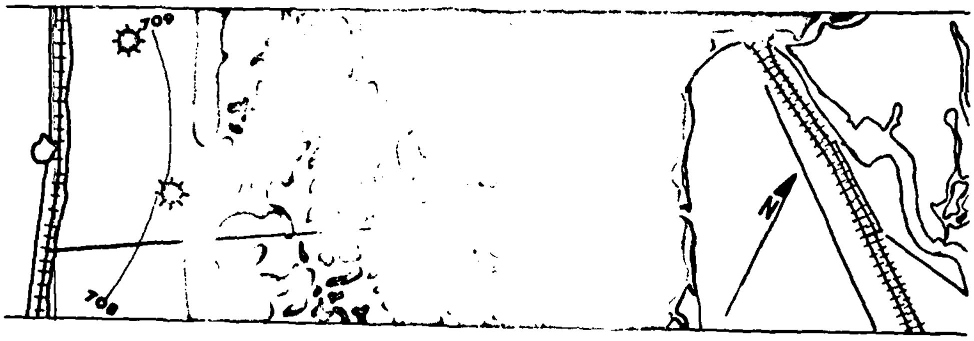
The transects were followed with the aid of a compass. The transect line was followed over open water with a canoe, and through marshes and alluvial forests on foot. The transects were visited during the early part of June and again in the middle of July. The rest of the summer was utilized to process the collections. There will thus obviously be some gaps in the report of late summer and fall flowering plants. All plants encountered within approximately 2-3 feet on either side of the transect line were collected. Notes were taken to record the plant associations encountered, for only representative specimens were collected from large monotypic assemblages, such as the frequencly encountered colonies of Sagittaria rigida, the arrowhead. Trees along the transect lines were marked with paint or colored pieces of plastic and can be revisited in the future. All islands or land masses falling under the transects were arbitrarily numbered beginning at the navigation channel and proceeding sequentially east on the Wisconsin side and west on the Minnesota side. Therefore, for example, the third island crossed by the transect line east of the channel is designated as "Wisconsin Island 3." Open water, sloughs, and marshes are identified as lying between islands or on one side or another of one of them. As the channel in Pool 7 is pressed against the Minnesota shore, there are no reports from "Minnesota Islands." The one Minnesota island crossed by the transect in Pool 8, and shown on the navigation map, has been worn away to a thin line with a few trees. This lack of conformity of the areas, as they existed during the summer of 1973 to what is shown on the maps occured frequently and probably testifies more to the rapidity with which changes are occuring on the River than to any negligence on the part of the map maker.

The results are reported for each transect seperately. In all cases the report will list the plants collected on the given island or body of water that is identified on the map that heads each listing. Each time a taxon is listed, the specimen which vouches for the presence of that taxon in that locality is cited. The citations are always numbers which refer to my collection. Although a taxon may have been collected many times in a given area, it is only listed once. However, all the collections of that taxon, made in that area are cited in each list.

It must be emphasized that this report represents the result of a rigorous and complete assessment of the vascular flora of the transects. This is not merely a phytosociological survey and, although it may be difficult for the non-taxonomist to appreciate the value of the labour involved in preparing the specimens, every single plant reported herein is vouched for in our herbarium. An exception to this is Toxicodendron rydbergii, the poison ivy, to which I demonstrate an acute reaction and therefore could not collect. However, its presence was always noted when encountered. I believe this report is a significant contribution to the knowledge of the vascular flora of the Mississippi in general and to the environmental impact statement into which this report will go in particular.

VASCULAR FLORA OF TRANSECT B, POOL 7

1. Minnesota Shore between the railroad tracks and the channel



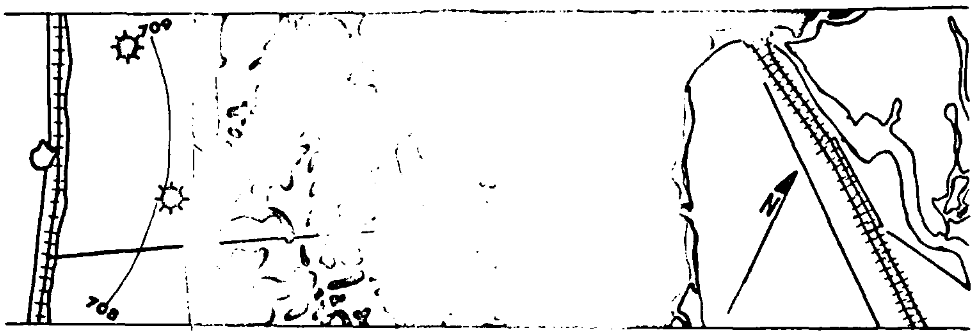
POOL 7 TRANSECT B

The following taxa were collected along the very steep slope traversed by the transect.

Taxon	Collection No.
TREES	
Fraxinus pennsylvanica Marsh.	7403
Juglans cinerea L.	7413
Rhus typhina L.	7414
Ulmus americana L.	7410
SHRUBS	
Rubus sp.	7404
VINES	
Parthenocissus quinquefolia (L.) Planch	7402
Vitis riparia Michx.	7411
HERBS	
Aquilegia canadensis L.	7405,7408
Ambrosia artemisiifolia L.	7409
Galium aparine L.	7417
Mirabilis myctaginea (Michx.) MacM.	7406

Taxon	Collection No.
Pilea pumila (L.) Gray	7401
Poa pratensis L.	7416,7418
Polygonatum canaliculatum (Muhl.) Pursh.	7400,7407
Ranunculus abortivus L.	7415
Thalictrum dasycarpum Fish. & Lall	7412

2. Wisconsin Island 1. Mature alluvial forest disturbed on west side by deposition of dredge spoil. Heavy undergrowth of Toxicodendron rydbergii, Laportea canadensis, and Polygonum virginianum.

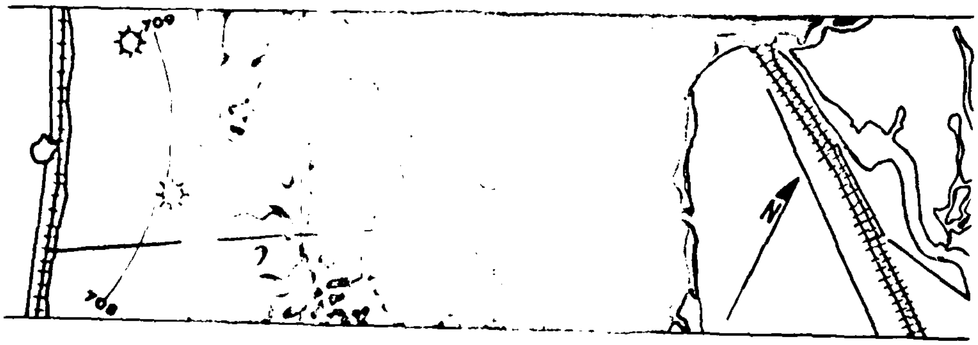


POOL 7 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7848,7849,7850
Betula nigra L.	7842
Carya cordiformis (Wang.) K. Koch	7844
Fraxinus pennsylvanica Marsh.	7838
Quercus bicolor Willd.	7820,7824
Salix interior Rowlee	7856
Salix rigida Muhl.	7855
Tilia americana L.	7816
Ulmus americana L.	7843
Zanthoxylem americanum Mill.	7845
SHRUBS	
Cephlanthus occidentalis L.	7817
Cornus obliqua Raf.	7851,7852

Taxon	Collection No.
HERBS	
Anemone canadensis L.	7826
Arisaema dracontium (L.) Schott	7840,7847
Boehmeria cylindrica (L.) S.W.	7837,7839
Carex tribuloides Wahlenb. (?)	7821
Circaea quadrisulcata (Maxim.) Franch. & Sav.	7822,7831,7833
Cirsium vulgare (Savi) Tenore	7853
Eleocharis obtusa (Willd.) Shultes	7834,7835,7854
Geum canadense Jacq.	7832
Laportea canadensis (L.) Wedd.	7836
Onoclea sensibilis L.	7815,7818,7819
Phalaris arundinacea L.	7841
Polygonum virginianum L.	7836
Ranunculus abortivus L.	7829
Smilacina stellata (L.) Desf.	7825
Thalictrum dioicum L.	7827

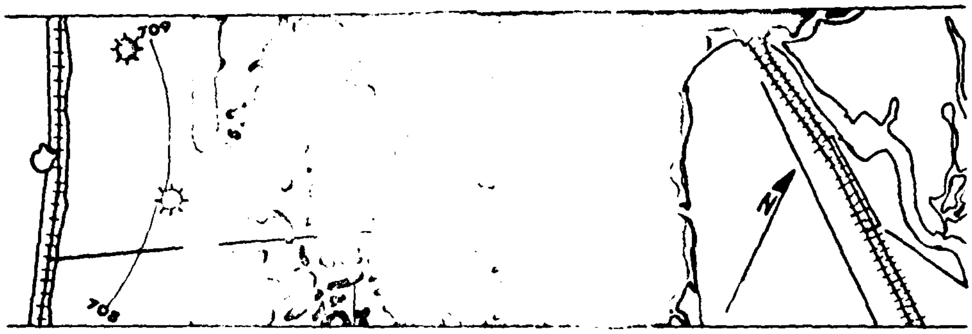
3. Water between Wisconsin Islands 1 & 3. Depths quite variable. Colonies of Sagittaria in shallows near shores.



POOL 7 TRANSECT B

Taxon	Collection No.
SUBMERGENT, AQUATIC PLANTS	
Ceratophyllum demersum L.	7877,7878,7879
Elodea canadensis Michx.	7881,7882
Heteranthera dubia (Jacq.) MacM.	7883,7884,7885
Nelumbo pentapetala (Walt.) Fern.	7864,7865
Nymphaea tuberosa Paine	7859
Potamogeton crispus L.	7880
Potamogeton foliosus Raf.	7870,7886
Potamogeton nodosus Poir.	7871,7872,7873 7874,7875,7876
Potamogeton zosteriformis Fernald	7887,7888
EMERGENT, MARSH PLANTS	
Phalaris arundinacea L.	7866,7868,7869
Scirpus validus Vahl.	7862,7863
Sagittaria latifolia Willd.	7857
Sagittaria rigida Pursh.	7858,7861

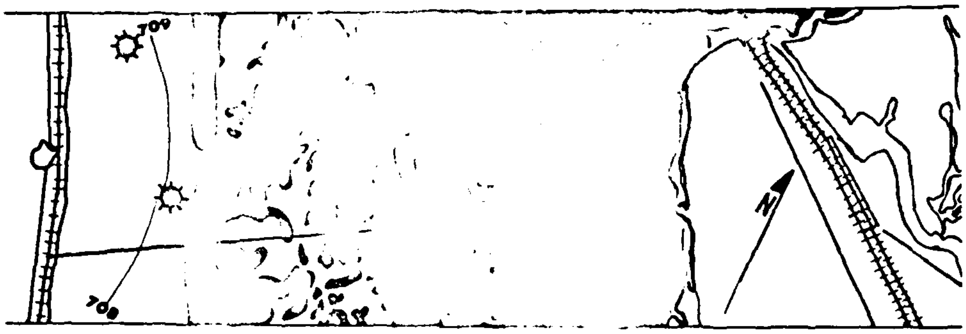
4. Water and Marsh west of Wisconsin Island 3.



POOL 7 TRANSECT B

Taxon	Collection No.
SUBMERGENT PLANTS	
Ceratophyllum demersum L.	7929
Potamogeton foliosus Raf.	7930
Potamogeton nodosus Poir.	7970
Potamogeton zosteriformis Fern.	7972
EMERGENT, MARSH PLANTS	
Sagittaria rigida Willd.	7968,7969
Sagittaria rigida forma fluitans (Engelm.) Fern.	7941
Scirpus fluviatilis (Torr.) Gray	7934,7948
Scirpus validus Vahl.	7951
Sparganium eurycarpum Engelm.	7950,7956

5. Wisconsin Islands 3 & 4. Mostly mature alluvial forest divided by a shallow slough. Dominant trees *Ulmus americana* and *Acer saccharinum*.

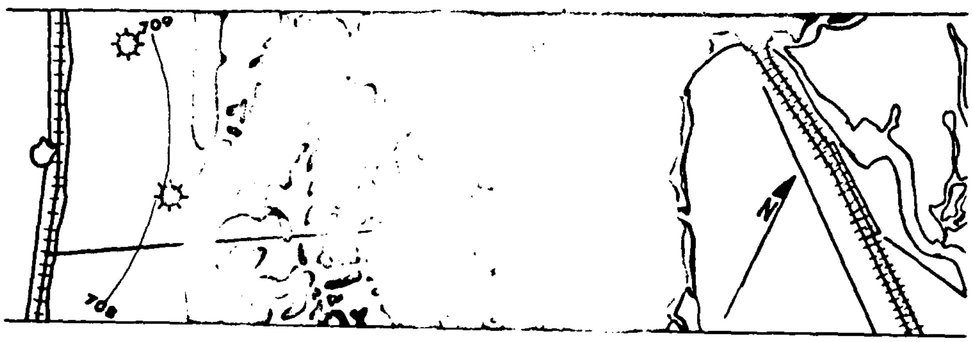


POOL 7 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7936,7962
Betula nigra L.	7914,7915
Fraxinus pennsylvanica Marsh	7938,7947,7954
Quercus bicolor Willd.	7921
Quercus bicolor Willd. x Michx.	7945
Salix interior Rowlee	7911
Salix rigida Muhl.	7913
Ulmus americana L.	7922,7955
SHRUBS	
Cephalanthus occidentalis L.	7924,7952
VINES	
Cuscuta sp.	7916
Smilax hispida Muhl.	7926

Taxon	Collection No.
HERBS	
Ambrosia trifida L.	7940
Asclepias incarnata L.	7920,7939,7957
Boehmeria cylindrica (L.) SW.	7964
Carex intumescens Rudge	7967
Carex scoparia Schk.	7918
Carex tribuloides Wahlenb. (?)	7933
Cicuta maculatum L.	7937
Impatiens pallida Nutt.	7912
Lysimachia nummularia L.	7953,7958,7959
Onoclea sensibilis L.	7960,7961
Phalaris arundinacea L.	7925,7927,7944
Polygonum arifolium L.	7928
Polygonum sagittatum L.	7935
Rumex verticillatus L.	7923,7965
Urtica dioica L.	7932

6. Land area 5. Marsh area east of Dodge Chute. Mostly Sagittaria latifolia and Phalaris arundinacea, with Sparganium eurycarpum abundant. Slightly elevated portions of are with Salix & Cephalanthus.



POOL 7 TRANSECT B

Taxon	Collection No.
TREES	
Salix lucida Muhl.	7998
SHRUBS	
Cephalanthus occidentalis L.	8002
EMERGENT, MARSH HERBS	
Phalaris arundinacea L.	7996,7997
Sagittaria latifolia Willd.	8003
Scirpus validus Vahl.	8001
Sparganium eurycarpum Engelm.	8000

7. Wisconsin Land area 6. Area east of a slough that is not depicted on map. Mostly mature alluvial forest with the vast majority of the trees Ulmus americana.

POOL 7 TRANSECT B

Taxon	Collection No.
TREES	
Acer saccharinum L.	7978
Fraxinus pennsylvanica Marsh.	7980,7984,7992
Salix lucida Muhl.	7979
Tilia americana L.	7975
Ulmus americana L.	7977,7982,7991
SHRUBS	
Cephalanthus occidentalis L.	7973
HERBS	
Ambrosia trifida L.	7993
Arisaema dracontium (L.) Schott	7987
Boehmeria cylindrica (L.) SW.	7981,7983
Cryptotaenia canadensis (L.) DC.	7989,7990
Equisetum arvense L.	7995
Laportea canadensis (L.) Wedd.	7974,7988
Onoclea sensibilis L.	7976
Phalaris arundinacea L.	7994

There are three major classifications vascular plant habitats utilized for this study. They are defined and limited by water depth and/or duration of flooding and are: 1) areas covered with flood waters during part of the growing season, at least on some years; 2) areas covered with several to many feet of water during flood stage but reduced to shallow water or wet soil later in the growing season; 3) areas covered with more than 6 to 12 inches of water at all times, except, perhaps in instances of drought. The vascular plant communities present in these habitats are broadly defined for this report as alluvial forest, marsh, and submergent aquatic respectively. Trees always indicate alluvial forest, emergent herbs, most commonly the arrowheads, indicate marsh, and submergent vascular plants, such as species of Potamogeton, and Ceratophyllum demersum, indicate the submergent communities.

ALLUVIAL FORESTS

None of the land areas traversed by the transects are free from flooding. Exceptions to this statement would be the steep Minnesota banks and those portions of the islands adjacent to the channel that are built up by the deposition of dredge spoil. There were a total of 15 such land areas or islands on the transects ranging in width from several feet to over a mile. The particular associations of woody plants found on these islands will vary somewhat depending upon how often the islands or land areas in question are flooded and how long the flooding lasts. This would evidently be related directly to the elevation of the land areas or islands in question. It has not been found profitable to seperate different associations of plants other than to state here that Betula nigra and Quercus bicolor appear to favor wetter situations and are relegated to the margins of alluvial islands once the soil has been built to a point where Ulmus americana and Acer saccharinum have invaded and become dominant.

The less often an island or land mass appeared to be flooded, judging from what was seen on the transects, the more diverse, relatively speaking, was the vascular flora. The greater the frequency and duration of inundation, the fewer the total number of taxa. Table A15 demonstrates the dominant members of the alluvial forest as determined by frequency of occurrence. This table, as all the others tha follow, was obtained by determining the frequency with which a particular species was found in that habitat on tha transects. Ulmus americana, for example, found at least once on 13 of the 15 alluvial islands or land masses crossed by the transects, is given the frequency index of .87. This is a very rough estimate of the frequency of occurrence of a particular species, but still, I believe, a very useful indicator. Tables A16, A17 and A18 give frequency values for alluvial forest shrubs, vines, and herbs respectively. This data is essentially the same manner of reporting this information as the present values of Curtis (1959).

MARSH

All emergent vegetation was defined as marsh vegetation. Indeed, the vegetation itself indicated the habitats herein defined as Marsh. This is vegetation that cannot withstand total submersion for relatively long periods of time, particularly not during the middle and later parts of the growing season, nor can it withstand relatively dry conditions for long. The most frequently encountered species in this habitat was Sagittaria rigida. Some shrubs are often found in marshes, as herein defined, on land masses slightly raised above the surrounding areas, in much the same manner as these taxa are often found as transitional between the marsh and the alluvial forest. These shrubs, such as Cephalanthus occidentalis and species of Cornus and Salix, were counted with the alluvial forest vegetation. Table A19 gives frequency data for the species found in this habitat.

SUBMERGENT AQUATIC

Ceratophyllum demersum, Elodea canadensis, and Potamogeton crispus were the most frequently encountered species in this habitat. This is clearly demonstrated in Table A20. Again, it is necessary to bear in mind that these figures represent gross frequencies only; they are in no way indicators of abundance at a particular site. Standing crop figures may be intirely different from these. It is interesting to note that one of the most frequently encountered members of this habitat, Potamogeton crispus, is not a native member of our flora. The original submergent flora of the undisturbed

Mississippi River and its natural pools must have been far different in terms of species composition.

Waterfowl

The utilization of the Navigation Pool by waterfowl for resting and feeding areas has increased since 1947. Not only does the open pool area provide a resting habitat suitable for many species of ducks, geese and swans, but the rooted vegetation located in these areas provides an ample food source for these birds. The utilization of rooted vegetation by waterfowl in Navigation Pool No. 7 has not be studied, but other studies indicate that many of the species of plants found in Pool 7 are readily used by waterfowl in other areas. Diving ducks such as redheads and canvasbacks can be found in the vegetation beds during their fall migratory flights. The inundation of the floodplain in this area has thus provided suitable resting habitat for migratory waterfowl.

Fish

The inundation of the floodplain above Lock and Dam No. 7 has had an impact on the commercial and sport fishing. The increase in the surface area of the river with little or no increase in the depth has increased productivity, at least at the first trophic level. It follows that the increase in energy traffic will pervade through the entire ecosystem. Commercial fish statistics seem to support this thesis. Data collected from 1953 to 1971 indicate that:

1. The total catch per unit effort Pool 7 has steadily increased from 1953 to the present.

2. The total number of pounds caught has increased in the same fashion. The maximum number of fish caught per unit effort was with set lines (Table A9).

The formation of the navigation pools has definitely provided more suitable places to fish as well as probably increased the productivity of the commercial species.

Sport Fishing

The construction of the Lock and Dam has provided the following for sport fishing:

1. Areas where fish congregate due to obstructing natural migratory movements of species such as the walleye and northern pike.

2. Suitable spawning areas for panfish species such as the bluegill, pumpkinseed, and largemouth bass because of the stimulation of growth of rooted vegetation.

It must be noted, however, that there have been detrimental effects to some species. The hinderances of natural spawning migratory movements has a direct effect upon production, since most species of fish will only spawn under very well defined circumstances. Maintenance of the channel by dredging also increases the turbidity and effectively creates an unstable bottom type which often destroys fish eggs or at least retards their development and subsequent hatching.

Benthic Organisms

The formation of Navigation Pool No. 7 has resulted in the following changes in the benthic type:

1. The creation of habitat conducive for the growth of rooted vegetation has resulted in accumulation of organic nutrients in the sediments.

2. The reduction in current velocity has resulted in the accumulation of silt and clay size particles in the benthos of the open pool.

3. The actual reduction in current velocity has provided suitable habitat for those organisms not specifically adapted for lotic environments and has provided a much more stable bottom type than can be found in active channel areas.

Differences in the main portion of the pool on Transect BB are notable (Figure 20). The highest standing crop measured in the channel was 0.1 g/m^2. However, the average standing crop in the pool area was almost ten times as great. Differences are due to the presence of rooted vegetation and to the presence of suitable organic substrate in these lateral areas. The increase in benthic standing crop in the pool areas is due to a general increase in the number of burrowing mayflies and molluces (see table A21 to A39 for species composition).

There was a corresponding increase in the standing crop of rooted vegetation along this transect. They range from zero in the channel to a high of approximately 600 g/m^2 in the pool area (Figure 20). The creation then of these pool areas has affected the total productivity of the river system in that the newly created areas are much more productive than the original unstable channel areas. (Table A40)

LOCK AND DAM OPERATION

Lock operations are carried out on a regular basis during the navigation season. The loss of water from the navigation pool for these operations is negligible. Operations of the dam on the other hand, are carried out to maintain a navigable depth downstream and have a definite effect upon the elevation of the pool.

The short term variations in pool elevation probably have little effect upon the established populations of organisms dwelling there. More importantly, however, the high discharges through dam No. 7 reflect

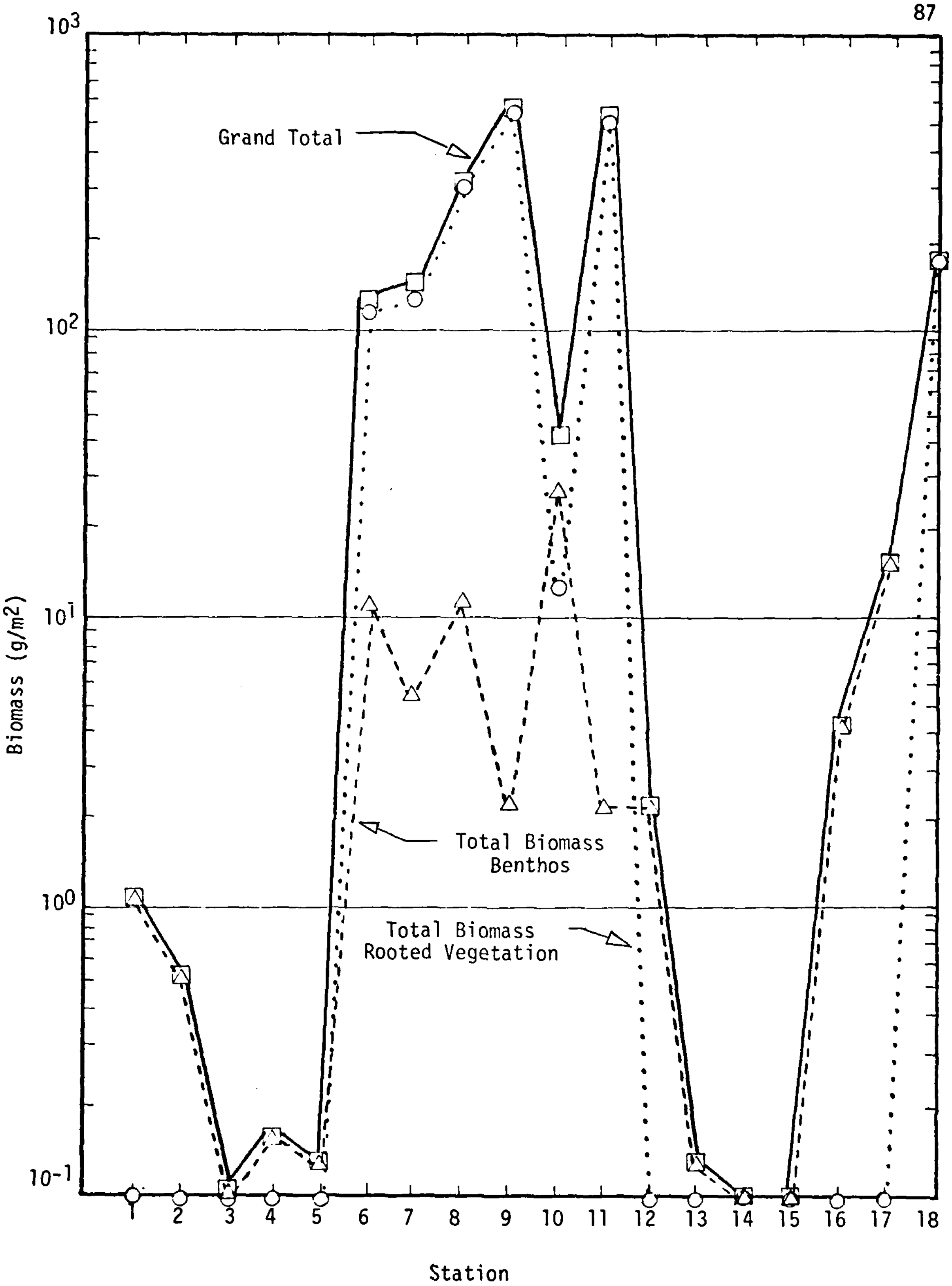


Figure 20. Biomass of benthos (g/m^2), rooted vegetation (g/m^2), and total; Transect BB, Pool No. 7, 1973.

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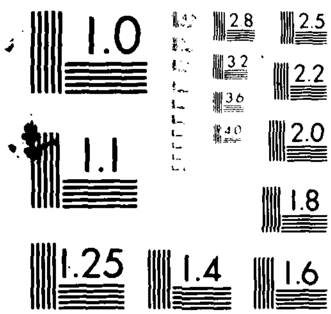

MICROCOPY RESOLUTION TEST CHART

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the upstream river discharge and therefore, the amount of water actually flowing into the open part of the pool and the backwaters in the upper reaches of the pool. The maximum one foot drawdown now being practiced minimizes the pool's fluctuations and thus minimizes the long term effects of fluctuations. The immediate effects upon fish movements and behavior may or may not be existent.

Maintenance of a low pool elevation during the entire growing season, on the other hand, does have the effect upon the communities growing in the pool.

During the summer of 1972, Lake Onalaska was maintained at a lower elevation for a sustained period of time to accomodate the repair of the Onalaska spillway. Observation made during the autumn of that year indicated that the standing crops of rooted vegetation were higher than in previous years. No quantitative measurements were made, however, to substantiate a cause. However, areas that were never previously vegetated did possess high standing crops of dominant species.

SOCIOECONONOMIC SYSTEMS

Specific impacts of Corps' operations on the subdivisions of socioeconomic systems for Pool 7 are identified below and then discussed in detail.

Identification of Impacts

The impacts on the socioeconomic systems related to the study area of the Upper Mississippi River divide into the industrial, recreational, and cultural effects.

Industrial Impacts

In contrast to some pools in the study area that have had considerable industrialization along their banks, Pool 7 has had comparatively little and is the origin or destination of none of the commodities that move through the pools. The result is that the industrial impacts of operating and maintaining the nine-foot channel in Pool 7 have been limited. The principal industrial impacts are:

1. Increased turbidity of water in some portions of the Upper Mississippi River due to barge movement.
2. Additional employment due to the operation of Lock and Dam 7.
3. An initial increase in commercial fishing and trapping because higher water levels caused increased acreage of suitable fish and fur-bearer habitat. More recently, a potential decline in commercial fishing because recent improper dredge spoil placement has reduced suitable fish habitat.

To summarize, beneficial industrial impacts that result from operating and maintaining the nine-foot channel and its associated locks and dams by the Corps of Engineers are the through-traffic link for commodities moving up and down the river, the employment in lock and dam operations, and an initial increase in the potential for commercial fishing and trapping. The detrimental effects are a decline in water quality due to river barge movement and spills, and --with continued improper dredge spoil placement-- a likely decline in commercial fishing.

Recreational Impacts

1. An increase in recreational boating due to stable, navigable water levels which leads directly to more recreational facilities -- and their accompanying employment.

2. An immediate increase in sport hunting and fishing due to and increase in --

   a. Waterfowl habitat, and

   b. Fish spawning areas resulting from rising water levels

   Again, as with commercial fishing cited above, improper dredge spoil placement has recently had a detrimental effect on sport hunting and fishing.

3. An increase in sightseeing visitors to the locks and dams at both ends of the pool.

Cultural Impacts

No archaeological, historical, or contemporary sites of cultural significance in Pool 7 are known to have been affected by Corps' operations.

Discussion of Impacts

The industrial, recreational, and cultural impacts identified above are examined in detail in the following three sections. Resource implications of these three socioeconomic impacts are discussed in Section 6.

Industrial Activities

The economic effect of the activities of the Corps of Engineers on the Mississippi River in the St. Paul District can be measured mainly in terms of three major elements. They are:

1. The channel itself with its associated locks and dams and navigational aids;

2. The installations at riverside for the transfer of cargo, storage facilities, and access;

3. The vessels using the waterway.

In these terms the impact of the Corps' activities in Pool 7 is not as great as in some of the other pools in the Northern Section of the Upper Mississippi River.

Barge Activity. The greatest and most obvious impact of the activities of the Corps of Engineers in Pool 7 has been the modification of the transportation system due to the growth of barge traffic. The visual evidence of the impact is seen in the physical structures (e.g., locks and dams) on the shores and the barge tows moving along the river. However, Pool 7 is not the origin of terminal for any of the commodities that move in barges along the Upper Mississippi River. Rather, it serves as an important water link between important commodity terminals upstream and downstream from it.

Figures 21 and 22 show graphically the growth of receipts into and shipments from the St. Paul District in the 30 years from 1940 to 1970. Commodities shown in the figures illustrate the diverse economic

Figure 21. Total receipts into St. Paul District, 1940-1970.

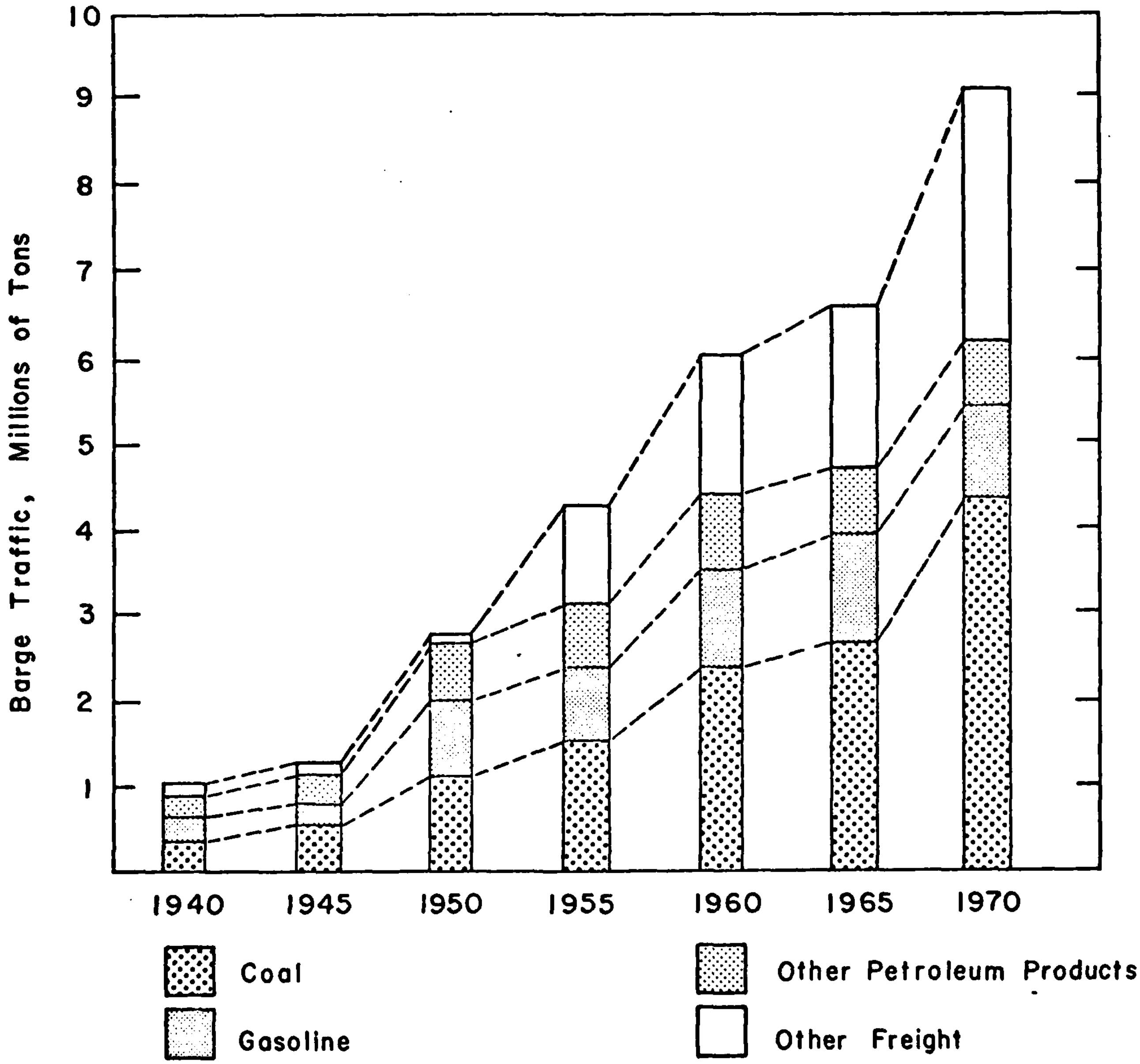
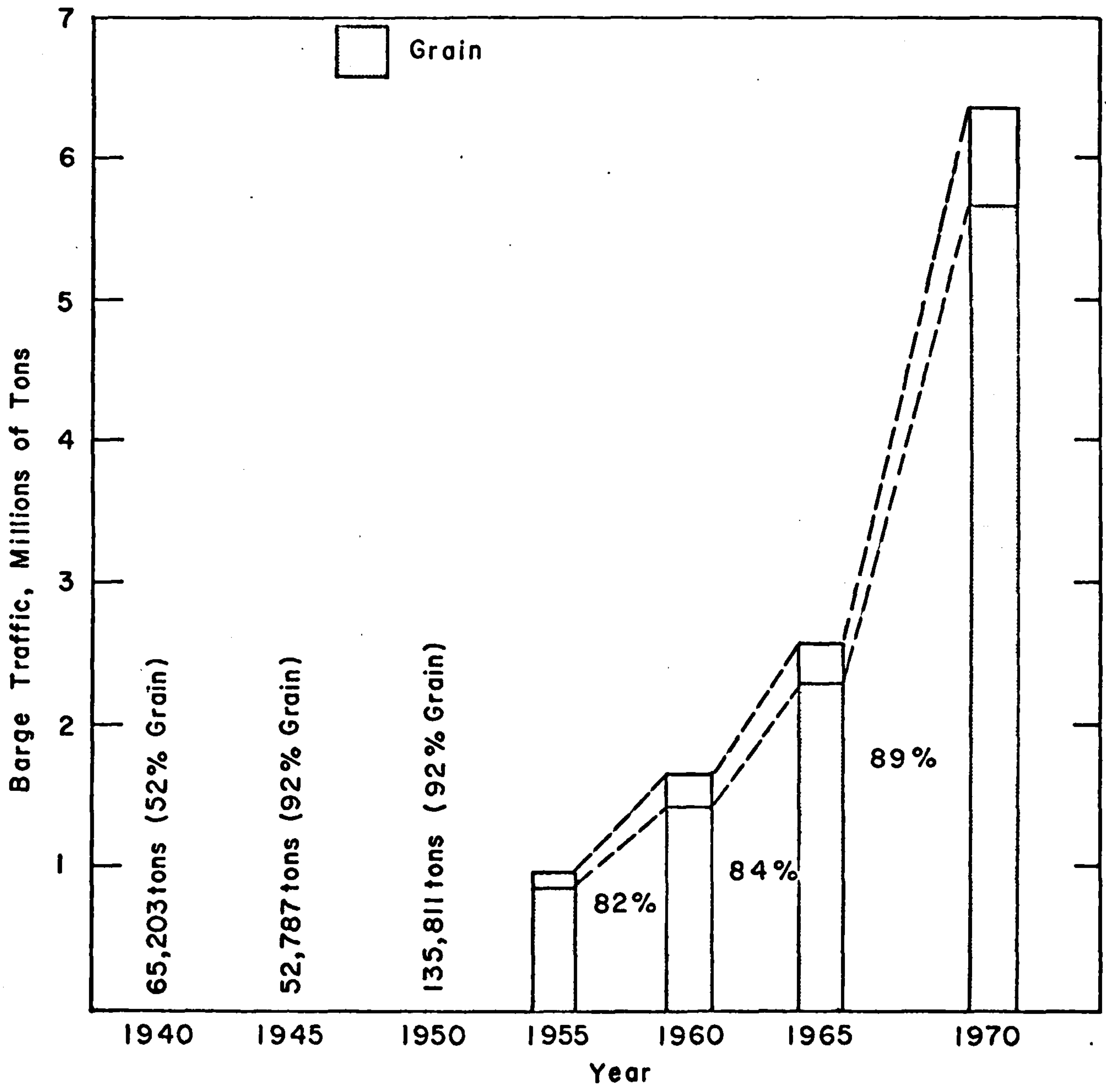


Figure 22. Total grain shipments from St. Paul District, 1940-1970.



activity within the St. Paul District. Although receipts in the St. Paul District still substantially exceed shipments, the growth in shipments (89 percent grain) from the district in these three decades indicates the great impact of the river on the regional economy.

In 1970 some rough projections (based on 1964 data) were made of the growth of commerce in the St. Paul District (UMREBS, Study Appendix J, 1970). The projections suggest that the tonnage of barge traffic moved in the Upper Mississippi River basin will about double from 1964 to 1980 and about trip le from 1964 to 2000.

It is noteworthy that receipts into the St. Paul District have always exceeded shipments. In earlier years this imbalance was often extreme (e.g., 1953 receipts = 3,052,144 tons, shipments = 334,233 tons). Recently, however, the ratio has been around 2:1. Inasmuch as grains and soybeans constitute the preponderant tonnage of shipments, fluctuation in waterborne transport of these products can be profound due to crop conditions and storage facilities, foreign sales, and competing forms of transportation.

Data are not available on the numbers of vessels originating, terminating, or passing through the St. Paul District. However, some comparative idea of shipping activity can be gained from the following information. Vessel traffic measured in tons from Minneapolis to the mouth of the Missouri River is shown for selected years as follows:

Year	Total Vessel Traffic (Tons)
1962	30,526,626
1964	34,108,482
1966	41,311,941
1968	46,174,929
1970	54,022,749
1971	52,773,097

Some comparative idea of barge activity can be gained from studying the commercial lockages through Lock 7 and Lock 6 -- the locks at either end of Pool 7 -- which are shown in Table 6 . From 1960 to 1972 commercial lockages through Lock 7 increased by 83 percent and those through Lock 6 increased 56 percent.

Commercial Dock Facilities. Pool 7 contains no commercial docks or terminals.

Commercial Fishing. There is substantial commercial fishing in Pool 7 although catches showed significant year-to-year variation in the 1960's. Table 7 gives the commercial catch in pounds of fish from 1960 through 1969. The wide variations in commercial catches are illustrated by comparing the catch for 1962 that represented three times the catch obtained in 1969.

However, even with the wide variations in commercial fish catches in Pool 7 shown in Table 7 , the level of commercial fishing is greater than prior to the lock and dam construction. This increased commercial fishing in Pool 5 since the lock and dam construction is at least partially due to the beneficial impact of a larger area of fish habitat caused by the rising water level. However, in recent years improper dredge spoil placement and sedimentation below wing dams has reduced fish habitat. Some experts on river fishing believe that major year-to-year variations in commercial fish catches are less affected by the supply of fish in the river than by market demand, as reflected in prices commercial fishermen receive for their catch. For example, high meat prices in mid-1973 have caused fish prices to increase with an attendant increase in commercial fishing activity on the river (Fernholtz, personal communication).

Table 6 . Commercial Lockages in Pool 7, 1960-1972

Year	Commercial Lockages	
	Lock 7	Lock 6
1960	1,324	1,295
1961	1,212	1,281
1962	1,660	1,368
1963	2,038	1,544
1964	1,977	1,483
1965	1,756	1,425
1966	1,982	1,658
1967	1,953	1,724
1968	1,957	1,244
1969	1,653	1,500
1970	2,265	1,918
1971	2,270	1,945
1972	2,429	2,018

Source: Annual Lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

Table 7 . Pounds of Fish Caught Annually by Commercial Fishermen in Pool 7 of the Upper Mississippi River, 1960-1969.

Year	Commercial Fish Catch
1960	283,000
1961	416,000
1962	721,000
1963	530,000
1964	458,000
1965	Not Available
1966	259,000
1967	517,000
1968	528,000
1969	242,000

Source: Proceedings of the Annual Meetings of the Upper Mississippi River Conservation Commission, 1962-1971.

Recreational Impacts

Recreational impacts may be divided into boating activities and related facilities, sport fishing and hunting, and other recreational activities.

Boating Activities and Related Facilities. For Pool 7 the best available measures of pleasure boating activity are records of pleasure boats locking through Locks 7 and 6 -- the locks at each end of the pool. These data -- along with the total pleasure-boat lockages through these two locks -- are shown in Table 8 for the years 1960 to 1972. The table shows signigicant increases in pleasure craft locking through both Lock 7 (from about 6,800 in 1960 to about 9,200 in 1972) and Lock 6 (from about 3,700 to 5,800 during the period). The table also shows an accompanying increase in the number of pleasure boat lockages at both locks during the period although the increases have not been as dramatic as for the number of pleasure boats moving through the two locks because several pleasure boats can be handled in each lockage.

The nine-foot channel and associated locks and dams have provided stable water levels that have contributed significantly to the increased boating activity in Pool 7, as have increased regional population, higher levels of family income, and more leisure time.

A variety of physical facilities have been developed in Pool 7 that exist mainly to serve boaters and fishermen using the pool. These include:

Facility	Number
Small boat harbors, marinas, boat clubs	
Recreational site without ramp	1
Public boat launching sites with parking areas	9
Commercial recreational sites	11
Wildlife refuges	1

Table 8 . Measures of Boating Activity in Pool 7, 1960-1972

Year	Pleasure Boats Through		Pleasure Boat Lockages Through	
	Lock 7	Lock 6	Lock 7	Lock 6
1960	6,849	3,697	3,528	2,351
1961	8,041	3,828	4,100	2,312
1962	7,152	3,591	3,673	2,096
1963	8,337	4,095	3,836	2,527
1964	8,603	4,484	4,216	2,739
1965	6,226	3,505	3,207	2,124
1966	8,239	4,291	4,208	2,657
1967	6,879	4,317	3,620	2,666
1968	6,806	5,010	3,664	3,387
1969	6,535	3,772	3,193	2,273
1970	7,339	4,137	3,674	2,386
1971	8,281	4,734	3,307	2,641
1972	9,184	5,823	4,164	3,312

Source: Annual Lockage Data, (St. Paul, U. S. Corps of Engineers, St. Paul District, Unpublished Reports).

Except possibly for the recreational site without ramp, which does not cater primarily to boaters, these facilities generally result from Corps' operations on the river that contributed the channel and stable water levels.

The large number of recreational sites in this pool testify to the importance of the river as a recreational resource for both boaters and non-boaters. The lack of commercial docks on the shoreline and the wide expanses of water outside of the navigation channel allow for excellent cooperative use of the river by both commercial and recreational users.

Sport Fishing, Hunting, and Other Recreational Activities. The variety of access points and the lack of an adequate survey program have precluded obtaining an accurate count of Pool 7 visitation for past years. Neither the Wisconsin Department of Natural Resources (Fernholtz, personal communication) or the Minnesota Department of Natural Resources (Gulden and Sternberg, personal communications) nor the U. S. Bureau of Sport Fisheries and Wildlife (Chase, personal communication) have recent, continuing data on sport fishing, sport hunting, and other recreational activities for Pool 7. The most precise data available are for 1963 and appear in Table 9 . The data are a composite of both Corps of Engineers and Bureau of Sport Fisheries and Wildlife (from the Upper Mississippi River Wildlife and Fish Refuge) visitation compilations for that year. In addition to being the most accurate data available to date, they are the most usable since visitation survey estimates were broken down to show ratios of participation in the seven most appropriate activities on an annual and peak month basis. Total annual visitation to Pool 7 in 1963 was estimated at about 160,000 which represents the equivalent of about two visits for each of the 80,000 people residing in the area of the pool (St. Paul District, November, 1967).

Table 9. Pool 7 visitation - 1963

Activity	Annual 1963		Peak month (July)	
	Percent of total	Activity participation	Percent of total	Activity participation
Camping	0.94	1,500	1.5	650
Picnicking	3.68	5,900	6.2	2,675
Boating	37.50	60,000	38.2	16,500
Fishing	51.20	81,900	49.5	21,385
Hunting	4.00	6,400		
Water skiing	0.38	600	0.6	260
Swimming	2.30	3,700	4.0	1,730
Total	100.00	160,000	100.0	43,200

Source: St. Paul District of the U. S. Army Corps of Engineers. November, 1967. Page 18.

Visitation during the peak month of July, 1963 was estimated at about 43,200 or more than 25 percent of the annual visitation. Table shows a breakdown of total annual visitation and peak month visitation by activities. Visitation for hunting appears only under the annual category since it does not occur in the summer months and does not influence determination of summertime peak loads. It is estimated that about 75 percent of the total visitation shown in Table 9 is generated at or through available public-use sites. With the possible exceptions of camping and picnicking, the other five activities cited in Table , which account for over 95 percent of the total participation, are water-related. It seems reasonable to conclude that the higher, stable water level in Pool 7 resulting from the construction of Lock and Dam 7 has had a favorable impact on these five activities.

The Winona District of the Upper Mississippi River Wildlife and Fish Refuge has collected public-use data on the portion of the refuge that lies in Pools 7 and 8. These data appear in Table 9 . These data again emphasize the importance of the river as a recreational resource for fishermen, water-sport, and camping activities -- about 80 percent of the visitors using the river for these purposes.

Another source of data on sport fishing is available because attendants at each lock and dam make daily observations at 3:00 p.m. each day throughout the year of the number of sport fishermen observed from their work location. Annual data for the most recent years for which these records are available appear in Table 4 . The table shows some variation in sport fishermen observed from Lock and Dam 6 and 7 since 1960. Because most sport fishermen observed from a lock and dam are downstream from the dam, most of the fishermen seen from Lock and Dam 7 are in Pool 8. Fishermen in Pool 7 -- as seen from Lock and Dam 6 fluctuated by about

2,300 people during the period from 1960 to 1970. However, it should be emphasized that these data are not precise and only an index to sport fishing activity in the pool.

In terms of impact on sport fishing, the higher water level in Pool 7 has increased the spawning areas for fish. In theory this offers the potential for more sport fishing. However, the potential both for increased commercial and sport fishing in Pool 7 may be partially offset by river pollution and turbidity from barge activity in it. Also in recent years improper dredge spoil placement has reduced the acreage of available fish habitat in Pool 7, and sedimentation has also hurt fish habitat -- particularly in areas below wing dams. Therefore, Corps' operations following the construction of Lock and Dam 7 have had both positive and negative effects on fish (and also waterfowl) habitat in the pool.

As the water levels in Pool 7 was raised by Corps' operations, habitat for residentail and migratory waterbirds was initially increased. As with fish habitat, improper dredge spoil placement in recent years has also reduced waterfowl habitat. This suggests the potential for greater bird hunting adjacent to Pool 7. Some measure of hunting activity in the pool is shown in Table 9 that notes 6,400 visits to Pool 7 in 1963.

Recreational sites along the perimeter of Pool 7 also facilitate sightseeing, picnicking, hiking, and camping. While non-boating visitors to these sites might be there whether Corps' operations existed on the Upper Mississippi or not, virtually all of the activities at these sites by boaters are attributable to Corps' activities. In addition, visitors to overlooks at locks and dams are a direct result of Corps' operations.

Cultural Impacts

Research and conversations with the State Archaeologists for Minnesota and Wisconsin (Streiff and Freeman, personal communication) revealed no evidence to indicate any archaeological impacts on sites in Pool 7 through the activities of the Corps of Engineers. An area upstream from French Island (including Red Oak Ridge) was the site of two or three early homesteads and has been inundated by the rising water level. (See Appendix for summary of archaeological summary of Wisconsin, Minnesota, and Iowa).

4. UNAVOIDABLE ADVERSE EFFECTS

The unavoidable adverse effects associated with the project include the following:

1. Those caused by the filling of the Navigation Pool; i.e. inundating existing habitat with water to a depth of 1-9 feet.

2. The changes involved in converting riverine habitat to a series of pools above the dams.

3. The presence of the dam and lock equipment as a barrier for upstream movements of organisms.

4. The inundation of the floodplain adjacent to the present location of Lock and Dam No. 7 to change what was basically a lowland forest habitat with open hay meadow areas, into a shallow lake.

The decreased current velocity in this area of the pool has caused an increase in the sedimentation rates in the upstream portion of the pool. The resulting decrease in depth has accommodated the rapid encroachment of rooted aquatic vegetation and accumulation of nutrients. This has secondarily created a nutrient cycling system similar to that found in closed lake situations. The result is subsequent fluctuations of nutrients that are released into the river system. A comparison of nitrogen and phosphorus levels, determined in the river proper and in the lower portion of Navigation Pool No. 7 indicate the following:

1. That the river nitrogen levels in 1967 are closely correlated to those in 1971 (correlation coefficient r = 0.8788).

2. The river phosphorus levels in 1967 are closely correlated to those found in 1971 (correlation coefficient r=0. 8986).

3. The nitrogen levels in the pool in 1967 and 1971 are closely correlated (r=0.9012), and

4. The phosphorus levels in the pool in the two years are closely correlated (r=0.8587).

The correlation between nitrogen in the river and in the navigation pool was poor (r=0.3156 and r=0.4386 respectively for 1967 and 1971). The phosphorus levels followed the same pattern (r=0.344 and r=0.5644 respectively for 1967 and 1971). This indicates that nutrients are being cycled and released from the navigation pool independently of the river system. The high levels found during the late autumn during the period of decay of rooted vegetation and the low levels found during the periods of assimilation by plants in the early and middle summer are thus explained.

By filling the floodplain at Lake Onalaska, the accumulation of nutrients and the establishment of a relatively high standing crop of rooted vegetation has resulted in the establishment of cyclic nutrient phenomena. Whereas the phenomena are not necessarily detrimental, in this case, they are indicators of nutrient accumulation.

The maintenance dredging operations in Navigation Pool No. 7 have caused some adverse effects as have been discussed in previous sections. Whereas some of the effects have been unavoidable, in that dredging must occur, alternate operational plans appear to be available for this phase of the project, that would tend to minimize the damages incurred. The fact that Lake Onalaska tends to be isolated from the main channel system, supports the thesis that dredging operations have helped to isolate it. Whereas much of the material actually forming the physical barrier between the channel and Lake Onalaska is from maintenance dredging activities, natural sedimentation processes account for much of the actual deposition in the lake due to decreased current velocity.

The presence of the dam and lock system across the entire river system has resulted in the establishment of an effective barrier for migratory movements of fishes. This is supported by the large numbers of game and rough species that accumulate below the structures especially during the migratory periods. The long term effect on these species has yet to be determined. There seems to be a sustained production of most species affected. The possible exceptions to this are the blue sucker (*Cycleptus elongatus*), and the lake sturgeon (*Acipenser fulvescens*).

5. ALTERNATIVES

The alternatives delineated here are concerned primarily with the operation of the project, with particular reference to maintenance dredging. The greatest number of options that would deter the degradation of the environment or that would indeed, enhance environmental factors, are associated with dredging.

These options are:

1. The application of equipment sufficient to deposit spoil material greater distances from the channel to minimize channelization.

2. The stabilization of spoil material by containment structures to increase the rate of colonization by pioneer plant species.

3. To stabilization of the spoil material by containment structures to minimize the return of the material to the channel.

4. To encouragement of beneficial and practical use of the spoil material by public and private groups and agencies.

5. The examination of the possibility of complete removal of the spoil material from the immediate river basin.

6. The initiation of remedial dredging operations to enhance areas that have been adversely affected by previous maintenance dredging.

7. The initiation of procedures to revegetate the spoil deposition sites, to minimize wind and water erosion.

6. RELATIONSHIPS BETWEEN SHORT TERM USE OF MAN'S ENVIRONMENT AND LONG TERM PRODUCTIVITY

The increases in population in the upper Mississippi River basin created a greater demand for the commercial use of the river, and subsequently led to the construction and maintenance of the nine foot navigation channel. The impact of increased navigation and commerce on the river has in turn, resulted in a greater population density in the same area. With this increase in population came an increase in land use for agricultural and urban development, and subsequently resulted in vast increases in the amount of sediment entering the Mississippi River through tributary streams. The construction of the nine foot navigation channel during the 1930's resulted in the removal of vast areas of low wetland forest and meadow, and in turn created large shallow pool areas, for fish and wildlife habitat. The increase of man's activities tended to fill these areas. If this rate of filling in the pool areas remains constant, the creation of wildlife and fish habitat during the early years of the project should in fact, be categorized as a short term benefit. That is, measured in years of the projected life of the nine foot channel, these areas will cease to be usable habitats as we know them now.

The creation of the navigation pools also resulted in an increased hydraulic efficiency within the channel areas and diverted water from backwater areas. This accounted for the increase in the state of eutrophy in most of the middle and lower pool areas, in that it allowed nutrients to accumulate at a rate probably much higher than was projected.

This tendency toward a eutrophic state in these areas has, no doubt, been reinforced by the recycling of autochthonous materials due to the rapid establishment and growth of populations of vegetation that did not exist prior to the project.

Resource Implications for Socioeconomic Activities

Table 10 summarizes the major resource implications of continuing to :operate and maintain the nine-foot channel in the St. Paul Distirct. Resource implications for these four groups are discussed in sequence below.

Corps' Operations

Table 10 identifies the major first order direct benefits associated with lock and dam operations and dredging operations. These include employment in lock and dam and dredging operations, maintenance of relatively stable water levels in each pool, and the presence of a navigable nine-foot channel in the St. Paul District. About 150 people are involved with lock and dam operations in the district and about 75 with dredging operations; thus about 225 people derive jobs and income directly from Corps' operations. The annual direct cost to taxpayers for lock and dam operations in $2,601,000 (FY 1970) and for dredging operations is $1,2000,000. Specific environmental costs of the stable water levels in the pools and the nine-foot channel in the St. Paul District are an increase in sedimentation behind dams and wing dams and a reduction in fish and waterfowl habitat due to improper dredge spoil placement.

Table 10. Major Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Activity	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Corps' Operations	Lock and dam (L/D) operation	1. L/D employments. 2. Stable water levels.	1. Cost of L/D operation. 2. Sedimentation behind dams and wing
	Dredging Operations	1. Dredging employment. 2. 9-foot channel	1. Cost of dredging operation 2. Destruction of fish and wildlife habitat due to improper dredge spoil placement.
Industrial	Barge Operation	1. Barge Employment. 2. Low cost water transportation. 3. Energy saving compared to alternate transportation modes.	1. Increased river turbidity. 2. River pollution from oil and gasoline from barges.
	Commercial Dock Operation	1. Dock employment. 2. Attraction of barge transportation oriented firms that provide local employment.	1. Increased river pollution from industrial activities along shore.
	Commercial Fishing and Trapping	1. Increased employment of fishermen and trappers. 2. Increased number of fish and pelts available for consumers.	
Recrea-tional	Boating Activity	1. Increased recreational opportunities for boaters.	
	Operation of Recreational Facilities	1. Increased employment and business opportunities for facilities serving recreational users of the river (boaters, sport fishermen and hunters, etc.)	

Table 10. Major Benefits and Costs to Socioeconomic Activities of Maintaining the Nine-Foot Channel (Continued)

Socioeconomic Activity		Qualitative Summary of Socioeconomic Benefits and Costs	
General Category	Specific Acitivty	First-Order Socioeconomic Benefits	First-Order Socioeconomic Costs
Recrea-tional (con't.)	Sport Fishing	1. Initially increased habitat for fish	1. Increased sedimentation in fish habitat. 2. Decreased fish habitat from improper dredge spoil placement.
	Sport Hunting	1. Initially increase habitat for waterfowl.	1. Decreased waterfowl habitat from improper dredge spoil placement.
	Sightseeing, camping, picnicking, swimming, water skiing	1. Improved opportunities for miscellaneous recreational activities.	
Cultural	Archaeological Sites		1. Loss of selected sites due to L/D construction and rising water.
	Historical Sites		1. Loss of selected sites due to L/D construction and rising water.
	Contemporary Sites		1. Loss of selected sites due to L/D construction and rising water.

Industrial Activities

As summarized in Table 10 , the major direct impacts of Corps' operations on industrial activities are for barge operations, commerical dock operations, and commercial fishing. Table 10 notes that there are employment implications for each of these three activities but these benefits must be balanced against accompanying increases in sedimentation, turbidity, and possibly other pollution in the river.

Of special importance in the current energy crisis are the answers to two questions that relate to barge transportation: How effective is barge transportation relative to other modes of transportation with respect to:

1. Energy usage:
2. Air Pollution?

Because the answers have major resource allocation implications for the Upper Mississippi River, these two questions are analyzed below in some detail. In addition savings in transportation costs due to barge movements are discussed.

Barge Transportation and Energy Usage. Effective energy utilization is particularly important due to the present (and probably continuing) energy crisis. It also affects air pollution which relates directly to transportation energy consumption.

At present transportation utilizes about 25 percent of the total U.S. energy budget for motive power alone. This usage has been increasing at an average annual rate of about 4 percent per year.

In comparing the efficienty of energy utilization between various transportation modes the term "energy intensiveness" is commonly used. Energy intensiveness is defined as the amount of energy (in BTU's) needed to deliver one ton-mile of freight. The following table compares the energy intensiveness of various modes of freight transportation (Mooz, 1973):

Freight Mode	Energy Intensiveness (BTU's/ton-mile)	Ratios of E.I.
Waterways	500	1
Rail	750	1.5
Pipeline	1,850	3.7
Truck	2,400	4.8
Air Cargo	63,000	126

It is apparent from this table that motive energy is utilized more efficiently in water transportation than through any other mode of freight transportation. Therefore, under conditions of restricted petroleum energy availability the use of barging wherever feasible should be encouraged. Indeed, an increased use of the Upper Mississippi and its tributaries is likely. Influencing this will be increased shipments of grain out of the St. Paul District and increased imports of coal and petroleum products into the region. Exports of grain to other countries and shipments of other parts of the U.S. are expected to increase. Energy demands in the Upper Midwest are also expected to rise. In addition freight which is now only marginally involved in barging may shift from other forms of transportation to the less energy-intensive forms. This shift may also be expected to change existing concepts of the kinds of freight suitable for barging with consequent impact on storage facilities. In many cases economic trade-offs may exist between the mode of transportation and the size of inventories considered to be suitable. If the costs energy rise sufficiently, increased capital necessitated by use of the slower-moving barge transportation and tied up in inventory and in storage space may be justified. If this occurs, other kinds of cargoes presently shipped by rail or turck or pipeline may diverted to barge.

In addition to energy conservation, the importance of the Upper Mississippi as a transportation artery is shown by the burden which would be placed on the rail system (as the major alternative transportation mode used to move heavy, high-bulk commodities) in the absence of barge traffic on the river. In 1972 an estimated 16,361,174 tons of various commodities were received ans shipped from the St. Paul District. Under the simplifying assumption that the average box or hopper car carries 50 tons, this amounts to the equivalent of 327,223 railroad cars or some 3,272 trains of 100 cars each or approximately nine trains each day of the year.

Barge Transportation and Air Pollution. Barge transportation also results in less air pollution per ton-mile than either rail or truck modes. Diesel engines are the most common power plants used by both tugboats and railroads. A large percentage of over-the-highway trucks use diesel engines as well. The diesel engine is slightly more efficient than the gasoline engine due to its higher compression ratio. Thus, less energy is used to move one ton of freight over one mile by diesel than by gasoline engines. Among users of diesel engines, barging is mor efficient than either rail or truck, as we have seen. Consequently a smaller amount of fuel is required to move freight. With less used, air pollution is reduced.

The amount of air pollution caused by either diesel fuel or gasoline varies substantially only in the type of air pollution. The following table illustrates these pollution effects(U.S.P.H.S., 1968):

Type of Emission	Emission Factor: Pounds/1,00 gallons diesel fuel	Emission Factor: Pounds/1,000 gallons gasoline
Aldehydes (HCHO)	10	4
Carbon monoxide	60	2300
Hydrocarbons (0)	136	200
Oxides of Nitrogen (NO_2)	222	113
Oxides of Sulfur (SO_2)	40	9
Organic Acids (acetic)	31	4
Particulates	110	12

Based upon the energy intensiveness ratios shown earlier, a diesel train will produce 1.5 times as much air pollution and a diesel truck 4.8 times as much air pollution per-ton-mile as a tug and barges. In any event, no matter which kind of pollutant is of concern in a particular case, the efficienty of barging compared with other modes of freight transportation will result in reduced air emissions per ton-mile.

Barge Transportation and Cost Savings. A further benefit which can be attributed to the maintenance of navigation on the Upper Mississippi is in the savings in transportation costs, particularly for bulk commodities. Estimates of these savings have been made. One of these estimates the savings over the other various least cost alternatives of between 4.0 and 5.4 miles per ton-mile (UMRCBS, 1970). It is generally recognized that bulk commodities, particularly those having low value-to-weight ratios, are appropriate for barge transport. Coal, petroleum, and grain that have these characteristics are examples of such commodities that originate, terminate, or move through the St. Paul District pools on river barges.

Recreational Activities

Table 10 identifies the variety of recreational activities -- from boating and sport fishing to sightseeing and camping -- that may be helped or hindered by Corps' operations. Ideally it would be desirable to place dollar values on each of the benefits and costs to the recreational activities cited in Table 10 to weigh against the benefits of barge transportation made possible by maintaining the nine-foot channel. Unfortuantely both conceptual problems and lack of precise data preclude such an alalysis. The nature of these limitations can be understood by (1) looking initially at the theoretical approach for measuring the benefits and costs of recreational activities and (2) applying some of these ideas to the measurement of only one aspect of all recreational activities -- sport fishing.

Benefits and Costs of Recreational Activities. Theoretical frameworks exist ot preform a benefit-cost analysis of a recreation or tourism activity. One example is s tudy prepared for the U.S. Economic Development Administration (Arthur D. Little, Inc., 1967). Unfortunately even this example closes with a "hypothetical benefit-cost analysis of an imaginary recreation/tourism project" that completely neglects the difficulty of collecting the appropriate data.

Valueing Sport Fishing in the Study Area. A variety of studies have been done on recreation and tourism in Minnesota and the Upper Midwest during the past decade (North Star Research Institute, 1966; Midwest Research Institute, 1968; Pennington, et al., 1969). For purpose of analyzing sport fishing and other recreational activities on the Upper Mississippi River, however, they have a serious disadvantage; these studies are generally limited to recreationers who have at least one overnight stay away from home. In the case of the St. Paul District, with the exception of campers and boaters on large pleasure craft with bunks virtually all river users are not away from home overnight and are omitted from such studies.

Information is then generally restricted to the available in the UMRCC sport fishing studies such as those shown below for 1967-68 (Wright, 1970):

Pool Number	Total Number of Fishing Trips	Value at $5.00 Per Trip[a]	Value at $1.50 Per Trip[b]
4	169,361	$846,805	$254,042
5	51,786	258,930	77,699
7	63,238	316,190	94,857

[a]Based on data reported in the "1965 National Survey of Fishing and Hunting" that the average daily expenditure for freshwater sport fishing was &4.98 per day.

[b]Based on data in Supplement No. 1 (1964) to Senate Document 97 that provides a range of unit value of $0.50 to $1.50 a recreation day for evaluating freshwater fishing aspects of water resource projects.

Thus the sum of the values of sport fishing given above for these three pools varies from about $0.4 million to $1.4 million depending upon the valuation of a fishing trip. Assuming one of these values were usable, the researcher is still left with the task of determining the portion (either as a benefit or cost) of Corps' operations. With the limited funds available for the present research and the limited existing data, detailed analysis is beyond the scope of the present study.

Similar problems are present in evaluating the other recreational activities in the study area.

Cultural Sites

No attempt has been made in the present study to place dollar values on archaeological, historical, or cultural sites damaged or enhanced by Corps' operations. Rather, such sites have merely been identified, where existing data permit.

SECTION 6 - SOCIOECONOMIC REFERENCES

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7. IRREVERSIBLE COMMITMENTS

A simple inventory of commitments and their implications in Navigation Pool No. 7 can probably best describe the situation.

1. Loss of Natural Resources

   A. Loss of Wetlands due to inundation of the floodplains in the pool areas. (Table 1).

2. The commitment of labor, materials and energy for the construction of the lock and dam, and related facilities.

3. The commitment of dollars for the purchase of the land now inundated in Navigation Pool No. 7.

4. The loss of wildlife and fish habitats at the following points in Pool No. 7 due to the deposition of maintenance dredge spoil (Table A-13).

   A. Mile 704-705 Dresbach Island 6734 cu. yds/yr. (average)

   B. Mile 705-706 Upper Dresbach Island 8149 cu. yds/yr.

   C. Mile 706-707 Dakota Minnesota 13688 cu. yds/yr.

   D. Mile 708-709 Upper Lake Onalaska 15239 cu. yds/yr.

   E. Mile 709-710 (Shingle Creek) 154969 cu. yds/yr.

   F. Mile 711-712 (Richmond Island) 28396 cu. yds/yr.

   G. Mile 712-713 Upper Richmond Island 22085 cu. yds/yr.

   H. Mile 713-714 Tailwaters L & D 6 125583 cu. yds/yr.

5. The dollars and labor required to effect the above mentioned maintenance dredging.

8. SUMMARY OF RECOMMENDATIONS

The significant changes that have occurred in Navigation Pool No. 7 are those that are associated with the transformation of a riverine type habitat to that which approximates a lake. The following recommendations are those that refer to the items discussed in the alternative section and presumably are those that can be studied and carried out.

We recommend:

1. that a review of all dredge spoil sites be made to determine whether the sites can adequately handle the proposed amount of dredge spoil in the future.

2. The Corps of Engineers investigate the development of a market for dredge spoil materials, so that they can be used for beneficial purposes outside of the floodplain.

3. That equipment (shore pipe, floating pipe, and booster pumps) be purchased to move the dredge material greater distances from the main channel.

4. That a study and demonstration project be initiated to determine whether the channel can be maintained at a lesser depth, to minimize the amount of "over dredging" in areas where materials are dredged every year.

5. That areas upstream from any feeder channel to the open portions of the pool, and backwaters, distant from the main

channel, not be used for spoil deposition, to maintain these channels as water supply streams to these remote areas.

6. That revegetation procedures be initiated to stabilize the dredge spoil so that pioneer species of naturally occurring organisms can reinvade the spoil sites at a higher rate.

7. That dredged materials not be placed in a linear fashion along the channel sides and result in effective channelization.

The examination of the conditions in Navigation Pool No. 7 with regard to maintenance dredging has revealed that there are areas that are particularly sensitive to the deposition of spoil material.

They are:

1. Richmond Island
2. Winter's Landing
3. Dresbach Island

Specific recommendations regarding these areas are as follows:

1. That spoil deposited on these sites be contained by structures, or revegetated.

2. That material dredged in the area of Winter's Landing be removed from the floodplain completely.

3. That dredged spoil in the area of Dresbach be removed completely from the floodplain.

It is recommended that no spoil material be placed along the Wisconsin side of the main channel from Mile 704 to Mile 710.

Furthermore, it is recommended that remedial dredging be undertaken to create feeder channels into backwater areas where deemed appropriate by further study.

Discussion

It is apparent that much of the sediment material entering the backwater areas in middle pool No. 7 and the lower portion (Lake Onalaska) are derived directly or indirectly from maintenance dredging. The presence of these materials has affected the water quality and the suitability of the habitat in many ways. The immediate effects are:

1. The loss of navigability of the affected areas by recreational craft.

2. The replacement of productive sediments with unstable, unproductive sediments, and

3. The increase of the rate of eutrophication in the backwater areas.

Secondarily, this has led to a reduction in the acreage and suitability of the habitat for fishing. The recommendations listed above are associated with maintenance dredging operations which appear to have the greatest number of alternate options available in the project. The process of channelization in other river systems has led to the total loss of the backwater areas, which are environmentally the most valuable in the system. Whereas the backwater areas of Navigation Pool No. 7 are still viable and still represent a great natural resource, data indicate that the major portion of the pool is still relatively unstable and still receives large quantities of materials from upstream. The accumulation and subsequent cycling of nutrients will probably result in conditions that will render the pool less valuable for recreational purposes and as fish and wildlife habitats. The open pool area in addition to the marshes and sloughs in the upper and middle portion of the pool depends almost solely upon a rich supply of silt free water from the main channel system for its existence. Without this it will continue to become shallower and less valuable as a resource in the river valley.

APPENDIX

APPENDIX A TABLES

Table A1. Average tree composition of southern Wisconsin upland xeric forest, importance value, and percent constancy (from Curtis, 1971).

SPECIES	AVE. I.V.	CONSTANCY
Quercus alba	80.3	88%
Q. borealis	21.7	54
Q. vetulina	98.3	92
Tilia americana	0.8	10
Prunus serotina	23.2	86
Quercus macrocarpa	25.6	64
Acer saccharum	0.2	2
Ulmus rubra	3.8	20
Carya ovata	8.2	53
Fraxinus americana	1.2	.0
Quercus ellipsoidalis	10.6	10
Ostryia virginiana	0.6	10
Populus grandidentata	1.3	18
Ulmus americana	3.7	24
Acer rubrum	1.5	14
Carya cordiformis	2.1	16
Juglans nigra	2.7	34
J. cinerea	0.2	6
Quercus muhlenbergii	2.6	2
Acer negundo	1.8	10
Populus tremuloides	1.8	16
Betula papyrifera	0.4	8
Fraxinus pennsylvanica	0.6	2
Fagus grandifolia	....	...
Ulmus thomasi	....	...
Celtis occidentalis	0.2	2
Quercus bicolor	....	...
Fraxinus nigra	....	...
Betula lutea	....	...

Table A2. Prevalent upland groundlayer species, southern Wisconsin, percent presence and average frequency (Curtis, 1971).

SPECIES	PRES.	AV. FREQ.
Adiantum pedantum	81%	6.9%
Agrimonia gryposepala	43	1.0
Amphicarpa bracteata	94	21.6
Anemone quinquefolia	65	6.2
A. virginiana	41	0.8
Apocynum androsaemifolium	52	2.6
Aralia nudicaulis	76	11.9
A. racemosa	61	1.2
Arisaema triphyllum	81	17.2
Aster saggitfolius	54	3.9
A. shortii	61	4.7
Athyrium filix-femina	74	7.6
Botrychium virginianum	83	6.3
Brachyelytrum erectum	67	7.2
Carex pennsylvanica	78	14.4
Caulophyllum thalictroides	65	3.3
Celastrus scandens	67	7.8
Cornus alternifolia	48	1.6
C. racemosa	70	11.5
C. rugosa	43	2.2
Corylus americana	82	10.7
Cryptotaenia canadensis	59	5.4
Desmodium glutinosum	93	7.9
Dioscorea villosa	57	2.7
Fragaria virginiana	57	4.1
Galium aparine	50	10.1
G. concinnum	93	26.0
G. triflorum	50	4.3
Geranium maculatum	100	35.8
Geum canadense	50	6.4
Helianthus strumosus	63	6.7
Hydrophyllum virginanum	44	5.5
Hystrix patula	67	2.6
Lactuca spicata	52	2.0
Lonicera prolifera	57	3.6
Osmorhiza claytoniana	46	3.9
Parietaria pennsylvanica	43	4.6

Table A3. Average tree composition, southern Wisconsin wet lowland forest, importance value, and percent constancy (Curtis, 1971).

SPECIES	AVE. I.V.	CONSTANCY
Acer saccharinium	81.6	81.5%
Ulmus americana	26.5	66.7
Salix nigra	64.0	70.3
Populus deltoides	54.5	70.4
Fraxinus pennsylvanica	8.2	51.9
Betula nigra	24.4	51.8
Quercus bicolor	15.2	29.6
Tilia americana	1.6	11.1
Fraxinus nigra	2.9	18.5
Quercus borealis	0.3	3.7
Fraxinus americana	0.8	11.1
Quercus macrocarpa	5.8	3.7
Ulmus rubra	0.8	3.7
Carya ovata	0.2	3.7
Quercus alba	0.2	3.7
Q. velutina	3.6	3.7
Acer negundo	3.0	22.2
Carya cordiformis	0.4	7.4
Prunus serotina	0.7	3.7
Populus tremuloides	0.2	3.7
Salix amylaloides	0.2	3.7

Table A4. Prevalent lowland groundlayer species, southern Wisconsin, percent presence, and average frequency (Curtis, 1971).

SPECIES	PRES	AVE. FREQ.
Amphicarpa bracteata	34%	10.1%
Areniaria lateriflora	34	9.0
Arisemea triphyllum	66	17.2
A. dracontium	44	2.5
Aster lateriflorus	41	12.5
Athyrium filix-femena	39	3.8
Boehmeria cylindrica	47	7.6
Circaea quadrisulcata	34	8.8
Crypotaenia canadensis	45	12.9
Cuscuta gronovii	31	3.3
Dioscorea villosa	31	3.3
Elumus virginicus	39	9.1
Galium triflorum	44	6.4
Geum canadense	61	11.5
Glyceria striata	41	6.7
Impatiens biflora	67	21.4
Laportea canadensis	77	39.7
Leersia virginica	36	11.8
Lycopus uniflorus	36	5.7
Menispermum canadense	34	4.8
Onoclea sensibilis	56	6.9
Osmorhiza claytoni	33	6.6
Parthenocissus vitacea	80	23.0
Polygonatum pubescens	33	6.2
Ranunculus abortivus	47	5.0
Rhus radicans	59	6.7
Ribes americanum	48	6.8
Sambucus canadensis	42	3.2
Sanicula gragaria	36	13.1
Smilacina stellata	34	5.5
Smilax ecirrhata	41	4.7
S. herbacia	39	4.2
Solanum culcamara	39	4.2
Solidago gigantea	34	6.3
Steironema ciliatum	57	10.2
Viola cucullata	63	16.3
V. pubescens	36	11.2
Vitis riparia	58	3.4
Zanthozylum americanum	36	3.9

Table A5. Prevalent species of emergent aquatic communities, southern Wisconsin (Curtis, 1971).

SPECIES	PRES.
Eleocharis acicularis	38%
Iris shrevei	29
Phragmites communis	38
Pontideria cordata	51
Sagittaria latifolia	62
Scirpus acutus	73
S. americanus	42
S. validus	49
Sparganium eurycarpum	51
Typha latifolia	71
Zizania aquatica	53

Table A6. Prevalent species of submerged aquatic communities, southern Wisconsin (Curtis, 1971).

SPECIES	PRES.
Anarchis canadensis	42%
Ceratophyllum demersum	32
Eleocharis acicularis	26
Najas flexilis	68
Potamogeton gramineus	35
P. zosteriformis	28
Vallisneria americana	39
Other species with presence over 10%	
Bidens beckii	11%
Myriophyllum exalbescens	10
Potamogeton amplifolius	19
P. foliosum	11
P. friesii	16
P. illinoiensis	25
P. natans	11
P. pectinatus	26
Sagittaria graminea	10

Table A7. A checklist of algae collected from Navigation Pool No. 7, Upper Mississippi River, 1970-1971.

CHLOROPHYTA

Class Chlorophyceae
- Order Volvocales
  - Family Volvocaceae
    - _Eudorina elegans_
    - _Gonium pectorale_
    - _Pandorina morum_
    - _Platydorina caudatum_
    - _Volvox aureus_
- Order Tetrasporales
  - Family Coccomyxaceae
    - _Elakatothrix gelatinosa_
  - Family Palmellaceae
    - _Sphaerocystis schroeteri_
- Order Ulotrichales
  - Family Ulotrichaceae
    - _Ulothrix cylindricum_
    - _Ulothrix zonata_
  - Family Chaetophoraceae
    - _Draparnaldia_ sp.
- Order Cladophorales
  - Family Cladophoraceae
    - _Cladophora fracta_
- Order Chlorococcales
  - Family Chlorococcaceae
    - _Acanthosphaera zachariasi_
    - _Golenkinia radiata_
  - Family Characiaceae
    - _Characium ambiguum_
  - Family Hydrodictyaceae
    - _Hydrodictyon reticulatum_
    - _Pediastrum boryanum_
    - _Pediastrum boyranum_ var _undulatum_
    - _Pediastrum duplex_
    - _Pediastrum simplex_
  - Family Coelastraceae
    - _Coelastrum microporum_
  - Family Oocystaceae
    - _Ankistrodesmus falcatus_

Table A7 (cont).

Cerasterias stuarastroides
Chlorella sp.
Chlorella vulgaris
Dictyosphaerium pulchellum
Echinosphaerella limnetica
Polyedriopsis spinulosa
Quadrigula chodatii
Seleastrum gracile
Treubaria setiherum
Family Scendesmaceae
Actinastrum hantzschii
Actinastrum hantzschii var. *fluviatile*
Crucigenia tetrapedia
Errerella bormhemiensis
Micractinium pusillum var. *elegans*
Scenedesmus quadricauda
Scenedesmus quadricauda var. *maximus*
Scenedesmus quadricauda var. *Westii*

Order Zygnematales
Family Zygnemataceae
Mougeotia sp.
Spirogyra sp.
Family Desmidiaceae
Closterium sp.
Staurastrum sp.

EUGLENOPHYTA
Order Euglenales
Family Euglenac3ae
Euglena sp.
Phacus sp.

PYRRHOPHYTA
Class Dinophyceae
Order Dinokontea
Family Ceratiaceae
Ceratium hirundinella
Order Dinococcales
Family Dinococcaceae
Cystodinium cormifax

CHRYSOPHYTA
Class Chrysophyceae
Order Chrysomonadales
Family Mallomonadaceae
Chrysophaerella longispina
Mallomonas alpina

Table A7. (cont.)

Family Synuridae
- *Synura uvella*

Family Ochromaonadaceae
- *Dinobryon* sp.

Class Bacillariophyceae
Order Centrales

Family Coscinodinscaceae
- *Coccinodiscus* sp.
- *Cyclotella* sp.
- *Stephanodiscus* sp.

Family Rhizosoleniaceae
- *Rhizosolenia* sp.

Order Pennales

Family Tabellariaceae
- *Tabellaria* sp.

Family Fragillariaceae
- *Asterionella* sp.
- *Fragillaria* sp.

Family Naviculaceae
- *Navicula* sp.

CYANOPHYTA
Class Mysophyceae
Order Chroococcaceae

Family Chroococcaceae
- *Aphanocapsa* sp.
- *Chroococcus* sp.
- *Coelosphaerium* sp.
- *Gloeocapsa* sp.
- *Gomphosphaeria* sp.
- *Marssoniella elegans*
- *Merismopedia glauca*
- *Microcystis* sp.

Order Hormogonales

Family Oscillatoriaceae
- *Oscillatoria* sp.
- *Spirulina laxa*

Family Nostocaceae
- *Anabaena* sp.
- *Aphanizomenon flos-aquae*

Family Fivulariaceae
- *Rivularia haematites*

Table A8 Checklist of mammals and waterfowl inhabiting the upper Mississippi River, Navigation Pool No. 7, 1970.

Moose	Rock Dove
Whitetail Deer	Woodcock
Antelope	Common Snipe
Black Bear	King Rail
Snowshoe Hare	Virginia Rail
Whitetail Jackrabbit	Sora Rail
Swamp Rabbit	Canada Goose
E. Cottontail Rabbit	Snow Goose
E. Fox Squirrel	Blue Goose
E. Gray Squirrel	Mallard
Red Fox	Black Duck
Gray Fox	Gadwall
Raccoon	Pintail
Opossum	Green-wing Teal
Mink	Blue-wing Teal
River Otter	American Widgeon
Least Weasel	Shoveler
Shorttail Weasel	Wood Duck
Longtail Weasel	Redhead
Striped Skunk	Canvasback
Spotted Skunk	Lesser Scaup
Beaver	Ring-necked Duck
Muskrat	Bufflehead
Ruffed Grouse	Ruddy Duck
Sharp-tailed Grouse	Common Merganser
Bobwhite Quail	Red-breasted Merganser
Hungarian Partridge	Hooded Merganser
Ring-necked Pheasant	Coot
Wild Turkey	Common Galinule
Mourning Dove	

Table A9. Commercial fishing, average catch per unit effort with setlines, gillnets, and seines; total pounds caught per year, Navigation Pool No. 7, Upper Mississippi River.

YEAR	SETLINE	GILL NET	SEINE	TOTAL POUNDS
1953	7.20	0.07	0.30	174667
1954	8.24	0.09	0.34	243705
1955	12.33	0.15	0.29	218065
1956	10.37	0.12	1.39	171554
1957	10.05	0.16	0.33	192520
1959	8.31	0.20	1.01	190955
1960	10.09	0.19	0.58	241722
1961	14.28	0.30	1.83	391143
1962	10.19	0.17	3.78	680772
1963	11.01	0.14	3.59	462451
1964	14.54	0.18	3.08	430681
1965	14.37	0.22	10.02	426249
1966	15.63	0.37	1.78	254160
1967	6.34	0.39	4.07	500859
1968	16.66	0.38	6.99	521390
1969	17.62	0.37	1.84	225000
1970	21.52	0.26	6.87	820816
1971	16.83	0.37	5.48	503953

Table A10. Nitrogen (NO_2, NO_3) and phosphorus (total) levels recorded in lower Navigation Pool No. 7 (adjacent to the east shore of French Island) and the lower main channel of Pool No. 7, 1967 and 1971).

		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Nitrite Nitrate 1967	Pool	0.60	0.71	0.97	0.69	0.63	0.40	---	0.30	0.71	1.43	0.97	---
	River	0.61	0.67	0.51	0.63	0.71	0.70	---	0.61	0.74	0.83	0.89	---
1971	Pool	0.73	0.71	0.81	0.77	0.74	0.51	0.69	0.56	0.98	1.39	1.31	0.94
	River	0.71	0.81	0.67	0.69	0.63	0.67	0.77	---	0.81	0.79	0.93	0.86
Phos 1967	Pool	---	0.06	0.05	0.37	0.05	0.16	0.18	0.23	0.73	1.37	1.03	---
	River	0.07	0.18	0.17	0.63	0.57	0.27	0.21	0.19	0.17	0.43	0.51	---
1971	Pool	0.09	0.17	0.11	0.36	0.10	0.18	0.23	0.31	0.91	1.72	1.37	0.18
	River	0.09	0.31	0.20	0.78	0.68	0.37	0.41	0.17	0.27	0.31	1.48	0.47

Supplement for Tables A11-A14

Transect	Subdivisions (Stations)	F-table Coordinates	99%	95%
AA	(1-4)(5-8)	1,6	13.74	5.99
BB	(1-5)(6-11)(12-17)	2,14	6.51	3.74
CC	(1-12)(13-17)	1,15	8.68	4.54
DD	(1-5)(6-17)(18-22)	2,19	5.93	3.92

Computer Treatments (RFSFT Create Program for UWL AN01W Analysis of Variance Program) **

1. Temperature
2. Depth
3. Turbidity
4. Conductivity
5. Nitrate
6. Nitrite
7. Phosphate
8. Dissolved Oxygen

** Means, F-distribution value and significance levels are listed in the numerical order shown above. Only the 95% and 99% limits were listed. Any value below this was interpreted as not significant.

Table A11. Subgroup sample mean values, F-distribution value and level of significance for all parameters determined on Transect AA, Navigation Pool No. 7, Summer, 1973 ·

PARAMETER	TBAR 1 (1-4)	TBAR 2 (5-8)	F-value (1,6)	Sig.
1. Temp	17.625	17.500	1	none
2. Depth	1.95	8.0	19.948	99%
3. Turb.	137.0	134.0	4.758	95%
4. Cond.	39.0	41.75	0.353	none
5. Nitrate	1.312	0.804	177.0	99%
6. Nitrite	0.019	0.014	3.826	none
7. Phosphate	0.170	0.172	0.154	none
8. D.O.	8.75	8.35	8.730	95%

**see supplement on preceding page.

Table A12. Subgroup sample mean values, F-distribution values and levels of significance for all parameters determined on Transect BB Navigation Pool No. 7, Summer, 1973

PARAMETER	TBAR 1 (1-5)	TBAR 2 (6-11)	TBAR 3 (12-17)	F-value (2,14)	Sig.
1. Temp	26.400	25.916	23.250	5.068	95%
2. Depth	2.179	1.066	0.250	5.423	95%
3. Turb.	45.600	49.000	49.000	0.619	none
4. Cond.	28.600	44.166	59.000	7.852	99%
5. Nitrate	0.030	0.020	0.030	---	none
6. Nitrite	0.008	0.002	0.006	11.721	99%
7.Phosphate	0.150	0.196	0.205	0.792	none
8. D. O.	10.899	12.149	10.050	1.455	none

**see supplement on preceding page.

Table A13. Subgroup sample mean values, F-distribution values and levels of significance for all parameters determined on Transect CC, Navigation Pool No. 7, Summer, 1973.

PARAMETER	TBAR 1 (1-12)	TBAR 2 (13-17)	F-value (1,15)	Sig.
1. Temp.	26.625	26.200	2.472	none
2. Depth	2.183	5.159	16.570	99%
3. Turb.	45.500	19.000	31.640	99%
4. Cond.	26.000	27.400	7.860	95%
5. Nitrate	0.153	0.012	0.596	none
6. Nitrite	0.018	0.010	26.301	99%
7. Phosphate	0.380	0.187	20.684	99%
8. D. O.	10.541	11.219	1.229	none

**see supplement on preceding page.

Table A14. Subgroup sample mean values, F-distribution values and levels of significance for all parameters determined on Transect DD, Navigation Pool No. 7, Summer, 1973.

PARAMETER	TBAR 1 (1-5)	TBAR 2 (6-17)	TBAR 3 (18-22)	F-value	Sig.
1. Temp.	24.800	26.000	25.200	21.375	99%
2. Depth	1.779	1.624	2.579	2.346	none
3. Turb.	67.800	50.570	61.800	10.537	99%
4. Cond.	28.800	31.750	28.200	0.824	none
5. Nitrate	0.000	0.030	0.000	0.000	none
6. Nitrite	0.006	0.003	0.004	1.388	none
7. Phosphate	0.161	0.279	0.113	11.550	99%
8. D. O.	10.299	9.008	10.219	3.903	95%

**see supplement on preceding page.

TABLE A15

Frequency of Trees in Alluvial forest encountered along Transect 7*

Alluvial forest-Trees	
Ulmus americana L.	.87
Acer saccharinum Marsh.	.80
Quercus bicolor Willd.	.73
Betula nigra L.	.60
Fraxinus pennsylvanica Marsh.	.60
Salix interior Rowlee	.27
Salix rigida Muhl.	.27
Carya cordiformis (Wang.) K. Koch	.13
Gleditsia triacanthos L.	.13
Populus deltoides Marsh.	.13
Tilia americana L.	.13
Ulmus rubra L.	.13
Zanthoxylem americanum Mill.	.13
Betula pumila L. var glandulifera Regel	.07
Quercus bicolor Willd. x Q. macrocarpa Michx.	.07
Quercus bicolor Willd. with Q. macrocarpa Michx. introgressions	.07
Quercus rubra L.	.07
Salix amygdaloides Anderss.	.07
Salix lucida Muhl.	.07
Salix pyrifolia Anderss.	.07

* The figures represent the frequency with which a given species was found on islands or land masses classified as alluvial forest. Only one specimen need have been collected or noted for that species to be counted. This table can not be used to indicate relative abundance at a given site.

TABLE A16

Frequency of shrubs found in alluvial forest encountered along Transect 7

Alluvial forest-Shrubs

Cornus obliqua Raf.	.47
Cephalthus occidentalis L.	.40
Cornus racemosa Lam.	.13
Sambucus canadensis L.	.07
Spiraea alba Du Roi	.07
Viburnam lentago L.	.07

TABLE A17

Frequency of vines in alluvial forests encountered along Transect 7.

Alluvial forest-Vines	
Menispermum canadense L.	.27
Smilax herbacea L.	.20
Vitis riparia Michx.	.20
Smilax hispida Muhl.	.13
Parthenocissus quinquefolia (L.) Planch.	.13
Cuscuta sp.	.07
Parthenocissus inserta (Kerner) k. Fritsch.	.07

TABLE A18

Frequency of herbs in alluvial forests encountered along Transect 7.

Phalaris arundinacea L.	.87
Toxirodendron rydbergii	.47
Onoclea sensibilis L.	.47
Arisaema dracontium (L.) Schott	.27
Boehmeria cylindrica (L.) S.W.	.20
Carex tribuloides Wahlenb. (?)	.20
Equisetum arvense L.	.20
Laportea canadensis (L.) Wedd.	.20
Pilea pumila (L.) Gray	.20
Ranunculus abortivus L.	.20
Ambrosia trifida L.	.13
Anemone canadensis L.	.13
Carex scoparia Schk.	.13
Achillea millefolium L.	.07
Carex intumescens Rudge	.07
Cucuta maculatum L.	.07
Circaea quadrisulata (Maxim.) Franch. & Sav.	.07
Cirsium vulgare (Savi.) Tenore	.07
Cryptotaenia canadensis (L.) D.C.	.07
Eleocharis obtusa (Willd.) Schultes.	.07
Galium obtusum Bigel	.07
Geum canadense Jacq.	.07
Impatiens biflora Walt.	.07
Impatiens pallida Nutt.	.07
Lysimachia nummularia L.	.07
Oxalis stricta L.	.07
Physalis heterophylla Nees.	.07
Poa pratensis L.	.07
Polygonum arifolium L.	.07
Polygonum sagittatum L.	.07
Polygonum virginanum L.	.07
Rumex verticillatus L.	.07
Smilacina stellata (L.) Desf.	.07
Smilax ecirrhata (Engelm.) S. Wats.	.07
Thalictrum dioicum L.	.07
Urtica dioica L.	.07
Viola cucullata Ait (?)	.07
Viola missouriensis Green	.07

TABLE A19

Frequency of emergent species encountered in marshes along Transect 7.

Herbs	
Sagittaria rigida Pursh.	.64
Sagittaria latifolia Willd.	.54
Phalaris arundinacea L.	.36
Sagittaria rigida forma *fluitans*	.36
Scirpus validus Vahl.	.27
Sagittaria engelmannia J.G. Smith	.18
Sparganium eurycarpum Engelm.	.18
Scirpus fluvitilis (Torr.) Gray	.09

TABLE A20

Frequency of submergent species found along Transect 7.

Deep Water

Ceratophyllum demersum	1.0
Elodea canadensis Michx.	.93
Potamogeton crispus L.	.93
Potamogeton foliosus Raf.	.64
Potamogeton pectinatus L.	.57
Potamogeton zosteriformus Fern.	.57
Potamogeton nodosus Poir.	.50
Nymphaea tuberosa Paine.	.36
Heteranthera dubia (Jacq.) MacM.	.21
Nelumbo pentapetala (Walt.) Fern.	.14
Vallisneria americana Michx.	.14
Myriophyllum exalbescens Fern.	.07
Ranunculus circinatus Sibth.	.07

Table A21 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 1 , Navigation Pool No. 7 , 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.897
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.018
Heleidae	0.095
others	0.009
Total	1.019

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A22 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 2 , Navigation Pool No. 7 , 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.032
Isopoda	0.000
Amphipoda	0.291
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.000
Heleidae	0.201
others	0.000
Total	0.524

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A23 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 3 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.000
Heleidae	0.049
others	0.000
Total	0.049

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A24 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 4 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.041
Isopoda	0.000
Amphipoda	0.031
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.013
Heleidae	0.045
others	0.029
Total	0.159

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A25 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 5 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.004
Diptera	
Tendinedidae	0.006
Heleidae	0.109
others	0.007
Total	0.126

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A26 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 6 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	4.020
Annelida	
Hiruninea	0.040
Oligochaeta	0.238
Isopoda	0.412
Amphipoda	0.310
Insecta	
Ephemeroptera	
Baetidae	0.029
Ephemeridae	5.279
Coleoptera	0.089
Trichoptera	0.000
Diptera	
Tendipedidae	0.146
Heleidae	0.014
others	0.828
Total	11.405

TAXON (Vegetation)	BIOMASS (g/m^2)
Vallisneria americana, Michx	.822
Phalaris arundinacea, L.	20.832
Nelumbo pentapetala, Fern.	71.403
Ceratophyllum demersum, L.	1.371
Potamogeton crispus, L.	10.005
Heteranthera dubia, MacM.	16.994
Lemnaceae	.548
Total	121.975

Table A27 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 7 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	3.015
Annelida	
Hiruninea	0.000
Oligochaeta	1.514
Isopoda	0.045
Amphipoda	
Insecta	
Ephemeroptera	
Baetidae	0.015
Ephemeridae	0.728
Coleoptera	0.006
Trichoptera	0.000
Diptera	
Tendipedidae	0.006
Heleidae	0.000
others	0.163
Total	5.565

TAXON (Vegetation)	BIOMASS (g/m^2)
Elodea canadensis, Michx	2.193
Nelumbo pentapetala, Fern.	134.309
Total	136.502

Table A28 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 8 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	1.005
Annelida	
Hiruninea	0.740
Oligochaeta	0.903
Isopoda	1.425
Amphipoda	4.475
Insecta	
Ephemeroptera	
Baetidae	0.097
Ephemeridae	2.935
Coleoptera	0.000
Trichoptera	0.231
Diptera	
Tendipedidae	0.085
Heleidae	0.029
others	0.168
Total	12.093

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton crispus, L.	15.213
Elodea canadensis, Michx	26.862
Heteranthera dubia, MacM.	13.979
Ceratophyllum demersum, L.	245.457
Total	301.511

Table A29 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 9 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.010
Annelida	
Hiruninea	0.000
Oligochaeta	0.300
Isopoda	0.043
Amphipoda	0.083
Insecta	
Ephemeroptera	
Baetidae	0.004
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.025
Heleidae	0.000
others	0.000
Total	2.465

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton nodosus, Poir.	382.507
Potamogeton zosteriformis, Fern.	.548
Ceratophyllum demersum, L.	.137
Vallisneria americana, Michx.	.959
Elodea canadensis, Michx.	15.760
Nelumbo pentapetala, Fern.	140.065
Total	539.976

TableA30 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 10 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	21.108
Annelida	
Hiruninea	0.401
Oligochaeta	0.262
Isopoda	0.623
Amphipoda	0.495
Insecta	
Ephemeroptera	
Baetidae	0.112
Ephemeridae	3.496
Coleoptera	0.009
Trichoptera	0.000
Diptera	
Tendipedidae	0.279
Heleidae	0.002
others	0.168
Total	26.955

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton crispus, L.	.685
Ceratophyllum demersum, L.	11.512
Heteranthera dubia, MacM.	2.056
Total	14.253

Table A31 Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 11 , Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.010
Annelida	
Hiruninea	0.040
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.001
Heleidae	0.024
others	0.000
Total	2.075

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton nodosus, Poir.	511.764
Elodea canadensis, Michx.	.822
Total	512.586

Table A32 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 12, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	2.010
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.005
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.002
Heleidae	0.008
others	0.010
Total	2.035

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

TableA33 Standing crop (g/m2) of benthic organisms, and standing crop (g/m2) of rooted vegetation, Transect B station 13 , Navigation Pool No. 7 , 1973.

TAXON (Benthos)	BIOMASS (g/m2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.024
Isopoda	0.000
Amphipoda	0.020
Insecta	
Ephemeroptera	
Baetidae	0.002
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.022
Diptera	
Tendipedidae	0.018
Heleidae	0.017
others	0.000
Total	0.103

TAXON (Vegetation)	BIOMASS (g/m2)
NONE	

Table A34 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 14, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.006
Isopoda	0.000
Amphipoda	0.030
Insecta	
Ephemeroptera	
Baetidae	0.015
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.003
Heleidae	0.000
others	0.000
Total	0.054

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A35 Standing crop (g/m²) of benthic organisms, and standing crop (g/m²) of rooted vegetation, Transect B station 15, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m²)
Mollusca	0.000
Annelida	
Hiruninea	0.000
Oligochaeta	0.000
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.032
Diptera	
Tendipedidae	0.004
Heleidae	0.001
others	0.000
Total	0.037

TAXON (Vegetation)	BIOMASS (g/m²)
NONE	

TableA36 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 16, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	4.020
Annelida	
Hiruninea	0.005
Oligochaeta	0.070
Isopoda	0.000
Amphipoda	0.000
Insecta	
Ephemeroptera	
Baetidae	0.000
Ephemeridae	0.000
Coleoptera	0.000
Trichoptera	0.000
Diptera	
Tendipedidae	0.009
Heleidae	0.002
others	0.005
Total	4.111

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A37 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 17, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	14.072
Annelida	
Hiruninea	0.245
Oligochaeta	0.470
Isopoda	0.010
Amphipoda	0.024
Insecta	
Ephemeroptera	
Baetidae	0.219
Ephemeridae	0.094
Coleoptera	0.001
Trichoptera	0.000
Diptera	
Tendipedidae	0.175
Heleidae	0.010
others	0.067
Total	15.387

TAXON (Vegetation)	BIOMASS (g/m^2)
NONE	

Table A38 Standing crop (g/m^2) of benthic organisms, and standing crop (g/m^2) of rooted vegetation, Transect B station 18, Navigation Pool No. 7, 1973.

TAXON (Benthos)	BIOMASS (g/m^2)
Mollusca	
Annelida	
Hiruninea	
Oligochaeta	
Isopoda	
Amphipoda	
Insecta	
Ephemeroptera	(NOT SAMPLED)
Baetidae	
Ephemeridae	
Coleoptera	
Trichoptera	
Diptera	
Tendipedidae	
Heleidae	
others	
Total	

TAXON (Vegetation)	BIOMASS (g/m^2)
Potamogeton foliosus, Raf.	.274
Potamogeton nodosus, Poir.	50.983
Potamogeton zosteriformis, Fern.	3.289
Ceratophyllum demersum, L.	11.238
Elodea canadensis, Michx	9.319
Heteranthera dubia, MacM.	99.087
Total	174.182

Table A39 Biomass of benthic organisms and rooted vegetation, Transect B, Stations 1-18, Navigation Pool No. 7, 1973

STATION	TOTAL BIOMASS BENTHOS (g/m^2)	TOTAL BIOMASS ROOTED VEGETATION (g/m^2)	GRAND TOTAL (g/m^2)
1	1.019	NONE	1.019
2	0.524	NONE	0.524
3	0.049	NONE	0.049
4	0.159	NONE	0.159
5	0.126	NONE	0.126
6	11.405	121.975	133.380
7	5.565	136.502	142.067
8	12.093	301.511	313.604
9	2.465	539.976	542.441
10	26.955	14.253	41.208
11	2.075	512.586	514.661
12	2.035	NONE	2.035
13	0.103	NONE	0.103
14	0.054	NONE	0.054
15	0.037	NONE	0.037
16	4.111	NONE	4.111
17	15.387	NONE	15.387
18	(not sampled)	174.182	174.182

TABLE A40 Maintenance dredging activity; Cu. yds./mile reach of river/year, 1936-1967, average/yr. total average/yr, Pool No. 7.

YEAR	MILE 702-3	703-4	704-5	705-6	706-7	707-8	708-9	709-10	710-11	711-12	712-13	713-14	TOTAL
1936				61210	16152	45362	48143	48807	37242	99220			356135
1938					80944						75509	595	157048
1939												164000	164000
1940													-0-
1941													-0-
1942												23947	23947
1943				52842						180605	133924	68567	435938
1944											54747	112580	167327
1945					2681	6077		51559				23437	83754
1946				50505	33164			100560		45988		46120	306337
1947												46187	46187
1948						1883	33807				60041	3893	99624
1949							75460			119206	39428		234094
1950								32712			32693	34132	99537
1951					46081			37080		33168	27706	2849	146884
1952							23583			49328	52966	19213	145090
1953				30951	48734			28083	22362	62976	47600		234661
1954			38478				77340				43836	93701	253335
1955								58447			76731	170806	305984
1956			102658										102658
1957									30843				30843
1958											48535		48535
1959													-0-
1960					8444								8444
1961								27354					27354
1962				29461	44752								74213
1963							53794			99052	22607		175453
1964		21887			13748				38480				78377
1965					19826			60976		52711	12485		145988
1966					41450								41450
1967			81089	43956	95756		238889	64921		194821			719432
AVE/Yr.	-0-	663	6734	8149	13688	1615	15238	15469	3906	28396	22085	25583	150303

APPENDIX B ARCHAEOLOGICAL BACKGROUND

ARCHAEOLOGICAL BACKGROUND INFORMATION

Archaeological and historic sites of importance consist of such diverse elements as prehistoric village sites, petroglyphs (rock pictures), burial mounds, log cabins, forts, and so forth. Sites of significance may date from thousands of years ago to very recent times. Interest in studying elements of human history also varies as much with the times as interest in studying elements of natural history.

STUDIES IN THE LATE 1800's: THE LEWIS AND HILL SURVEY

Fortunately for our study now, there was a strong interest in the late 19th Century in burial mounds; a massive study was pursued for approximately 20 years by Alfred J. Hill and Theodore H. Lewis. The extent of their work is best understood by examining a few of their manuscripts, a few samples of which are reproduced in this report. In 1928, Charles R. Keyes wrote of their accomplishments:

> "The great extent of the archeological survey work accomplished by Lewis and Hill cannot be appreciated except through an extended examination of the large mass of manuscript material that has been preserved. This consists approximately of the following forty leather-bound field notebooks well filled with the original entries of the survey; about a hundred plats of mound groups drawn on a scale of one foot to two thousand; about eight hundred plats of effigy mounds (animal-shaped mounds from Minnesota, Wisconsin, Iowa, and Illinois) on a scale of one foot to two hundred; about fifty plats of "forts" (largely village sites of the Mandan type) and other inclosures on a scale of one foot to four hundred; about a hundred large, folded tissue-paper sheets of original, full-sized petroglyph rubbings with from one to six or more petroglyphs on each; about a thousand personal letters of Lewis to Hill; four bound "Mound Record" books made by Hill and in his handwriting; [illegible] well filled scrapbooks of clippings on archeo- [illegible] made by Lewis; numerous account books, vouchers [illegible]

"A single sheet of summary found among the miscellaneous papers of the survey, apparently made by Lewis, is eloquent in its significance. Tabulated by years and place of entry, the mounds alone that were actually surveyed reach a grand total of over thirteen thousand -- to be exact, 855 effigy mounds and 12,232 round mounds and linears...

"The survey is quite full for Minnesota, where work was done in all but three counties of the state, resulting in records of 7,773 mounds, besides a number of inclosures... much information was also gathered from the river counties of Iowa, Nebraska, Kansas, and Missouri. In Wisconsin the survey touched more than two-thirds of all the counties, mostly in the field of the effigy mounds in the southern half of the state, where the records supply detail for no less than 748 effigies and 2,837 other mounds. Iowa was explored most fully in the northeastern counties as far south as Dubuque, yielding data on 61 effigy mounds, 553 other mounds, and several inclosures. ...the survey yielded its richest results in Minnesota, the eastern parts of the Dakotas, northeastern Iowa, and the southern half of Wisconsin..." (Surveys were also conducted in the Dakotas, Manitoba, Missouri, Nebraska, Kansas, Illinois, Indiana, and Michigan -- in all, eighteen states.)

"The strength of the survey consists, first of all, in the dependability of Lewis as a gatherer of facts... he worked as a realist, measuring and recording what he saw with painstaking accuracy and unwearying devotion... And the fact that these surveys were made at a time when a large number of mound groups that have since disappeared, or all but disappeared, were still intact, gives the work of Lewis and Hill an incalculable worth... So far as Iowa is concerned, something like half of the antiquities of the northeastern part of the state are recoverable only from the manuscripts of the Northwestern Archeological Survey..."

A typical description of the reporting format followed by Lewis and Hill is reproduced here:

(IN: MOUNDS IN DAKOTA, MINNESOTA AND WISCONSIN)

3. OTHER MOUNDS IN RAMSEY COUNTY, MINNESOTA

At the lower end of the Pig's Eye marsh already mentioned, there stood (April, 1868) an isolated mound, not situated on the bluffs, but below them, near their foot, at the highest part of the river bottom on the sloping ground half-way between

> the military road and the road-bed of the St. P. & C. R. R., then in course of construction, and distant about three hundred and fifty feet southward from the culvert on the former. It was in a cultivated field, and had itself been plowed over for years; yet it had still a mean height of six and a half feet; its diameter was sixty-five feet. The top of it was only thirty-one feet above the highwater of the Mississippi, according to the levels taken by the railroad engineers. The location of the mound, according to U. S. surveys, was on the N. ½ of SE. ¼ of Sec. 23, T. 28, R. 22, and about one mile north of Red Rock landing. Mr. J. Ford, one of the old settlers of the neighborhood, said that a man named Odell had, some years previously, dug into it far enough to satisfy his curiosity, as the discovery of human bones clearly proved it to have been built for sepulchral purposes.
>
> 7. MOUNDS AT PRESCOTT, WISCONSIN
>
> At the angle formed by the confluence of the St. Croix and Mississippi rivers, on the eastern bank of the former, is the town of Prescott, Wisconsin. On May 13, 1873, three hours' time was employed in making such reconnaissance survey as was feasible of the mounds which stretch along the bluff on the Mississippi there. The smallest of them was about twenty-five feet diameter and one foot high, and the largest fifty-six feet diameter and four feet high, as nearly as could be then ascertained.

Pictographs were common on caves along the Mississippi River bluffs. Lewis and Hill recorded their locations and frequently the pictures themselves. Although specific reference was made to them in Houston, Winona, Washington, and Ramsey counties in Minnesota and Alamakee and Clayton counties in Iowa, it would be unwise to assume that they were limited to these locations.

Captain Carver, in 1766-67 explored a cave (in present day Ramsey County) as being of "amazing depth and containing many Indian hieroglyphics appearing very ancient." The cave, called by the Dakota "Wakanteebe", become a popular tourist attraction in the 1860's. Railroad construction was responsible for its destruction in the 18880's.

PRESENT CONSIDERATIONS

The difficulty, then, is not the absence of records of significant sites, but rather that records of thousands of sites exist. And although archaeologists have resurveyed some of the sited, vast areas have not been checked since the original surveys. The farmer, in the course of clearing and farming his land, is chiefly responsible for the destruction of the sites, and most of the sites have by now been destroyed.

MINNESOTA

This section contains information on significant archaeological and historic sites in Minnesota.

Background

This format evolved from problems encountered in developing an inventory of sites. The listing of reasons for not doing so which follows is included because it may shed some light on future problems also.

Original plans were made to provide an inventory of Minnesota archeological sites which lie in the study area. This ideas was abandoned, however, due to the following considerations:

1. The number of sites in close proximity to the river in large and the amount of work required to review existing records (beginning in the early 1800's) exceeds the value of such an inventory in this report;

2. The records are known to be incomplete in many cases, scanty for certain areas or incorrect so that reliability of the inventory is questionable;

3. Many sites once recorded have been destroyed by the action of others (not the Crops of Engineers) but the records have never been updated. Nor has there ever been a complete systematic inventory of archaeological sites in Minnesota.

4. In many cases the location of sites given is not sufficiently accurate to determine if the site is close enough to the river bank to be threatened. In some cases, where the bluffs are close to the river bed, a vertical elevation of many feet may effectively remove a site from any threats of water, dredge spoil, or construction. The records may not show this.

5. The Minnesota State Archaeologist is understandably reluctant to publish for public consumption a list of inventory

of archaeological sites because of risk of robbery, despoliation, vandalism, or unauthorized unscientific excavation. Such cases have been known in the past. However, the State Archaeologist and his staff have expressed the willingness and desire to assist individuals or government bodies in locating and identifying sites for preservation or excavation before destruction.

Impact on Prehistoric Archaeological Sites

Because the files of the State Archaeologist are located in the Twin Cities, it was possible to engage a professional archaeologist to investigate the current status of those archaeological sites in the Mississippi, Minnesota, and St. Croix River areas in Minnesota. The report by consultant Jan Streiff is reproduced here in its entirety.

A Report of the Impact of the U. S. Army Corps of Engineers on Prehistoric Archaeological Sites on the Lower Mississippi, Lower St. Croix, and Lower Minnesota Rivers in Minnesota

By Jan E. Streiff, Archaeologist, Department of Anthropology, University of Minnesota, Minneapolis.

Introduction. There are approximately eighty-five (85) designated sites in the Corps of Engineers area under consideration (i.e., the Mississippi River from St. Anthony Falls to the Minnesota-Iowa border, the Minnesota River from Shakopee to Pike Island, and the St. Croix from above Stillwater to Prescott). The information on these sites has been collected since the late 1880's and all the data is filed in the Archaeological Laboratory at the University.

Although some of these sites have been revisited since being recorded, and a few have been excavated, most have not been rechecked. Consequently there are many unknown things about most of the sites listed in this report. Ideally, a crew should have been sent out to resurvey the river valleys in question, to determine if sites formerly recorded are still there and, if not, how they were destroyed -- particularly if by the Corps of Engineers.

Since such an on-site survey was impossible at this time, the written records will have to suffice. I have organized the known sites into the three categories shown below.

Classification of Sites.

Group I. These are sites definitely known to have been destroyed by Corps of Engineers activities. There are nine (9) of these sites.

Group II. These are sites in the area under consideration which should not be affected by the Corps because they appear too high above the river channels. Although they may never be flooded by raised water levels, they should be kept in mind as possibly being destroyed by burrow activity, dredging, etc. There are six (6) of these sites.

Group III. This is the largest group of sites (73) within the Corps of Engineers area. This is the group for which no definite classification can be given. There are many reasons:

a. our site location description is too vague to determine if the site is or was in danger

b. sites which were destroyed, such as the mound groups at Dresbach, but where we cannot determine if the destruction was carried out by the Corps of Engineers dam construction or by some unrelated project.

c. sites, such as those on Pig's Eye Island, which have not been reexamined since recorded but are so located as to be assured destruction by a fluctuation in the river level or at least damaged by erosion by the river. Any dredging of the river and subsequent depositing of the debris on the nearby shore would undoubtedly cover the site.*

The Effect of Corps of Engineers Activities on Archaeological Sites By Pool.

The following chart is a breakdown by pool of archaeological sites affected by the Corps of Engineers. The sites are listed using the groupings defined above.

Pool No.	Group #1* (destroyed)	Group #2 (not affected)	Group #3* (uncertain)
2	2	1	7
3	4	2	11
4	0	1	7
5	1	0	1
5 or 5A	2	0	3
6	0	0	1
7	0	0	7
8	0	0	6
St. Croix	0	0	5
Minnesota	0	2	25
	9	6	73

*For a detailed description of the sites destroyed by the Corps of Engineers projects, see Appendix 1. A description of the Group III sites is included in Appendix 2.

Conclusions. Although this report is rather inadequate to determine the real impact of the Corps of Engineers on archaeological sites (there are still those 73 sites for which we have no information on Corps of Engineers impact), it does point up the great need for future surveys along Minnesota's three greatest rivers to determine what effect the Corps of Engineers will have on prehistoric sites.

The importance of these rivers to life was no less important to the original Americans than it is to us today. And it is vital to the history of the American Indians that an attempt be made, if not to preserve, then at least to record the habitation and burial areas that are so numerous along these waterways.

The Corps of Engineers can expect that the professional archaeologists in Minnesota will do everything possible to cooperate with them to see that these ends are achieved.

Jan E. Streiff
University of Minnesota
February 1973

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Description of Sites Destroyed by Corps of Engineers Activity.

1. 21 WA 1 Schilling Site located SE ¼ Sec 32 T 27N R 21W
   A mound and village site located on Grey Cloud Island, Washington County, Pool #2. Site has been destroyed by raised water level.
2. 21 DK 1 Sorg Site located NE ¼ NE ¼ Sec 23 T 115N R 18W
   A habitation site located on Spring Lake, Dakota County, Pool #2. The site is under water now.
3. 21 GD 75 SW ¼ SE ½ Sec 32 T 114N R 15W
   A group of 45 mounds located on Prairie Island, Goodhue County, Pool #3. Thirty-eight mounds are under water, 7 are still above water but are being eroded away by the river.
4. 21 GD 1 Nauer Site located NW ¼ Sec 9 T 113N 15W
   A mound and village group located on the southern tip of Prairie Island, Goodhue County, Pool #3. The mounds were destroyed with the construction of Lock and Dam #3.
5. 21 GD 57 Nauer Site located NW ¼ Sec 9 T 113N R 15W
   Part of Site 1, above, Pool #3. Part of the village and several mounds were destroyed with the construction of the recreational area known as "Commissary Point", a picnic ground.

6. Unnumbered LeSueur and Perrot French Trading Post

This site is listed as destroyed through "negative evidence". The site is recorded as being on Prairie Island, Goodhue County, Pool #3, and all attempts to locate the site have failed. It is thus assumed that because the post was on the water's edge that it is now under water.

7. Unnumbered, Unnamed Sec 34 T 109N R 9W

This was a mound and habitation site at the mouth of the Whitewater River, Wabasha County, Pool #5. The landowner pointed the site out to the State Archaeologist after it had been covered with water.

8. Unnumbered Location T 108N 7W

The site is a group of mounds on Prairie Island, Winona County. The site was covered by a Corps of Engineers levee. Pool #5 or 5A.

9. Unnumbered same location as above

This site, although spared in the first levee construction, was buried with the addition of a later levee.

Appendix 2.

Location of Sites Potentially Vulnerable to Damage by Future Construction, Operations, and Maintenance Activities.

Winona County	WN 8	T106 R5	WN 4	T105 R4	T = township
	WN 9	T106 R5	WN 3	T105 R4	R = range
	WN 5	T106 R5	WN 15	T105 R4	

National Register of Historic Places

Archaeological and Historic Sites in Minnesota in the Study Area along the Mississippi, Minnesota, and St. Croix Rivers Which are Now Listed in the National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation. Listed in the latest (1972) edition of the National Register of Historic Places are the following sites adjacent to the Mississippi, Minnesota, and St. Croix Rivers in Minnesota. These sites have not been destroyed or damaged extensively by previous Corps of Engineers activity, but must be considered as possibly vulnerable in the future:

Fort Snelling - located near the confluence of the Minnesota and Mississippi Rivers in Hennepin and Dakota Counties. This was the State's first military post and, until 1849, the northwesternmost outpost in the nation. Restoration of the fort is continuing and live interpretation of the past is scheduled daily for visitors. Cantonment New Hope, the site of the makeshift encampment occupied by the soldiers who built Fort Snelling, and located on low ground near the east end of the present day Mendota Bridge has been located by archaeological excavation, but has not been opened to the public.

Mendota Historic District - located in Dakota County, across the Minnesota and Mississippi Rivers from Fort Snelling. Mendota is the oldest permanent white settlement in Minnesota. The historic buildings are located on the bluffs.

St. Anthony Falls Historic District and Pillsbury "A" Mill - an area on the east and west banks of the Mississippi River at St. Anthony Falls including Nicollet Island. The St. Anthony Falls district was the origin of the city of Minneapolis. The Falls area was rich in Indian folklore, before it was first seen and described in 1680 by Father Hennepin. The falls, about 75 feet high and several hundred yards wide, were originally valued for their scenic beauty and the area became important as a tourist attraction. Later, the Falls provided power for lumbering and flour milling, and in 1882, became the location of the first hydroelectric plant in the Western Hemisphere. Construction of a concrete apron over the falls to halt their once-rapid erosion generally diminished their scenic beauty. The falls were bridged in the 1880's by a stone arch railroad bridge, still in constant use, which is said to resemble a Roman aqueduct. The lower lock and dam were completed in 1956 and the upper lock and dam in 1963 by the Corps of Engineers.

Structures and sites considered worthy of preservation in the area include: Ard Godfrey Cottage, Lady of Lourdes Church, Nicollet Island, the Third Avenue Bridge, Stone Arch Bridge, and the Pillsbury "A" Mill, built in 1881, then the largest flour mill in the world, and still in operation today.

Bartron Site - located in Goodhue County on the southern portion of Prairie Island in the Mississippi River bottomlands. (¼ Sec 9, T 113N., R 15W). This is a relatively undisturbed (by farming) site containing possible evidence of house form, village arrangement, and artifacts from the major Mississippian culture (1000 A.D. to 1700 A.D.). The site is owned by NSP and has been excavated by Professor Eldon Johnson (State Archaeologist). It is known that Pierre Le Sueur spent the winter of 1696 there.

Prairie Island is part of Sioux Indian Reservation which as described by Roy W. Meyer in 1961 as "...the last portion of Goodhue County to be settled. Although often described as an island in the Mississippi, the area is actually a part of the right bank of that river, cut off from the upland by an arm of the Vermillion River which parallels the Mississippi from Hastings to the lower end of the island. Since the construction in 1938 of Lock and Dam Number 3 in the Mississippi and the diversion of the Vermillion, the "island" has become a peninsula, slightly more than two miles in width. Prairie Island is almost completely flat and only about sixteen feet above the average water level of the river; hence, it is partially covered with lakes and sloughs and is subject to flooding. The soil is rich in humus, but sandy, and in drought years crops which mature late are likely to dry up." Meyer writes that muskrat

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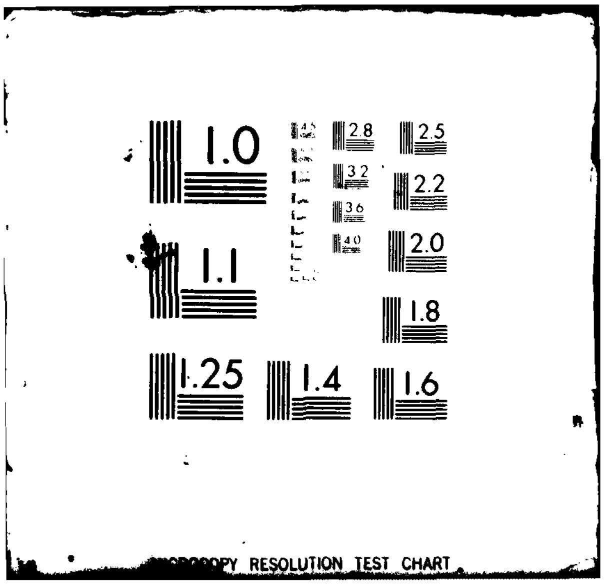
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trapping was suggested as a possible source of income when the dam then being built raised the water level and produced ponds and sloughs.

Information on Prairie Island should continue to be studied. Suggested sources: the N. S. P. study by Eldon Johnson, "An Economic Survey of the Prairie Island Indian Community" by Clyde G. Sherman in Minnesota (an unpublished study in the possession of the Minnesota Agency in Bemidji), as well as those listed in the bibliography.

St. Croix Boom Site - located three miles north of Stillwater on the St. Croix River in Washington County. From 1840 to 1914 this was the terminal point for the white pine lumber industry. Here millions of logs were sorted, measured, and rafted to downstream sawmills. The boom site died naturally as a result of the depletion of timber late in the 19th Century. There are no remains of the log boom, but the general setting is unimpaired.

Marine Mill Site - located in Washington County at Marine-on-St. Croix. It is the site of Minnesota's first commercial saw mill which was founded in 1839. At present only the ruins of the engine house and a marker specify the site.

Sites Designated as Historic and Worthy of Preservation, Not Yet Included in The National Register, in Minnesota Which are Adjacent to the Minnesota, Mississippi, and St. Croix Rivers

1) The historic Old Frontenac area which includes the site of the

French Fort Beauharnais (Goodhue County) located on Pointe au Sable along the Mississippi. The original fort was flooded its first year and was later rebuilt on higher ground. Burned and abandoned in 1737, it was rebuilt and finally abandoned again in 1756. Nothing remains of the fort. However, cannon balls and lead bullets were recovered from Lake Pepin in the 1890's.

2) Shakopee Historic District (Scott County) along the lower bluffs of the Minnesota River near Shakopee. The location of Chief Shakopee's village from the 1820's to 1852 as well as a concentration of prehistoric Indian mounds and a grist mill. Additional buildings of historical significance are being brought to the site.

3) Silverndale Site and Associated Mounds (Goodhue County) adjacent to the Red Wing Industrial Park.

WISCONSIN

Early Archaeology

Increase A. Lapham recorded the results of Wisconsin archaeological research which he began in 1836 in The Antiquities of Wisconsin, published in 1850. Although his work was extensive and continued until his death in 1875, it focused on areas other than the Mississippi River Valley. He described sites along the Mississippi River as far north as the LaCrosse River; then concluded: "Only an occasional mound was observed along the valley of the LaCrosse River; and it is believed that no works of any considerable extent exist above this point on the Mississippi." See Figure 1.

A review of the publications of Lapham, Robert Ritzenthaler, and Charles E. Brown reveal that Wisconsin archaeological and historic sites, especially burial mounds, were extensive. The number of mounds in Wisconsin were estimated to number 15,000. Sites occurred on and near the shores on nearly every stream and lake. In addition to burial mounds, "sites of native villages, camps and workshops, plots of corn hills and garden beds; enclosures; burial places and cemeteries; refuse heaps and pits; cave shelters; shrines; pictograph rocks; boulder mortars; sources of flint, quartz, quartzite and pipestone; lead diggings; copper mining pits; stone heaps and circles; cairns; and trails" are of interest to the Wisconsin archaeologist. Burial mounds, village sites, forts, and pictographs are found in the Mississippi River Valley. See Figure 2.

Recent Archaeology

An important discovery was made in 1945 by two Mississippi River fishermen who "saw some artifacts projecting from the bank which had been undercut by the action of the River." The "Osceola Site" in Grant County is located two miles south of Potosi on the Mississippi River bank (NW ¼ of Sec. 14 T.2, N. Range 3, W of 4th Principal Meridian). Excavation of the burial mound revealed copper implements, as well as projectile points and banner stones. The copper implements provide evidence of the presence of Indians belonging to the "Old Copper Culture" who probably arrived in the State about 3000 B. C.

The site has been damaged, however, by rising water. Ritzenthaler who described the site in 1946, stated:

> Up to 8 years ago this was the bank of the Grant River, but the installation of a dam at Dubuque raised the water and widened the Mississippi at this point ... Test pits revealed that the burial pit extended about 70 feet along the bank, and was about 20 feet wide at this time, but it must have been considerably wider originally judging from the amount of material washed into the river.

No mention was made about intended future disposition of the site. Ritzenthaler also mentioned that another site, Raisbeck, in Grant County had been excavated, but he did not give an exact location. Other mounds were located on the Mississippi River bluffs above Potosi and were mentioned in the 1927 edition of Scenic and Historic Wisconsin.

Dr. Freeman stated that an extensive survey of sites was conducted in Crawford County when the St. Feriole Island buildings were recommended for inclusion in the National Register of Historic Places. St. Feriole

Island was originally a prairie between the Mississippi River and the bluffs of Prairie du Chien. It contained many burial mounds which were not effigy shaped. An article in 1853 by Lapham stated that the mounds "are so near the river that their bases are often washed by floods." During the highest known flood -- 1826 -- only the mounds could be seen above the surface of the water. The first fort was built on an Indian mound, as were several French homes. Lapham stated that the mound was excavated but that no remains were found in it. He did note some remains of an "American fort taken by the British in the War of 1812." Lapham, in visiting the mounds in 1852, found them "almost entirely obliterated due to cultivation and the light sandy nature of the materials."

In Pepin County, Ritzenthaler reported the existence of an Indian village site, 2 miles east of Pepin, along a wide terrace to the Mississippi. Pepin is also mentioned as the site of French forts including St. Antoine, built in 1686, above the mouth of Bogus Creek. In Trempealeau County, Nicolls Mound, the Schwert Mounds, and the Trowbridge site have been excavated. Perrot State Park in Trempealeau contains Indian mounds and the site of a log fort erected by N. Perrot, a French explorer, in 1685-6. Indian mounds are also preserved in LaCrosse.

In an article published in 1950, "Wisconsin Petroglyphs and Pictographs", Ritzenthaler enumerated the existence of the following petrographs. He did not specify their exact location. Their condition had been unchecked since 1929. Exact location and current condition should be checked with the state archaeologist. In Vernon, LaCrosse, Crawford, and Trempealeau Counties, sandstone and limestone cliffs and caves with petrographs were recorded. Larson Cave in Vernon County contained petroglyphs described as being in excellent condition in1929; Samual's Cave, LaCrosse County, containing petroglyphs and pictographs was first investigated in 1879 -- and was still in excellent condition in 1929. Galesbluff, LaCrosse County, contained petroglyphs carved on soft limestone. Nearly all of the petroglyphs in Trempealeau County in the Trempealeau and Galesville rock shelters have been destroyed -- either by road builders, erosion, or tourists. Pictographs were described by L. H. Bunnell in 1897, "a short distance above Prairie du Chien." Ritzenthaler did not report their present condition.

Future Studies

Dr. Freeman mentioned specific sites which have been flooded are located on Lake Pepin, at Trempealeau, and at Wyalusing. In the limited time available, this author could not locate any current publication describing the extent or present condition of sites known to have existed in Wisconsin. The Wisconsin Archaeologist, if reviewed issue by issue, would reveal considerably more data on the above mentioned sites, as well as other, perhaps more important, sites. However, lack of time precluded that examination. An examination of that publication, a review of the files in the historical society, and on-site visits would be required before one could be assured of an accurate analysis of present conditions of the sites.

National Register of Historic Places

In 1966, the National Historic Preservation Act was passed. It provides for comprehensive indexing of the properties in the nation which are significant in American history, architecture, archaeology, and modern culture. The Register is an official statement of properties which merit preservation.

The only Wisconsin archaeological or historic site bordering the Mississippi or St. Croix rivers listed in the Register is in Crawford County on St. Feriole Island in the Mississippi River, at Prairie du Chien.

Astor Fur Warehouse, Brisbois House, Dousman Hotel, Second Fort Crawford, Villa Louis

All of the above structures are remains of the early settlement of Prairie du Chien as an early fur trade, steamship, and railroad center. They were constructed between 1808 and 1864 and most are still under private ownership.

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APPENDIX C METHODS OF DATA COLLECTION

APPENDIX C. Methods of Data Collection

Water samples were collected at the surface with a Kemmerer bottle (capacity = 2 liters). The water temperatures were recorded immediately. The samples collected for oxygen determinations were fixed on site with Winkler reagents. All samples were stored in a refrigerator until analyses were completed.

Conductivity measurements were made with a Type RC Conductivity Bridge (Industrial Instruments Inc., Cedar Grove, N.J.). All readings were later converted to u mhos at 25C.

Turbidity was determined with a 110 volt Turbidimeter (Model 1860 Hach (Hach Chem Corp., Ames Iowa).

Dissolved oxygen determinations were made using the azide modification of the Winkler technique. Determinations were made spectrophotometrically with a Spectronic 20 (Bausch and Lomb), at 450 mu.

Orthophosphate, nitrate nitrogen, and nitrite nitrogen determinations were made using Hach reagents, with the quantitative determinations made on a Spectronic 20 spectrophotometer.

The benthos was sampled using either a Petersen dredge or an Eckman dredge, depending upon the depth and the consistency of the sediments. All samples were washed through a #30 brass screen, and were preserved in formalin for later analysis. The samples were transported to the laboratory where they were placed in a sugar solution (density = 1.16) and were floated prior to separation. All were then resuspended in water for futther visual separation techniques. The organisms were then replaced in formalin prior to identification.

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