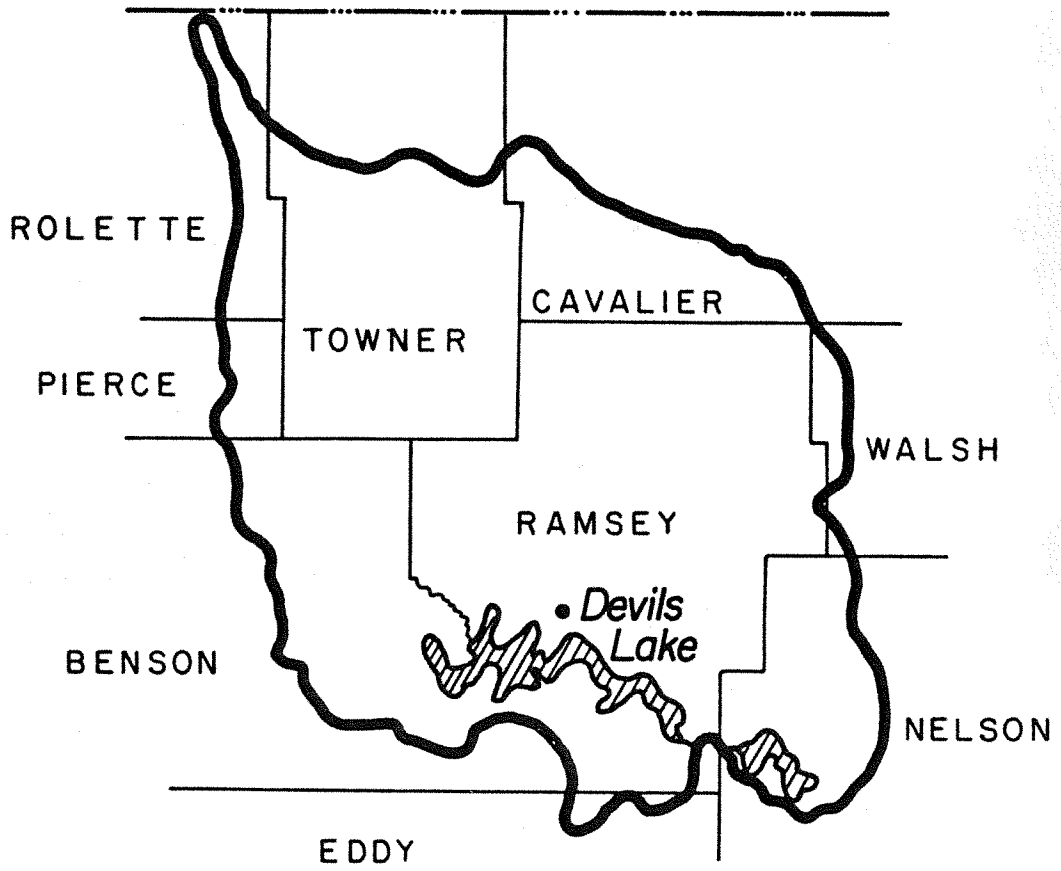
US Army Corps
of Engineers
St. Paul District

DEVILS LAKE BASIN
NORTH DAKOTA



RECONNAISSANCE REPORT

November 1984

DEVILS LAKE BASIN, NORTH DAKOTA
RECONNAISSANCE REPORT

ST. PAUL DISTRICT, CORPS OF ENGINEERS
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DEVILS LAKE BASIN, NORTH DAKOTA
RECONNAISSANCE REPORT

PREFACE

This report summarizes information on the water resource problems in the Devils Lake basin, North Dakota, with a special emphasis on the flood-related losses that would result if the level of Devils Lake continues to rise. The information in this report is based on a reconnaissance level of detail and is subject to change upon collection and analysis of additional information.

The level of Devils Lake has gone from an elevation of about 1446 feet msl (feet above mean sea level) in 1830, down to an elevation of 1402 in 1940, and back to its current elevation of about 1427. If the lake continues to rise to elevation 1445 (about the same level it was nearly 150 years ago), it could cause about $100 million of flood damages. The natural outlet from the Devils Lake chain is at elevation 1457. At this elevation, water would flow into the Sheyenne River basin and then would start flowing toward Lake Winnipeg via the Sheyenne River and the Red River of the North. At this natural overflow elevation, the rising lake level would cause over $200 million of losses.

Several alternatives have been identified to address the rising lake level problem. Most of the alternatives are outlets from the lake chain. Two of these outlet alternatives were evaluated in a preliminary manner for this reconnaissance study. Both outlets were to the Sheyenne River, one from West Bay Devils Lake and the other from East Devils Lake through Western Stump Lake. Both alternatives are economically justified and both would increase flows periodically to the Sheyenne River during low-flow periods on the Sheyenne River. The quality of the Devils Lake water being tranferred to the Sheyenne River

is of concern since the total dissolved solids concentrations are several times higher than those of the Sheyenne River. This increase in salinity may cause adverse effects to the fishery and to water treatment costs along the Sheyenne River and the Red River of the North.

There is substantial local, regional, and State interest in the implementation of a solution to the lake level problem. Local and regional interests are very anxious to see an outlet to the Devils Lake chain constructed.

Additional studies are needed to address the hydrological, water quality, ecological, and political issues associated with implementation of potential alternatives. These studies should be accomplished as soon as practical so that the issues can be resolved to allow implementation of a plan when needed.

DEVILS LAKE BASIN, NORTH DAKOTA
RECONNAISSANCE REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLES

FIGURES

PLATE

DEVILS LAKE BASIN, NORTH DAKOTA
RECONNAISSANCE REPORT

PURPOSE AND SCOPE

This reconnaissance report has been prepared to document water resource problems in the Devils Lake basin, especially those associated with the rising water levels of Devils Lake, and to outline studies and resources needed to address alternative solutions to those problems.

AUTHORITY

The authority to study the water resource problems in the Devils Lake basin is contained in various congressional committee resolutions and acts relating to the Red River of the North basin and/or the Devils Lake basin. They include the following:

- The House Committee on Public Works: March 15, 1949; June 27, 1950; July 19, 1950; August 16, 1950; March 16, 1954; June 19, 1963; and October 5, 1966.

- The Senate Committee on Public Works: June 15, 1950; June 22, 1961; July 12, 1973; and September 30, 1974.

- Section 205 of the Flood Control Act of 1950, May 17, 1950.

- Supplemental Appropriations Act, 1984, Public Law 98-181, approved November 30, 1983.

PRIOR REPORTS

A number of previous studies and reports have addressed the water resource problems of the Devils Lake basin. These studies are summarized in table 1. Prior to 1980, most of the studies considered

Table 1 - Summary of Reports on Water Resource Problems in the Devils Lake Basin, North Dakota

Year of Report	Title of Report	Agency	Remarks
1972	Souris-Red-Rainy Basins, Comprehensive Study; Type II Study of Selected Subbasins of the Red River of the North Basin	Souris-Red-Rainy River Basins Commission	Describes the Devils Lake basin and flood problems, flood damages, and alternative flood damage reduction measures.
1975	Water Quality Studies, Information Report Proposals to Freshen, Restore, and Stabilize Devils Lake Chain of Lakes	U.S. Department of the Interior, Bureau of Reclamation	Outlines portions of proposed plan of the Garrison Diversion Unit to restore desirable lake levels to the Devils Lake chain by the transfer of Missouri River water.
1976	Study Report, The Devils Lake Basin Study	Devils Lake Basin Advisory Committee	Inventories land and water resources of the basin, identifies problems, discusses alternative solutions, and recommends additional studies.
1979	Analysis of Lake Levels on State Highways, Devils Lake Area	North Dakota State Highway Department	Analysis of elevations of highways around Devils Lake. Recommends raises of highways to elevation 1440.
1980	Section 205 Flood Control Reconnaissance Report, Devils Lake	U.S. Army Corps of Engineers, St. Paul District	Preliminary analysis of effects of high levels of Devils Lake and discusses alternative solutions. Recommends development of levees to protect city of Devils Lake. Concludes that the development of a long-term plan would be desirable to address potential future raises in the lake level.
1980	Red River of the North Reconnaissance Report, Devils Lake Subbasin	U.S. Army Corps of Engineers, St. Paul District	Preliminary overview of water and land resource problems and needs in the Devils Lake basin. Identifies additional study needs for basin, including need to understand the causes of the fluctuations in lake levels.
1983	Section 205 Detailed Project Report, Flood Control Project at Devils Lake, North Dakota	U.S. Army Corps of Engineers, St. Paul District	Presents a detailed plan for the construction of a levee system to protect the city of Devils Lake from potential future raises of lake level up to elevation 1440.
1983	Pre-Reconnaissance Evaluation Report, Devils Lake Basin	U.S. Army Corps of Engineers, St. Paul District	Preliminary summary of water resource problems in the Devils Lake basin with emphasis on the rising lake level. Concludes that additional studies are justified to evaluate alternatives to solve the problems caused by the rising lake level.

bringing water into the basin to irrigate cropland and/or to freshen Devils Lake and make it a more valuable fishery and recreation resource. These studies were accomplished in conjunction with the Garrison Diversion Unit being developed by the Bureau of Reclamation. Other studies analyzed the agricultural flooding problems in the upper watersheds. After the substantial increase in lake level during 1979, the potential threat of the higher lake levels prompted studies to analyze solutions to prevent damages caused by a potential continued raise in the lake level.

DESCRIPTION OF SUMMARY AREA

LOCATION AND DESCRIPTION

The Devils Lake basin is in northeastern North Dakota, in the northwest corner of the Red River of the North basin (see figure 1). It is bounded on the south by the Sheyenne River basin, on the north by the Pembina River basin, and on the east by the Park, Forest, and Turtle River basins. Although historically Devils Lake has always been considered a part of the Red River basin, at present it is actually a closed drainage system. No flow from this basin to the Red River has occurred since at least the 1830's when the level of the lake was first recorded. The basin drains about 3,810 square miles from portions of the counties of Benson, Eddy, Nelson, Walsh, Cavalier, Towner, Rolette, Pierce, and Ramsey (see figure 2).

The basin is between the Turtle Mountains to the northwest and a series of prominent hills to the south of Devils Lake. The land surface is a rolling glacial plain characterized by numerous prairie potholes, sloughs, and occasional morainic ridges.

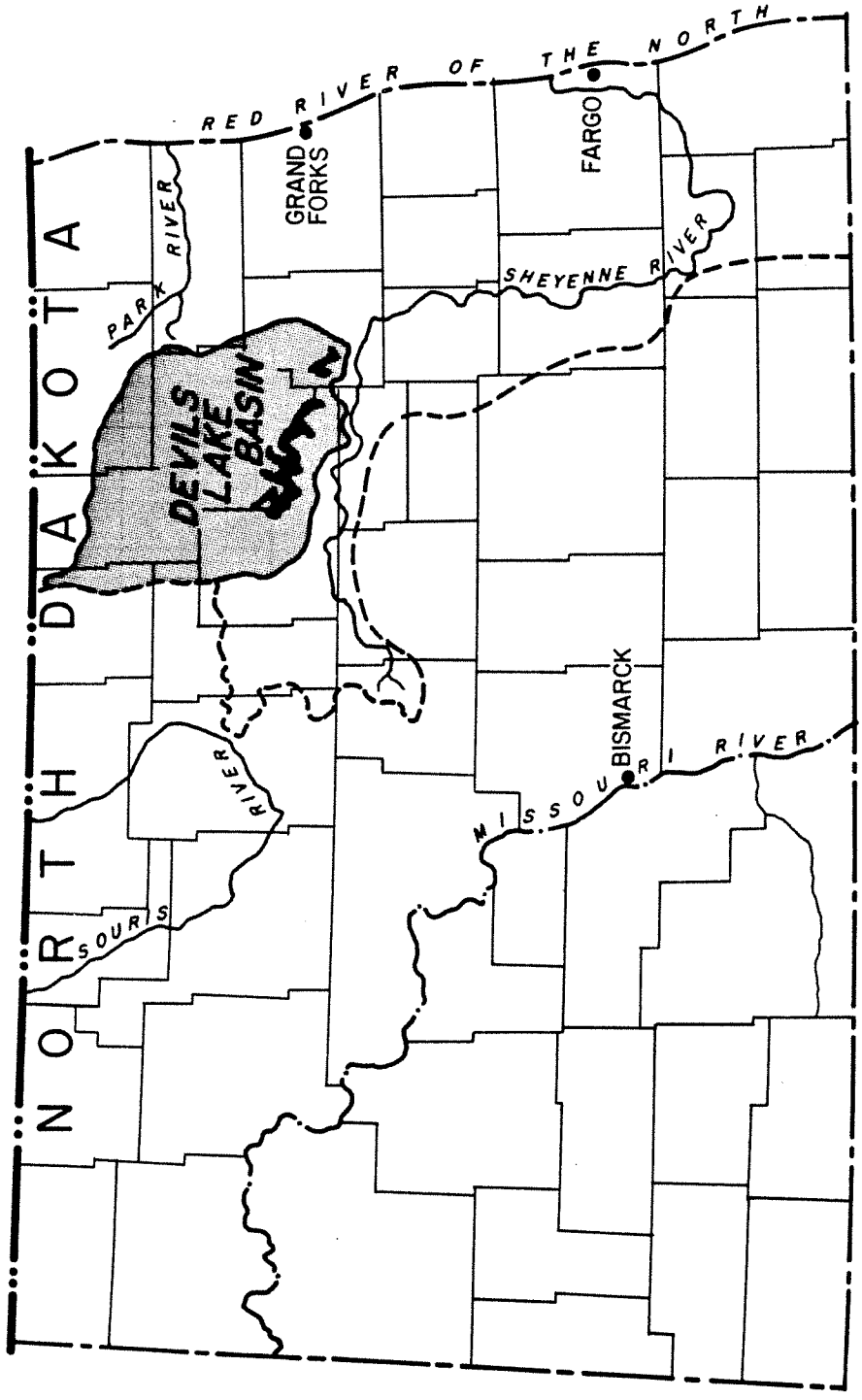

FIGURE. I STUDY AREA LOCATION MAP, DEVILS LAKE BASIN

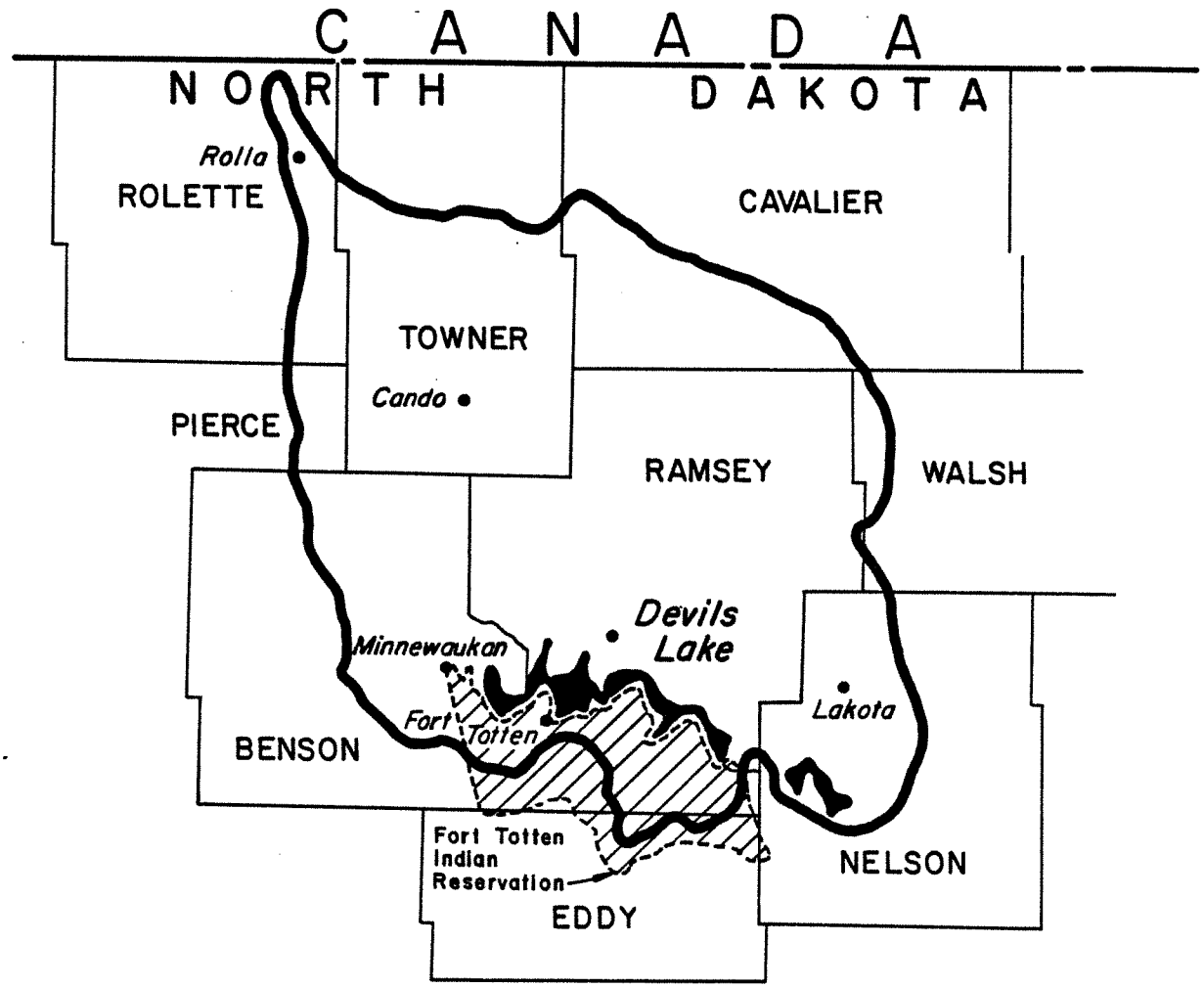

FIGURE 2. DEVILS LAKE BASIN MAP

The surface water drainage system for the basin includes numerous small coulees (streams) and lakes (see figure 3), and it generally flows from north to south. Most of the water eventually flows into Devils Lake or Stump Lake, the lowest areas in the basin. These lakes serve as the final receptors of the surface runoff. The Devils Lake basin has no outlet until its water level reaches elevation 1457 feet msl (feet above mean sea level) (about 30 feet above its current level) when water would flow from Devils Lake through Stump Lake and Tolna Coulee into the Sheyenne River near Tolna, North Dakota.

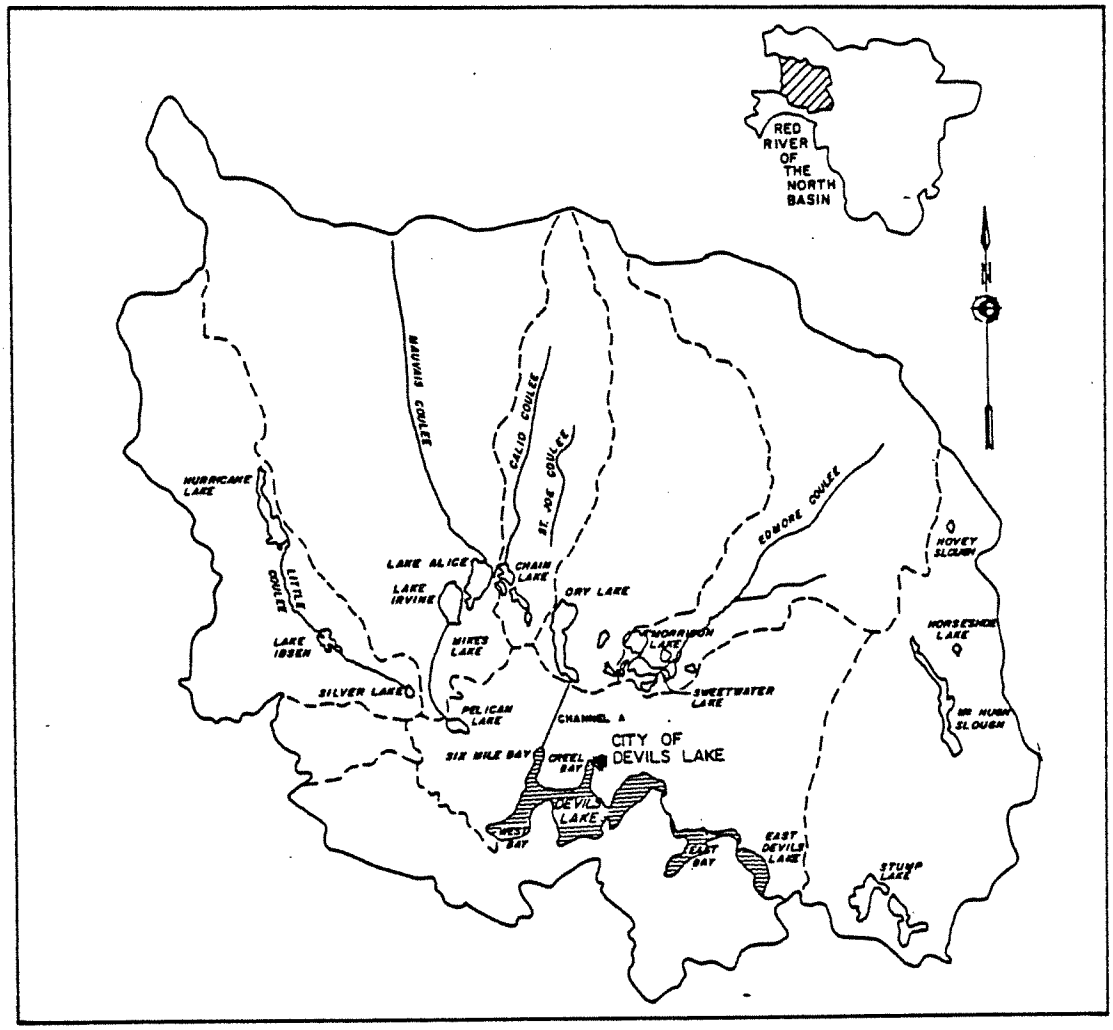

Figure 3 - Surface Water Systems - Devils Lake Basin

The land use in the basin is primarily cultivated agriculture (70 percent), with water (16 percent), grassland (8 percent), woodland (3 percent), and other (3 percent) uses making up the remainder. The largest city in the basin, the city of Devils Lake (1980 population of 7,442), is on the north shore of the main body of Devils Lake. The Fort Totten Indian Reservation, home of the Devils Lake Sioux, occupies about 244,000 acres, and covers most of the basin's drainage area south of Devils Lake.

LAKE LEVEL FLUCTUATIONS

The level of Devils Lake has fluctuated significantly. According to early accounts, the elevation of Devils Lake was about 1446 feet msl in 1830. After this date, the elevation of the lake fell in an irregular pattern until it reached a low of 1402 feet msl in 1940. After 1940, the lake began to rise and reached 1428 feet in 1983. Figure 4 shows recorded lake levels for Devils Lake since 1830.

Inspection of stage hydrographs indicate that the period of record is rather short to show any clear pattern of variation in lake levels. However, archeological and sedimentological investigations provide some additional insight. Recent excavations at the Irvin Nelson site, on the south shore of Devils Lake, have revealed stratigraphic evidence that the lake had been at elevation 1453 at least once since the early Holocene (S. Fox 1982: 10). The land surface in the area shows evidence of being smoothed by sedimentation and wave action when Devils Lake was at an elevation much higher than it is now. The lake level has probably been up between elevations 1440 and 1453 and down to nearly dry several times during this period.

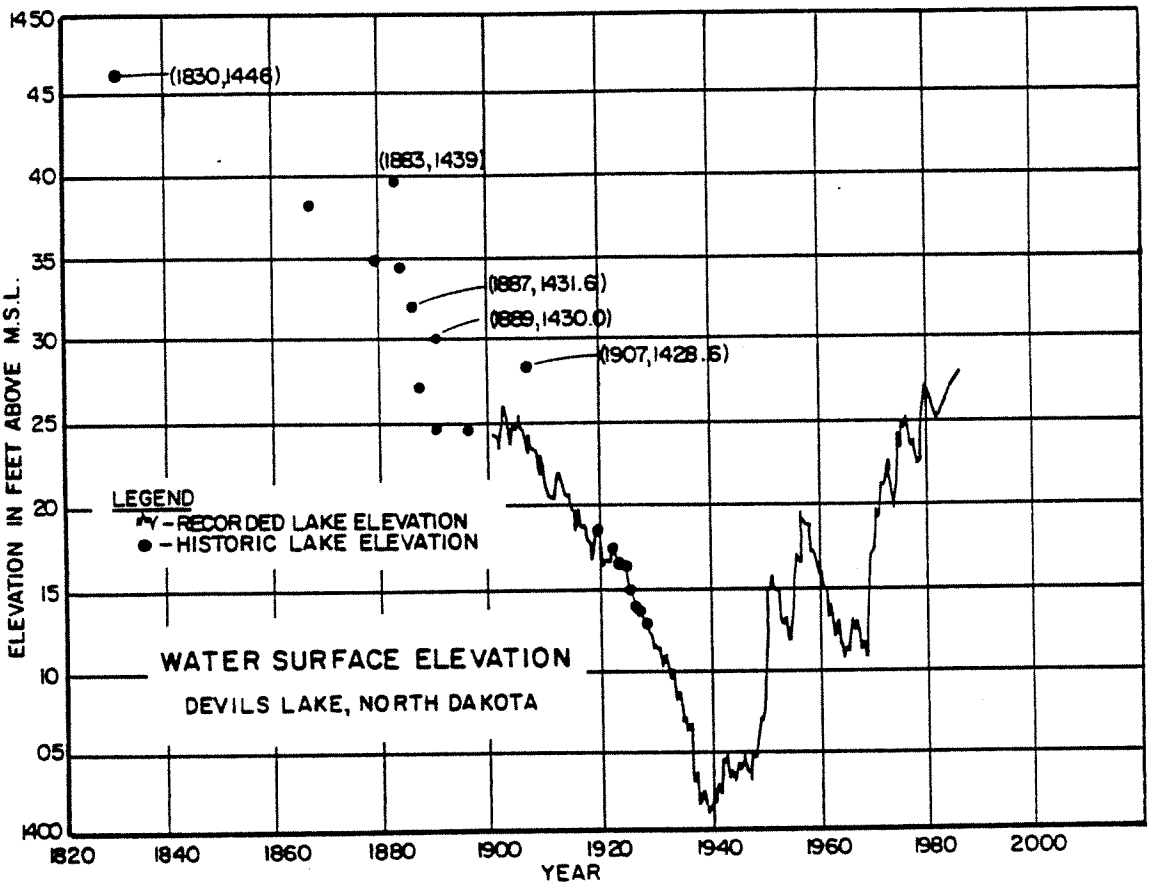

Figure 4 - Water Surface Elevation, Devils Lake, North Dakota

DEVELOPMENT AND ITS RELATIONSHIP TO DEVILS LAKE

Historically, during the Euro-American settlement of the Devils Lake area, in the late 1800's, the lake levels were sufficiently high to support steamboat transportation, a resort industry, and commercial navigation. Several townsites were specifically located on the lake shore (Schweigert 1977: 8).

However, between 1880 and 1910, the lake level fell 12 feet, and commercial navigation ceased. The lake level continued to drop, and by 1932, a major resort had to close its bathing beaches. By 1940, the lake level declined to its lowest point recorded in recent history. The loss of water and an increase in the salinity of the water

contributed to "the decline of the area as a waterfowl hunting resort, an industry which plays a considerable part in the local economy" (Schweigert 1977: 8).

Since 1940, the water level of the lake has risen in a sawtoothed fashion (see figure 4 on the previous page). The water quality of the lake has improved substantially, and sport fishing and other recreational water activities are once again popular. However, the rising level is beginning to threaten the substantial amount of development constructed on the dry lakebed during the earlier low water period. In the spring of 1979, a road had to be raised to protect the city sewage lagoons from damage. By the summer of 1983, the lake level had reached elevation 1428 feet msl - the highest level in about 100 years. After the experiences of declining water levels since settlement, the residents' concerns with the low lake levels were exhibited with water planning work, such as the Garrison Diversion Unit studies, that addressed the problem of low water level and poor water quality. In the late 1970's, however, the concern of the basin residents shifted to reflect their concern with the significant amounts of land and development that would be lost if the lake levels continued to rise. Figure 5 illustrates this relationship between development and lake levels.

WATER QUALITY

The water quality of the Devils Lake chain of lakes changes continually with lake stage. It also varies with location in the lake chain. During periods of low lake levels, the concentration of total dissolved solids (TDS) increases. During periods of high lake levels, the concentration decreases. The TDS concentration in the main bay of Devils Lake decreased from 25,000 mg/l in 1948 to 2,000 mg/l in 1983 as the lake level rose from 1404 feet msl to 1427 feet msl. This decrease occurred because of dilution with fresher water entering the lake during the recent "wet" period. A similar "freshening" trend is

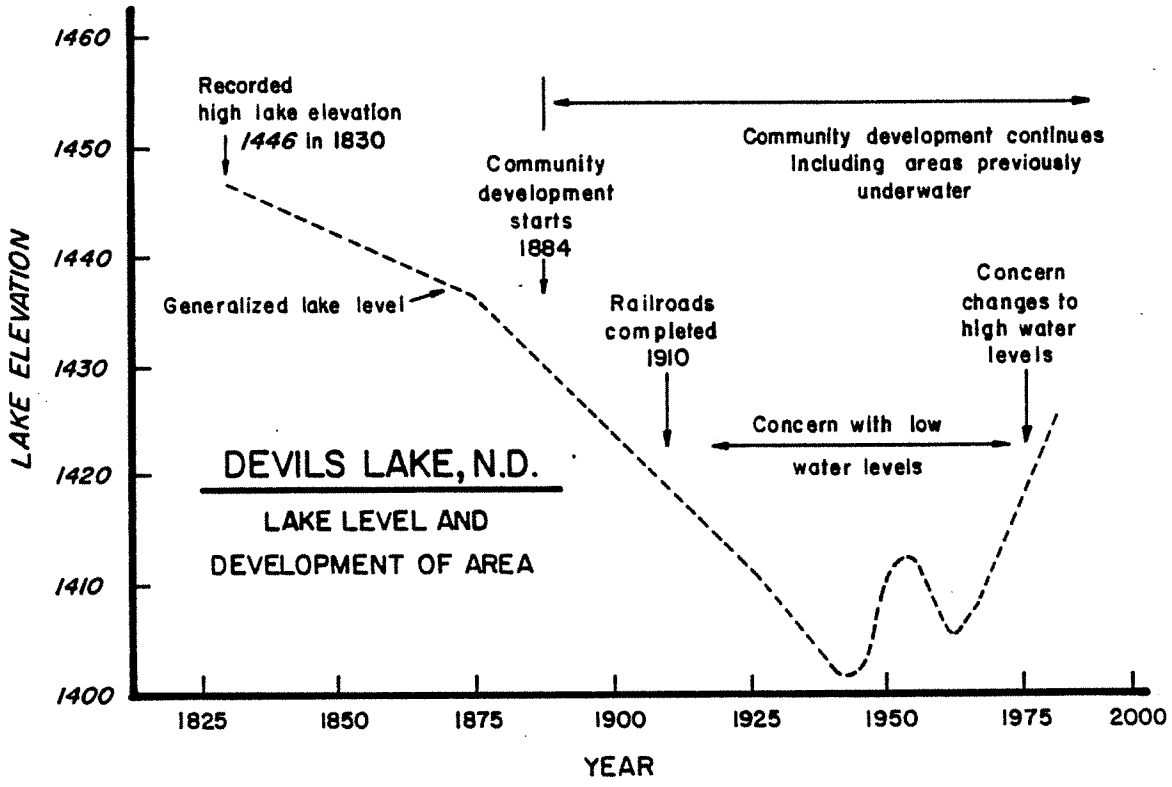

FIGURE 5. LAKE LEVELS AND DEVELOPMENT

apparent in East Bay and East Devils Lake (see table 2). The water quality of Western and Eastern Stump Lakes remained unchanged because their lake levels did not rise. The data in table 2 also illustrate a TDS gradient occurring from the western to the eastern ends of the lake chain, the fresher waters being to the west where the major tributaries enter the lake chain. An abrupt change in TDS occurred in East Devils Lake in 1979 when its water level rose more than 20 feet between January and August.

Devils Lake is extremely rich in nutrients, especially phosphorus, which promote the production of algae and other aquatic plants. The average concentration of dissolved phosphorus during the period 1969 to 1979 was 0.49 mg/l. The phosphorus concentration fluctuates on a seasonal basis because it relates to the growth cycles of aquatic plants. Phosphorus concentration does not appear to be related to lake level fluctuation.

Table 2 - Devils Lake Chain of Lakes Water Quality

	Devils Lake		East Bay Devils Lake		East Devils Lake		Western Stump Lake		Eastern Stump Lake	
Date	Elev.[1]	TDS[2]	Elev.[1]	TDS[2]	Elev.[1]	TDS[2]	Elev.[1]	TDS[2]	Elev.[1]	TDS[2]
Oct 64	1411.1	12,100			1398.9	81,700		21,300		119,000
Oct 65	1411.3	11,900			1399.6	54,600		6,530		105,000
Oct 66	1412.0	11,300			1401.1	47,900		5,940		91,600
Oct 67	1411.2	12,800			1399.8	61,600	1398.1	7,090	1384.5	95,600
Oct 68	1410.8	13,300			1400.8	64,000	1397.7	8,190	1384.2	103,000
Oct 69	1417.2	8,185			1399.3	56,200	1398.5	6,980	1384.0	107,000
Oct 70	1419.1	6,510			1400.1	57,300	1398.1	8,560	1384.1	112,000
Nov 71	1421.2	5,000			1400.6	48,200	1399.2	7,380	1380.7	71,600
Nov 72	1420.5	4,480			1400.4	45,000	1398.5	9,400	1384.5	80,700
Nov 73	1419.3	4,660	1414.4	8,580	1399.6	53,700	1397.6	11,200	1383.7	85,300
Dec 74	1422.9	3,370	1424.9	7,720	1401.6	51,400	1399.3	8,790	1384.4	79,400
Oct 75	1423.5	2,880	1425.4	7,010	1401.2	40,200	1398.9	9,300	1384.1	110,000
Oct 76	1423.1	2,850	1423.5	7,240	1404.1	29,100	1397.5	15,700	1382.9	143,000
Oct 77	1421.9	3,000	1427.3	7,810	1404.1	29,500	1397.3	25,100	1382.6	142,000
Oct 78	1422.3	3,080	1421.2	10,300	1403.9	30,500	1396.5	23,400	1382.2	149,000
Aug 79	1426.5	1,960	1426.4	5,110	1424.6	8,670	1398.4	7,530	1384.2	96,000
Nov 83		1,950		4,890		8,910				
Feb 84							1399.9	8,280	1384.9	94,500

1 Lake elevation (feet msl).
2 Total dissolved solids (mg/1).

PROBLEMS AND OPPORTUNITIES

The principal water-related problems and opportunities in the basin include flood-induced damages, water quality, fish and wildlife, and recreation. The most urgent concern of residents around the lake chain is the flooding and potential flood damages caused by the higher lake levels.

There is also a great deal of concern being expressed by area residents about the effects of poor water quality on the fishery and the recreational resources in the lake chain and the subsequent effect on the economy of the region.

FLOOD DAMAGES

The flood-induced damages in the basin can be grouped into two major categories: (1) those caused by rising levels of Devils Lake, and (2) those in the basin upstream of the area influenced by the lake level. Prior to 1979, the principal focus of flood control concerns was the upstream areas of the basin. These upstream flood-prone areas were primarily cultivated agricultural lands along the streams and/or the shorelines of small lakes in the upper watershed. Snowmelt runoff in 1954, 1955, 1956, 1969, and 1979 and summer rainfall in 1954 and 1955 resulted in widespread flooding throughout the upper watershed areas. Several drainage and channel modification projects have been proposed in the upper watersheds to relieve the flooding; however, few of these have been implemented. The most recent work that has been implemented is the Channel A project, which provides a drainage connection from Dry Lake to Devils Lake. This very controversial project was made operational during the spring runoff of 1979. Many of the wetland areas in the basin also have been drained to reduce flooding in the upper watershed and to increase the tillable acreage. Many basin residents believed that this drainage has been the principal cause for the increases in the water levels of Devils Lake.

Although no conclusive evidence has been obtained to determine the influence of the upstream drainage on water levels at Devils Lake, a regional climatic shift has resulted in an overall net surplus of water in the Upper Mississippi River basin, the Red River of the North basin, and the Devils Lake basin from about 1940 to the present. This net surplus of water has caused the general increase in the water levels of Devils Lake. As the Devils Lake level has risen, thousands of acres have once again become covered by water and areas where developments have been built when the lake was low are now being threatened with inundation. A summary of the agricultural, urban, and transportation damages to be inflicted if the lake level continues to rise is presented in table 3. For example, if the lake rose to elevation 1440, an additional 36,000 acres, 35 buildings, and over 13 miles of roads would be subject to flooding damage. The levee currently under construction at the city of Devils Lake provides protection to an additional 118 buildings up to this 1440 level. If the lake would continue its rise to elevation 1457 (its natural outlet elevation), over $230 million in damages would be incurred.

WATER QUALITY

The changing water quality of the Devils Lake chain of lakes caused by the recent filling and freshening has brought both new recreational values and new problems to the basin. The fresher water has not only enhanced the productivity of the freshwater fishery but the productivity of aquatic plants and algae as well. Nutrient concentrations have not declined. An abundant supply of phosphorus is apparently available in the lake sediments from which it periodically recirculates. Algal blooms in the summer create conditions that are objectionable to boaters and swimmers. The death and decay of large crops of algae causes dissolved oxygen depletion and possibly production of toxic ammonia resulting in fish kills. High pH levels

Table 3 - Summary of Potential Damages if Level of Devils Lake Continues to Rise[1]

	Elevation (Feet msl)					
	1428-1430	1430-1435	1435-1440	1440-1445	1445-1450	1450-1455
Agriculture						
Acres flooded						
Incremental	5,000	14,000	17,000	22,000	25,000	25,000
Cumulative[2]	5,000	19,000	36,000	58,000	83,000	108,000
Damages ($1,000's)						
Incremental	790	4,000	7,900	11,000	13,200	13,200
Cumulative[2]	790	4,790	12,690	23,690	36,890	50,090
Urban						
Structures affected						
Incremental						
City of Devils Lake	6[3]	63[3]	49[3]	107	205	49
Other	3	8	24	60	133	99
Total	9	71	73	167	338	148
Cumulative[2]	9	80	153	320	658	806
Damages ($1,000's)						
Incremental	2,850	18,250	6,800	23,650	15,400	15,300
Cumulative[2]	2,850	21,100	27,900	51,550	66,950	82,250
Transportation						
Miles of road affected[4]	(5)	(5)	13.3	23.7	28.7	29.0
Damages ($1,000's)[6]						
Incremental	(5)	(5)	7,000	22,000	32,000	40,000
Cumulative[2]	-	-	7,000	29,000	61,000	101,000
Total Damages ($1,000's)						
Incremental	3,640	22,250	21,700	56,650	60,600	68,500
Cumulative[2]	3,640	25,890	47,590	104,240	164,840	233,340

(1) Based on a preliminary analysis of additional lands, properties, and roads affected above elevation 1428.
(2) Cumulative from elevation 1428 through the upper elevation of the column indicated.
(3) Structures and properties in the city of Devils Lake would be protected from lake levels up to elevation 1440.
(4) Miles of road below the upper elevation.
(5) Current information not available.
(6) Damages are estimated as the costs to raise the affected sections of road by 5 feet.

have been observed in recent years. These high pH levels may be significant in that the equilibrium relationship between ammonia and its toxic un-ionized component (NH_3) is highly dependent upon pH and water temperature.

If the lakes continue to rise, the freshening trend would continue. Salinity, however, could continue to be a limiting factor in East Devils Lake. Continued freshening would permit higher productivity and possibly cause an increase in noxious algal blooms. Discharge from East Devils Lake into the Stump Lakes, which would occur at about elevation 1450, would gradually freshen these lakes.

FISH AND WILDLIFE

Closely associated with the water resource problems are fish and wildlife concerns. The recent raise in lake level plus the improvement in water quality has resulted in increased habitat for waterfowl and produced a better survival record for stocked sport fish. If the lake elevation stabilizes at or near its present level, or if it continues to rise and if water quality does not deteriorate, the fishery resource should continue to thrive. One of the three largest blocks of native forest in the State of North Dakota is in the Devils Lake basin. The prevention of future loss and the wise management of this woodland habitat are major goals for the preservation of a good quality wildlife resource for the basin. The wetland areas of the basin are also an important natural habitat for not only the region but also the Nation. The basin's wetlands provide one of the Nation's prime waterfowl production areas and are also very important to migratory waterfowl. Of the approximately 600,000 acres of wetlands in the basin, about 25 percent were drained for agricultural uses by 1975. Continued pressure to drain additional wetlands would further jeopardize the natural values of these wetland areas.

RECREATION

The sport fishery of Devils Lake has become an extremely valuable resource to the region. Since the mid-1970's, the lake has again been able to support a viable fishery and angler-days of use have increased from about 60,000 in 1973-74 to about 500,000 in 1982-83. For the 1983-84 fishing season, it has been estimated that anglers made total gross expenditures of about $14 million in the Devils Lake area. Boating use has also increased substantially in recent years, including uses such as sailboat regattas. A water-based recreation resource of this type and significance has not been available to the region's residents since the early 1900's. This recreation resource has resulted in a noticeable boost to the region's economy. Maintenance and/or improvement of the quality of this lake chain's recreational resource value is a high priority item for basin residents. The waterfowl hunting in the basin is also a regionally important recreational resource.

ALTERNATIVES

Identification of long-term solutions to the water resource problems and opportunities of the Devils Lake basin will require a comprehensive evaluation of a number of alternatives and their impacts. The principal alternatives to be evaluated are those that would address the problems associated with potential future rises in the lake level. An initial list of these alternatives is in table 4. Other alternatives that would address flood damage reduction in the upstream areas, plus water quality, fish and wildlife, and recreation concerns will also be considered, but to a limited degree.

Table 4 - Alternatives to Address/Prevent Continued Increases in the Level of Devils Lake

A. Control of Inflow:

1. Restoration of drained wetlands

2. Increasing storage capacity of existing wetlands

3. Increasing storage capacity of existing upstream lakes
   a. Dry Lake
   b. Sweetwater Lake
   c. Hurricane Lake
   d. Lake Irvine
   e. Lake Alice
   f. Others

4. Upstream reservoirs

B. Outlets From Devils Lake (to):

1. Sheyenne River
   a. Plan 1 (from Mauvais Coulee via Peterson Coulee - west of Minnewaukan)
   b. Plan 2 (from West Bay Devils Lake via Peterson Coulee)
   c. Plan 3 (from West Bay Devils Lake)
   d. Plan 4 (from Devils Lake)
   e. Plan 5 (from Mission Bay)
   f. Plan 6 (from East Devils Lake via Tolna Coulee)
   g. Plan 7(a) (from Stump Lakes via Tolna Coulee - gravity flow)
   h. Plan 7(b) (from Stump Lakes via Tolna Coulee - pumping)

2. James River

3. Lonetree Reservoir

C. Other:

1. Floodproofing
2. Flood insurance
3. Control of drainage
4. Evacuation of flood-prone development
5. Levees at urban areas, farmsteads, etc.
6. Diking off bays of lake
7. Consumptive uses - (pipeline for coal slurry)
8. Other

ALTERNATIVE EVALUATION

GENERAL

The evaluation of the various water management alternatives will have to consider many factors, including economic, environmental, and social well-being considerations. The effects of these alternatives in achieving the intended objectives of reducing potential future lake level rises, and the effects on the recreation, fish and wildlife, water quality, and other resource values must be considered. While several of the alternatives involve essentially intra-basin issues, many also involve both interstate and international concerns. Additionally, the potential effects and interrelationships of the Garrison Diversion Project must also be considered in the alternative evaluation and plan formulation process.

To properly evaluate potential alternatives, the anticipated conditions with the alternative in place must be compared to the conditions anticipated to occur if a project were not implemented in the Devils Lake basin (future without-project condition). This comparison of the with-project conditions to the without-project conditions provides estimates of the beneficial and adverse effects of a project.

FUTURE WITHOUT-PROJECT CONDITION

Some of the parameters of the future without-project condition, as estimated for this reconnaissance effort, that are important to the evaluation of the considered alternatives are briefly outlined below.

Level of Devils Lake

The level of Devils Lake will continue to rise for the next 50 to 100 years. The rate of rise will be variable during any short period with this time frame, and the lake level may actually drop from one year to

the next. However, over the total period, an average net increase of in-lake water volume of about 20,000 acre-feet per year is expected. This is the same average rate as has occurred during the period from 1940 through 1982. This rate of rise would result in the lake level reaching elevation 1435 in 2005, 1440 in 2025, and 1445 in 2045.

Water Quality

As the lake continues to rise, the concentrations of total dissolved solids will continue to decrease because of the dilution of the Devils Lake chain waters by the relatively fresh water from the upper watershed. High nutrient concentrations would continue to cause major algal blooms in the mid to late summer.

Fishery in Devils Lake Chain

Fish stocking programs would be continued as in the past, and the fishery would continue to be a major regional attraction. Any significant decline in the water level, even a short-term decline, could adversely affect the fishery. Increases in lake levels and freshening of the water could also adversely affect the fishery if the changes in water quality result in increased noxious algal blooms.

Drainage Activities

Drainage of wetland areas would continue. Although there would be increased desires to drain more wetland areas, there would also be increased concerns over the possible increases to the lake levels from the drainage activities. As a result of the great concern about lake levels, few drainage permits would be issued.

Wooded Shoreline Around Devils Lake Chain

The forested shoreline of Devils Lake would be reduced as the lake level continued its climb. Increased areas of submerged and dead trees would be found around the shoreline.

Levees at Devils Lake

Permanent levees will be constructed in 1985. These levees will prevent damage at the city of Devils Lake up to a lake elevation of 1440.

APPRAISAL

A preliminary appraisal of two of the outlet alternatives to the Sheyenne River was conducted for this reconnaissance report to provide a basis for economic, environmental, and other comparisons. The two alternatives selected for this appraisal are shown as plan 3 and plan 7 on plate 1 and are described in the following paragraphs. However, selection for this appraisal does not imply that either of these alternatives will be selected as the recommended project. Further, more detailed study is necessary before a decision on any alternative would be possible.

Plan 3

Plan 3 would consist of an outlet channel with pumping stations taking water from the West Bay of Devils Lake to the Sheyenne River about 12 miles to the southeast. Two pumping stations would be required to get the water over the drainage divide. Additional information on this plan is shown in table 5.

Plan 7

Plan 7 would consist of a connecting channel from East Devils Lake to Western Stump Lake and then an outlet channel from Western Stump Lake to the Sheyenne River via Tolna Coulee. This channel option could be either a pumping or gravity flow option, but for this preliminary evaluation, a gravity flow option will be evaluated. Because of the very high total dissolved solids (TDS) concentrations in Eastern Stump Lake, an embankment between Eastern and Western Stump Lakes would be constructed to prevent transfer of this high TDS water to the Sheyenne River. Additional information on this plan is in table 5.

The alternatives discussed and appraised represent only two of the many possible variations of outlets from the Devils Lake chain to the Sheyenne River. Both of these alternatives are rather straightforward and effective solutions to the problems of continued raises in the lake level but do not necessarily reflect any greater merit than other alternatives. These two alternatives also represent a likely range of the costs and the probable type and location of impacts.

Both of these alternatives are economically justified if the lake should continue to rise in a manner similar to the trend of the past 40 years. Both alternatives also show major increases to the total dissolved solids concentrations in the downstream receiving waters during the periods when the water from the Devils Lake chain would be diverted into the Sheyenne River system. There are many benefits to be gained from each alternative, and there are several potential adverse effects to each.

Table 5 - Pertinent Information (Reconnaissance Level) on Outlets from Devils Lake Chain

	Outlet Channel From Devils Lake	Outlet Channel From Stump Lake
Plan Features		
Alignment (see map)	Plan 3	Plan 7
Length of channel (miles)	12	10
# Pumping head (feet)	50	None (gravity flow)
Pumping & channel, capacity (cfs)	200	200
Regulated lake level (elevation)	1435 to 1440(1)	1435 to 1440(1)
Number of pumping stations	2	None
Costs		
First cost ($million's)	12	18
Annual interest & amortization costs ($1,000's)(2)	1,000	1,500
Annual operation & maintenance costs ($1,000's)(2)	400	50
Total annualized costs ($1,000's)(2)	1,400	1,550
Benefits		
Annualized damages prevented(2)		
Urban ($1,000's)	900	900
Rural ($1,000's)	475	475
Transportation ($1,000's)	925	925
Total ($1,000's)	2,300	2,300
Benefit/Cost Ratio	1.6	1.5
Assumed Completion Date for Plan	2005	2005
Property Requirements		
Lands required for channels (acres)	200	300
Lands required for flowage (acres)(3)	1,700	3,500
Lands Benefited (acres)	90,000	90,000

Table 5 - Pertinent Information (Reconnaissance Level) on Outlets from Devils Lake Chain (Continued)

	Outlet Channel From Devils Lake	Outlet Channel From Stump Lake
Environmental Effects		
Wildlife habitat	Would prevent loss of trees above elevation 1440 caused by rising lake level. The zone of lake level fluctuation would be exposed more frequently and would reduce shoreline habitat and aesthetic values. Should provide a net benefit to wildlife habitat resources around the Devils and Stump Lakes chains. Some habitat along the channel would be disrupted. This disruption would have to be mitigated.	Similar to plan 3; however, the woodland around Western Stump Lake between elevations 1400 and 1440 would be inundated much earlier (10 to 30 years) than under the without-project condition. Some habitat along the channel alignments would be disrupted.
Fishery resources	The water in West Bay Devils Lake would be fresher. With the lake regulated to prevent long-term future raises, a reduced lake area would be available for the fishery in the Devils Lake chain. The Main Bay Devils Lake, East Bay Devils Lake, East Devils Lake, and the Stump Lakes would have less fresh water than under the without-project condition, and natural spawning in these areas may be adversely affected. The fishery in the Sheyenne River, Lake Ashtabula, and other downstream receiving waters could be affected by more saline water being put into the system.	West Bay Devils Lake through Western Stump Lake would have fresher water. Total lake areas would be reduced for the fishery in the Devils Lake chain. The fishery in the downstream receiving waters could be affected by more saline water being put into the system.
Waterfowl habitat	Wetlands along channels would be reduced. Total lake surface area would be reduced. Total available waterfowl habitat could be reduced.	Similar to plan 3.
Other	Wetland drainage in upper Devils Lake basin could be induced by the provision of an outlet. Some downstream habitat changes could occur, especially for aquatic species.	Similar to plan 3.

Table 5 - Pertinent Information (Reconnaissance Level) on Outlets from Devils Lake Chain (Continued)

	Outlet Channel From Devils Lake	Outlet Channel From Stump Lake
Water Quality Effects		
Total dissolved solids in Devils Lake (mg/l)	1,300 (Decreasing in future)	1,200 (Decreasing in future)
Total dissolved solids in Stump Lake (mg/l)	7,500 (4) (No change in future)	3,500 (4) (Decreasing in future)
Total dissolved solids in channel to Sheyenne (mg/l)	1,300 (Decreasing in future)	3,500 (Decreasing in future)
Total dissolved solids in Sheyenne (w/o condition)(mg/l)	200 - 600	200 - 600
Total dissolved solids in Sheyenne (w/condition)(mg/l)	200 - 1,300 (5)	200 - 3,500 (5)
Other Aspects		
Tribal interests	Outlet channel crosses tribal lands. Also, would affect tribal interests by reducing the increase in lake levels.	Outlet channel does not cross tribal lands. Also would affect tribal interests by reducing the increase in lake levels.
National and State wildlife areas	-------	Would affect Stump Lake National Wildlife Refuge and one State wildlife area.
Canadian waters	Potential increases in the low-flow volumes and also in the total dissolved solids in the Red River of the North as it enters Canada.	Similar to plan 3, except that the increase in the total dissolved solids concentrations in the Red River of the North would be slightly higher.

(1) The primary regulation level would be elevation 1435, with the lakes rising above elevation 1435 during major runoff events. Elevation 1440 would be reached at a frequency of about 1-percent chance recurrence.
(2) An interest rate of 8-3/8 percent was used for annualizing costs and benefits.
(3) Flowage rights would be required on some lands that would be inundated with the project earlier than without the project.
(4) For Western Stump Lake only. Eastern Stump Lake is much higher, but would not be connected to either outlet channel flow pattern.
(5) The lower range would remain essentially unchanged during flood periods on the Sheyenne River. During low flows on the Sheyenne, however, the levels of total dissolved solids would increase substantially to the level in the outlet channel from the Devils Lake basin.

SENSITIVITY OF EVALUATION PARAMETERS

The level of detail of evaluation for this reconnaissance effort indicated that at least two alternatives are economically justified and potentially implementable under the future condition that assumes a continued rise in lake level similar to the past 40 years. Variation of this rate of lake level rise as well as other factors can affect the economic justification and/or implementability of the alternatives. Estimation of the rate of lake level rise would depend on how much the drainage of the upstream watershed areas is contributing to the increase and how much the variation in climate is contributing. The other factors that may have a significant effect on the implementability or economic justifications of the alternatives include actual damages caused by the lake level rise, ecological effects of changes in total dissolved solids concentrations, and costs of the alternatives. A more comprehensive and accurate inventory of the damageable properties would most likely result in an increase in potential damages, particularly at elevations between 1430 and 1440 where much new development has taken place that was not indicated on the maps used in the analysis. Although the potential changes in the volumes and quality of water can be estimated, the potential ecological effects are very difficult to quantify. Additional study may provide a better understanding of what these ecological effects might be. A significant reduction in the anticipated adverse ecological effects could improve the implementability of the alternative, whereas a significant increase in the adverse effects would reduce the implementability. Changes in the costs of the alternatives could improve or reduce the feasibility of specific alternatives.

All of the above factors plus others need to be evaluated in greater detail to provide a supportable recommendation for a specific solution to the problems associated with the rising lake levels.

NON-FEDERAL SUPPORT

Non-Federal interests, particularly interests around the Devils Lake chain, have indicated a strong desire to have the lake level prevented from going any higher by the construction of an outlet. There is region-wide interest in the level and resources of the Devils Lake chain, because the lakes play in important role in the regional economy. The city of Devils Lake, the Cavalier County Water Management Board, the Ramsey County Water Resource District, Nelson County, and others have indicated their support for an outlet. The North Dakota State Water Commission has supported the study of alternatives to address the problems of rising lake levels on Devils Lake.

STUDY NEEDS

To properly address the complex water resource management issues associated with the rising levels of Devils Lake, additional studies need to be conducted. A firm understanding of basin hydrology and water quality is required to effectively evaluate the economic and environmental consequences of various water management alternatives. Accordingly, emphasis needs to be placed on hydrologic, water quality, and environmental studies. The development of an implementable alternative must also consider the views of not only those around the lake who would benefit but also upstream and downstream interests. Plans of other agencies must also be considered, especially those of the Garrison Diversion Unit of the Bureau of Reclamation. The following paragraphs outline the focus of future study needs.

HYDROLOGY

Hydrologic studies are needed to identify and quantify the causes of water-level fluctuations in Devils Lake. An understanding of the relationship between natural and man-induced factors is a prerequisite to formulating water management alternatives. The amount of influence

of drainage and of climate variation will be analyzed comparing the runoff characteristics of the Devils Lake basin with other basins where drainage has occurred and also some basins where little or no drainage has taken place. Development of a water balance model for the Devils Lake chain will also be needed. Stage/volume frequency analyses will be conducted. Collection of basic runoff data at several locations will be accomplished to assist in the development and calibration of the models. Storage-outflow relationships for the Devils Lake chain will also be developed.

WATER QUALITY

Basic water quality data will be collected to provide the current status of the lake system. These data will be used in the calibration and development of a model to estimate water quality changes with various alternatives and for future scenarios. Special studies will be accomplished to analyze the phosphorus levels in the lake.

ENVIRONMENTAL

Background data will be collected on the ecosystem of the lakes, including species composition of the aquatic community. The effects that changes in water levels, water quality, and salinity may have on the fish and wildlife resources of the Devils Lake chain will be analyzed. The effects of proposed alternatives on the environmental resources of not only the Devils Lake chain but also of the downstream and/or upstream areas will also be analyzed. However, the relationships between water level, water quality, and aquatic resources are extremely complex and cannot be assessed easily.

A detailed environmental impact assessment will be conducted, including those areas required by Section 122 of Public Law 91-611, the River and Harbor Flood Control Act of 1970. The study will also comply with other existing laws, including: the Endangered Species Act of 1973, as

amended; the Clean Water Act of 1977, as amended; Executive Orders such as 11990 on wetlands and 11988 on floodplains; the Fish and Wildlife Coordination Act, as amended; and other Federal and State statutes. The required National Environmental Policy Act (1969, as amended) documentation, including an environmental impact statement or environmental assessment and finding of no significant impact, will be prepared.

PUBLIC INVOLVEMENT

Because of the complex and controversial nature of the study, including both political and scientific issues, a comprehensive public information and involvement program will be undertaken. Progress reports will be distributed regularly to inform interested agencies, organizations, and individuals concerning the status of the study. Public informational meetings and agency coordination meetings will also be held to assure that open communication channels are maintained and that information is being exchanged.

OTHER STUDY AREAS

In addition to the items discussed, studies will also be undertaken to accomplish the following:

- o Determine the engineering and economic feasibility of identified alternatives.

- o Evaluate the institutional capability of non-Federal interests to participate in implementation of alternatives.

- o Address the interstate and international implications of transferring water from one basin to another.

- o Examine the recreational and land use opportunities created by stabilized lake levels.

- o Identify fish and wildlife enhancement opportunities associated with various alternatives.

- o Evaluate the potential impacts of various alternatives on cultural resources.

CONCLUSIONS

Based on the information available and the studies conducted for this reconnaissance-level effort, the following conclusions can be made:

1. There is a significant threat of flood damages in the Devils Lake basin, particularly around the lakes in the Devils Lake chain if the lake levels continue to rise. Although a levee is currently under construction to protect development at the city of Devils Lake for any near-term future lake level rises, continued long-term rises would affect not only development around the rest of the lake, including highways, but also the development at the city of Devils Lake.

2. There has been substantial local, regional, and State interest expressed for a solution to the rising lake level problem. Most local and regional interests have stated their desire to have an outlet from the Devils Lake chain constructed.

3. At least two alternative outlet solutions have economic justification. These alternatives and others should be evaluated in further detail. Other alternatives may also be economically justified and have potential for implementation.

4. Because of the complex technical and controversial political issues associated with the proposed alternatives, a substantial number of issues will have to be addressed during the feasibility level studies, including many of the issues related to the Garrison Divsion Unit. These studies should focus on hydrology, water quality, and ecological areas. These studies should be accomplished as soon as practical so that the issues can be resolved in time to allow implementation of a plan when needed.

Edward G. Rapp
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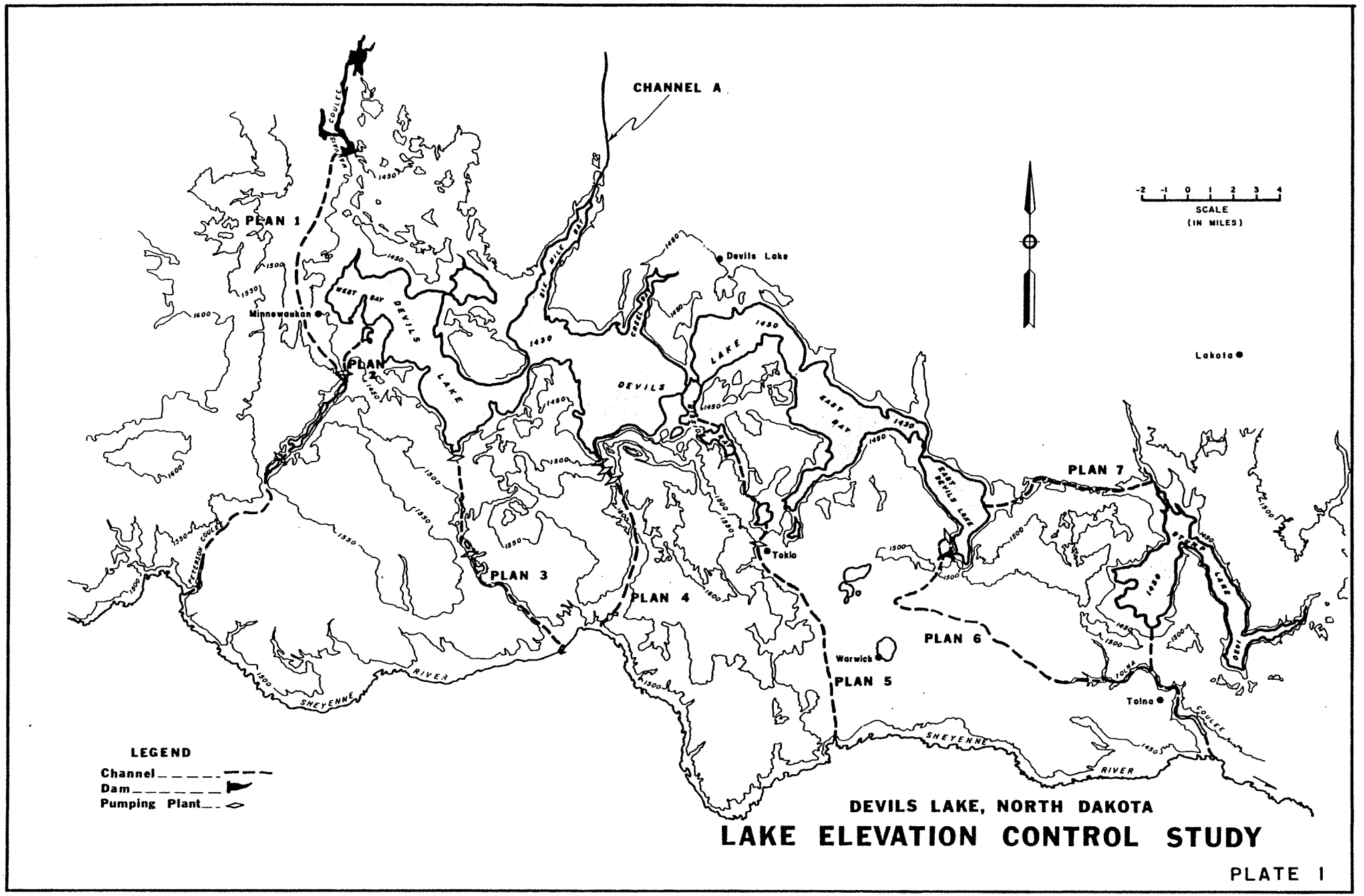
District Engineer



DEVILS LAKE, NORTH DAKOTA

LAKE ELEVATION CONTROL STUDY

PLATE I