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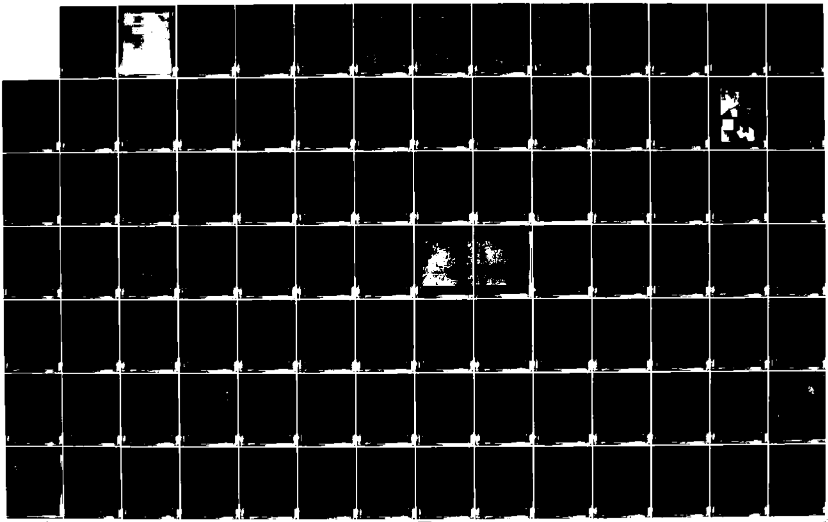

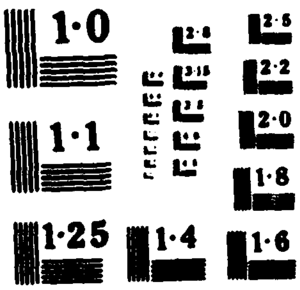
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DEVILS LAKE

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The Corps of Engineers was requested by the Devils Lake Basin Joint Water Management Board to investigate the feasibility of flood control measures at Devils Lake, North Dakota. The board requested the study because the water level has increased 28 feet in the last 40 years. This rising water level threatens to flood a considerable amount of property. The recommended plan rquires one main embankment across a narrow neck in Creel Bay plus two relatively, low tieback embankments. This plan (Plan B) is the most economically efficient because it uses the natural topographic features of the area.

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FINAL

# SECTION 205 DETAILED PROJECT REPORT
# FLOOD CONTROL PROJECT AT
# DEVILS LAKE, NORTH DAKOTA

(Contains signed finding of no significant impact plus letters of comment and Corps responses not available when this final report was first published in July 1983.)



JULY 1983
(REVISED OCTOBER 1983)

# DEVILS LAKE FLOOD CONTROL PROJECT

## SECTION 205

## DETAILED PROJECT REPORT

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DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

## THE STUDY

On October 3, 1979, the Devils Lake Basin Joint Water Management Board requested that the Corps of Engineers investigate the feasibility of flood control measures at Devils Lake, North Dakota. The board requested the study because the water level of Devils Lake has increased about 28 feet in the last 40 years. This rising water level threatens to flood a considerable amount of property. The request from the board and a supporting resolution from the Souris-Red-Rainy River Basin Committee of the Upper Mississippi River Basin Commission are in appendix H.

In February 1980, the St. Paul District of the Corps of Engineers completed a reconnaissance report. That report concluded that flood control measures were potentially feasible and recommended that more detailed studies be prepared. This detailed project report has been prepared in response to the reconnaissance report recommendation under the authority of Section 205 of the 1948 Flood Control Act, as amended.

## PRIOR REPORTS

Except for the reconnaissance report, no prior reports specifically address the flood threat to the city of Devils Lake. The following studies generally address water resource problems in the Devils Lake basin:

1. Proposed interim report on the Devils Lake basin.

In the early 1960's, the St. Paul District held a series of public meetings throughout the Red River basin, including one at Devils Lake and another at Lakota, North Dakota. The principal water resource problem reported was the inundation of agricultural lands caused by floodwaters collecting in depressed wetland areas and small lakes with inadequate outlets. Flooding caused by high water levels in Devils Lake was not a concern at that time. The St. Paul District developed a plan to reduce flood damages by improving the natural channel through the chain of lakes north of Devils Lake to the main lake via Mauvais Coulee and Big Coulee near Churches Ferry, North Dakota. However, because of the circuitous route of the natural channel and the large number of bridge changes, local interests favored a more direct route involving construction of a new channel from Dry Lake to Devils Lake. As a result, the proposed interim report on the Devils Lake subbasin was not completed.

2. Souris-Red-Rainy River Basins, Comprehensive Study: Type II Study of Selected Subbasins of the Red River of the North Basin, Souris-Red-Rainy River Basins Commission, 1972.

This report describes the Devils Lake basin and flood problems, flood damages, and alternative flood damage reduction measures. It refers to the local plan (prepared with technical assistance from the Soil Conservation Service) for channel improvement in the Starkweather Watershed, including the outlet (channel A) from Dry Lake to Six Mile Bay. Channel A was constructed and operated during the spring of 1979 as an emergency measure to prevent excessive flooding in the area north of Devils Lake.

3. 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, 1975.

This information report was published in 1975 as part of the Garrison Diversion Unit studies. The report updates data developed in the 1960's. It outlines the basic plan to restore desirable lake levels by transfer of Missouri River water from the proposed Warwick irrigation canal to Devils Lake and division of the lake into nine pools separated by dikes and outlet control structures. This feature of the Garrison Diversion Unit, which is dependent upon development of the Warwick-McVille irrigation area, has been indefinitely deferred, primarily because of Canadian objections to Missouri River waters entering streams flowing into Manitoba and because of concerns voiced by various wildlife organizations in the United States.

4. Study Report, The Devils Lake Basin Study, Devils Lake Basin Advisory Committee, Devils Lake, North Dakota, October 1976.

This report was authorized and funded by the North Dakota [illegible] Legislature. It inventories the land and water resources [illegible] he basin, identifies problems and discusses alternative [illegible] ans. Structural recommendations include channel improvements, c[illegible]l structures, and grade stabilization projects throughout the basin. Nonstructural recommendations include land treatment and floodplain management measures. The report recommends the following additional studies:

a. Additional environmental, hydrologic, and sociological data collection.

b. Comprehensive floodplain zoning program below the meander line of Devils Lake.

c. Impacts of land drainage.

d. Determination of an acceptable outlet from the basin.

5. An Analysis of Lake Levels on State Highways, Devils Lake Area, North Dakota State Highway Department, August 1979.

This report classifies the highways in the Devils Lake basin by elevation. About 6 miles of highway are below elevation 1435 feet msl (feet above mean sea level), 13 miles are below 1440, 24 miles are below 1445, and 29 miles are below 1450. The report recommends that the highways be raised to an elevation of 1440 feet msl (elevation 1435 plus 5 feet of freeboard). As of April 1981, the State had programmed $7,000,000 for this work.

6. Section 205 Flood Control Reconnaissance Report, Devils Lake, North Dakota, St. Paul District, U.S. Army Corps of Engineers, February 1980.

This report is a preliminary analysis of several structural and nonstructural measures to reduce the adverse effects of high lake levels. It investigates seven possible routes for diverting water from the lake to the Sheyenne River and a plan to provide local protection to the city of Devils Lake. The report also discusses flood proofing, evacuation, and floodplain management measures. The report concludes that a plan to protect the city from the immediate flood threat should be developed and implemented as soon as possible. The report also concludes that development of a long-term plan is desirable to prevent major damages throughout the basin if the lake level continues to rise.

7. Devils Lake Subbasin, Red River of the North Reconnaissance Report, St. Paul District, U.S. Army Corps of Engineers, December 1980.

This preliminary report provides an overview of the water and land resource problems and needs in the Devils Lake basin. It includes discussion of the flood threat to the city.

FUTURE STUDIES

An April 29, 1980, letter from the Devils Lake Basin Joint Water Management Board requested Corps assistance for a long-term plan to prevent major damages throughout the Devils Lake basin if the lake level continue to rise. The St. Paul District is developing a preliminary study of the water resource problems in the Devils Lake basin to determine if detailed feasibility studies are warranted.

The preliminary subbasin study includes the potential feasibility of an outlet for the lake. The preliminary study is scheduled for completion in 1983. A detailed feasibility study could best be prepared under the general Red River of the North basin authorities. However, as of June 1983, no funds for these authorities were in the fiscal year 1984 Federal budget.

The Devils Lake subbasin study would address all water resource problems in the entire subbasin, including both structural and nonstructural solutions to the problems associated with the rising lake levels. Implementation of any measures that address the flood problem in the city of Devils Lake could take 15 to 20 years, and substantial flood damages could occur before then.

This Section 205 detailed project report addresses the immediate need to protect the city of Devils Lake from rising lake levels. It deals with one problem - flooding - and with a small geographical study area - the city of Devils Lake. An expeditious planning and project implementation schedule is essential.

The Section 205 study and the subbasin study complement each other. As information generated by the subbasin study becomes available, it will be incorporated, where appropriate, into the 205 study.

## STUDY PARTICIPANTS AND COORDINATION

The St. Paul District prepared this Section 205 study with the assistance of the Devils Lake Basin Joint Water Management Board and the city of Devils Lake. The study has been coordinated with local, State, and Federal agencies. Appendix H contains copies of pertinent correspondence and a summary of coordination meetings. Hydrologic, hydraulic, geotechnical, design, economic, environmental, social, cultural, and recreational investigations were conducted by St. Paul District staff. Real estate information was provided by the St. Paul District office of the North Central Division. Topographic and cultural resource information was collected by private contractors.

## EXISTING CONDITIONS

### LOCATION AND DESCRIPTION

The city of Devils Lake, North Dakota, is in Ramsey County about 90 miles west of Grand Forks. U.S. Highway 2 runs east and west through the city. State Highways 19, 20, and 57 also pass through or originate in the city. Burlington Northern and Soo Line railroad main line tracks pass through the city in an east/west direction. Burlington Northern has branch lines running north and south of the city, although the south branch line was recently abandoned. Figure 1 shows the location of the city.

The city lies along the north shore of Devils Lake. Creel Bay, an arm of the lake, lies along the southwest side of the city.

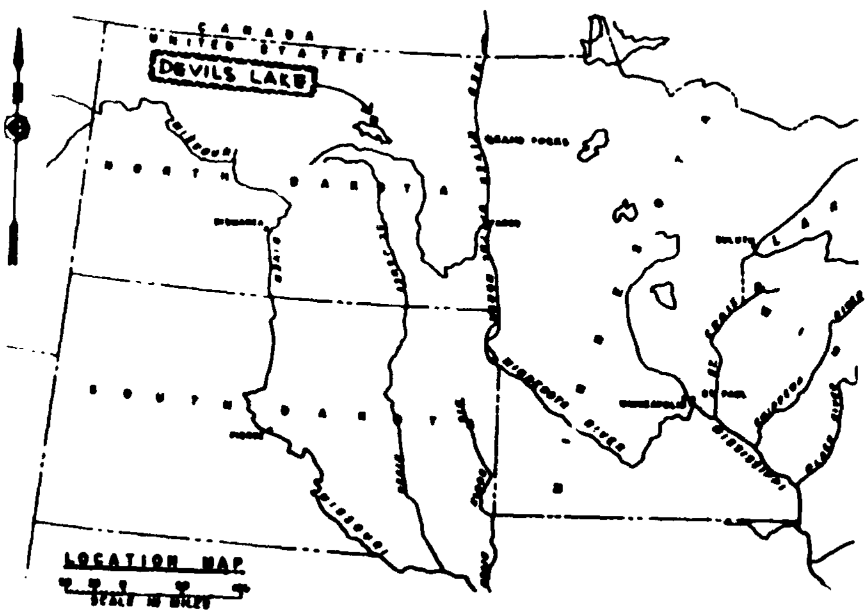



FIGURE 1

## TOPOGRAPHY

The Devils Lake basin is entirely in the Drift Prairie section of the Central Lowlands physiographic province. It is a large, closed drainage basin 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. Maximum relief in the subbasin is about 315 feet, with Devils Lake occupying the lowest area at roughly elevation 1428 feet msl and with the high elevation being 1740 feet msl at the crest of hills immediately south of Devils Lake.

The land surface in the area of the proposed embankments was smoothed by sedimentation and wave action in Devils Lake when it was at a much higher level. At the site of the Creel Bay or main embankment, the ground surface rises gently from a low elevation of 1428 feet msl to a high elevation of 1445 over a distance of 600 to 700 feet. Total relief at the smaller embankments near Highways 19 and 20 is less than 10 feet over a distance of 2,500 to 3,000 feet.

## GENERAL GEOLOGY

The geology of the Devils Lake subbasin is uncomplicated. It consists essentially of a mantle of glacial drift resting on an unevenly eroded Cretaceous bedrock surface. Sandy clay till comprises most of the drift, but beds, lenses, and channels of sand and gravel in the till are common. The thickness of the glacial drift varies from only a few feet in areas of bedrock highs to more than 350 feet in buried bedrock valleys. Little or no modification of the drift by erosion has occurred except in areas previously inundated by lakes. In those areas, surface irregularities were smoothed by wave action, low areas filled with fine-grained lacustrine sediments, and coarse-grained beach ridges developed along the old shorelines.

Bedrock underlying the drift is the Cretaceous Pierre Formation, which has a maximum thickness of 600 feet. This formation is a dark gray clay shale. Below the contact with the drift, the upper 50 to 200 feet of this shale are badly fractured. A thick sequence of Mesozoic and Paleozoic sedimentary bedrock underlies the Pierre Formation but is well below the influence of the proposed work and is not discussed in this report.

SITE GEOLOGY

In contrast to the simple overview presented for the regional geology, detailed site-specific stratigraphy in glacial drift is commonly complex. Such is the case at Creel Bay embankment where overburden materials are classified into four units, according to the time and mode of deposition. Two glacial tills separated by glacioaqueous sediments are recognized along with lacustrine sediments laid down in post-glacial Devils Lake. Plate E-4 shows the correlation of the units for the Creel Bay embankment. The units are discussed in the following paragraphs, along with discussions of the underlying bedrock.

Recent Lacustrine Sediments

Sediments classified as recent lacustrine are those materials deposited in Devils Lake since the last glacier receded from the area. These materials are primarily clays with minor amounts of silt and fine sand. They have never been consolidated by an overlying load of sediments or ice. These sediments exhibit a penetration resistance of 3 to 10 blows per foot (bpf) in standard penetration tests. A maximum of 17.4 feet of this material was encountered at the Creel Bay embankment site, 12.4 feet at the Highway 20 embankment site, and 10.9 feet at the Highway 19 embankment site.

Younger Glacial Till

Sediments classified as younger glacial till were deposited directly by the ice during the last glacial event. The material is predominantly sandy gravelly clay with occasional thin beds of sand and gravel. It shows a penetration resistance of 5 to 25 bpf in standard penetration tests. Zones with a penetration resistance less than 10 bpf are confined to areas immediately below a former surface that was inundated by the post-glacial lake and that is now mantled by recent lacustrine sediments. The reason for this lower penetration resistance is interpreted partially as reworking of the till by wave action but primarily as a residual high water content.

Glacioaqueous Sediments

Glacioaqueous sediments consist of lacustrine and possibly some fluvial sediments composed predominantly of clay with some silt and sand. These sediments are interpreted to have been consolidated by an overlying mass of ice after deposition. They exhibit a penetration resistance of 40 to 150 bpf (blows per foot) in standard penetration tests. They are easily differentiated from younger till by their uniform texture and high penetration resistance. Their stratigraphic position and high penetration resistance allow easy differentiation from recent lacustrine sediments.

Older Glacial Till

Sediments classified as older glacial till were encountered only on the abutments for the Creel Bay embankment. These sediments consist of gravelly sandy clay and clayey sand. The material is characterized by a low water content and a high penetration resistance ranging from 53 to 280 bpf in standard penetration tests. This material is differentiated from glacioaqueous sediments by its heterogeneous texture and from younger till by its lower water content and higher penetration resistance. The older till is interpreted to have been deposited by an early glaciation and to have been consolidated by subsequent ice and overburden loads.

## Bedrock

Bedrock is the Pierre Formation that underlies glacial drift throughout most of the region. The formation is a soft to moderately hard, dark gray clay shale. In the Devils Lake basin, the upper 50 to 200 feet are fractured sufficiently to serve as an aquifer. The shale was penetrated to a minimum depth of 14 feet in borings for the Creel Bay embankment. At that location, the shale is badly weathered and fractured at the overburden contact. It is more like a soil than a rock for 1 to 3 feet below the contact with the drift mantle. The shale improves in quality with depth, but it is badly fractured and characterized by a high water content to the depth penetrated during the borings. Samples of the shale were obtained by drive sampling. Resistance to standard penetration tests ranged from 55 bpf at the overburden contact to over 100 bpf within a few feet. The light loading proposed for the site and thick cover of impervious material make more detailed evaluation of the strength and water-bearing characteristics of the shale unnecessary.

## CLIMATE

The weather at Devils Lake varies widely with the season. Records at the Devils Lake weather station show mean monthly temperatures from 68 degrees Fahrenheit in the summer to 4 degrees Fahrenheit in the winter. The maximum recorded temperature is 112 degrees, and the minimum is 46 degrees below zero. The frost-free growing season lasts from about May 15 to September 23.

The mean annual precipitation is 16.98 inches. Mean snowfall is 36 inches. Snowmelt can cause flooding from March through May. Large rainfalls from May through September can cause low-capacity channels to overflow, resulting in flood damages to crops. Because the subbasin has no outlet near the existing water surface elevation, the meteorlogical conditions that cause agricultural spring and summer flooding can also result in increasing levels in Devils Lake and Stump Lake.

WATER QUALITY

The water quality of the Devils Lake chain of lakes significantly changes with lake stage and the location within the chain of lakes. During periods of low lake levels, the concentration of dissolved solids increases; and, during periods of high lake levels, the concentration decreases. For example, with the increase of lake level from 1404 feet msl in 1948 to 1415 feet msl in 1950, the concentration of dissolved solids dropped from 25,000 to about 6,500 parts per million. Since 1950, the concentration of dissolved solids has generally continued to decrease with the rising lake levels.

This improvement in water quality is reflected in the increase in the number of sport fish and the recreational use of the lake. Sedimentology studies have shown substantial variations in salinity, probably caused by changing lake levels, for a period of over 6,000 years. There is also a decrease in salinity following large spring inflows and an increase during the summer and fall.

Water quality data show an increase in salinity from the western to eastern end of the chain of lakes. For example, in January 1979 total dissolved solids in milligrams per liter varied from 3,620 in Devils Lake to 169,000 in East Stump Lake. This variance probably occurred because most of the inflow to the lake flows into the northwest corner of the lake (Mauvais Coulee).

Mauvais Coulee (Big Coulee), channel A, and the city of Devils Lake sewage lagoons are the three main sources of nutrients to the lake. The city of Devils Lake discharges water from its sewage lagoons into Creel Bay. Stormwater runoff from the city is diverted to holding ponds and eventually is also discharged into Creel Bay. This water contains nutrients, particularly nitrogen and phosphorus, that degrade the water quality of Creel Bay and Devils Lake. Channel A and Mauvais Coulee carry high levels of nutrients and frequently exceed State standards. Agricultural runoff and wetland drainage are some of the practices suspected of causing these high levels. Nitrogen and phosphorus are carried into the lake and stimulate the growth of aquatic plants such as algae.

Surface water in the Devils Lake basin is relatively high in dissolved minerals compared to most other drainage systems in North America. The surface waters are high in dissolved materials because of the geologically youthful character of the area, because of the cold, semi-arid climate that prevents excessive leaching of the soils, and because of the concentrating effect caused by the lack of an outlet.

The waters of the Devils Lake area generally contain excessive levels of hardness, total dissolved solids (TDS), and sulfates. They also have a high pH. Metals such as barium, boron, and lithium also cause water quality problems at times. Runoff from agricultural operations is the major contributor to the high metals and TDS concentrations. The water in Devils Lake does not meet North Dakota water quality standards.

Devils Lake is the most important water-based recreation area in eastern North Dakota. Primary species of game fish include northern pike, walleye, white bass, crappie, and yellow perch. A primary forage fish species is the fathead minnow. Some invertebrates that provide important fish food in the lake include midge, caddisfly, and amphipod. Groundwater supplies are generally good, although some have excessive levels of nitrates and sulfates.

TERRESTRIAL VEGETATION

Prior to Euro-American settlement, the Devils Lake basin was primarily a tall grass prairie, vegetated with a wheatgrass (Agropyron) - bluestem (Andropogon) - needlegrass (Stipa) association. Most of the woodland in the basin lies along watercourses and in the morainal hills around Devils Lake. Today, much of the tall grass prairie and some of the woodland areas have been cleared and converted to agricultural uses.

Upland portions of the project area are urban, residential, or agricultural. Most of the agricultural areas are pastureland covered with milkweed, Canada thistle, foxtail barley, goldenrod, curly dock, little sunflower, buckbrush, gumweed, poison ivy, and various grasses and sedges.

AQUATIC VEGETATION

Aquatic vegetation, except the planktonic algae, occupies the littoral zone (the interface between the land and open water). The wetlands, stream channels, and lakes in the Devils Lake basin generally have extensive littoral areas because of their low relief and shallowness.

In the immediate project area, the most significant wetland habitat consists of a three-cell, 270-acre sewage lagoon, the surrounding holding ponds, and the headwaters of Creel Bay. A 113-acre holding pond for effluent from the sewage lagoons is north of the lagoons. This holding pond is an artificially flooded wetland with emergent vegetation that includes cattail, horsetail, bulrush, and sedge. Immediately west of the sewage lagoon is a 65-acre emergent wetland impounded by the "Dump Road" (Landfill Road). Predominant vegetation in this wetland consists of the above species plus common reed. Southwest of the sewage lagoon is a 38-acre, intermittently-flooded wetland. Predominant vegetation there includes Nuttall's alkaligrass, foxtail barley, gumweed, curly dock, and kockia. The headwater area of Creel Bay is an intermittently-flooded wetland that is either vegetated, open water, or mudflat, depending on the water level of the lake. The lakeshore and areas with more permanent water are vegetated with cattail, sedge, grass, foxtail barley, kockia, prairie cordgrass, and other species. Between Highway 20 and the abandoned Burlington Northern railroad branch line is an approximately 40-acre wetland. This wetland is vegetated by cattail, bulrush, sedge, and common reed. The northern two-thirds of the wetland appear to be seasonally flooded, and the rest appears semi-permanently flooded.

These wetland areas provide good habitat for waterfowl, especially ducks. The fairly abundant aquatic vegetation provides food, while cover is available along the shore of the lake and wetlands where taller vegetation grows.

## THREATENED AND ENDANGERED SPECIES

The bald eagle and peregrine falcon are the only federally-listed endangered species that may occur in the project area. The presence of the falcon in the basin would be very rare. The bald eagle migrates through the area in the spring and fall but does not nest there.

## POPULATION

In the past decade, the city of Devils Lake has experienced considerable growth in population, in sharp contrast to its surrounding rural communities (see table 1). Of the counties forming most of the watershed (Benson, Towner, and Ramsey), only Ramsey showed any increase in population. Most of the small communities in the city's immediate vicinity declined to some extent. Because a very high percentage of persons changing residences in this region remain in their same county, Devils Lake serves as a significant population magnet. Some cities on the perimeter of the watershed also exhibit this trend.

A significant portion of the basin residents are of Norwegian descent, ranging from 36 percent in Walsh County to 50 percent in Benson. Approximately 45 percent of the Cavalier and Rolette county populations are of Canadian descent. The Fort Totten Reservation is the home of the Devils Lake Sioux and occupies a total of 244,000 acres. The total Indian population on the reservation was estimated in 1979 as 2,815.

Table 1 - Population in and around Devils Lake, North Dakota, 1970-1980

| | 1980 | 1970 | Percentage of change |
|---|---|---|---|
| **Watershed Counties** | | | |
| Ramsey | 13,048 | 12,915 | + 1.0 |
| Benson | 7,944 | 8,245 | - 3.7 |
| Towner | 4,052 | 4,645 | -12.8 |
| Subtotals | 25,044 | 25,805 | - 2.9 |
| **Cities near Devils Lake** (county in parentheses) | | | |
| Devils Lake City (Ramsey) | 7,442 | 7,078 | + 5.1 |
| Lakota (Nelson) | 963 | 964 | - 0.1 |
| Cando (Towner) | 1,496 | 1,512 | - 1.1 |
| Fort Totten (Benson) | 1,141 | N/A | N/A |
| Minnewauken (Benson) | 461 | 496 | - 7.1 |
| Starkweather (Ramsey) | 210 | 193 | + 8.8 |
| Leeds (Benson) | 678 | 626 | + 8.3 |
| New Rockford (Eddy) | 1,791 | 1,969 | - 9.0 |
| **Watershed Perimeter Cities** (county in parentheses) | | | |
| Langdon (Cavalier) | 2,335 | 2,182 | + 7.0 |
| Cooperstown (Eddy) | 1,368 | 1,485 | -11.9 |
| Carrington (Foster) | 2,641 | 2,491 | + 6.0 |

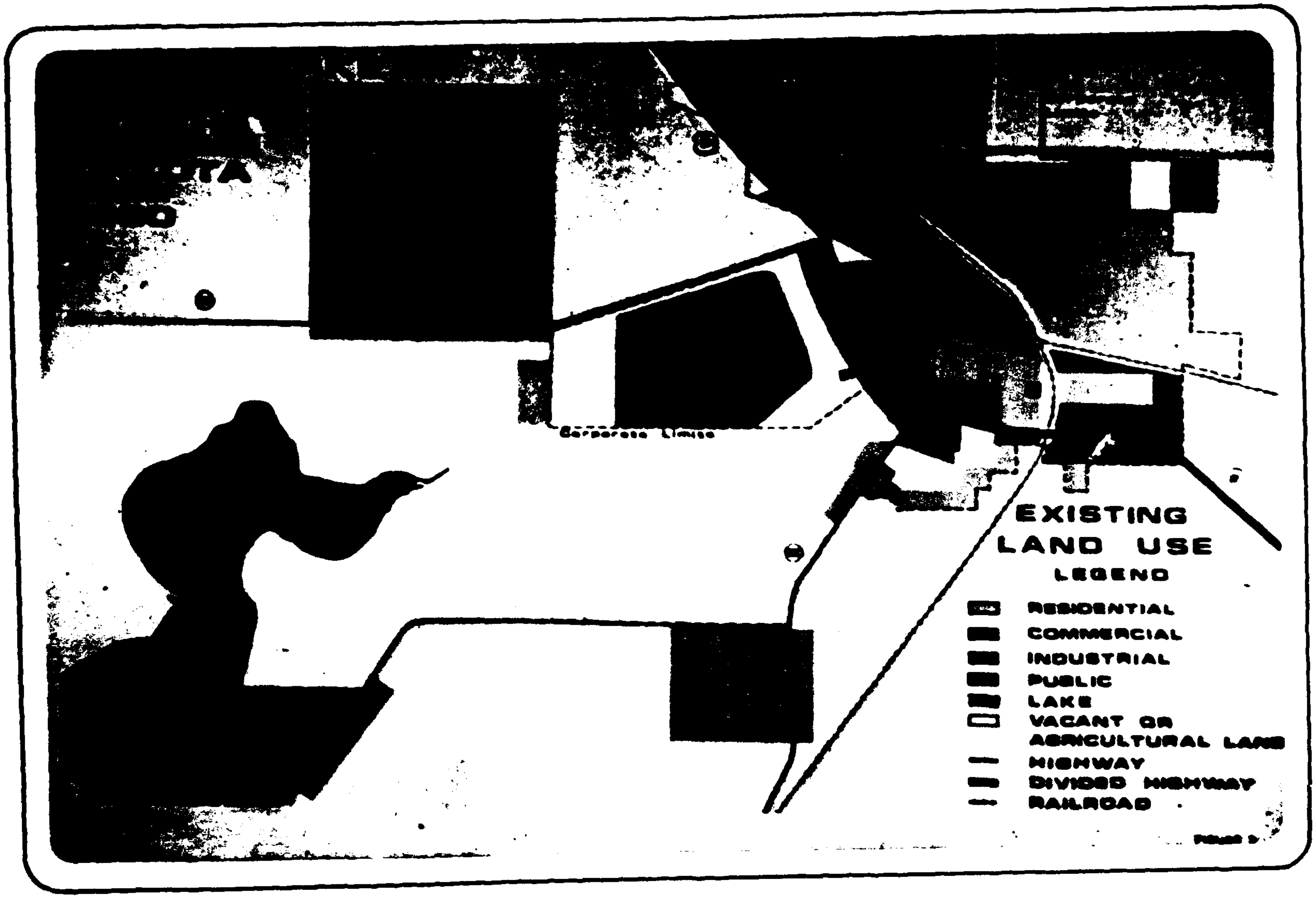
## LAND USE

A September 1974 satellite imagery analysis of land use showed that about 70 percent of the basin is cultivated land, 8 percent grassland, 3 percent woodland, 16 percent water, and 3 percent miscellaneous area.

Forested areas are mainly in the southcentral portion of the basin along the shore of Devils Lake and in the Devils Lake Indian Reservation. Although most of the land is cultivated, the richest soils are in the central and northern parts of the basin. Pasture and rangeland are more common in the southern portion of the subbasin.

Within the city of Devils Lake, most recent growth has occurred in the southwest. Significant subdivision zoning exists between the lake and the city. Commercial strip development is extensive along Highway 2.

Figure 2 is a land-use map for the city.


EXISTING
LAND USE
LEGEND
RESIDENTIAL
COMMERCIAL
INDUSTRIAL
PUBLIC
LAKE
VACANT OR
AGRICULTURAL LAND
HIGHWAY
DIVIDED HIGHWAY
RAILROAD
Corporate Limits

EMPLOYMENT

Although farm employment has decreased during recent years, it is still the most important sector in the Devils Lake basin economy. Employment in the basin centers around agriculture, retail trade, services, and education. These four sectors are estimated to account for more than 70 percent of the basin's employment. While farm employment has decreased, other sectors have increased, and the basin has had an increase in total employment. Between 1970 and 1977, total employment increased from 9,489 to 12,340, an increase of 30 percent.

Unemployment in the basin averaged about 6.5 percent during the 1970's. Employment is high during the spring, summer, and fall, which comprise the construction season and the time when agricultural crops are planted and harvested. During the winter, many agricultural activities decrease drastically.

INCOME

Total personal income for the basin increased from $160 million to $203 million between 1969 and 1977 (as expressed in 1979 dollars). Farm income accounts for more than half of the total personal income, and cash grain sales amount to more than 70 percent of the total farm income. Average per capita income during the same years increased from $5,875 to $7,242, which was slightly above the 1979 average income figure of $6,859 for the whole State.

AGRICULTURE

Agriculture is the predominant sector in the economy of the Devils Lake basin. The production of small grains is the most important agricultural component. Approximately 70 percent (or 1,787,136 acres) of the subbasin's land area is cultivated and another 8 percent is pastureland.

The major crops grown in the basin are identified in table 2. Wheat is the leading crop, accounting for 54 percent of the harvested acreage. This is followed by barley, sunflowers, hay, oats, and flax, which collectively amount to 45 percent of the harvested acreage. There are also minor acreages of rye, potatoes, sugarbeets, and corn. The importance of sunflowers has increased dramatically during the 1970's. Between 1977 and 1978, sunflower production in North Dakota increased by more than 50 percent. In the Devils Lake basin, sunflowers have became the third leading crop, accounting for 8 percent of the total harvested acreage.

Crop patterns within the basin floodplain are similar to those throughout the basin. Major crops are small grains, sunflowers, potatoes, corn, soybeans, and sugarbeets.

Table 2 - 1978 Crop Statistics, Devils Lake Basin

| Crop | Harvested Acres | Yield Per Acre | Total Production |
|---|---|---|---|
| Wheat | 617,100 | 30.9 bushels | 19,068,390 |
| Barley | 284,450 | 42.5 bushels | 12,089,125 |
| Sunflowers | 94,470 | 1,313 pounds | 124,039,110 |
| Hay | 85,680 | 2.0 tons | 171,360 |

Source: Gulf South Research Institute.

## MANUFACTURING

There are 55 manufacturing establishments in the Devils Lake basin, 29 of of them in the city of Devils Lake. More than 30 percent of the manufacturers are related directly to agriculture. The remainder of the manufacturers are a diversified industrial mix and account for about 6 percent of the basin's manufacturing employment. The manufacturing establishments are grouped in table 3 according to their Standard Industrial Code (SIC) numbers.

Table 3 - Manufacturing Establishments, Devils Lake Basin

| SIC | Description | Estimated Employment |
|---|---|---|
| 14 | Mining of Nonmetallic Minerals | 27 |
| 17 | Construction-Special Trade Contractors | 18 |
| 20 | Food and Kindred Products | 80 |
| 24 | Lumber and Wood Products | 9 |
| 27 | Printing and Publishing | 95 |
| 29 | Petroleum Refining and Related Industries | 20 |
| 30 | Rubber and Plastics Products | 20 |
| 32 | Stone, Clay, Glass, and Concrete Products | 60 |
| 34 | Fabricated Metal Products | 9 |
| 37 | Transportation Equipment | 9 |
| 39 | Miscellaneous Manufacturing Industries | 150 |
| 42 | Motor Freight Transportation/Warehousing | 45 |
| 50 | Wholesale Trade-Durable Goods | 9 |
| 51 | Wholesale Trade-Nondurable Goods | 54 |
| 54 | Food Stores | 70 |
| 76 | Miscellaneous Repair Services | 18 |
| TOTAL | | 693 |

Source: 1977 - 1979 Directory of North Dakota Manufacturing.

TRADE

In 1977, total trade receipts for the Devils Lake basin exceeded $240 million (expressed in 1979 dollars). Approximately 65 percent (or $156.6 million) of the receipts were in wholesale trade. Retail trade and selected service receipts were $83.5 million and $7.9 million, respectively, in 1977.

CULTURAL RESOURCES

In compliance with Section 106 of the National Historic Preservation Act of 1966, the National Register of Historic Places has been consulted. As of May 18, 1983, the study area had no sites on the National Register. Initial project coordination and report reviews have been coordinated with the North Dakota State Historic Preservation Officer and the National Park Service.

During September 1981, a cultural resources literature and records search and review plus a field reconnaissance survey of the Devils Lake project area were conducted. No historic or prehistoric sites were recorded in the project area. However, there is a high potential for sites in the surrounding area. At least 15 prehistoric burial mounds, 2 prehistoric occupation sites, and 5 historic cultural resource sites are close to the project area. Fluctuating lake levels affect the location and probability of identifying sites.

Appendix G has additional information on cultural resources.

DEVELOPMENT AND ITS RELATIONSHIP TO LAKE LEVELS

Early fur trade activities in the Devils Lake area are sketchy. However, sometime between 1817 and 1827, trader Robert Dickson, in an agreement with the Hudson Bay Company, established a post at Devils Lake. The post was on Graham's Island, almost 10 miles west and slightly north of the city of Devils Lake. At an undetermined date, possible in the 1820's, an American Fur Company post, Fort Rice, may have been established on the site where Fort Totten was built in 1867.

Fort Totten was established on July 17, 1867, on the south shore of the West Bay of Devils Lake. This site is about 10 miles south of the city of Devils Lake. The fort was one in a series of military outposts designed to protect the overland route from St. Paul to the gold fields of Montana and Idaho. It was also intended to protect settlers moving into the area and to serve as a control point for the Indian Reservation established earlier that year. Fort Totten remained a military post until 1890 when it became an industrial school for Indians.

At the time the Devils Lake area officially opened for settlement in 1883, about 15,000 acres were being cultivated by 3,000 squatters. The first squatters were former military personnel from Fort Totten who began developing tracts on Graham's Island in 1880.

Lieutenant Heber M. Creel, a topographic engineer at Fort Totten, resigned his position in 1882 and squatted on land then on the north shore of Devils Lake. The lake was at about elevation 1435, or 7 feet above its present elevation. Creel surveyed a townsite and named it Creelsburg. A post office was established there, and in 1883 the name was changed to Creel City. In 1884, the village was incorporated and the name changed to Devils Lake.

Devils Lake became a major commercial trading center for the region and has maintained its role to the present. The city's early success resulted from its association with the steamboat shipping industry and with the delayed westward railroad construction that allowed the community to be the railhead for 3 years. Steamboat navigation began in 1883 but ended in 1909 because of the steady decline in lake levels and because a rail line to Minnewauken was completed (a village on the west end of the lake). By 1910, construction of the five rail lines serving the Devils Lake area was complete.

The city of Devils Lake remains a minor railroad hub and the leading commercial center in a predominantly agricultural area.

Wide fluctuations in the water level of Devils Lake have affected conditions in the subbasin for several thousand years and will probably continue to do so. Fluctuating lake levels in prehistoric times affected game habitat and water quality in the lake. These fluctuations resulted in significant changes in patterns of Indian settlement, hunting, and fishing. Cultural artifacts in beach strands at different elevations provide evidence of these changes.

In the late 1800's and early 1900's when early Euro-American settlement took place, lake levels were relatively high. Railroads,

roads, and development were constructed at higher elevations. Steamboat transportation was feasible. The good water quality associated with the high water levels encouraged the development of recreational facilities.

By 1940, the steadily declining water levels had destroyed the steamboat industry and increased the salinity of the lake to the point where sport fishing, boating, and other water-related recreational opportunities were gone. The declining water levels also exposed large, flat areas of lakebed adjacent to the city of Devils Lake. The city had developed as a transfer point between steamboat and railroad transportation; however, by 1940 it was landlocked. Water planning work, such as the Garrison Diversion Unit studies, addressed the problem of low water level and poor water quality up to the 1960's and early 1970's.

Since 1940, the water level of the lake has risen in a sawtoothed fashion. 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, Landfill Road (Dump 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.

RECREATIONAL RESOURCES

The Devils Lake basin is one of the major recreation areas in North Dakota. Hunting is very popular. Upland game is limited because of lack of habitat, but the numerous wetlands and shallow lakes provide excellent habitat for migratory waterfowl. The area is known nationwide for goose hunting.

Devils Lake provides boating, water-skiing, picnicking, and camping opportunities. Fishing is very good in the lake: 48 percent of the 1974-1975 State pike harvest was from the lake.

Several parks and other recreational facilities are in the immediate area of the city of Devils Lake. These facilities offer opportunities for swimming, picnicking, ice skating, fishing, tennis, and other activities.

More detailed recreation information is in appendix G.

## FUTURE CONDITIONS

The future condition of the city will continue to depend on the lake level. It is very probable that, over the long term, the lake level will continue to fluctuate.

If a project is not constructed, the former lakebed area will probably flood again. This flooding would result in substantial economic losses and would disrupt local and regional road, sewer, telephone, and electric services. Loss of the city's sewage treatment plant would have environmental and health impacts. Economic and social impacts associated with flooding of the former lakebed could significantly retard future growth.

If a project is constructed, there would be no flood-induced disruption to the economy or to utility services unless the lake level exceeds the design water surface level for the project.

## THE PROBLEM

A number of water resource problems in the Devils Lake basin were discussed in the initial correspondence and coordination meetings with local interests and other public agencies (see appendix H). These problems include wetland drainage and its effects on agricultural production, wildlife habitat, and storage of floodwaters; the water quality of Devils Lake and its relation to the water level of the lake, to discharge from the city's sewage lagoons, and to storm-water holding ponds; the potential effects of spreading the effluent from the sewage lagoons on land; and the flooding caused by the rising water level in Devils Lake. The flooding problem associated with the increasing lake level has been divided into two components: (1) the immediate flood threat to the city of Devils Lake and (2) the flood threat to other cities in the subbasin, Fort Totten Indian Reservation, Camp Grafton, agricultural production, roads, and utilities.

This Section 205 detailed project report addresses only the immediate threat of flooding to the city of Devils Lake. All of the other problems are beyond the scope of the budget and schedule for a Section 205 study.

PAST WATER LEVELS

According to the accounts of early travelers to the area, 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 elevation 1428 feet in 1983. Figure 3 is a stage hydrograph for the lake. Figure 4 shows the approximate shoreline of the lake in 1882, 1928, and 1942.

Inspection of the stage hydrograph indicates that the period of record is too short to show any clear pattern of variation in lake levels. However, archaeological and sedimentological investigations provide some additional insight. Beach strands and cultural artifacts show that the lake elevation has changed significantly in the last 2,000 years. 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 feet msl and down to nearly dry several times during this period.

Some of the artifacts associated with the high lake levels are being analyzed to help estimate some of the dates of the high water levels. The cultural resource sections of the environmental assessment contain additional information on archaeological investigations.

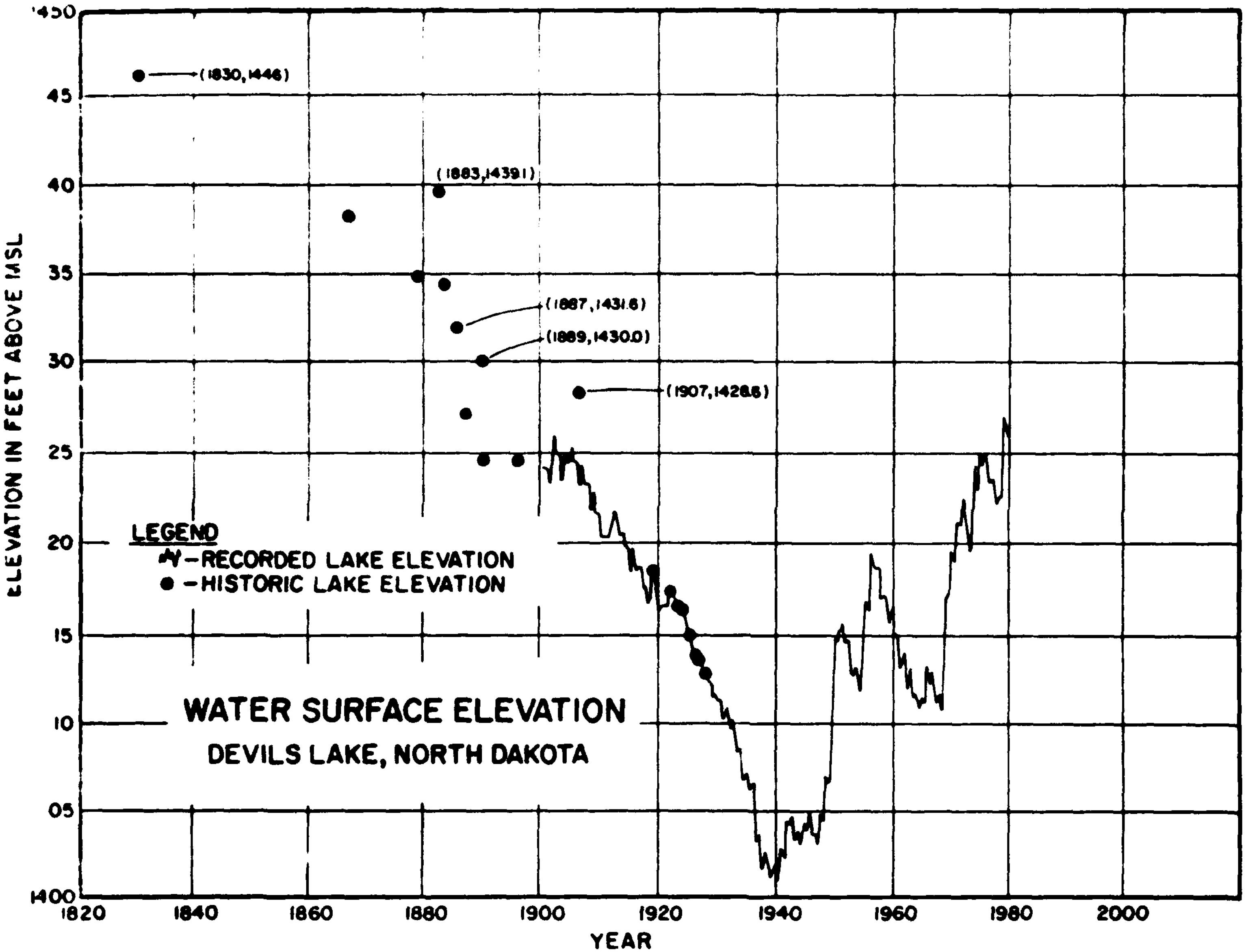
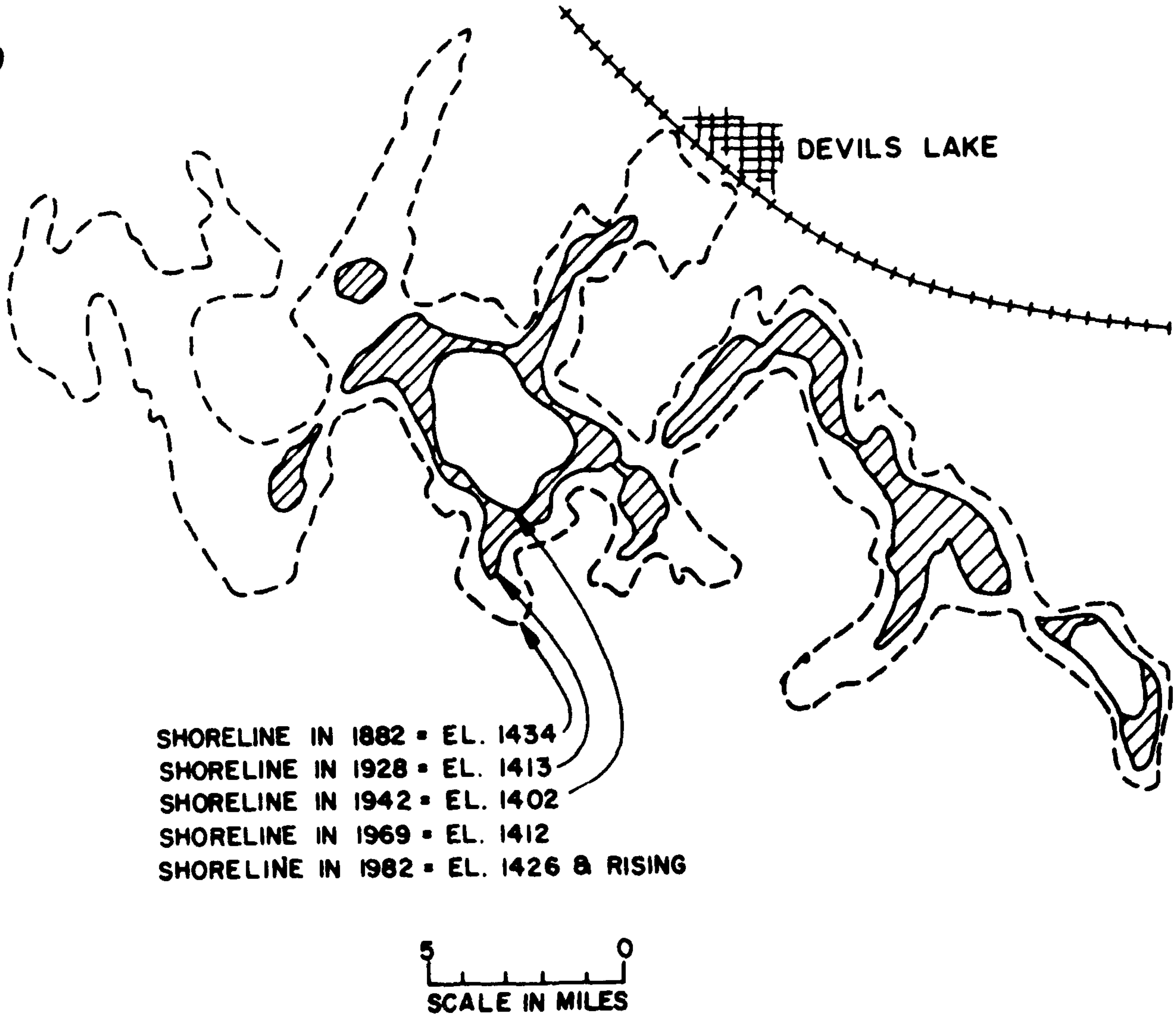

1450
45
40
35
30
25
20
15
10
05
1400
ELEVATION IN FEET ABOVE MSL
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000
YEAR
(1830, 1446)
(1883, 1439.1)
(1887, 1431.6)
(1889, 1430.0)
(1907, 1428.6)
LEGEND
-RECORDED LAKE ELEVATION
-HISTORIC LAKE ELEVATION
WATER SURFACE ELEVATION
DEVILS LAKE, NORTH DAKOTA

FIGURE 3




DEVILS LAKE SHORELINE
1882 - 1982

FIGURE 4

Edward Callender's 1968 dissertation, "The Postglacial Sedimentology of Devils Lake, North Dakota" (University of North Dakota) discusses the postglacial sedimentology of Devils Lake. Callender constructs a lacustrine chronology for the lake, using the chemical contents of several core samples. This chronology extends 6,000 years before the present time and indicates substantial variation in lake levels. The chronology does not directly relate to lake level elevations in feet above mean sea level. However, some of the layers of sediment would be typical of the fresh water conditions expected with a lake outlet. Such conditions require a lake elevation of about 1455 to 1460, given today's topography. Other layers would be typical of dry conditions.

Callender concludes that "the level of Devils Lake has fluctuated considerably during the past 6,500 years. Significantly higher lake levels occurred around 4,300; 3,500; 2,300; 1,250; 1,000; 750; and 250 years ago. Most of these dates coincide with periods of cooler, wetter climate in the Northern Hemisphere. Significantly lower lake levels occurred around 6,000; 4,000; 3,000; and 500 years ago which coincide with periods of warmer, drier climate in the Northern Hemisphere."

Saul Aronow's 1957 dissertation, "Problems in Late Pleistocene and Recent History of the Devils Lake Region, North Dakota" (University of Wisconsin), develops a chronology of lake-level fluctuations in the Devils Lake basin. This chronology is based on buried soils interstratified with beach sand and gravel, bison skulls, and rooted stumps of bur oak submerged in Stump Lake. His chronology also indicates substantial variations in lake levels over the last several thousand years.

EMERGENCY ACTIONS

As an emergency measure in the spring of 1979, the Corps of Engineers, in cooperation with the State Water Commission and the city of Devils Lake, raised the "Dump Road" (Landfill Road). This road lies between the head of Creel Bay and the city's sanitary sewage lagoons. The crest of the road was raised to about elevation 1431 feet msl. Allowing 2 to 3 feet of freeboard for waves and increased water levels due to wind, the emergency raise would protect the lagoons and the southwest side of the city from water levels up to about 1429 feet msl. Temporary pumps handle the interior drainage when the lake elevation precludes gravity flow.

PLANNING OBJECTIVES

According to Federal guidelines, national economic development (NED) is the national planning goal for water resource projects. Regional development (RD), other social effects (OSE), and environmental quality (EQ) are also important considerations. Objectives including NED, EQ, RD, and OSE have been established to evaluate the alternative plans from the national perspective.

Additional objectives reflecting local considerations were developed after an examination of the existing conditions in the study area, of the most probable future condition if no Federal action is taken, and of the study area's problems, needs, and opportunities. These local objectives are: (1) to contribute to the economic health of the city of Devils Lake by reducing the flood threat during the period from 1984 to 2084 and (2) to contribute to the health and sense of security of local residents and business interests by reducing the flood threat during the period from 1984 to 2084.

## ALTERNATIVE PLANS

Several plans were considered in the early stages of planning and rejected. The reconnaissance report considered seven channels that would divert water from Devils Lake to the Sheyenne River. These plans were very expensive, ranging in cost from $6,000,000 to $14,000,000. Each would require a complete economic, environmental, and engineering analysis for the entire Devils Lake basin. The scale of these alternatives would require a congressionally authorized study and possibly 15 to 20 years to implement. Because the flood threat to the city appears to be imminent, the diversion channel alternatives were rejected for this study.

The reconnaissance report also considered a relief channel from Devils Lake to Stump Lake without provision for transfer of water to the Sheyenne River. Stump Lake could store about 170,000 acre-feet of water if its level were raised from 1410 to 1430 feet msl. By using this Stump Lake storage, the elevation of Devils Lake could be lowered about 3 feet from 1433 to 1430 feet msl. Thereafter, since Devils Lake and its connected waters have about five times the storage capacity of Stump Lake, a raise to elevation 1435 feet msl on Devils Lake could only be reduced to 1434.2 by using Stump Lake storage. If Stump Lake were used for storage above elevation 1430 feet msl, then additional right-of-way would have to be purchased around Stump Lake. Natural overflow to Stump Lake would not occur until Devils Lake reached about elevation 1449 feet msl. This plan would cost more than $5,000,000. This relief channel plan was rejected because of its high cost and limited effectiveness.

The reconnaissance report recommended raising about 1 mile of Landfill Road and 1.5 miles of State Highway 19 to elevation 1445 feet msl. This action would meet the immediate need to protect the city of Devils Lake from the rising lake level. This plan also included a pumping station or facilities for emergency pumps. The plan was rejected for further study because detailed topographic mapping showed that a flood barrier could be constructed across the head of Creel Bay more economically by moving the alignment of the embankment about 1,700 feet west of Landfill Road.

Structural and nonstructural plans were developed and analyzed that would provide protection to water surface elevations of 1435 (plan A), 1440 (plan B), 1445 (plan C), and 1450 (plan D) feet msl. Plan A would allow the lake to rise only about 7 feet before the design surface elevation would be reached. This plan was selected as a minimum-scale alternative. Plan D would allow the lake to rise about

22 feet and was chosen as a maximum-scale alternative. The plans were developed in sufficient detail so that they could be evaluated according to their fulfillment of the planning objectives and so that the best plan could be selected.

The common characteristics of each plan are described first, and then each plan is described in more detail. The engineering, economic, and environmental information in this section of the report is preliminary. The selected plan is refined and analyzed in more detail in the detailed description of the selected plan.

## ECONOMIC FEASIBILITY

Since the cause of the fluctuating lake levels is not well understood and since the period of record for meteorological and hydrological data is very limited compared to the length of the trends for changing lake levels, a stage/frequency relationship could not be developed. This inability to develop a stage/frequency relationship is discussed in detail in appendix D. Because this relationship could not be developed, the traditional benefit/cost ratio analysis that draws upon discharge or stage frequency-damage relationships was not possible.

There is no certainty that the lake will continue to rise. However, it was at much higher elevations in the early 1800's and at several times in the geologic past. The standard project flood inflow to the lake (a flood based on the maximum probable precipitation in the watershed) would cause the lake to rise about 18 feet above its present elevation (see appendix D). Since the economic damages that would result from higher lake levels are significantly greater than the cost of constructing flood control measures to these levels, it appears prudent to construct these measures.

In order to better understand the economic feasibility of implementing flood control measures, economic data was collected and analyzed in terms of three scenarios for future lake levels. The economic data is an inventory of all property from elevation 1426 to 1455 feet msl in or immediately adjacent to the city of Devils Lake. The flood damages that would result from each scenario were calculated. The annualized damages were then used to calculate the benefit-cost (B/C) ratio.

With a traditional flood control project, the level of protection provided by the 100-year project could be estimated, and a 100-year floodplain and 500-year floodway could be established. However, the lack of a stage-frequency relationship prevents definition of a floodplain or floodway for this project.

Since the level of protection provided by the project cannot be identified, it would be prudent to manage the area threatened by the rising lake level to avoid endangering additional development. From the Federal perspective, this management program would limit the risk to the Federal investment in private and public development in the threatened area. This program would also be consistent with the principle that development in an area that faces a risk from inundation should not be encouraged by any Federal action. The management program could be developed by local interests in close coordination with the North Dakota State Water Commission, the Federal Emergency Management Agency, and the Corps of Engineers. No benefits for future development were computed because the land management plan would regulate future development. Appendix A contains the economic analysis.

COSTS

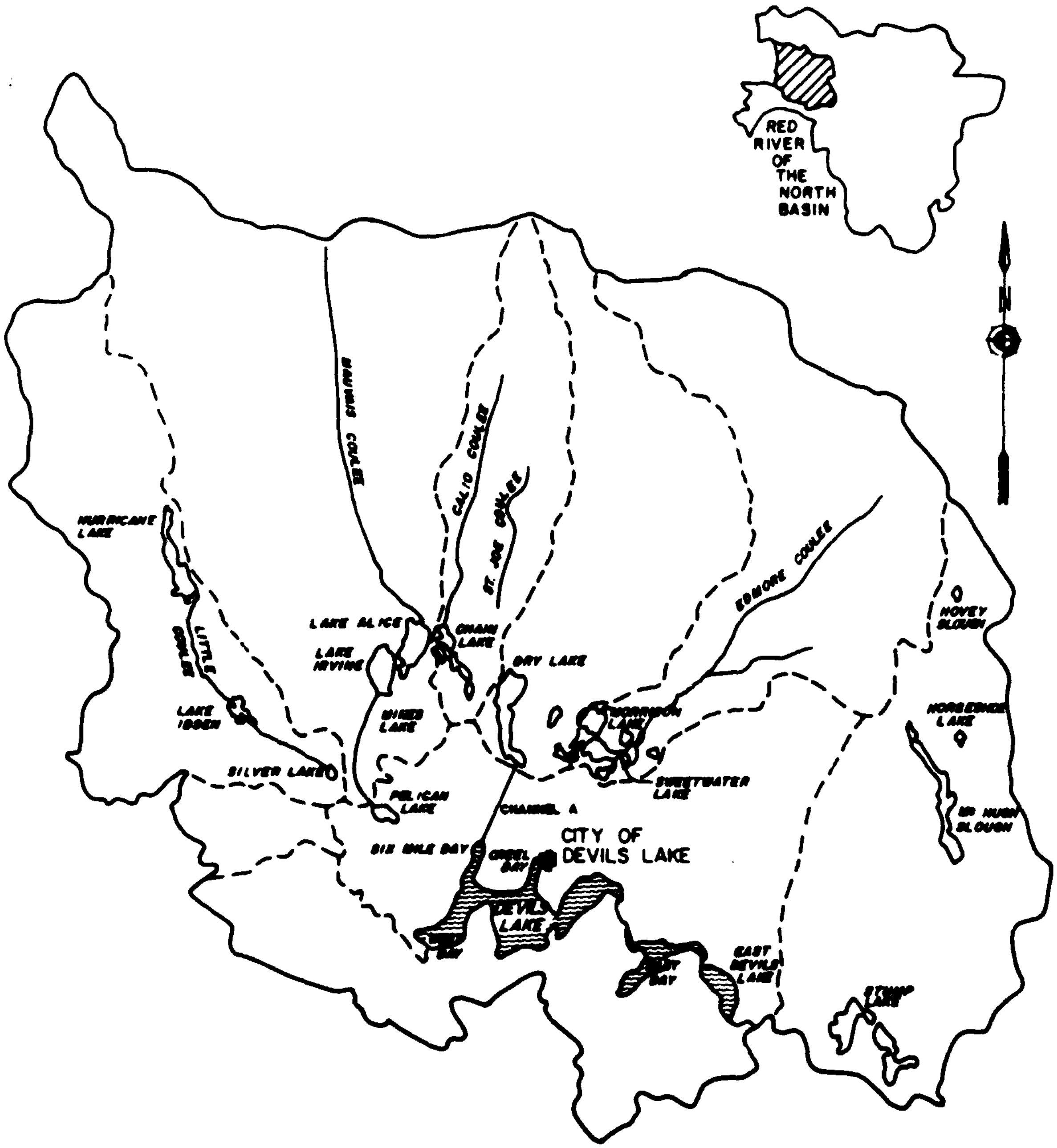
Preliminary plan layouts and detailed cost estimates were prepared for the structural plans that would provide protection to water surface elevations of 1435, 1440, and 1445 feet msl. The cost estimates are in appendix B. The cost for a structure that would protect to 1450 feet msl was extrapolated from a curve of cost versus water surface elevation prepared from the 1435, 1440, and 1445 elevation data. These data are shown on figure 9.

The cost of the nonstructural evacuation plan for each water surface design elevation was determined using the total market value of the property that would have to be acquired. A public agency would acquire all property with a first-floor elevation at or below the plan elevation. Property owners would then have the option of repurchasing and salvaging their property. The inventory of property used for the economic analysis was used as the source of market values.

HYDROLOGY

Devils Lake is in the Devils Lake subbasin of the larger Red River of the North basin. Figure 5 shows the location of these drainage areas. The Devils Lake basin includes about 3,580 square miles. The natural drainage system has a large number of wetlands, streams, and coulees. There are many shallow lakes, some of which are interconnected. In general, most of the surface water drains from north to south in eight watersheds. A ninth watershed that drains from south to north lies along the south shore of Devils Lake. Most of the water eventually flows into Devils or Stump Lakes. The Devils Lake basin has no outlet until it reaches a water surface elevation of about 1457 feet (about 29 feet above the present level of Devils Lake). At about elevation 1450 feet msl, water would flow through the chain of lakes from west to east from West Bay of Devils Lake to Stump Lake. At about elevation 1457 feet msl, the water would flow from the southwest corner of Stump Lake down Tolna Coulee to the Sheyenne River. Figure 6 shows the Devils Lake chain of lakes. The natural drainage system has limited capacity and has been supplemented by channels and ditches for agricultural drainage.

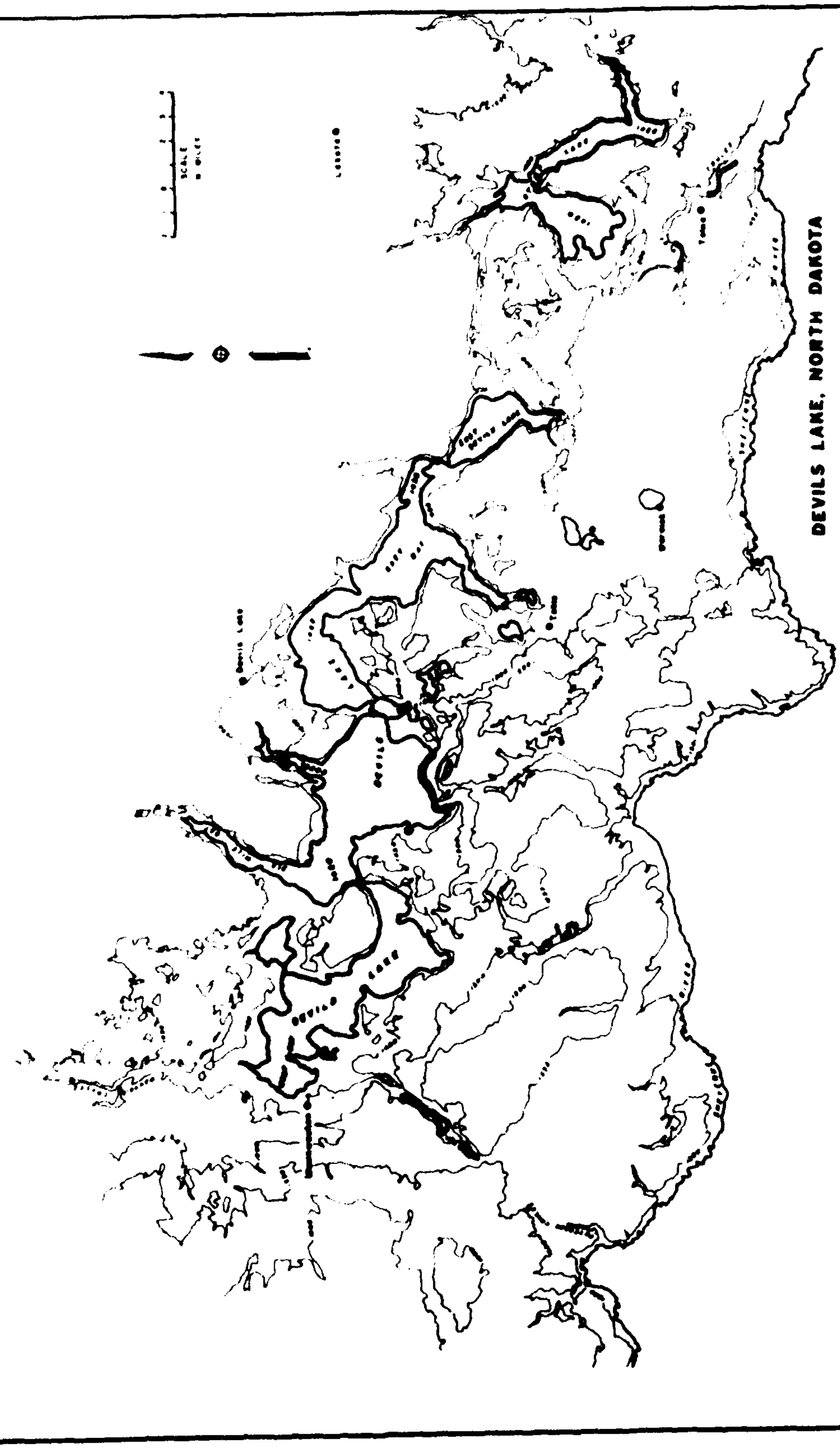
Precipitation data from 1870 to the present and temperature data from 1905 to the present are available. Evaporation data from 1930 to the present and stage data from 1901 to the present are also available. U.S. Geological Survey (USGS) gaging stations are available on five coulees that represent a contributing drainage area of 2,879 square




# SURFACE WATER SYSTEMS
# DEVILS LAKE SUB-BASIN



FIGURE 5



DEVILS LAKE, NORTH DAKOTA

miles (out of the total subbasin area of 3,580 square miles). Records date back to 1950 for one coulee, to 1958 for two coulees, to 1975 for one coulee, and to 1979 for another. Because of the limited streamflow data, the hydrologic budget equation was used to calculate monthly inflow values. USGS information indicates that groundwater flow was not significant.

Several methods were considered for estimating future Devils Lake water levels. Attempts were made to estimate the likelihood of future lake levels using the HEC-4 computer model and a statistical analysis. Because the HEC-4 model gave unrealistic results, it was rejected. Upon close examination, the hydrologic and meteorologic data was judged not adequate for a reliable statistical analysis. The hydrologic analysis was coordinated with hydrologists at the Corps North Central Division office and Hydrologic Engineering Center and with scientists at the Unversities of Colorado, Minnesota, and North Dakota.

A probable ma imum flood (PMF) was developed for the Devils Lake basin from detailed studies conducted for the Goose, Wild Rice, and Sheyenne Rivers in North Dakota. The standard project flood (SPF) flow to Devils Lake was estimated at 40 percent of the PMF. For the lake's present elevation of about 1428 feet msl, the SPF inflow would raise the lake to elevation 1446 feet msl, or about 18 feet. The spring inflow with a 1-percent chance of occurring in any one year would raise the lake to elevation 1432.5 feet msl, or about 4.5 feet above the present level. Appendix D contains the detailed hydrology analysis.

## INTERIOR DRAINAGE

The interior drainage facilities would consist of a basic system needed for all the alternative structural plans with additional facilities for plan D to accommodate drainage from the eastern part of the city.

The interior drainage system for plans A, B, C, and D would consist of two holding ponds, a large pumping station and a system of ditches and culverts linking the holding ponds to the pumping station. The north holding pond would be combined with the existing sewage lagoon effluent holding pond. The effluent presently meets State water quality standards and is periodically discharged to the lake. The combined storm and effluent water would also be discharged to the lake through the pumping station.

The interior drainage system for plan D would consist of the basic system plus an additional holding pond, pumping station, and ditch/culvert system. The interior drainage systems are shown on figure 7. Appendix C discusses interior drainage.

GEOTECHNICAL

Boring and testing data indicate no geotechnical problems that would complicate or adversely affect design or construction of the alternative plans. Appendix E discusses the geotechnical investigations that have been completed.

The proposed flood control structures could be expected to act as flood barriers for extended periods. Failure of these structures could cause catastrophic damages. The structures would therefore be designed in accordance with dam safety criteria. However, the structures would not cause the lake to rise as a dam would. They would instead prevent rising water levels from inundating developed property. The basic structures for each alternative are embankments.

All structural plans would use two borrow areas. One is immediately south of the airport across Trunk Highway 19. The other is about 1½ miles south of the city and is spoil from the construction of existing storm-water settling ponds. Soil from these sites has been tested and found to be appropriate fill for the embankments.

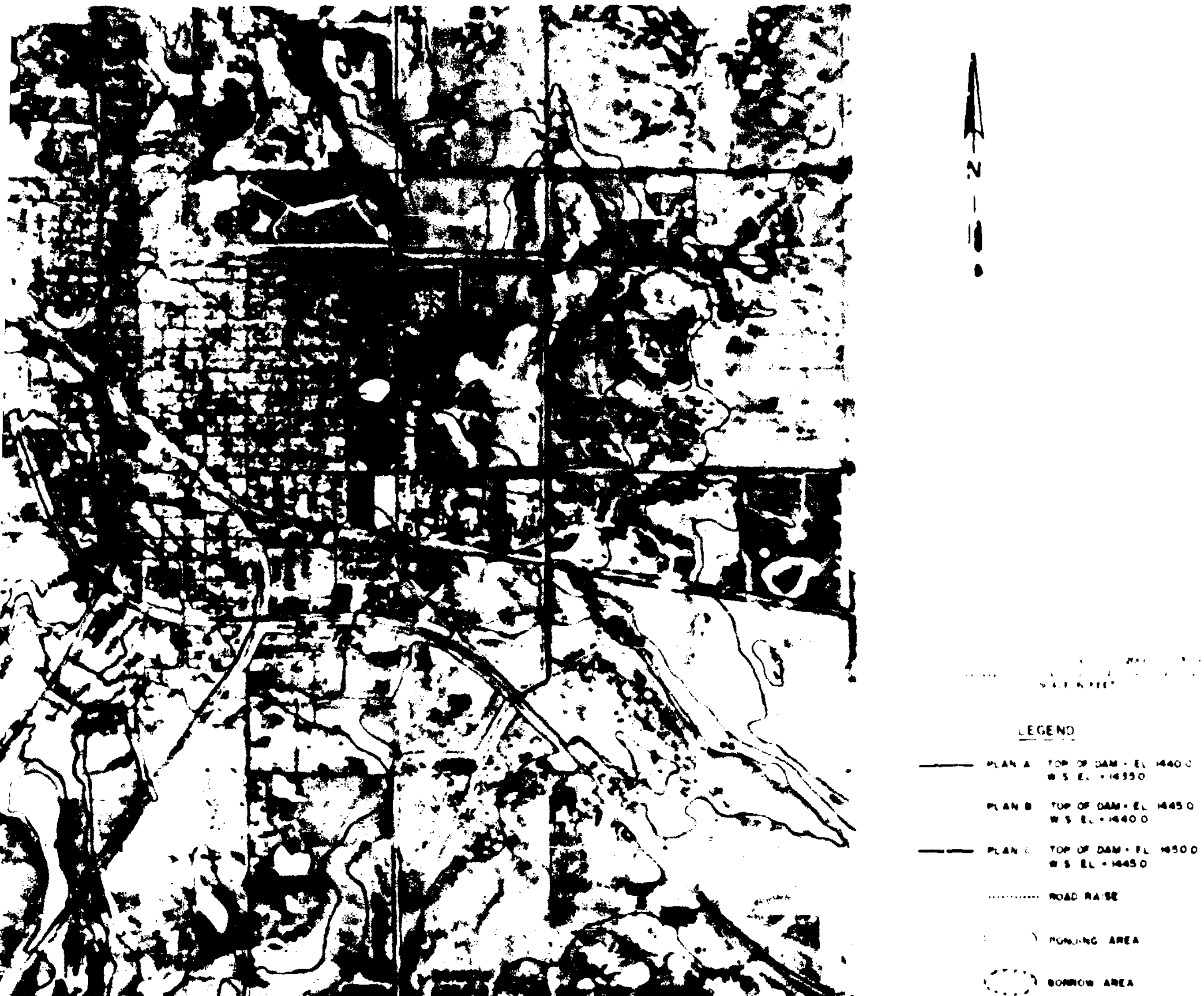
ENVIRONMENTAL IMPACT

A preliminary analysis did not identify any significant negative environmental impacts associated with the alternative plans.

Constructing an embankment at the head of Creel Bay would have minor environmental impacts. The construction would destroy some upland and lowland vegetation. The amount of lowland vegetation affected would depend on the lake level. This embankment also would affect the natural appearance of the landscape. For some people, the embankment would adversely affect the aesthetics of the area.

Protecting the city from water levels up to 1440 feet msl would require embankments west of the city near the airport and southeast of town as well as the embankment at the head of Creel Bay. These


PONDING AREA
W.S. EL - 1430
TOP OF DIKE - 1432




SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL PROJECT AT DEVILS LAKE, ND
ALTERNATIVE FLOOD CONTROL PLANS

FIGURE 7

2

additional embankments would be constructed in pasture or grassland that has moderate wildlife value. For most people, such additional embankments would have a minor adverse effect on the aesthetics of the area.

Protecting the city to a water surface elevation of 1445 feet msl would require higher and somewhat larger embankments than the previous plans. Impacts would be similar to those for the previous plans except somewhat greater because of the increased size of the embankments.

Protecting the city to a water surface elevation of 1450 feet msl would require a nearly continuous embankment enclosing the south and western sides of the city. An additional interior drainage system would also be needed to accommodate storm water from the eastern half of the city. Impacts would be greater for this plan than for the previous plans because of the additional structures.

Construction of the embankments would destroy some upland vegetation that has moderate wildlife value. However, after construction the embankments would be revegetated and would provide habitat similar to pre-project conditions. The embankment at the head of Creel Bay would also destroy some benthic habitat. However, after construction the riprap would provide habitat of greater variety than exists now. Two small wetland areas southwest of the city would be affected by the 1440-, 1445-, and 1450-foot msl plans. The existing outlets of these wetlands would be blocked by the project, and new drainage would have to be constructed to prevent flooding. However, control structures could be designed to match the elevation of the existing outlets and the water levels of the wetlands would not be affected.

Environmental impacts associated with not constructing a project could be substantial. Higher water elevations could inundate the sewage treatment lagoon, storm water facilities, and a large amount of development. Raw sewage effluent and debris from the flooded area could contaminate the lake. Evacuation of all development, including sanitary and storm sewage facilities, from the former lakebed and relocation to upland sites would have limited environmental impacts. However, evacuation would be prohibitively expensive and disruptive to the community.

Several potential environmentally beneficial project features have been identified. Interior drainage ponds north and south of the sewage lagoons and immediately east of the embankment at the head of Creel Bay could be designed and operated to serve as wetland areas. However, sufficient water storage capacity would have to be maintained to prevent flooding from runoff on the city side of the embankment. Combining the north sewage effluent pond with the storm water holding pond could dilute the effluent and filter it through an enlarged wetland. This process could benefit the water quality in Creel Bay. Spreading the effluent (and perhaps the storm water from the northern holding pond) on land has been proposed. However, because planning and funding of this feature have not progressed, it does not appear that this feature could be implemented in conjunction with the flood control project.

Much of the recent development in the city has occurred on the former lakebed. All alternative would include a land management plan. The land management plan discussed in the economics section would limit the risk of flooding of future development. It would help preserve wetlands and upland habitat. Executive Order 11988 on floodplain management is supported when planning efforts protect, manage, and enhance or restore the values of a floodplain. All the alternative plans would be consistent with this order.

All the alternative plans also would be consistent with Executive Order 11990, protection of wetlands. There is very limited potential that a project would induce the drainage of wetlands behind the embankments because of the natural topography and U.S. Fish and Wildlife Service wetland easements in the area. The design of interior drainage facilities would be based on no future drainage of wetlands within the interior drainage watersheds. Wetland drainage in these areas is discouraged.

The bald eagle and peregrine falcon, both on the Federal list of endangered species, could be found in the project area. However, the U.S. Fish and Wildlife Service has concurred with the St. Paul District's assessment that the project would not adversely affect these birds. Letters from the U.S. Fish and Wildlife Service are in appendix I.

The St. Paul District has initiated coordination with the National Park Service, State Archaeologist, State Historic Preservation Officer, U.S. Fish and Wildlife Service, Environmental Protection Agency, North Dakota Game and Fish Department, and other State and Federal agencies. No significant impacts or areas of controversy have been identified. The St. Paul District has prepared an environmental assessment and finding of no significant impact for the project. These documents are included in a later section of the report. Placement of fill in the waters of Devils Lake is authorized under the Corps of Engineers nationwide permit program because Devils Lake is a closed basin and is not tributary to interstate waters. Special conditions of the permit will be met and best management practice followed as far as practical. In accordance with the special permit, neither a Section 404(b)(1) evaluation nor a Section 401 water quality certification is needed to comply with the provisions of the Clean Water Act.

The selected plan's compliance and consistency with executive orders, laws, and regulations are discussed in later sections of this report.

SOCIAL IMPACT

Construction equipment would generate some noise. However, no sensitive receptors (such as hospitals or schools) are in the affected area, and the construction noise would have no appreciable effect. Some loss of aesthetic values could result because the proposed embankments would affect views of the lake and views from the shore to the upland areas. Construction activity could temporarily disrupt traffic. However, traffic patterns would not be significantly affected.

Substantial benefits to the public health and safety would result from protecting the local sewage, storm water, transportation, and electric utilities. There might be a minor negative effect on social cohesion because the project would protect the city but not other areas adjacent to the lake. Areas without protection (such as Camp Grafton, Fort Totten Indian Reservation, and the city of Minnewauken), might feel that they were unfairly treated.

The project would have substantial beneficial effects on community growth and development: (1) protection of vital city facilities (sewage, storm-water, transportation, and electric facilities), (2) protection of a major recreation and economic resource (the lake would not be contaminated with raw sewage and debris from inundation of development), (3) minor economic stimulus during construction, and (4) protection of development in the floodplain.

None of the structural alternative plans would require the relocation of homes or businesses. All of the nonstructural evacuation plans would require a substantial amount of relocation efforts and would be disruptive to the community.

All of the plans would provide a net social benefit. The plans with higher levels of protection would reduce the risk of flooding the most and would have the greatest net social benefit.

There is a potential for controversy around several issues: (1) allocation of local costs, (2) the limited area protected, and (3) the land management plan.

CULTURAL RESOURCES

If no project is implemented, cultural resources would potentially be affected as the lake level rises and falls. Prehistoric and historic sites could be flooded and might be buried or sustain increasing amounts of erosion and weathering. With repeated occurrences of the lake level rising and falling, historic structures would continue to be inundated, causing structures to sustain structural damage from flooding and erosion. Additionally, the architectural, historic, and scientific integrity of the buildings would be increasingly jeopardized.

The ponding and embankment areas for plans A and B were surveyed during September 1981. No recorded cultural resource sites are within the ponding and embankment areas that these plans would affect.

The ponding areas and part of the embankment areas for plans C and D would provide protection to elevation 1445 and were surveyed in September 1981. These plans were not completely surveyed because they were not developed until after the initial survey was completed. If one of these plans is selected, a complete cultural resource survey will be conducted for it.

The borrow areas for the selected plan will be surveyed by a St. Paul District archeologist in June 1983. If this new survey discovers any significant cultural resource sites, the St. Paul District will develop a mitigation plan with the help of the North Dakota State Historic Preservation Officer.

All plans have a high potential for affecting cultural resource sites. The St. Paul District will conduct additional coordination with the North Dakota State Historic Preservation Officer after

selection of a recommended plan to determine the need to monitor construction activities.

RECREATION

Appendix F discusses recreation concepts and potential recreation development associated with the project. Because the project would not significantly affect the water levels in the lake, it therefore would not affect the recreational opportunities associated with the lake.

The detailed discussion of the selected plan section of the report covers the potential recreational development associated with the project.

PLAN A - PROTECTION TO A WATER ELEVATION OF 1435

Structural

Plan A structural would protect the city from lake levels up to 1435 feet msl. A single embankment 1,100 feet long with a top elevation of 1440 feet msl would be constructed across Creel Bay about 1,700 feet west of Landfill Road. All structural plans would also include the interior drainage system discussed earlier. Total cost would be about $1,600,000. Figure 7 shows the plan. Table 4 presents the project first cost, annual cost, annual benefit, annual net benefit, and benefit-cost ratio for each plan.

Nonstructural

Plan A nonstructural would require evacuation of all buildings with a first-floor elevation of 1435 feet msl or lower. According to the inventory prepared for the economic analysis, about $41,000 of residential property, $10,802,000 of commercial property and $3,444,000 of public property, for a total of $14,287,000 of property, would have to be acquired.

PLAN B - PROTECTION TO A WATER ELEVATION OF 1440

Structural

Plan B structural would protect the city from lake levels up to 1440 feet msl. This plan would require several structures: (1) a 1,700-foot-long, low embankment immediately south of the airport, (2) a 4,000-foot-long main embankment across the head of Creel Bay, and (c) a 5,100-foot-long embankment south of the lagoon area. The structure would have a top elevation of 1445 feet msl. Total cost would be about $2,810,000. Figure 7 shows the plan. The detailed discussion of the selected plan in this report has a revised cost estimate and description for plan B.

Nonstructural

Plan B nonstructural would require the evacuation of all buildings with a first-floor elevation of 1440 feet msl or lower. According to the inventory prepared for the economic analysis, about $693,000 of residential property, $12,612,000 of commercial property, and $8,333,000 of public property, for a total of $21,638,000 of property, would have to be acquired.

PLAN C - PROTECTION TO A WATER ELEVATION OF 1445

Structural

Plan C structural would protect the city from lake levels up to 1445 feet msl. This plan would require two structures: (1) a 16,000-foot-long embankment across the head of Creel Bay, and (2) a 7,200-foot-long embankment south of the lagoon area. The structure would have a top elevation of 1450 feet msl. Total cost would be about $5,097,000. Figure 7 shows the plan.

Nonstructural

Plan C nonstructural would require the evacuation of all buildings with a first-floor elevation of 1445 feet msl or lower. According to the inventory prepared for the economic analysis, about $3,119,000 of residential property, $15,992,000 of commercial property, and $27,223,000 of public property, for a total of $46,334,000 of property, would have to be acquired.

PLAN D - PROTECTION TO A WATER ELEVATION OF 1450

Structural

Plan D structural would protect the city from lake levels up to 1450 feet msl. This plan would require a continuous embankment around the west and south areas of the city. This embankment would have a top elevation of 1455 feet msl. Total cost would be about $8,800,000.

Nonstructural

Plan D nonstructural would require the evacuation of all buildings with a first-floor elevation of 1450 feet msl or lower. According to the inventory prepared for the economic analysis, about $6,983,000 of residential property, $19,577,000 of commercial property, and $33,000,000 of public property, for a total of $59,560,000 of property, would have to be acquired.

NED PLAN

The plan with the greatest net national economic development benefits is designated the NED plan. One way to determine the NED plan is to plot the economic benefits compared to implementation costs.

Appendix A details the economic benefits, and appendix B contains the cost estimates.

The economic optimum for each benefit-cost curve is the tangent drawn at a 45-degree angle to either axis. Figure 8 plots the curves and 45-degree tangent lines for each of the three lake-rise scenarios.

Scenario number 2 (with the middle rate of lake rise) shows that the NED plan would have an implementation cost of $3.3 million and benefits of $9.9 million. According to the graph of cost versus lake elevation shown on figure 9, a project cost of $3.3 million would provide flood protection for lake elevations up to about 1441.5 feet msl.

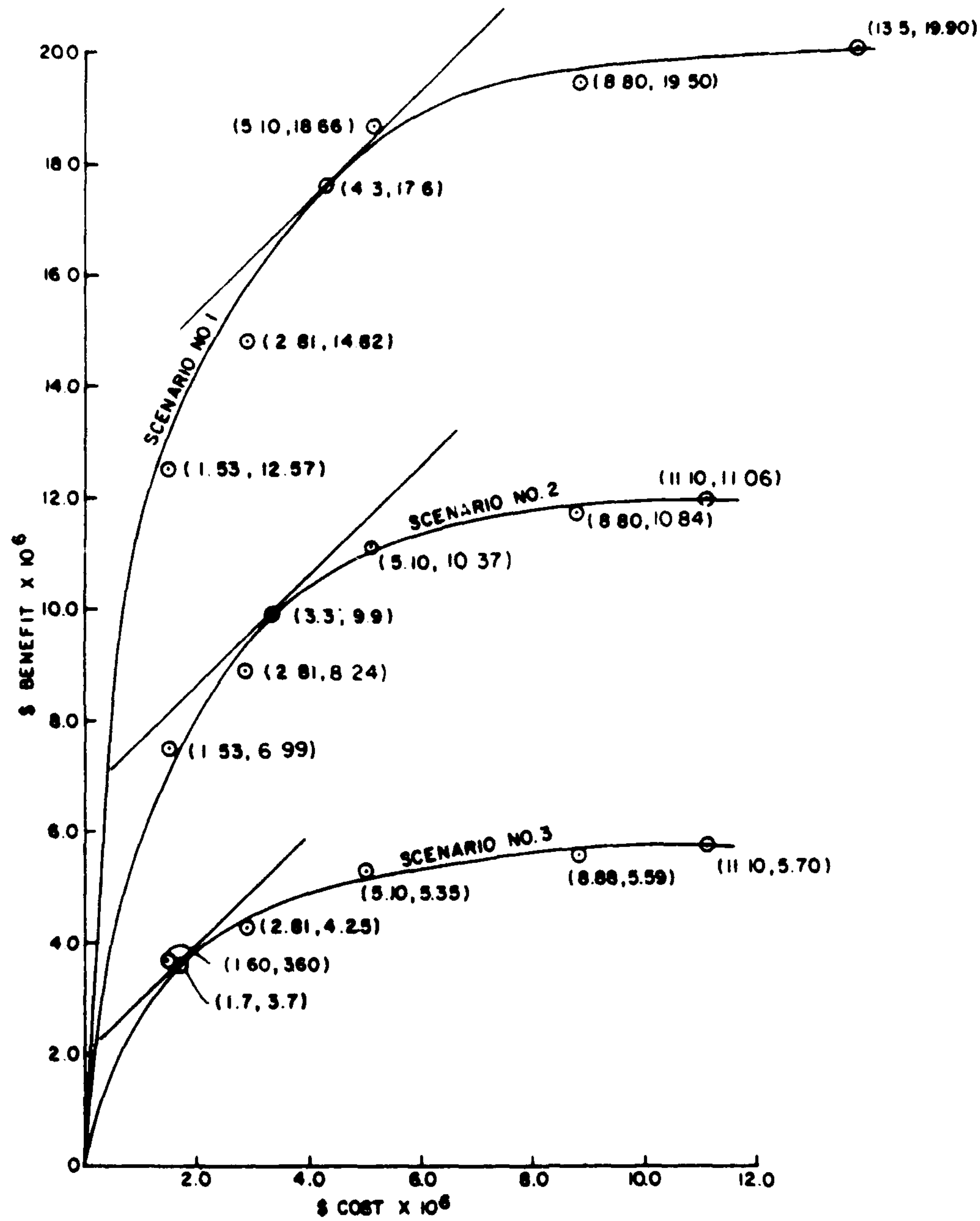
Because plan B would provide protection most similar to this theoretical optimum, this alternative was designated the NED plan.

PLAN LEAST DAMAGING TO THE ENVIRONMENT

The plan that would make the greatest net environmental contribution to the project area is designated the EQ plan. No EQ plan could be developed for this project because no opportunities for clearly improving environmental quality would be related to or created by the project.

Even though no EQ plan exists, no significant loss of environmental quality could be predicted for any of the plans. The plans with a higher level of protection would require more construction activity and would disturb larger areas of upland and lowland vegetation. However, these plans would also provide the greatest reduction in the threat of inundation of the city's sewage treatment facilities and thus would reduce chances of contaminating the lake.

Because plan B provides the best combination of these effects, it was designated the least environmentally damaging plan.




DEVILS LAKE SEC 205
BENEFITS VS COSTS

FIGURE 8

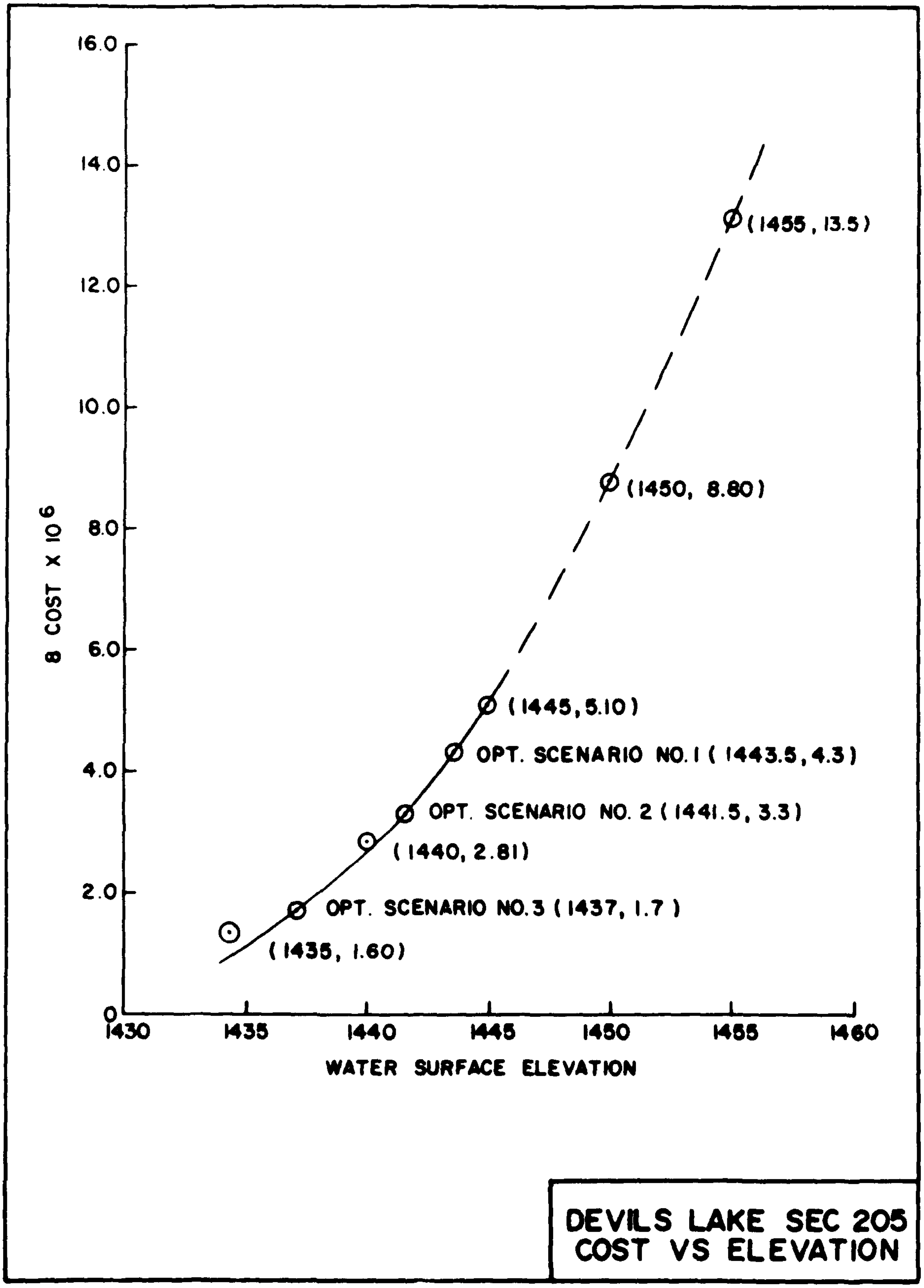

16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
$ COST X 10 6
1430
1435
1440
1445
1450
1455
1460
WATER SURFACE ELEVATION
(1455, 13.5)
(1450, 8.80)
(1445, 5.10)
OPT. SCENARIO NO. 1 (1443.5, 4.3)
OPT. SCENARIO NO. 2 (1441.5, 3.3)
(1440, 2.81)
OPT. SCENARIO NO. 3 (1437, 1.7)
(1435, 1.60)
DEVILS LAKE SEC 205
COST VS ELEVATION



FIGURE 9

SELECTION OF THE RECOMMENDED PLAN

Plan B, the recommended plan, provides the best combination of economic, environmental, and engineering characteristics. Summaries of the advantages and disadvantages of plans A, B, C, and D follow.

Table 4 is a summary comparison of the alternative plans.

Plan A would not provide sufficient flood protection for the city. It would protect against a lake rise of only 7 feet above its present level. As shown by recent history, such a rise could occur in only a few years. The standard project flood (SPF) would cause the lake level to rise about 18 feet.

Plan B is the NED plan. It is an economically efficient plan because it fully exploits the opportunities for flood control provided by the natural topographic features in the area. Plan B requires only one main embankment across a narrow neck in Creel Bay plus two relatively short, low tieback embankments.

Plans C and D are considerably more costly because they would require a nearly continuous ring embankment around the south and west sides of the city plus additional interior drainage features. The higher the design water surface level, the less likely it is that the lake will reach this level.

In addition, alternative measures to relieve flooding in the entire Devils Lake basin would probably be taken before the lake would reach the levels of protection provided by plans C and D. Action would be needed to protect against substantial damages to developed property, farmland, utilities, highways, and railroads. The city of Devils Lake would be isolated, with all major transportation facilities and utilities under water. This large amount of potential damages would probably provide sufficient reason to dig an outlet to stabilize the lake level.

Table 4 - Summary Comparison Of Alternative Plans

| Evaluation Items | Plan A (1435 design water surface) Embankment | Plan A Evacuation | Plan B (1440 design water surface) Embankment | Plan B Evacuation | Plan C (1445 design water surface) Embankment | Plan C Evacuation | Plan D (1450 design water surface) Embankment | Plan D Evacuation |
|---|---|---|---|---|---|---|---|---|
| **National Economic Development:** | | | | | | | | |
| First cost | $1,600,000 | $14,287,000 | $2,810,000[3] | $21,638,000 | $5,097,000 | $46,334,000 | $8,800,000 | $59,560,000 |
| Annual cost[1] | 122,000 | 1,090,000 | 214,000[3] | 1,651,000 | 389,000 | 3,535,000 | 671,000 | 4,544,000 |
| Annual benefit[2] | 533,000 | 533,000 | 626,000[3] | 626,000 | 791,000 | 791,000 | 827,222 | 827,000 |
| Annual net benefit | 411,000 | -557,000 | 412,000[3] | -1,025,000 | 402,000 | -2,744,000 | 156,000 | -3,717,000 |
| Benefit/cost ratio | 4.4 | 0.5 | 2.9[3] | 0.4 | 2.0 | 0.2 | 1.2 | 0.2 |

**Other considerations:**

**Environmental** — None of the plans would constitute a major Federal action significantly affecting the human environment. All structural plans would include features to maintain wetlands and manage the development of the former lakebed. The structural plans which could provide the higher levels of protection would have larger structures and more construction related impacts. However, they would also provide a higher degree of protection for the sewage lagoons and reduce the chances of sewage contaminating the lake. The evacuation plans would result in the development of upland areas. No threatened or endangered species would be affected. Plan B is designated the plan least damaging to the environment.

**Social** — None of the structural plans would require relocation of homes or businesses. The plans with the higher levels of protection would have the greatest construction-related impacts (noise, traffic) and effects on the natural appearance of the area. The nonstructural evacuation plans would require relocation of homes and businesses and would be disruptive to the community. However, the plans with the greatest impacts (structural and nonstructural) would also reduce the chance of impacts associated with flooding the most.

**Cultural resources** — The project might prevent flooding of unidentified cultural resource sites. No recorded sites would be affected by plan A or B. Plans C and D were not surveyed.

**Public laws, regulations and Executive Orders** — All plans would be consistent with Executive Orders 11990 (protection of wetlands) and 11988 (floodplain management), and the Council on Environmental Quality (CEQ), Memorandum of June 11, 1980 (impacts on prime and unique farmlands). Section 122 evaluation items are addressed in the final stage of this study.

1 Based on 100-year evaluation period and 7 5/8 percent interest rate.
2 Based on scenario 2 stage hydrograph, 100-year period and 7 5/8 percent interest rate.
3 See revised numbers for plan B structural in the Detailed Description of the Selected Plan section of this report.

In short, plan A provides insufficient protection for the city. Plan B provides a substantial increase in protection at relatively low cost. Plans C and D are considerably more costly, and damages throughout the basin associated with such high lake levels would be so great that stabilizing the lake level would probably be a better alternative.

Other factors considered during selection of plan B include the following:

1. All plans were formulated for consistency and compliance with environmental and other laws, regulations, and executive orders. Plan B provides the best tradeoff between environmental benefits and costs. It was designated the least environmentally damaging plan.

2. None of the plans would affect any identified cultural resources. The plans with the higher levels of protection would protect more potential cultural resource sites; however, they would also require more construction activity and would increase the chance of disturbing unidentified sites. Based on existing data, cultural resource considerations do not significantly determine selection of a plan.

3. All plans would have a net social benefit. The plans with the higher levels of protection would offer somewhat greater net social benefits.

4. The nonstructural evacuation plans are clearly not economically feasible and were rejected.

5. If the lake continues to rise and if an outlet is not excavated, the embankments for plan B could be used as a base for constructing either higher emergency levees or permanent levees. If an outlet is excavated, implementation of plan B would allow the lake to be stabilized at a higher level. This higher level would reduce the cost of the outlet and would provide greater benefits for water

quality, water supply, and recreation. Plan B would not constrain any future decisions that may be made.

6. Local interests support selection of plan B.

## DESCRIPTION OF THE RECOMMENDED PLAN

After selection of plan B as the recommended alternative, the St. Paul District conducted more detailed economic, environmental, and engineering analyses of this plan. The recommended plan was coordinated with the city of Devils Lake, the North Dakota State Water Commission, the North Dakota State Highway Department, the U.S. Fish and Wildlife Service, and other agencies and interests.

The original plan B (described in the previous section of this report) has been revised to reflect updated costs, benefits, design refinements, and environmental considerations. Figure 10 shows the general features of the recommended plan.

### ALIGNMENT

The recommended plan would have four separate flood barriers: the Creel Bay embankment, the Creel Bay south tieback embankment, the Creel Bay north tieback embankment, and the south embankment. Continuous stationing for the embankments was started at the east end of the south embankment (station 0 + 00) and extended through the north end of the Creel Bay embankments (station 212 + 00). Plate 1 shows the general plan. Plates 2 through 9 show additional detail.

#### South Embankment

The south embankment would be south of the city, just north of where Trunk Highway 20 and the abandoned Burlington Northern Railroad line run immediately adjacent to each other. This embankment is needed to keep water in the main body of Devils Lake from flowing up a valley and behind the main embankment across Creel Bay. Such flows would occur when lake stages are greater than 1435 feet msl. The south embankment would be

3,100 feet long and would vary from 0 to 9.5 feet high. (The plan and profile for this reach of the embankment are shown on plates 2 and 3.)

The south embankment begins where the abandoned railroad embankment intersects with the natural ground at elevation 1,445 feet. For approximately its first 1,400 feet, the embankment would be built on the existing abandoned railroad embankment. The measure would reduce fill quantities and impacts on agricultural land. The embankment would then run due west for about 1,700 feet, except for the last 500 feet, which would be bent north to avoid some homes. The west end of the embankment would tie into high ground at Trunk Highway 20.

The service road on the east side of the highway would have to be raised about 3 feet where the embankments would cross the road. The road would ramp over the levee and would match the existing ground about 200 feet north and 200 feet south of the centerline of the levee. Fill would be placed in the ditch between the service road and the highway.

After plan B was selected, several alternative plans for providing flood control in the south levee area were identified and analyzed.

Three additional embankment alignments north of the original alignment and four methods to handle interior runoff (pumping, fill, an open ditch, and an intercepter sewer) were developed.

An open ditch would have been economical, but would have drained a 40-acre wetland. It was therefore determined to be unacceptable.

An interceptor sewer, fill, or pumping plant was needed for three of the alignments. However, it was determined that the fourth and selected alignment did not require any interior runoff features because this alignment is on the drainage divide between Creel Bay and the main body of Devils Lake.

The relocated and refined south embankment plan costs about $400,000 less than the south embankment plan developed earlier. All of the buildings that lie between the earlier and revised alignments have a first-floor elevation of 1,440 feet msl or higher. Since no future development benefits were taken for any of the study area, the projected economic benefits for the south embankment alternatives are the same. The revised south embankment alignment therefore saved about $400,000 without any reduction in economic benefits.

Creel Bay Embankment

The Creel Bay embankment would be west of the city's sewage lagoon, about 1,500 feet west of Landfill Road (also referred to as Dump Road). As Creel Bay approaches the city from the west, it narrows to a neck and then broadens considerably. The Creel Bay embankment would be constructed across this neck. The embankment would be 1,810 feet long and would vary from 0 to 27 feet high. Plate 5 shows the plan and profile for this reach of embankment.

South Creel Bay Tieback Embankment

The south Creel Bay tieback embankment is 1,030 feet long and varies from 0 to 3 feet high. Plate 4 shows the plan and profile for the south Creel Bay tieback embankment.

This reach of levee was reevaluated after plan B was selected and additional topographic information was available. The reevaluation determined that the south 1,300 feet of the original design would be 1 foot high or less, would have gently sloping land on both sides, and would be relatively well protected from large waves. The embankment for this 1,300-foot-long reach was therefore eliminated. As a result, the natural elevation in this area would allow 4 feet of freeboard rather than the 5 feet that the embankments allow.

North Creel Bay Tieback Embankment

The north Creel Bay tieback embankment is northwest of the main embankment. This tieback embankment is needed to keep Creel Bay waters from flanking the main embankment for lake stages of 1,438 feet or higher. This embankment would be about 2,400 feet long and would vary from 0 to 8.5 feet high.

Trunk Highway 19 and the north/south township road immediately west of the airport would have to be raised. These roads would be the northern terminus of the embankment. Trunk Highway 19 would be raised 1 foot. Highway ramps about 500 feet long on the east and 350 feet long on the west side of the embankment would be constructed to provide a safe transition over the embankment. The township would be raised a maximum of 3 feet and would have a ramp length of about 620 feet. Plates 6 and 7 show the plan and profile for this levee.

CROSS SECTION

Plate 8 shows typical embankment sections. Plate 9 shows typical road raise and borrow area sections.

All of the embankments would provide flood protection for lake stages up to 1,440 feet msl. Each embankment would have a completed top elevation of 1,445 to provide 5 feet of freeboard. The freeboard analysis section of this report describes the calculations of the freeboard requirement.

The south and tieback embankments are relatively long, low structures. Compacted impervious fill would be placed to a top elevation of 1,445 feet. The city side of the embankments would have a slope of 1 foot vertical for every 3 feet horizontal. The mild slope on the lake side would protect the embankment from erosion at a lower cost than that of riprap. Six inches of topsoil would be stripped before the levee fill was placed, except under the 1 vertical on 15 horizontal slope where no stripping would be necessary. The south and tieback embankments would have a top width of 15 feet. The surfaces of the embankments would be covered with 4 inches of topsoil and seeded with native grass species. These reaches of embankment are all in upland areas.

The main embankment across Creel Bay can be expected to serve as a flood barrier for many decades. Since failure of this embankment would result in catastrophic damages, the embankments are designed to meet dam safety criteria. A lakeside cofferdam and probably a city-side cofferdam (the contractor might choose to use Landfill Road as the city-side cofferdam) would be needed so that the structures could be constructed in the dry. The cofferdams would be constructed by pushing or end-dumping impervious fill across Creel Bay. The bay presently has 3 to 4 feet of water at the proposed cofferdam location. After the lakeside cofferdam is no longer needed, it would be pulled back toward the main embankment to form a berm.

The lakeside cofferdam is necessary to construct the main embankment; however, it could also provide flood protection for the city until the main embankment is in place.

The main embankment would have a top widtn of 20 feet. Both sides would have slopes of 1 foot vertical for every 3.5 feet horizontal. The lake side would be protected by 9 inches of aggregate bedding material plus 18 inches of riprap.

Borings indicate that the foundation soils are relatively impervious. Seepage through the embankment would be controlled by the use of impervious fill and a sand drain. An inspection trench 6 feet deep and 10 feet wide would be excavated across the valley and filled with compacted impervious material. The sand drain would be protected by 6 inches of bedding and 12 inches of riprap where the drain surfaces on the city side of the embankment.

All surface area not protected by riprap would be covered with 4 inches of topsoil and seeded with native grass species. One foot of topsoi' would be stripped from under the main embankment. To allow for settling, the embankment would be overbuilt by one foot to a top elevation of 1,446 feet.

Plates 8 and 9 snow the road raise cross sections and profiles. Plans and specifications for these raises will be coordinated with the North Dakota Highway Department and township officials.

One foot of topsoil would be stripped from the Creel Bay borrow areas. After the borrow is removed, these areas would be graded for drainage, covered with four inches of topsoil, and seeded.

Appendix E contains additional information on the geotechnical design of the project.

INTERIOR FLOOD CONTROL FACILITIES

The interior flood control system was formulated to meet the following concerns:

1. To provide the most cost-effecti·e plan.

2. To provide facilities for pumping during high lake stages and gravity flow during low stages.

3. To minimize the impact on wetlands.

4. To be compatible with future plans to land-spread treated effluent from the sewage lagoons.

The recommended plan includes a system of storm-water holding ponds, a pumping station, and culverts and ditches. The capacities of the holding ponds and pumping station were optimized to provide the most cost-effective system. Large amounts of relatively low-cost former lakebed land are available for ponding. By using the maximum ponding available, the recommended plan minimizes the required capacity of the pumping station and the total cost of the interior flood control system.

During low lake stages and gravity flow conditions, the interior flood control system could accommodate, with no damages, a storm with a 1-percent probability of occurring in any single year. During high lake stages and blocked gravity conditions (pumping mode of operation), the proposed system could accommodate, with no damages, a 15-day, 4-percent storm event. With present high lake stages (elevation 1,428 feet in May 1983), the existing system probably cannot accommodate a 4-percent event without damages.

An economic analysis showed that increasing the size of the pumping station to accommodate a design storm larger than a 4-percent event would not be justified.

To reduce future pumping costs, a siphonic pump design was chosen. With this design, the pump only needs to lift the water for the height that is the difference between the water elevations on both sides of the embankment rather than for the total height of the embankment. Because the pumps might have to operate for many years, this design could result in considerable energy cost savings.

Special attention was also given to insulation, earth sheltering, and ventilation because of the need for extended pumping during all seasons of the year. A gravity outlet was incorporated into the design of the pumping station so that, if lake levels fall to 1,424 feet msl or lower, pumping costs could be eliminated.

The interior flood control system is not designed to accommodate any significant increase in interior runoff area. Because of the topography in the area, it is unlikely that additional wetland water storage areas would be drained to flow into the interior runoff area. Any additional drainage is strongly discouraged because of the negative effects of such drainage on the interior flood control system as well as on [illegible] wildlife habitat.

Impact on Wetlands

An important design consideration was to minimize the impact on wetlands.

The proposed south embankments would block the existing control for a [illegible]0-acre wetland immediately north of that embankment. However, a new outlet at the same elevation would be excavated. A shallow, sod-lined swale would be constructed to drain toward an existing culvert under Trunk Highway 20.

The project would also drain a 38-acre intermittently-flooded wetland southwest of the sewage lagoon plus a 20-acre wetland between Landfill Road and the proposed Creel Bay embankment. These wetlands must be drained to allow sufficient slope in the ditches that would transport water from the holding ponds to the pumping station. After the project is constructed, these areas would be intermittently flooded when needed for ponding capacity, but they would have less water for shorter durations than under existing conditions.

About 167 acres of permanent wetland would be maintained in the north ponding area. The 65-acre wetland between Landfill Road and the sewage lagoon would be preserved. Notches would be cut down to elevation 1,428 feet msl in the berm along the wetland. During high-flow conditions, water from the north holding pond would recharge the wetland. Under existing conditions, the only exterior source of water is sewage effluent that the city may choose to pump into the area.

The interior flood control plan was reviewed and approved by the U.S. Fish and Wildlife Service.

Land-spreading of Sewage Effluent

A long-term goal of the city is to eliminate the discharge of treated sewage effluent into Creel Bay. The effluent presently meets State and Federal water quality standards.

In 1983, the city initiated planning studies for land-spreading or evaporation of the sewage effluent. At present, there appears to be limited further economic benefits associated with combining the storm water and effluent water pumping facilities. In addition, the schedules for the flood control and land-spreading projects do not correspond. Pumping facilities for sewage effluent have therefore not been incorporated into the flood control project.

If opportunities for combining these facilities are well developed before planning for the flood control project is completed, the decision not to incorporate land-spreading could be reevaluated. Any additional project costs for pumping sewage effluent to land-spreading or evaporation facilities would be a local cost.

Ponding Areas

Interior flood control facilities would consist of five holding ponds: a 299-acre north pond, a 195-acre south holding pond, a 127-acre east pond, a 107-acre Landfill Road pond, and a 32-acre pond between the proposed embankment and Landfill Road, for a total of 760 acres.

Except for the north and Landfill Road ponds, the ponds would only have water when runoff was greater than the capacity of the pumping station and only until the pumping station could drain down the ponds. However, a large storm might require several days for the pumping station to draw down the ponds.

Although this land could be used for grazing, hay meadows, or other compatible purposes, these areas would have to remain available for ponding water at any time.

Pipes and Ditches

Three culverts would be removed from under Trunk Highway 19, and two new 36-inch by 58-inch arch pipes would be installed. Each new pipe would have a weir to maintain a minimum water elevation of 1426.75 feet in the north holding pond.

As discussed earlier, notches would be cut in the existing berm adjacent to the Landfill Road pond to recharge this wetland and to provide ponding capacity. Minor clearing and grading in the existing storm-water ditches adjacent to the sewage lagoon would increase their capacity. The existing culverts under Landfill Road would be removed and a new 72-inch pipe installed there.

As discussed earlier, a new sod-lined swale would be constructed to control the elevation of the wetland adjacent to the south embankment. This swale would have the same control elevation as the present wetland control.

Pumping Station

The pumping station would be on the south abutment of the Creel Bay embankment. The pumping station would be designed for all-season operation and would have two 8,000-gallon per minute submersible electric pumps.

Plates 10, 11, and 12 show the holding ponds and other interior flood control features. Plates 15, 16, and 17 show the pumping station. Appendix C is a detailed analysis of the interior flood control system.

FREEBOARD ANALYSIS

Freeboard requirements for the embankments comply with the criteria and principles in a Corps publication, ETL 1110-2-221, "Wave Runup and Wind Setup on Reservoir Embankments," dated November 29, 1976. Overland wind velocities were adjusted to over-water conditions for an effective fetch of 2.11 miles. Wind velocity computations resulted in a design wind of 55 mph over a 28-minute duration. Recommended procedures for developing wind setup and and maximum wave runup on a riprapped embankment produced a 5.0-foot freeboard requirement. The maximum wave runup was determined to be 4.7 feet with a wind setup equivalent to 0.3 feet. The design water surface elevation of 1440.0 feet along with the computed freeboard allowance of 5.0 feet established the top of embankment at elevation 1445.0 feet for all reaches of embankment. As discussed earlier, a portion of the embankment was eliminated in an area that has 4 feet of freeboard with its present elevation.

GROUND WATER AND SEEPAGE

Natural foundation materials at all of the embankment sites are predominantly impervious. Out of 546.2 linear feet of overburden samples for the project, only 31.2 feet were evaluated as pervious. These pervious materials occurred as beds less than 5 feet thick in an impervious soil mass. A total of 97.4 linear feet of fractured shale was sampled. In all cases, the fractured shale was mantled by an impervious soil cover.

Although not verified by borings for this project, glacial till is normally weathered and occasionally fissured to a depth of 5 to 10 feet. In areas of poor surface drainage, water is requently stored in fissures in this zone. Water may also seep into shallow excavations. Migration of water through these fissures is, however, generally not significant.

Movement of water therefore would be limited to thin, sandy beds in the overburden and to the fractured shale. Based on this interpretation, seepage under the embankments is not a problem caused by a limited ability of the foundation to receive and transmit water.

The water table was poorly defined for this study because of the low permeability of the soils and the short observation time allowed for water levels in boreholes to become static. Based on the simple definition of the water table as the surface of the zone of saturation, the water table is interpreted as fairly shallow at all sites. Free water is, however, not readily available.

## IMPACT ON GROUND WATER

The project is proposed to protect the city of Devils Lake from inundation. It will not cause a perceptible difference in the level that the lake would attain if no action were taken. No adverse impact on the ground water of the area would, therefore, result from the project. The project would, in fact, provide some relief to normal high ground-water levels under the city by maintaining surface drainage and by keeping sewers functioning during periods of high lake levels.

Although the project should have no adverse impact on the ground water of the area, a brief discussion of ground water at the city of Devils Lake and probable ground-water conditions during periods of excessively high lake levels follows to clarify what might otherwise be perceived as a project-related problem.

The city of Devils Lake is underlain by glacial drift and minor lacustrine sediments resting on shale of the Pierre Formation. Free ground water is present in sand seams, lenses, and channels in the glacial drift. Such features often yield water to shallow excavations, particularly in the west and central parts of town. Seepage from shallow water-bearing seams is also evident in a drainage ditch around the north and east sides of the city. This seepage reportedly contributes to sewage treatment demands because of infiltration into the sewer pipes. Water is also present in fractured shale of the Pierre Formation, which is too deeply buried to be encountered in excavations for normal construction. Wells tapping this source are over 40 feet deep, but those in the drift are as shallow as 12 feet.

Other major aquifers under or near the city are the Dakota and the Spiritwood Aquifers. The Dakota Aquifer lies 1,500 feet below ground surface. It is a sandstone that yields salty water under artesian pressure. The Spiritwood Aquifer is a drift-filled bedrock valley south and west of the city. This aquifer produces poor quality water from sand and gravel beds in the drift.

The only water-bearing strata of interest in the evaluation of the relationship of ground-water and lake levels are the shallow sandy beds in the drift. These sandy beds are recharged by local precipitation. Natural drainage from these beds is poor because they lack a hydraulic connection with an effective base level. Drainage is presently assisted by ditches to the lake and infiltration into sewer pipes. These artificial factors make drainage responsive to lake levels only when the lake is at a lower level than the area drained.

Since the level of the lake depends directly on precipitation, high lake levels would naturally coincide with high ground-water levels in the city. A casual observer could therefore easily misinterpret the high ground-water levels as the result of the high lake level.

With the project in place, a pumping facility would provide some relief to high ground-water levels by maintaining surface drainage and by keeping the sewer systems operational. Subsurface seepage from the lake to the protected area is predicted to be insignificant because of the overall fine texture of the soils. Demands on the pumping facility due to seepage from the lake are predicted to be insignificant.

RIGHTS-OF-WAY

The non-federal project sponsor would be responsible for acquiring all lands, easements, and rights-of-way for the project. The easements described below are the minimum interests that the sponsor would have to acquire. The sponsor may choose to acquire a greater interest, such as fee title ownership, however.

About 32 acres would be needed for the earth embankments, pumping station, and access road. The city would have to acquire a perpetual easement.

About 760 acres would be needed for interior runoff ponding areas. The city would have to acquire a perpetual easement for these lands. The ponding land could be used for compatible purposes, such as grazing or hay meadows. However, such uses would have a lower priority and could not interfere with the primary purpose of the land, which would be to store water.

Perpetual easements would be needed for the Trunk Highway 20 and township road raise near the airport and for the service road raise near the south embankment.

Fill for the project would be excavated from an existing stockpile of earth south of the city (approximately 300,000 cubic yards of earth excavated from storm-water settling ponds) and from borrow areas north of the Creel Bay embankment. The city owns the stockpile of earth, but it would have to acquire temporary borrow easements north of the main embankment.

Much of the land needed for the project lies below the meander line of the lake, which generally varies between 1435 and 1437 feet msl in the Creel Bay area. State officials have indicated that the State of North Dakota owns this land. Several recent court cases have confirmed the State ownership of this land. State officials have indicated the State-owned land necessary for the project would be conveyed to the project sponsor.

Some of the land needed for the main Creel Bay embankment is owned by the city. The balance of the land needed for the project is owned by three or four private parties.

Appendix B includes the real estate cost estimate.

*RELOCATION OF BUILDINGS, STREETS, AND UTILITIES*

No known buildings, streets, or utilities would need to be relocated for construction of the recommended plan. Relocation of these items would be a local responsibility.

An underground water main would pass beneath the south embankment. This pipe may need to be modified so that failure of the main and the resulting breakage would not endanger the embankment. These modifications are considered an integral part of the structures. The cost of such modifications would be a Federal responsibility.

ECONOMIC BENEFITS

As discussed in appendix A, the traditional benefit-cost ratio analysis that uses discharge or stage frequency-damage relationships could not be conducted for this project. However, the lake will probably continue to rise. The standard project flood inflow to the lake would cause the lake to rise about 16 feet above its present elevation (1428-plus feet msl).

Because the economic damage resulting from higher lake levels would be much greater than the cost to protect against these damages, it appears prudent to construct the proposed flood control measures. A lake level of 1440 feet msl (the design water surface for the recommended plan) would flood about $26,000,000 worth of property. The cost of a project to protect against these damages would be about $2,000,000.

Three scenarios for future lake levels were developed and are analyzed in appendix A. The national economic development (NED) average annual benefits were calculated using scenario 2. This scenario involves an intermediate rate of lake rise.

The total present value of future damages, based on scenario 2 and a design water surface elevation of 1440 feet msl, is $9,880,000. For a 100-year project life and a 7-7/8 percent interest rate, the average annual economic benefits associated with the project would be $778,000[1].

The three scenarios indicate the sensitivity of the economic feasibility to the rate of rise of lake levels. However, the economic analysis showed that, even for the most conservative rate of lake rise (scenario 3, where the lake would not get to elevation 1430 feet until the year 2000), flood control measures would be economically feasible. Benefit-cost ratios for the selected plan range from 5.3 to 1 (scenario 1) down to 1.5 to 1 (scenario 3).

(1) The total present value of future damages was updated for the recommended plan using an interest rate of 7-7/8 percent and a base year of 1984. These figures differ from those presented for plan B during an earlier stage of the study because the earlier figures used an interest rate of 7-5/8 percent and a base year of 1982. Updating all of the alternatives would not have resulted in selection of a different plan.

LEVEL OF PROTECTION/FLOODPLAIN MANAGEMENT

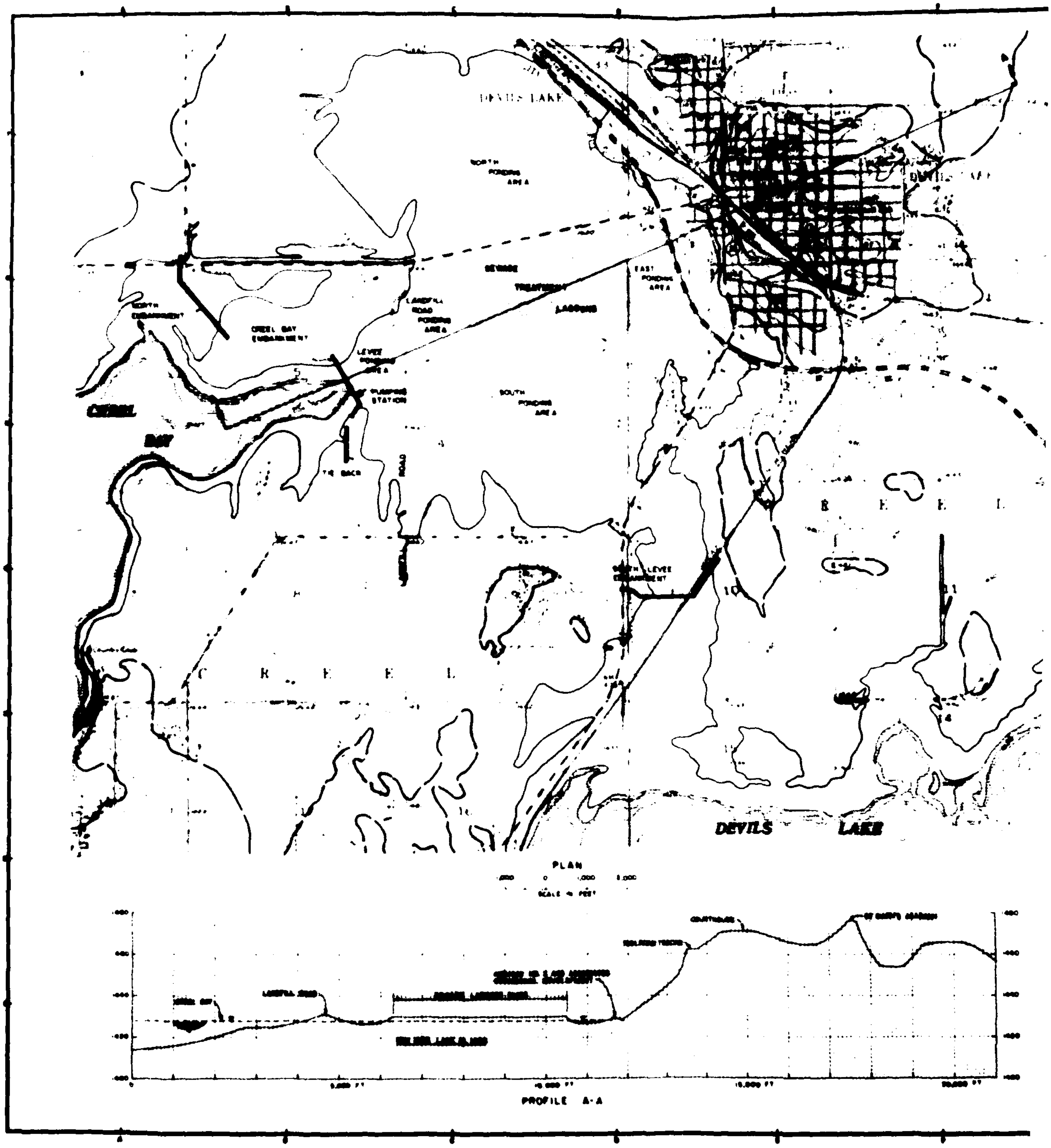
For a traditional flood control project, the level of flood protection provided can be estimated. This level of protection is generally stated in terms of the probability of occurrence for a flood larger than the project is designed to control. However, the lack of a stage-frequency relationship for the Devils Lake water levels makes it impossible to calculate this probability for the recommended plan.

The standard definition of a floodplain includes the land with a 1-percent chance of being inundated in any one year. The lack of a stage-frequency relationship also makes it impossible to define the floodplain in the project area according to standard criteria.

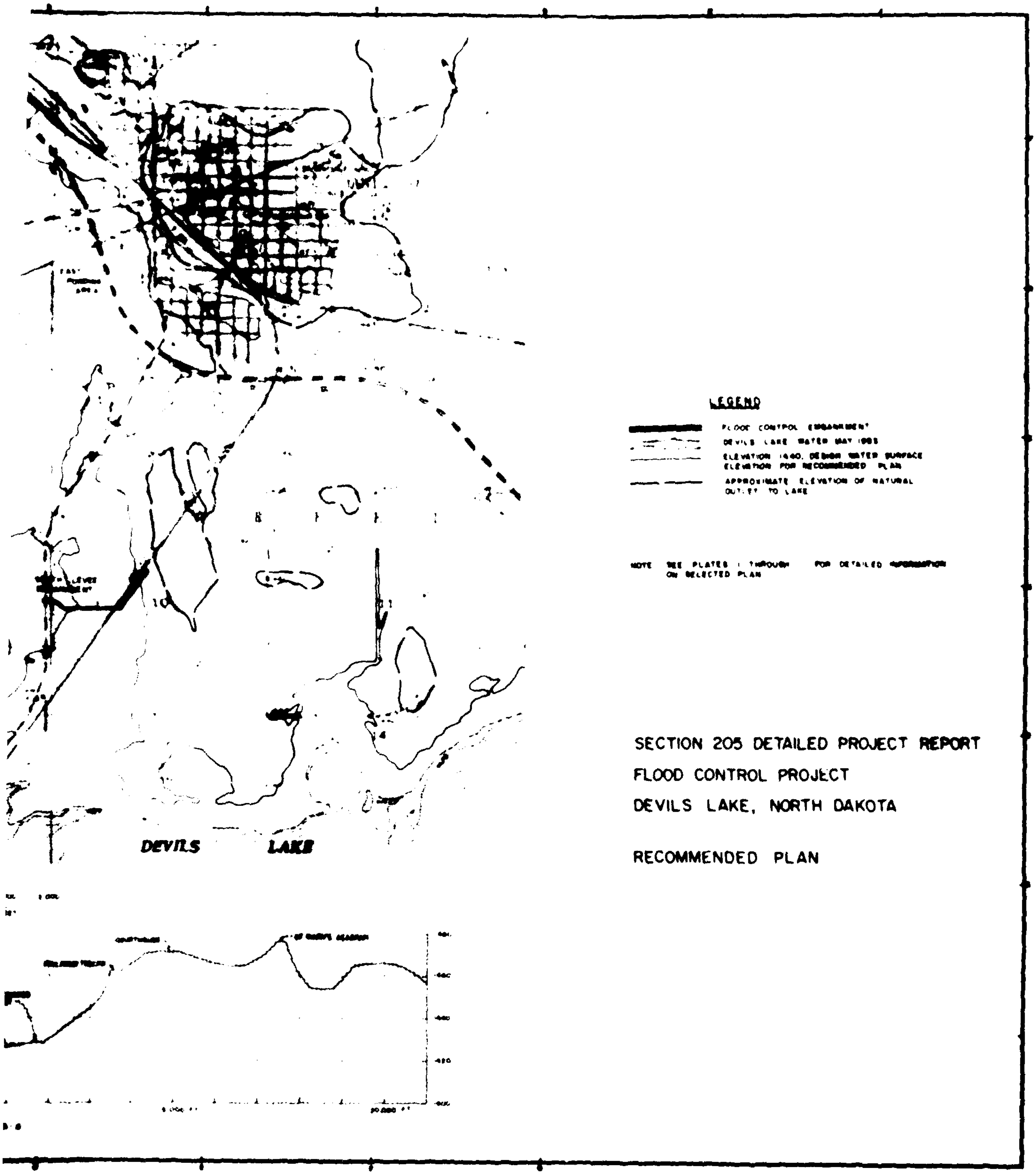
Since the level of flood protection provided by the project cannot be identified, the area protected by the flood barriers cannot be removed from the floodplain and must be managed to avoid endangering additional development.

From the Federal perspectives, this management program would limit the risk to the Federal investment in public development within the area. The Federal flood control project must also be consistent with the principle that Federal action should not encourage development in an area at risk from flooding. Executive Order 11988 requires that the Corps avoid inducing development in the floodplain.

The need for floodplain management in the project area has been stressed by Corps representatives at several meetings with local and State interests. These interests concur with the need for such a management program. In cooperation with the North Dakota State Water Commission, the Federal Emergency Management Agency, and the Corps, the city of Devils Lake is developing a floodplain management ordinance. Enactment and enforcement of this ordinance would be an item in the local cooperation agreement. (See local responsibility item 9 on page 84.)



DEVILS LAKE
NORTH PONDING AREA
SEWAGE TREATMENT LAGOONS
EAST PONDING AREA
NORTH EMBANKMENT
CREEL BAY EMBANKMENT
LEVEE PONDING AREA
PUMPING STATION
SOUTH PONDING AREA
TIE BACK
ROAD
SOUTH LEVEE EMBANKMENT
CREEL
BAY
C R E E K
DEVILS LAKE
PLAN
SCALE IN FEET
COURTHOUSE
RAILROAD TRACKS
LANDFILL ROAD
PROFILE A-A




SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA

RECOMMENDED PLAN

FIGURE 10

Figure 10 shows contour lines for elevation 1440 feet msl (the design water surface for the recommended plan) and the approximate elevation of the natural outlet. The figure also shows a profile across Creel Bay, the sewage lagoons, and the city.

The standard project flood (SPF) would cause the lake to rise to elevation 1446 feet msl from its 1983 elevation of 1428. This SPF level would be 1 foot over the top of the levee and 6 feet above the design water surface level for the project. However, because of the slow rate in the rise of the lake, emergency action to raise the levee or excavate an outlet would be feasible. If these actions were not taken, there would be time to evacuate people and removable property.

ENVIRONMENTAL EFFECTS

The recommended plan is preferred from an environmental standpoint.

Habitat losses resulting from the project have been minimized. The higher quality wetlands in the project area would not be adversely affected by the project. A minimum water level would be held in the north holding pond to maintain a wetland. Terrestrial habitat losses would be restricted to grassland areas, and those losses would be replaced by grass plantings on the levees.

Other measures are also in the recommended plan to help minimize environmental impacts. The project would be compatible with a system to land-spread waste water. The city, in cooperation with State and Federal agencies, is investigating such a system.

A land management plan is also part of the recommended plan. This land management plan would help to reduce future flood damages and to preserve the floodplain values of the area.

As part of the selected plan, wetland drainage is discouraged. Discouraging drainage would preserve wetland values and maintain the effectiveness of the interior drainage facilities.

The recommended plan is designed to minimize environmental impacts. The loss of aquatic habitat at the head of Creel Bay is not considered significant. The recommended plan does not result in unacceptable impacts. It is also the least environmentally damaging plan.

SOCIAL EFFECTS

Construction equipment would generate some noise. However, no sensitive receptors (such as hospitals or schools) are in the construction area, and the noise would have no appreciable effect. Views of the lake and upland areas would be affected by the structures. To some this effect could be a loss of aesthetic values, but to others the structure could be an attractive item of interest. Traffic patterns would not be significantly affected by construction activity.

Substantial benefits to the public health and safety would result from protecting the local sewage, storm water, transportation, communication, and electric utilities. The project could have a minor negative effect on community cohesion because it would protect the city but not other areas adjacent to the lake. Residents and businesses in those areas not protected (such as Camp Grafton, Fort Totten Indian Reservation, and Minnewauken) might feel unfairly treated.

The project would have substantial beneficial effects on community growth and development. The project would (1) protect vital city services, (2) protect a major recreation and economic resource (the lake would not be contaminated with raw sewage and debris from inundated development), (3) provide minor economic stimulus during construction, and (4) protect the development in the floodplain.

The recommended plan would not require relocation of homes or businesses.

Although there is the potential for controversy about the issues of allocation of local costs, the limited area protected, and the floodplain management plan, no project-related controversy is apparent. Local, regional, and State interests have shown strong, continuing support for the project. Their chief concern has been that the schedule for implementation of a plan be accelerated to prevent imminent flooding.

CULTURAL RESOURCES EFFECTS

No cultural resource sites are known within the area of the recommended plan. All proposed project lands have been surveyed except for the access road to the pumping station and the north borrow area. The access road location was not identified until after surveys were completed. Permission to survey the north borrow area could not be obtained. When permission from this property owner is obtained, the access road and borrow area will be surveyed.

If any significant cultural resource sites are discovered in the project area, the St. Paul District will initiate coordination with the North Dakota State Historic Preservation Officer to develop a mitigation plan.

RECREATION AND AESTHETICS

St. Paul District representatives and local public officials have discussed recreational opportunities associated with the project. The St. Paul District has prepared a conceptual plan showing trails on the Creel Bay embankments and associated facilities. Although local officals were interested in these concepts and confirmed the need for these facilities, they did not indicate a firm willingness to participate in recreation features. Therefore, no recreation features are in the recommended plan.

Plantings will be used to visually screen project structures. Native grass species will be used when appropriate to provide wildlife habitat, minimize maintenance, and provide a more natural appearance.

## PUBLIC LAWS, REGULATIONS, AND EXECUTIVE ORDERS

The project was reviewed with respect to Executive Order 11988 (floodplain management), Executive Order 11990 (protection of wetlands), the Council on Environmental Quality (CEQ) memorandum of June 11, 1980, (impacts on prime and unique farmland), items specified by Section 122 of Public Law 91-611, the Clean Water Act of 1977, and Public Law 96-159 (endangered species).

This review determined that the project would be consistent with these laws, regulations, and executive orders. The reasons for this determination are discussed in the environmental assessment section of this report.

## PROJECT IMPLEMENTATION COSTS

Table 5 shows the total investment cost needed to implement the project.

The annualized total project investment cost, benefit-cost ratio, and net annual economic benefits are indicators of the economic feasibility of a project. Table 6 shows these indicators for the Devils Lake flood control project.

Table 5 - Total Project Investment Cost

| | | | |
|---|---|---|---|
| Construction (each item includes a 15-percent contingency) | | | |
| Embankments | $819,000 | | |
| Road raises, access road | 105,000 | | |
| Pumping plant | 540,000 | | |
| Direct construction cost subtotal | | $1,464,000 | |
| Engineering and design (includes preparation of plans and specs.) | 176,000 | | |
| Supervision and administration | 127,000 | | |
| Indirect construction cost subtotal | | 303,000 | |
| Total construction cost | | | $1,767,000 |
| Lands, easements, and rights-of-way | | | 160,000 |
| Interest during construction | | | 46,000 |
| Total project investment cost | | | 1,973,000 |

Table 6 - Economic Feasibility

| | |
|---|---|
| Annualized total project investment cost ($1,973,000 x 0.07879)[1] | $155,000 |
| Annual operating and maintenance cost[2] | 6,000 |
| Total annual cost | 161,000 |
| Annual benefits | 649,000 |
| Annual net benefits ($649,000 - $161,000) | 488,000 |
| Benefit-cost ratio ($649,000 ÷ $161,000) | 4.0 |

(1) Based on an interest rate of 7-7/8 percent and a 100-year evaluation period.

(2) $3,500 for operation and maintenance of pumping plant. $2,500 for mowing and maintenance of embankments and ponding areas.

## IMPLEMENTATION RESPONSIBILITIES

The single purpose of this project is flood control. Costs between local and Federal interests would be allocated according to current Federal flood control law.

The Federal Government would bear all of the costs for construction of the flood barriers and interior flood control facilities, up to a maximum cost of $4,000,000. Local interests would provide all lands, easements, and rights-of-way. Local interests would be assigned all costs for the relocations of any buildings, roads, or utilities (none have been identified). Local interests would also operate and maintain the project after completion.

Table 7 shows allocations of project costs between the local sponsor and the Federal Government.

Table 7 - Allocation of Project Costs (May 1983 price levels)

| Item | Federal[1] | Local Sponsor | Total |
|---|---|---|---|
| Construction | $1,767,000 | $0 | $1,767,000 |
| Lands, easements and rights-of-way | 0 | 160,000 | 160,000 |
| Total project cost | 1,767,000 | 160,000 | 1,927,000 |

(1) Does not include $5,000 for the initial reconnaissance report or $295,000 for detailed studies prior to authorization of project construction.

LOCAL RESPONSIBILITIES

Non-Federal Interests must agree in writing to:

1. Provide, without cost to the United States, all lands, easements, and rights-of-way, including ponding and borrow areas, necessary for the construction, operation, and maintenance of the project.

2. Accomplish, without cost to the United States, all alterations and relocations of buildings, streets, and utilities except those utilities that are an integral part of project structures, necessary for the construction, operation, and maintenance of the project.

3. Hold and save the United States free from damages caused bv the construction and subsequent operation and maintenance of the project, except damages due to the fault or negligence of the United States or its contractors.

4. Provide all project costs in excess of the $4,000,000 Federal statutory cost limitation.

5. Maintain and operate the project after completion, without cost to the United States, in accordance with regulations prescribed by the Secretary of the Army.

6. Prevent any encroachment on constructed works and ponding areas that would interfere with the proper functioning of the project and, if ponding is impaired, provide promptly and without cost to the Unit States, substitute storage or equivalent pumping capacity.

7. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved January 2, 1971, in the acquisition of lands, easements, and rights-of-way necessary for the construction and subsequent maintenance of the project and advise affected persons of pertinent procedures, policies, and benefits in connection with the Act.

8. Comply with Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11 issued pursuant thereto and published in Part 300 of Title 32, Code of Federal Regulations, in connection with the construction, operation, and maintenance of the project.

9. Within one year after the execution of this agreement, enact and commence the enforcement of a floodplain zoning ordinance which shall apply to that part of the area protected by the project, which is subject to the zoning authority of the City of Devils Lake, North Dakota. The said ordinance shall:

a. Prohibit all new construction or additions or improvements to existing structures which will increase the existing assessed valuation by a factor of 50 percent or more, below elevation 1440 feet, mean sea level, unless elevated, floodproofed or otherwise protected against damages resulting from floods occurring at or below elevation 1440 feet, mean sea level.

b. Be coordinated with the State and Federal Emergency Management Agencies and be consistent with State and Federal floodplain management regulations.

c. Be amended, upon receipt of written notification from the undersigned District Engineer or his successor, to reflect the results of further hydrologic studies by the Corps of Engineers which result in development of a stage-probability relationship indicating probable flooding to an elevation other than 1440 feet, mean sea level, by applying the said prohibition of construction to said elevation.

10. The City shall cause an annual publication of notification in a newspaper of general circulation in the City, advising all who may be concerned that all land below elevation 1457.1 feet, mean sea level, the elevation of the natural lake outlet, has been inundated by the waters of Devils Lake in the past, and could be so inundated again.

11. The City shall notify in writing all persons requesting land use or building permits in connection with land lying below elevation 1457.1 feet, the elevation of the natural lake outlet, that such land has been inundated by the waters of Devils Lake in the past and could be so inundated again.

FEDERAL RESPONSIBILITIES

Federal (Corps of Engineers) responsibilities would include the following:

1. To prepare construction plans and specifications.

2. To administer and supervise construction.

3. To bear all of the costs for construction of the flood barrier and interior flood control system up to the Federal cost limit of $4,000,000.

4. To provide the city an operating and maintenance manual for the project.

The final project cost would be determined after final payment to the construction contractor. The local share of project costs would then be adjusted to reflect actual rather than estimated cost.

## PUBLIC VIEWS AND COORDINATION

The Devils Lake Section 205 flood control has been closely coordinated with the city of Devils Lake and with State and Federal agencies. The project was discussed at several meetings with city, regional, and State officials. These meetings were open to the public. The project was also coordinated through many letters and telephone conversations with these interests. Appendix H contains documentation of the most significant coordination items. Local and State interests have shown strong, continuing support for the project, and they have taken an active role in helping to formulate the final plan.

## SUMMARY ANALYSIS OF FINAL PLAN

Table 8 summarizes the final plan and shows contributions of the plan to the four national planning accounts (national economic development (NED), environmental quality (EQ), regional development (RD), and other social effects (OSE).

One local planning objective, to contribute to the economic health of the city of Devils Lake by reducing the flood threat during the 1984 to 2084 period, was determined to be very similar to the national objective of regional development. The local objective of economic health is therefore discussed in the regional development sections. Similarly, another local planning objective, to contribute to the sense of security of local residents and business interests by reducing the flood threat, was combined with the other social effects national objective.

Table 8 compares the final plan to the existing conditions and to the most probable future if the plan is not implemented. The environmental assessment section of this report contains additional summary information on the compliance of the plan with the requirements of Section 122 of Public Law 91-611, and with other environmental laws, regulations, and policies.

Table 9 summarizes the response of the recommended plan to the evaluation criteria.

Table 8 - Summary Analysis Of The Final Plan

| Item | Base Condition 1983 | Without Condition Most Probable Future without the Plan | Selected Plan |
|---|---|---|---|
| A. National Economic Development (NED) | | | |
| Project investment cost<br>Annual project cost<br>Annual operation and maintenance cost<br>Total annual cost<br>Annual benefits<br>Benefit-cost ratio<br>Net annual benefits | Expenses to repair Landfill Road and sewage lagoon dikes and to operate emergency pumps are being incurred. A heavy rain could overtop the road and result in substantial damages to public and private property. | Because this condition would be a long term problem, emergency actions would continue until they failed with possible catastrophic effects or until an emergency outlet was constructed. These emergency actions would be less safe and more costly then the recommended plan. | $[illegible]<br>[illegible]<br>[illegible]<br>[illegible]<br>[illegible]<br>4.[illegible]<br>488,[illegible] |
| B. Environmental Quality (EQ) | General environmental quality is good, with some water quality problems. Drainage of wetlands and farm practices have destroyed some wildlife habitat. | High lake levels could destroy the sewage lagoons and contaminate the lake with sewage and debris. Wetland drainage throughout the basin would probably continue, and development on the former lakebed might continue. Emergency action to dig an outlet might occur. | The plan could protect the sewage lagoons from inundation. The plan would have no significant adverse effects. |
| C. Regional Development (RD) | The area has experienced a small but steady rate of economic growth. The city is a regional agri-business, transportation, shopping, and cultural center. The flood problem is beginning to threaten the economic health of the city. | The city would continue as a regional center. However, the need to fight higher lake stages could divert economic resources from more growth. Catastrophic economic losses could occur if the former lakebed becomes inundated. Threat to economic health increases. | The city would continue to grow as a regional center. The public and private investment on the lakebed would be protected. Floodplain management would guide future growth. The plan would contribute to the economic health of the city. |
| D. Other Social Effects (OSE) | The flood threat is beginning to threaten the public health and safety. The sense of security of local residents and businesses is being threatened. | The continued emergency flood fight at increasing levels of effort would result in greater risks to the public health, safety, and security. Local residents and businesses would feel an increased threat to their sense of security. | The plan would protect the health, safety, and security of the city. Floodplain management would control future increases in the development at risk. The plan would contribute to the sense of security of local residents and businesses by reducing the flood threat. However, some people whose property is not protected or who favor immediate construction of an outlet could resent the final plan. |

Table 9 - Response to Evaluation Criteria

| Item | Response of Plan |
|---|---|
| acceptability | Favorable. Plan is acceptable or strongly supported by all identified groups. |
| completeness | Favorable. The plan would provide complete exterior and interior flood protection for the design events. |
| effectiveness | Favorable. The plan would make significant contributions to all planning accounts. |
| efficiency | Favorable. The plan would fully exploit flood control opportunities provided by the natural topography. |
| certainty | Favorable. Although the probability of future lake stages could not be quantified, recent trends and past lake elevations indicate that the lake will continue to rise. The risk of constructing a project that is not needed because lake levels suddenly and consistently fall appears to be small. The risk appears to be much greater for expensive, inefficient, and unsafe emergency actions and/or catastrophic damages if the lake continues to rise. |
| geographic scope | The plan applies only to the city of Devils Lake. |
| reversibility | Favorable. If the lake level falls, the gravity outlet could be opened and the drainage system would function as it did before the lake level reached its current elevation. If lake levels rise and an outlet is constructed, the project would allow the lake to be stabilized at higher levels. |
| stability | Favorable. Three scenarios for lake levels reaching elevation 1430 feet in 1983, 1991, and the year 2000 were analyzed. The project was feasible for all three scenarios. |
| benefit-cost ratio | Favorable. 4:1 |

## RECOMMENDATIONS

I recommend that the United States construct a flood control project at Devils Lake, North Dakota, generally in accordance with the selected plan described in this report, provided that the local sponsor fulfills the items of local cooperation. The project would have an estimated total cost of $1,927,000, with a Federal cost of $1,767,000 and a non-Federal cost of $160,000.

________________

Date

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

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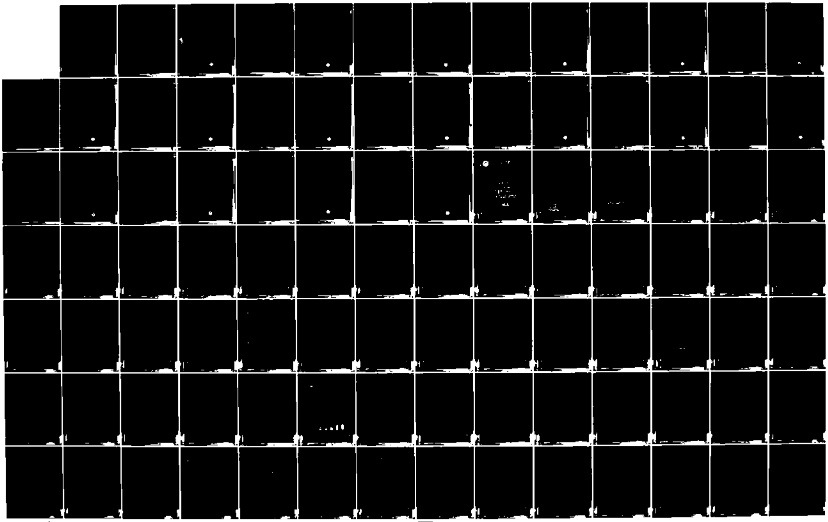

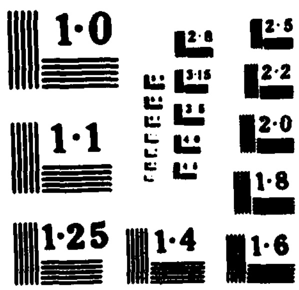
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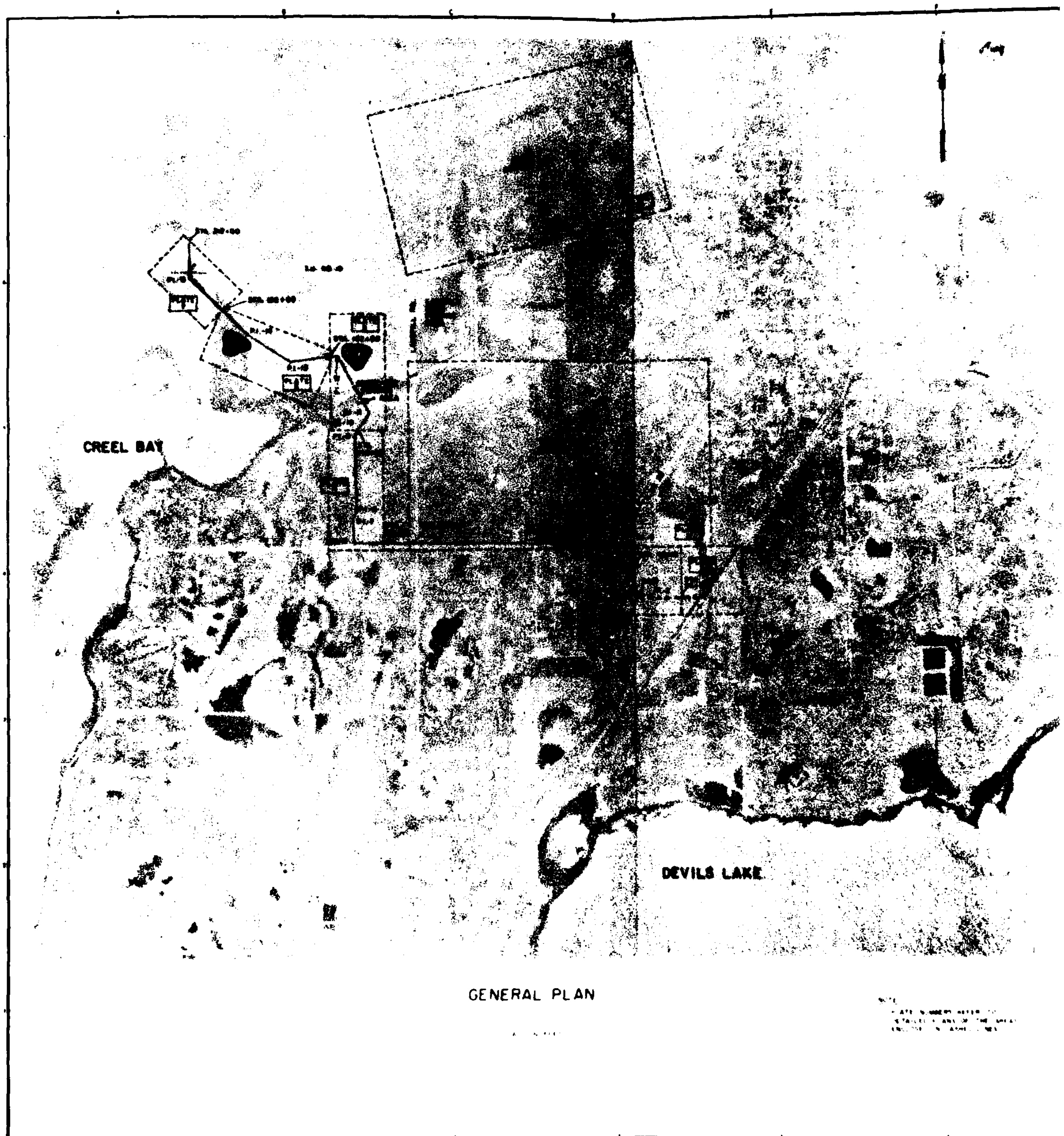



GENERAL PLAN


GENERAL LEGEND

...RAL PLAN

DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

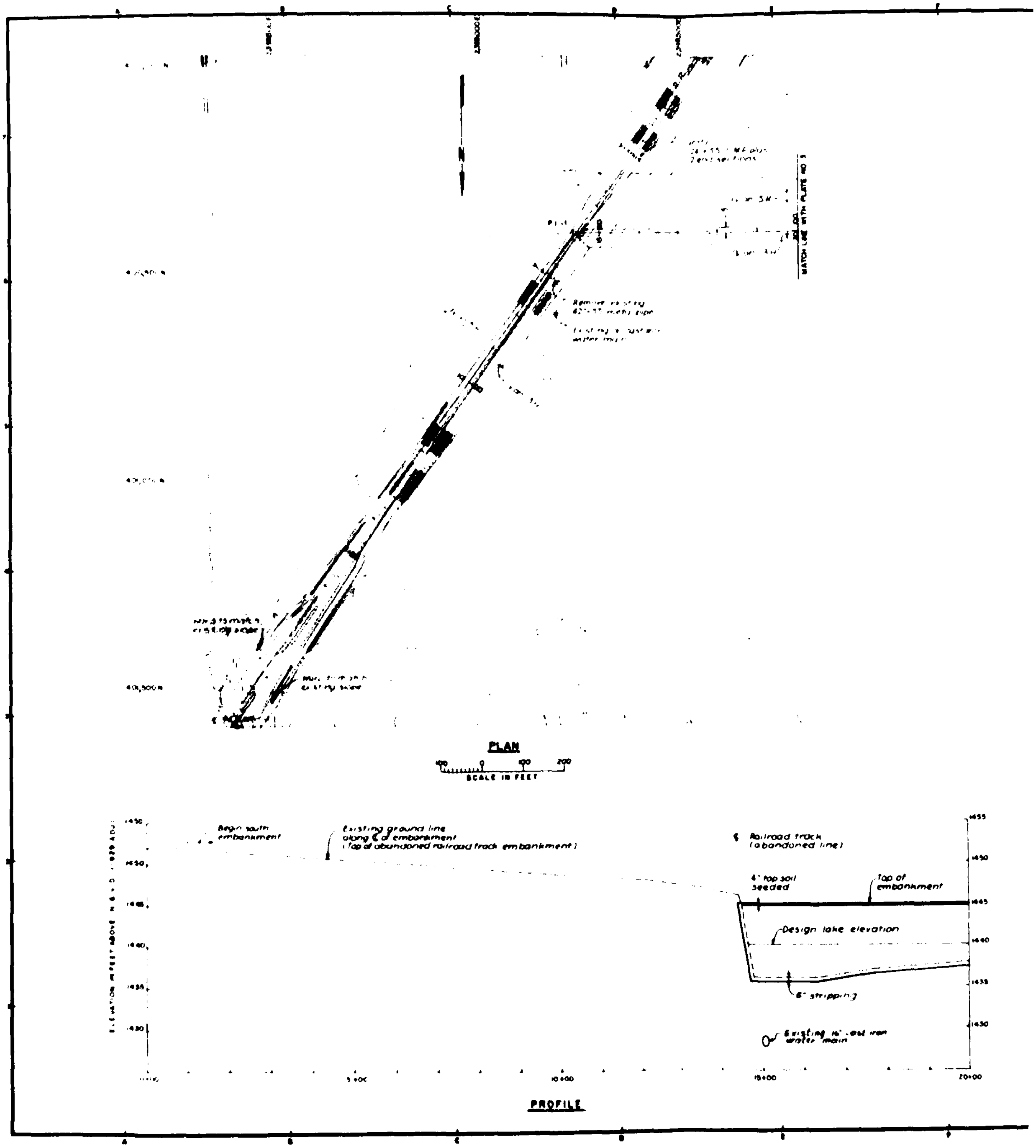
GENERAL PLAN AND LEGEND

JUNE 1983

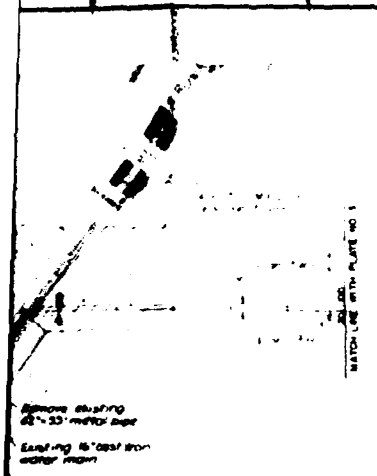
AS SHOWN

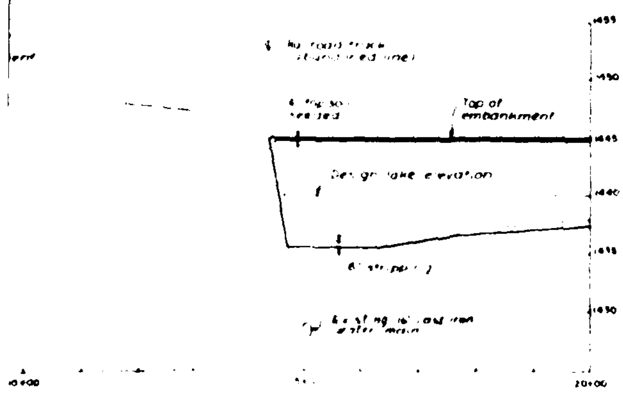
PLATE 1

2



MATCH LINE WITH PLATE NO. 5
Remove existing
Existing cast iron water main
PLAN
SCALE IN FEET
Begin south embankment
Existing ground line along ℄ of embankment (Top of abandoned railroad track embankment)
℄ Railroad track (abandoned line)
4" top soil seeded
Top of embankment
Design lake elevation
6" stripping
Existing 16" cast iron water main
PROFILE




**Note.**
1 Borrow area 1 is a spoil pile from the construction of existing storm water settling ponds.

**References.**

| References | Plate No. |
|---|---|
| 1 General legend | 1 |
| 2 Boring logs & legend | Appendix "E" |
| 3 Typical south embankment section | 6 |
| 4 Location of borrow area 1 | 1 |

DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

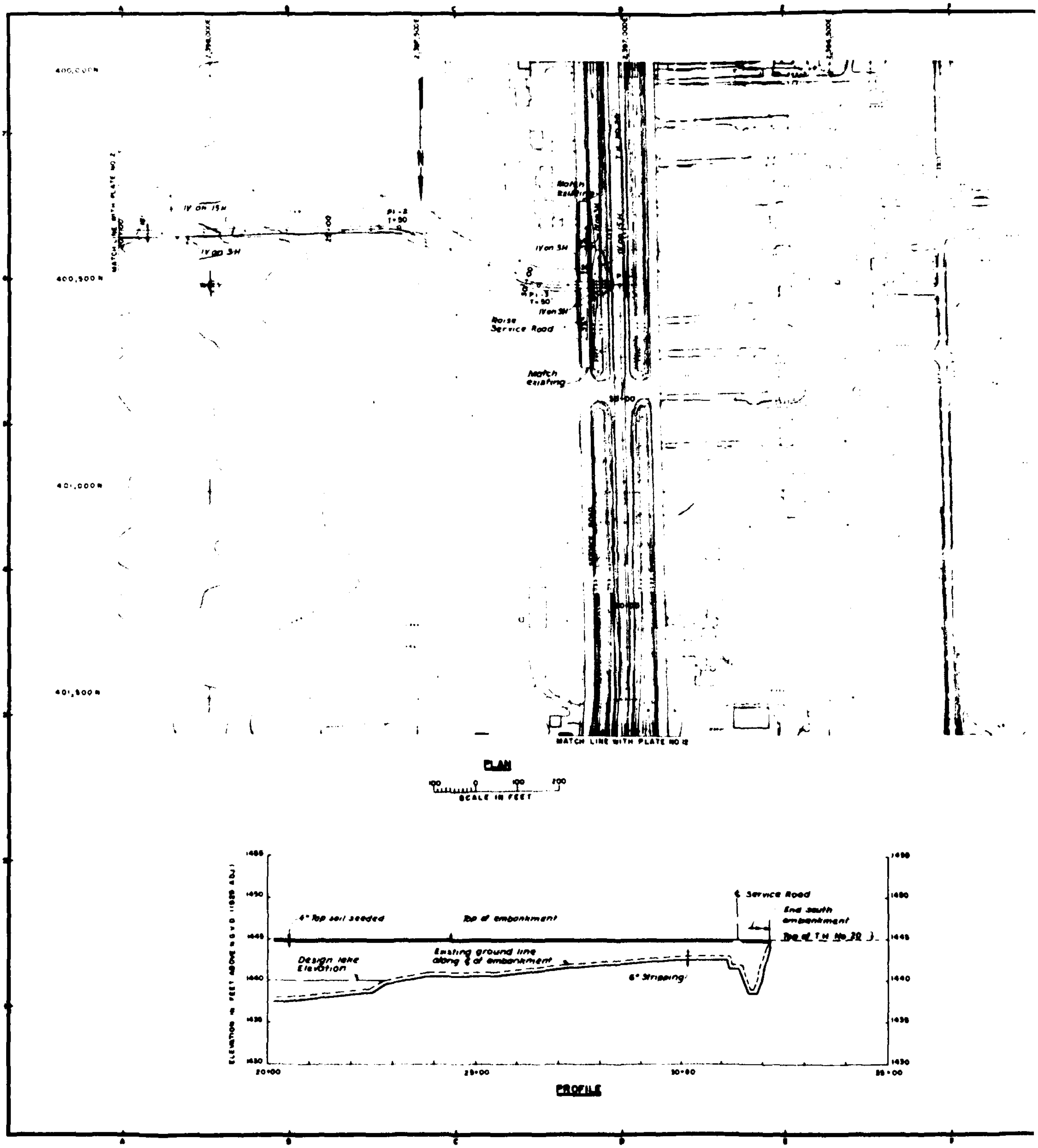
**PLAN AND PROFILE**
**SOUTH EMBANKMENT**
STA 0+00 TO STA 20+00

JUNE 1983

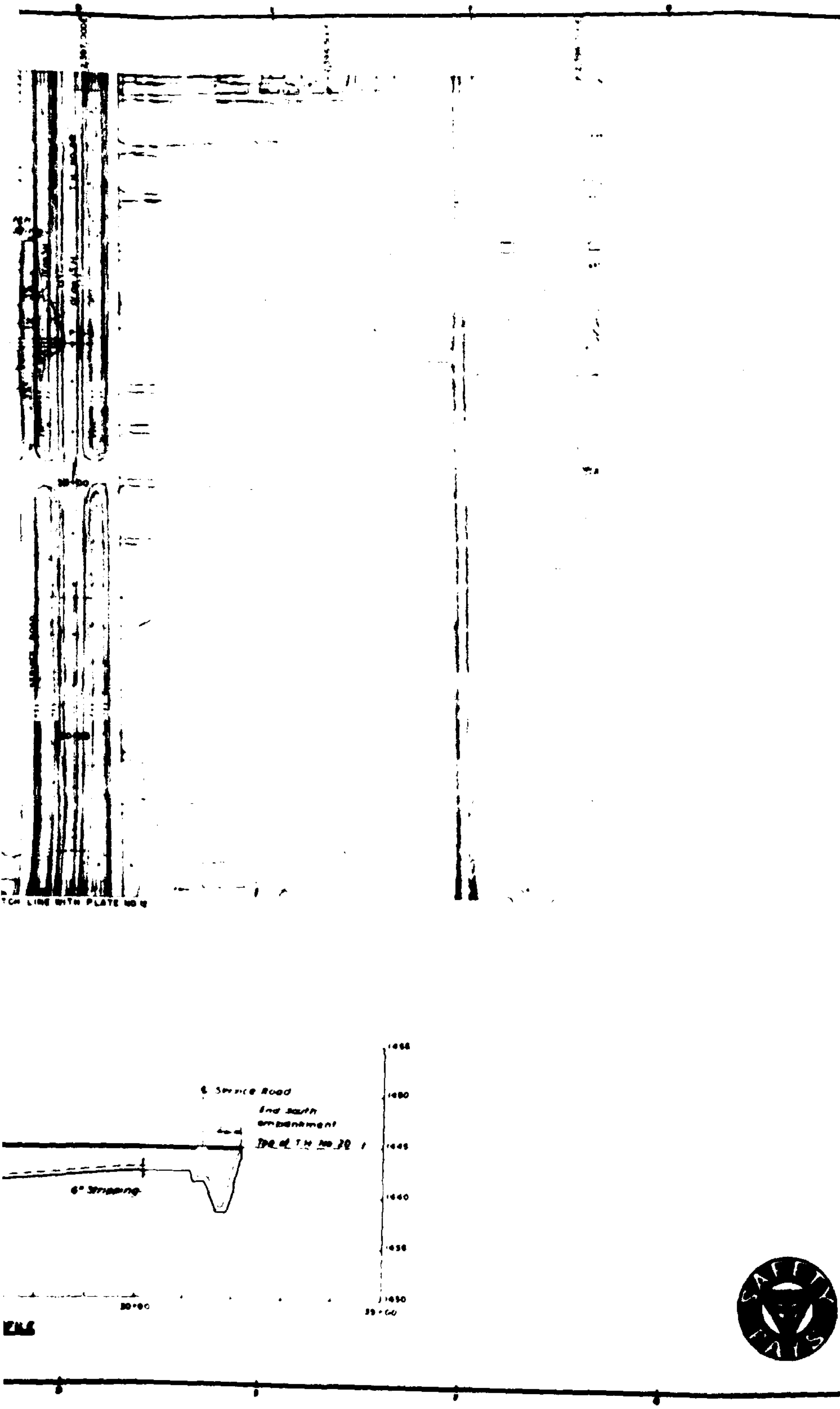
AS SHOWN

PLATE 2

2



400,500 N
401,000 N
401,500 N
IV on 15H
IV on 5H
Raise Service Road
Match existing
MATCH LINE WITH PLATE NO 12
PLAN
SCALE IN FEET
4" Top soil seeded
Top of embankment
Service Road
End south embankment
Design lake Elevation
Existing ground line along ℄ of embankment
6" Stripping
PROFILE




**Notes.**

1 Borrow area 1 is a spoil pile from the construction of existing storm water settling ponds.

| **References.** | **Plate No.** |
|---|---|
| 1 General legend | 1 |
| 2 Boring logs & legend | Appendix "E" |
| 3 Typical south embankment sections | 8 |
| 4 Service Road raise profile | 9 |
| 5 Location of borrow area 1 | 1 |

DEPARTMENT OF THE ARMY

CAC, MDL, R&B

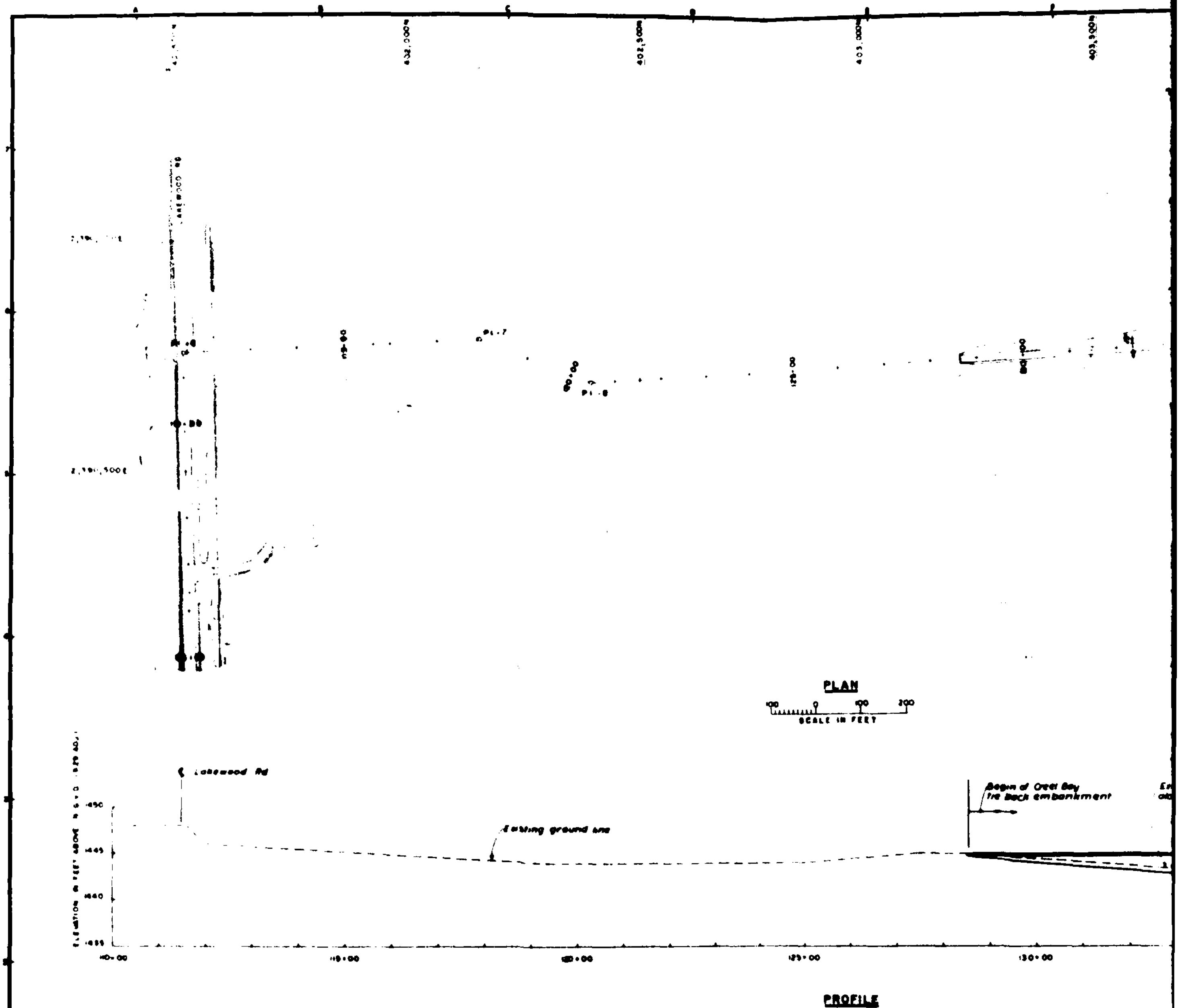
SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
PLAN AND PROFILE
SOUTH EMBANKMENT
STA. 30+00 TO STA. 33+00

JUNE 1983

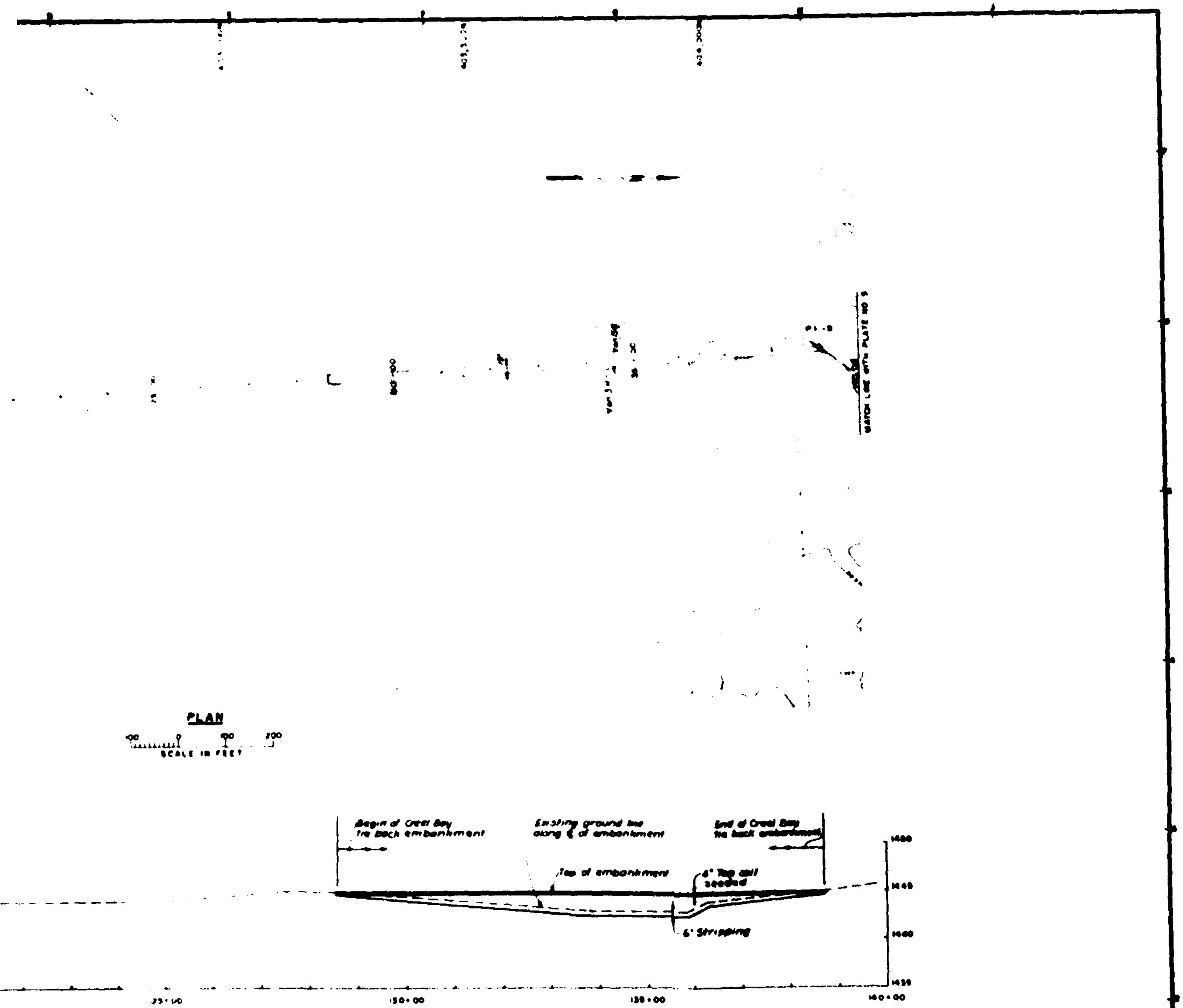
SCALE: AS SHOWN

PLATE 3

2




| References | Plate No. |
|---|---|
| 1. General legend | 1 |
| 2. Boring logs & legend | Appendix "E" |
| 3. Typical Creel Bay tie back embankment sections | 8 |
| 4. Location of borrow area 2 | 1 & 5 |
| 5. Typical section of borrow area 2 | 9 |




PLAN

SCALE IN FEET

PROFILE

| References | Plate No. |
| --- | --- |
| 1. General legend | 1 |
| 2. Boring logs & legend | Appendix "E" |
| 3. Typical Creel Bay tie back embankment sections | 8 |
| 4. Location of borrow area 2 | 4, 5 |
| 5. Typical section of borrow area 2 | 9 |

DEPARTMENT OF THE ARMY

CAC, MDL, RGD

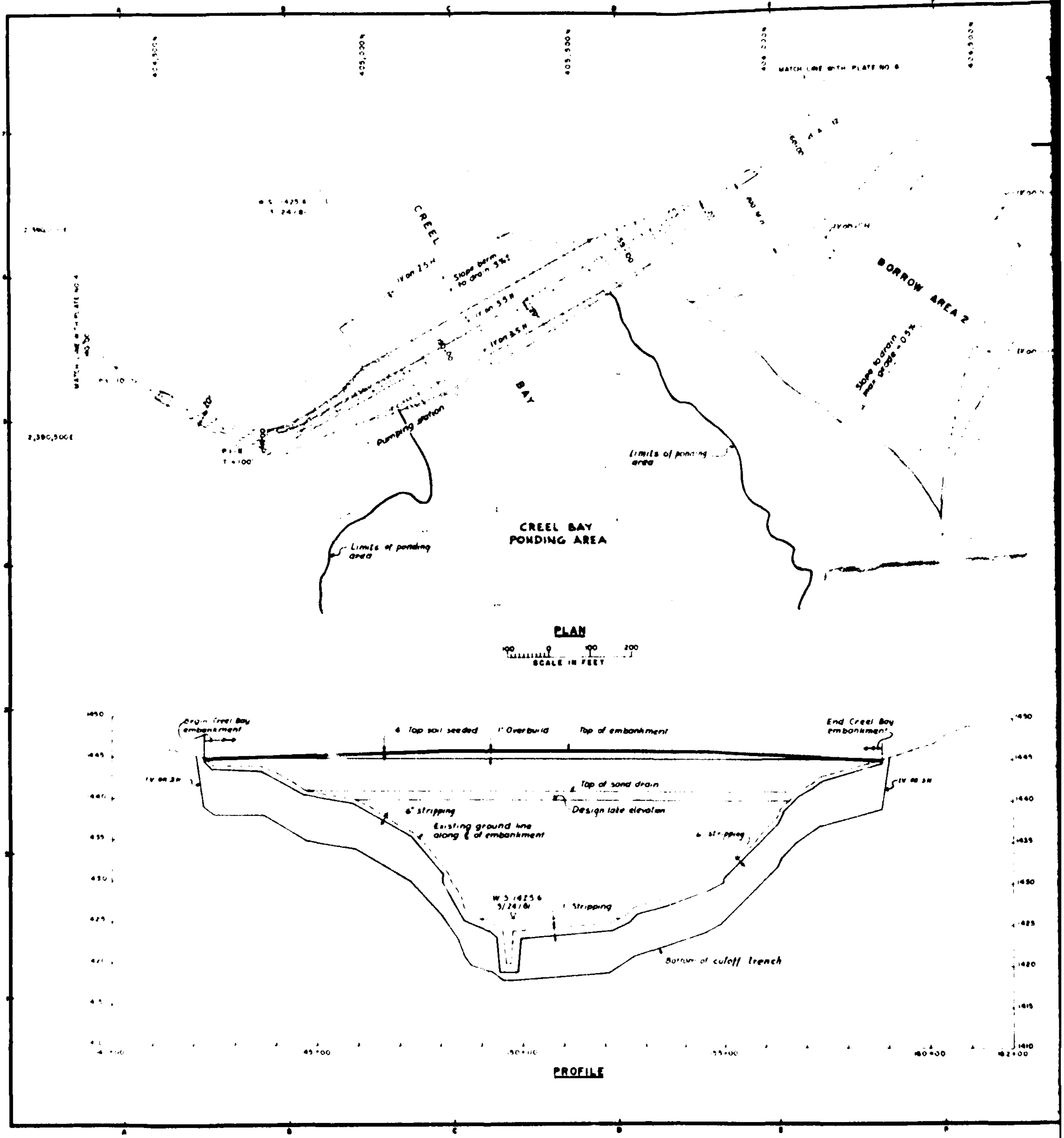
SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
PLAN AND PROFILE
CREEL BAY TIE BACK EMBANKMENT
STA 120+00 TO STA 140+00

JUNE 1981

AS SHOWN

PLATE 4

2



CREEL
BAY
BORROW AREA 2
CREEL BAY PONDING AREA
Limits of ponding area
Pumping station
Slope berm to drain 5%±
Slope to drain max grade = 0.5%
PLAN
SCALE IN FEET
Begin Creel Bay embankment
End Creel Bay embankment
Top soil seeded
1' Overbuild
Top of embankment
Top of sand drain
Design lake elevation
6" stripping
Existing ground line along ℄ of embankment
Bottom of cutoff trench
PROFILE

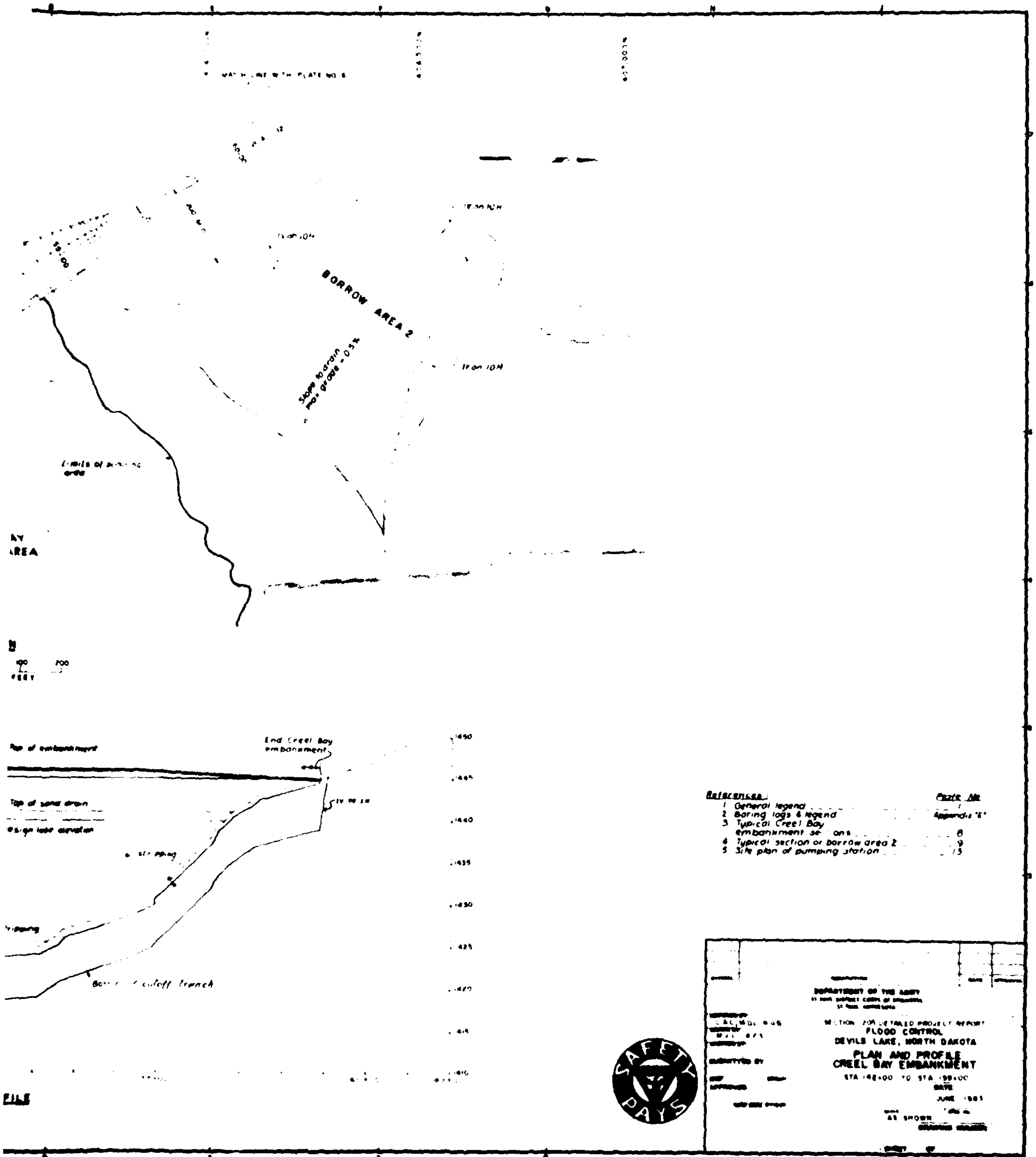
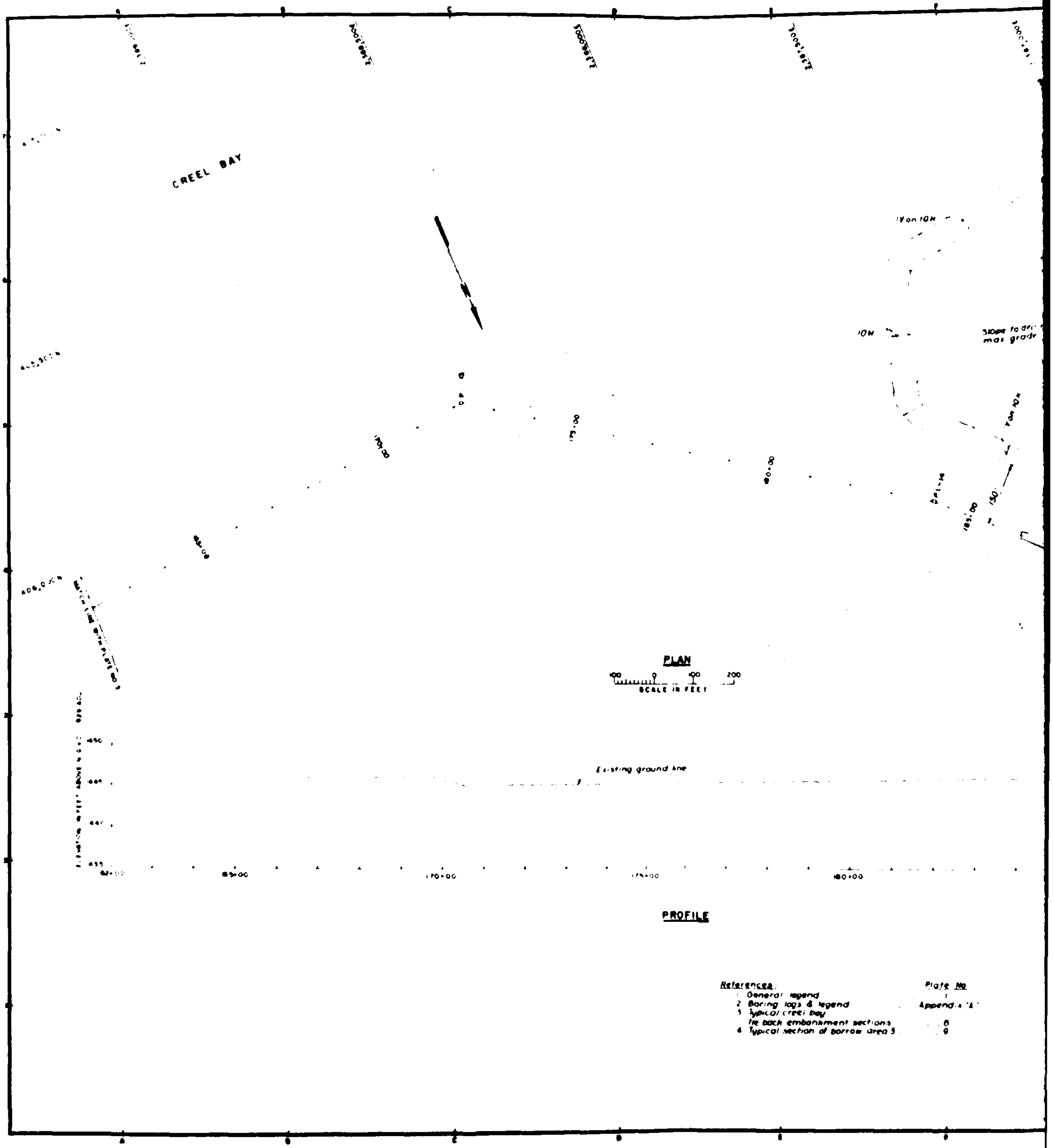

BORROW AREA 2
Slope to drain min grade = 0.5%
Iron ION
Limits of borrow area
End Creel Bay embankment
Top of embankment
Top of sand drain
Design lake elevation
Bottom of cutoff trench
FILE
References
Plate No
1 General legend 1
2 Boring logs & legend Appendix "E"
3 Typical Creel Bay embankment sections 8
4 Typical section of borrow area 2 9
5 Site plan of pumping station 13
SAFETY PAYS
DEPARTMENT OF THE ARMY
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
PLAN AND PROFILE
CREEL BAY EMBANKMENT
DATE
AS SHOWN

PLATE 5


CREEL BAY
PLAN
SCALE IN FEET
Existing ground line
PROFILE
References:
1 General legend
2 Boring logs & legend
3 Typical creel bay
tie back embankment sections
4 Typical section of borrow area 3
Plate No
1
Appendix "E"
8
9

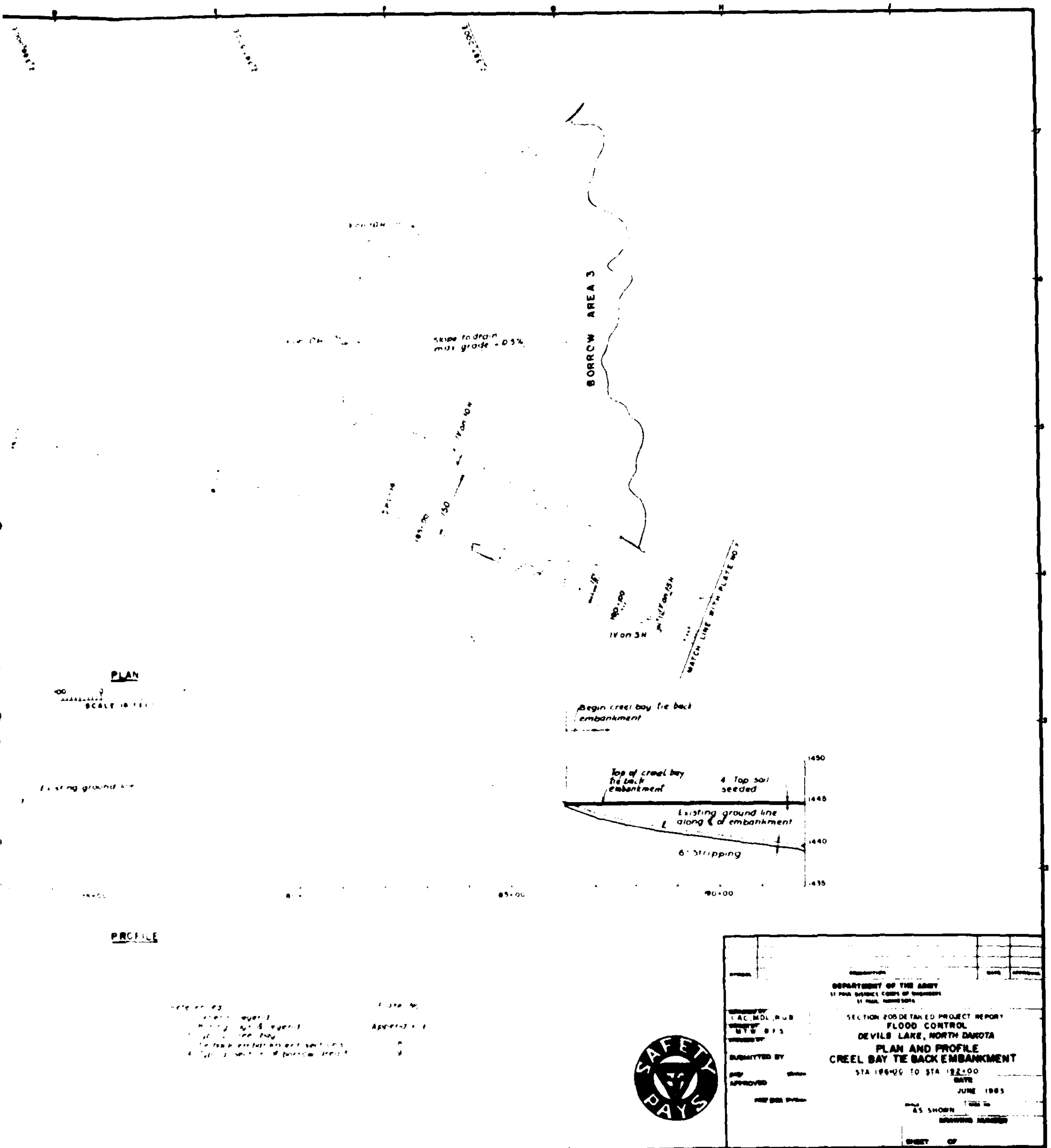
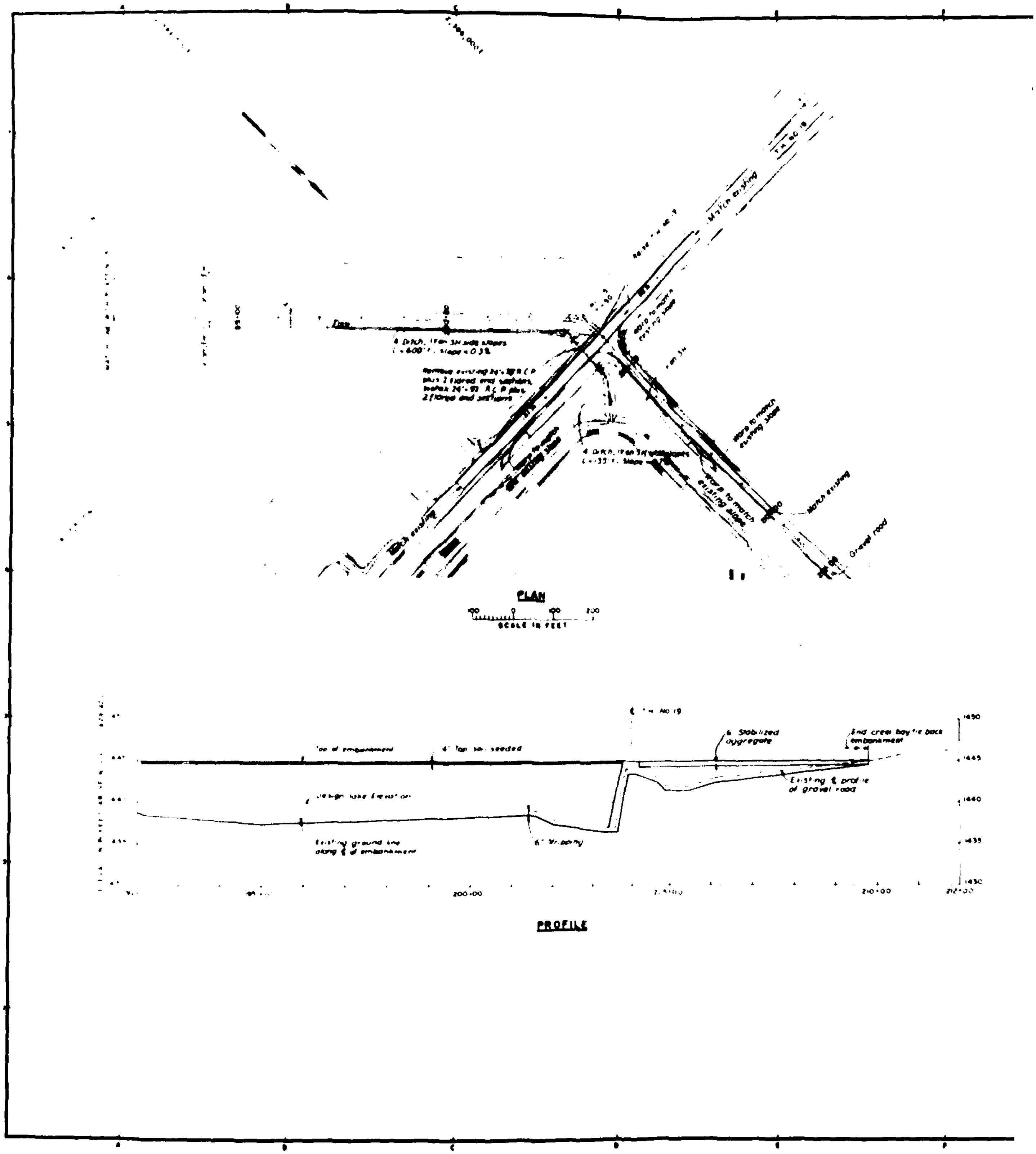
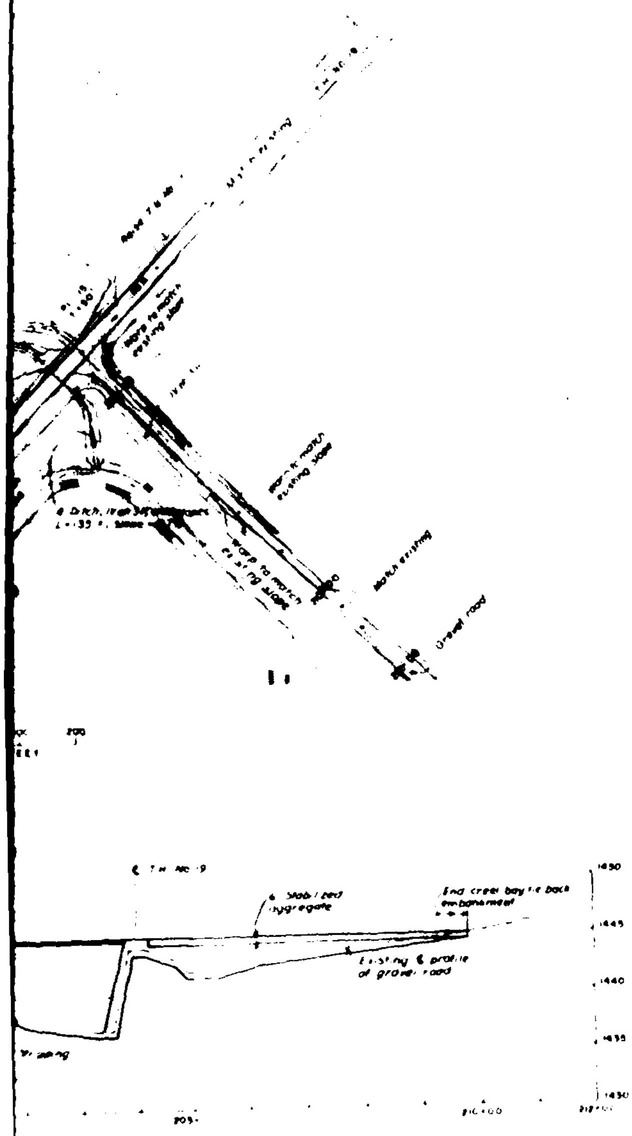

BORROW AREA 3
Slope to drain min. grade = 0.5%
1V on 3H
WATCH LINE WITH PLATE NO 7
PLAN
SCALE IN FEET
Begin creel bay tie back embankment
Top of creel bay tie back embankment
4" Top soil seeded
Existing ground line along ℄ of embankment
6" Stripping
Existing ground line
1450
1445
1440
1435
185+00
190+00
PROFILE
SAFETY PAYS
DEPARTMENT OF THE ARMY
SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
PLAN AND PROFILE
CREEL BAY TIE BACK EMBANKMENT
STA 186+00 TO STA 192+00
SUBMITTED BY
APPROVED
JUNE 1983
AS SHOWN

PLATE 6

2


Match existing
Gravel road
Warp to match existing slope
PLAN
SCALE IN FEET
Toe of embankment
4" Top soil seeded
6" Stabilized aggregate
Existing ℄ profile of gravel road
Design lake Elevation
Existing ground line along ℄ of embankment
200+00
210+00
PROFILE




ROFILE

**References:**

| | Plate No. |
|---|---|
| 1 General legend | 1 |
| 2 Boring logs & legend | Appendix "E" |
| 3 Typical creel bay tie back embankment section | 8 |
| 4 T.H. No. 19 road raise profile | 9 |
| 5 Typical T.H. No. 19 road raise section | 9 |
| 6 T.H. No. 19 culvert replacement profile | 9 |
| 7 Location of borrow area 3 | 1 & 8 |
| 8 Typical section of borrow area 3 | 9 |

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

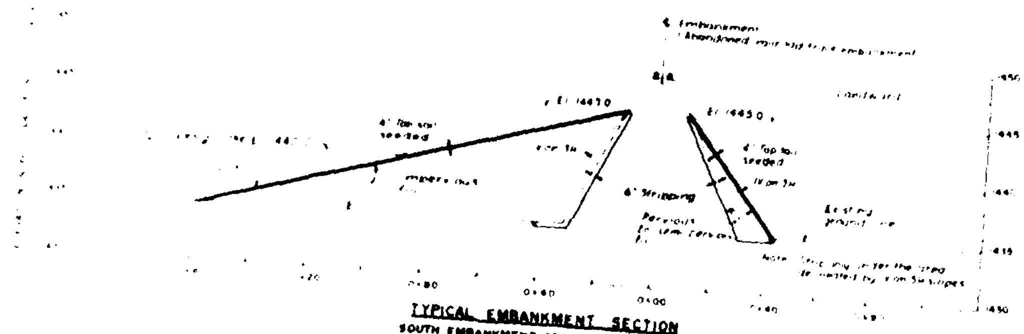
PLAN AND PROFILE
CREEL BAY TIE BACK EMBANKMENT
STA 187+00 TO STA 210+00

CAC, MDL, RGB
TSH

SUBMITTED BY
APPROVED

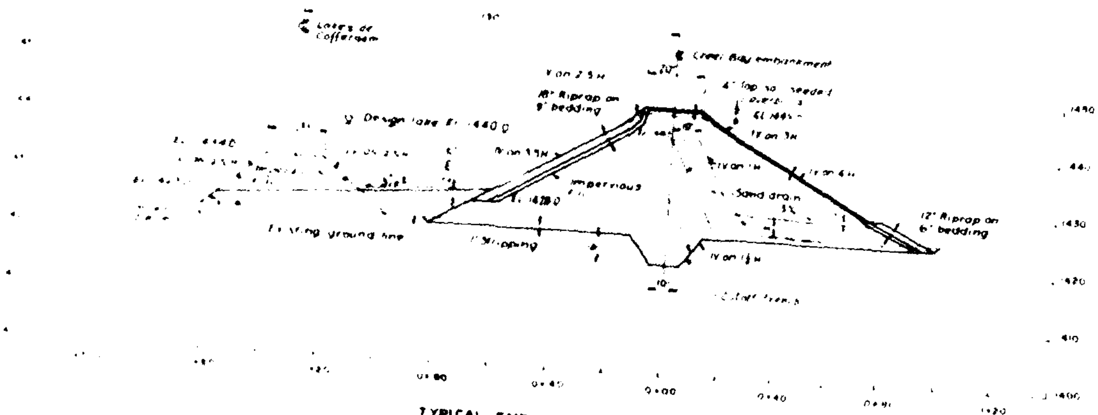
DATE: JUNE 1983
SCALE: AS SHOWN
DRAWING NUMBER
SHEET OF

PLATE 7



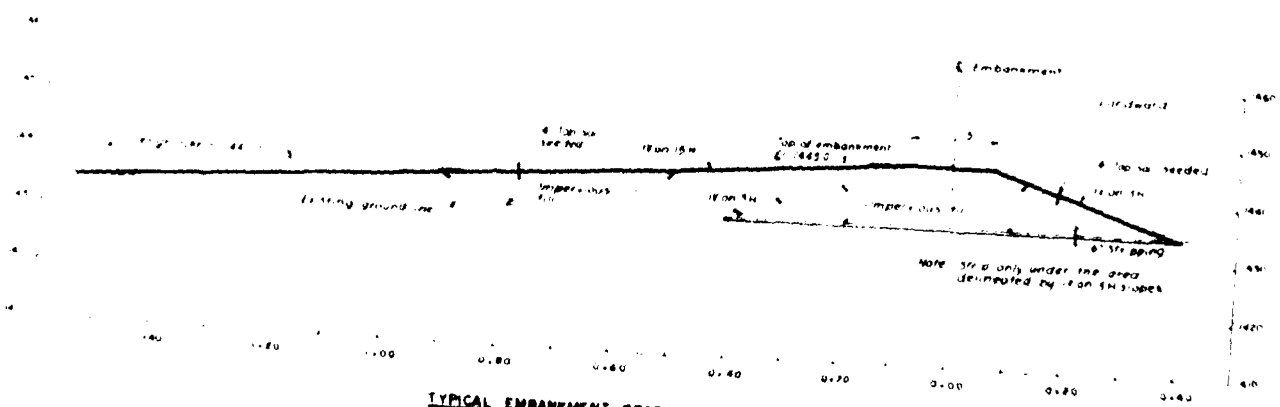

**TYPICAL EMBANKMENT SECTION**

SOUTH EMBANKMENT STA 1+00 TO STA 14+40




**TYPICAL EMBANKMENT SECTION**

CREEL BAY EMBANKMENT STA 142+00 TO STA 159+00

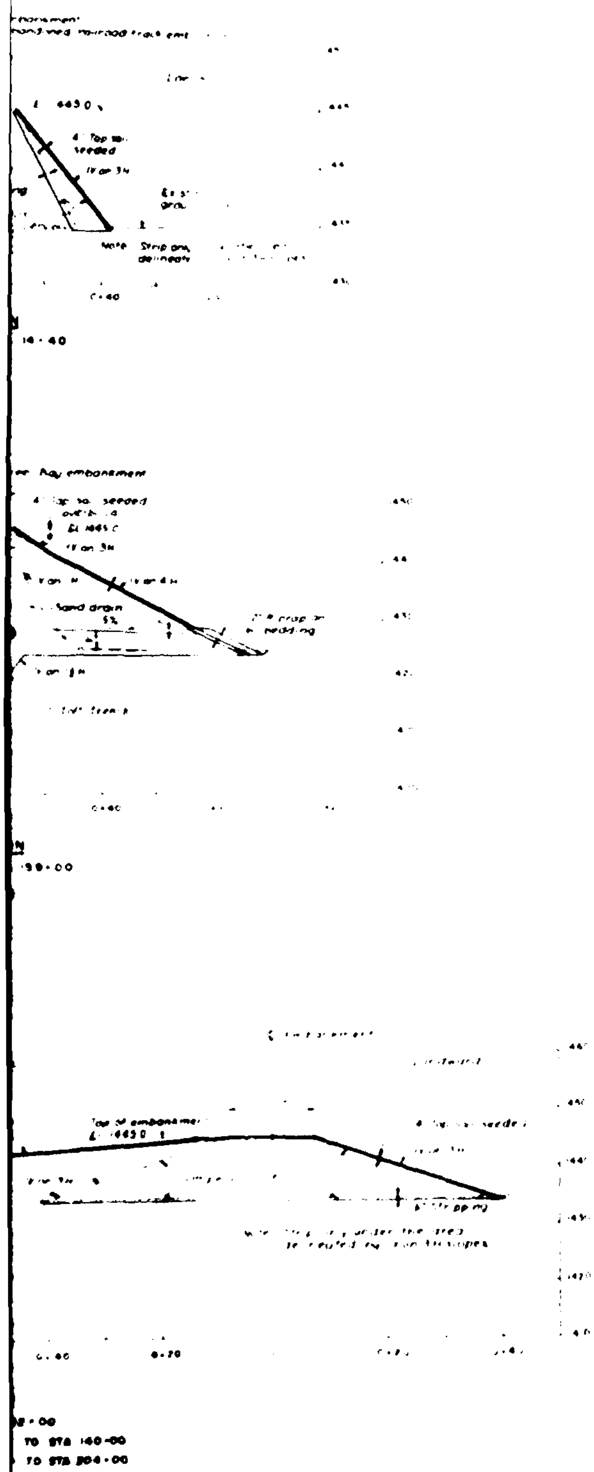



**TYPICAL EMBANKMENT SECTION**

SOUTH EMBANKMENT STA 14+40 TO STA 32+00

CREEL BAY TIE BACK EMBANKMENT STA 128+00 TO STA 140+00

CREEL BAY TIE BACK EMBANKMENT STA 186+00 TO STA 204+00





TYPICAL EMBANKMENT SECTION

CREEL BAY TIE BACK EMBANKMENT STA 204+00 TO STA 210+00

Notes

1. Borrow area is a spoil pile from the construction of existing storm water settling ponds

| References | Plate No. |
| --- | --- |
| 1 South embankment plan & profile | 2 & 3 |
| 2 Creel Bay embankment plan & profile | 3 |
| 3 Creel Bay tie back embankment plan & profile | 4, 6 & 7 |
| 4 Location of borrow area 1 | [illegible] |
| 5 Plan view of borrow area 2 | 5 |
| 6 Plan view of borrow area 3 | 6 |

DEPARTMENT OF THE ARMY

CAC, MDL, RGB

SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL

DEVILS LAKE, NORTH DAKOTA

TYPICAL EMBANKMENT SECTIONS

SUBMITTED BY

APPROVED

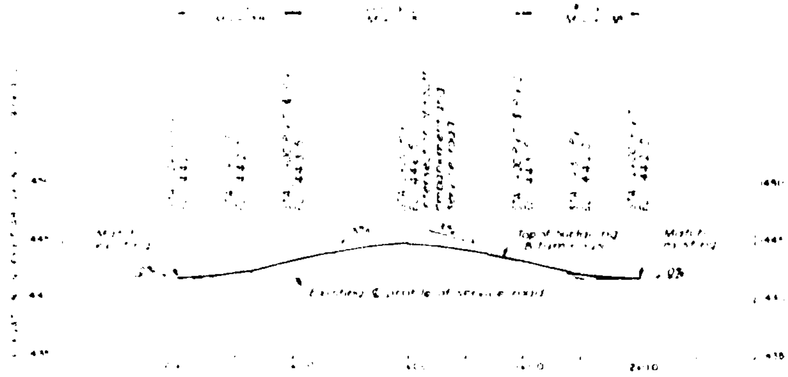
DATE JUNE 1983

AS SHOWN

SHEET OF

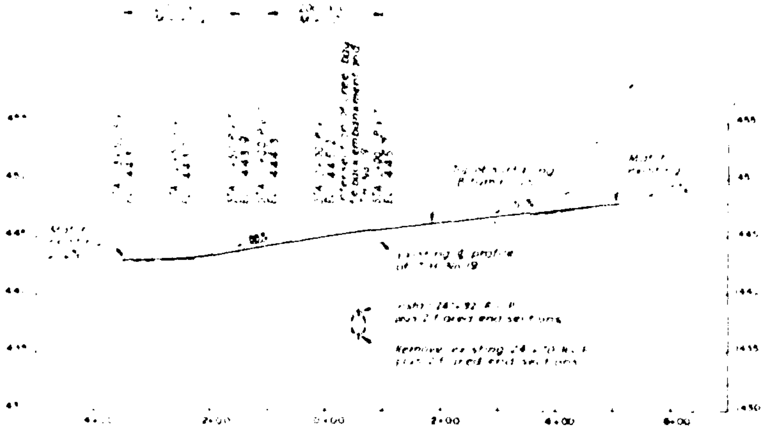
PLATE 8

2



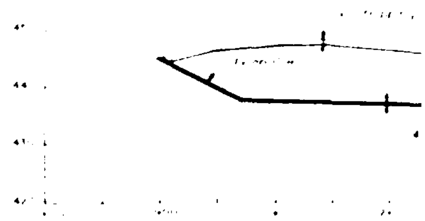
**SERVICE ROAD RAISE PROFILE @ STA 31+40**

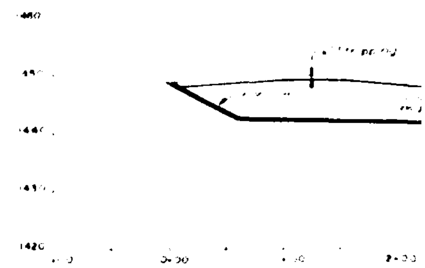
LOOKING WEST

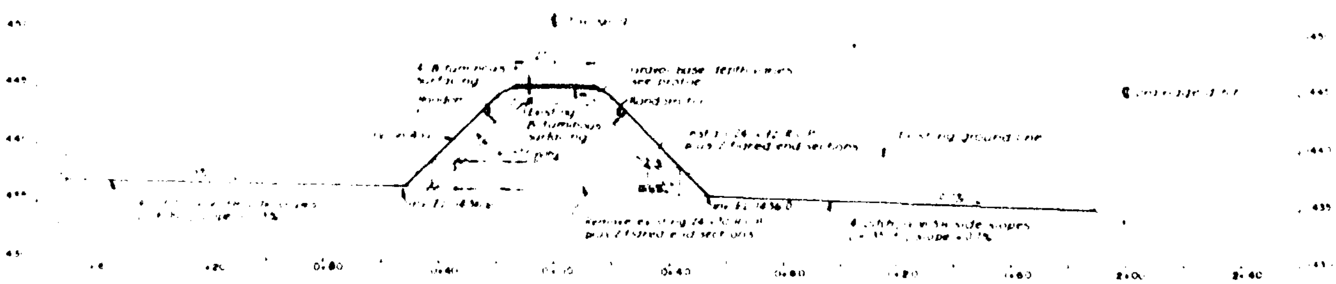


**T H No 19 ROAD RAISE PROFILE @ STA 204+00**

LOOKING NORTH



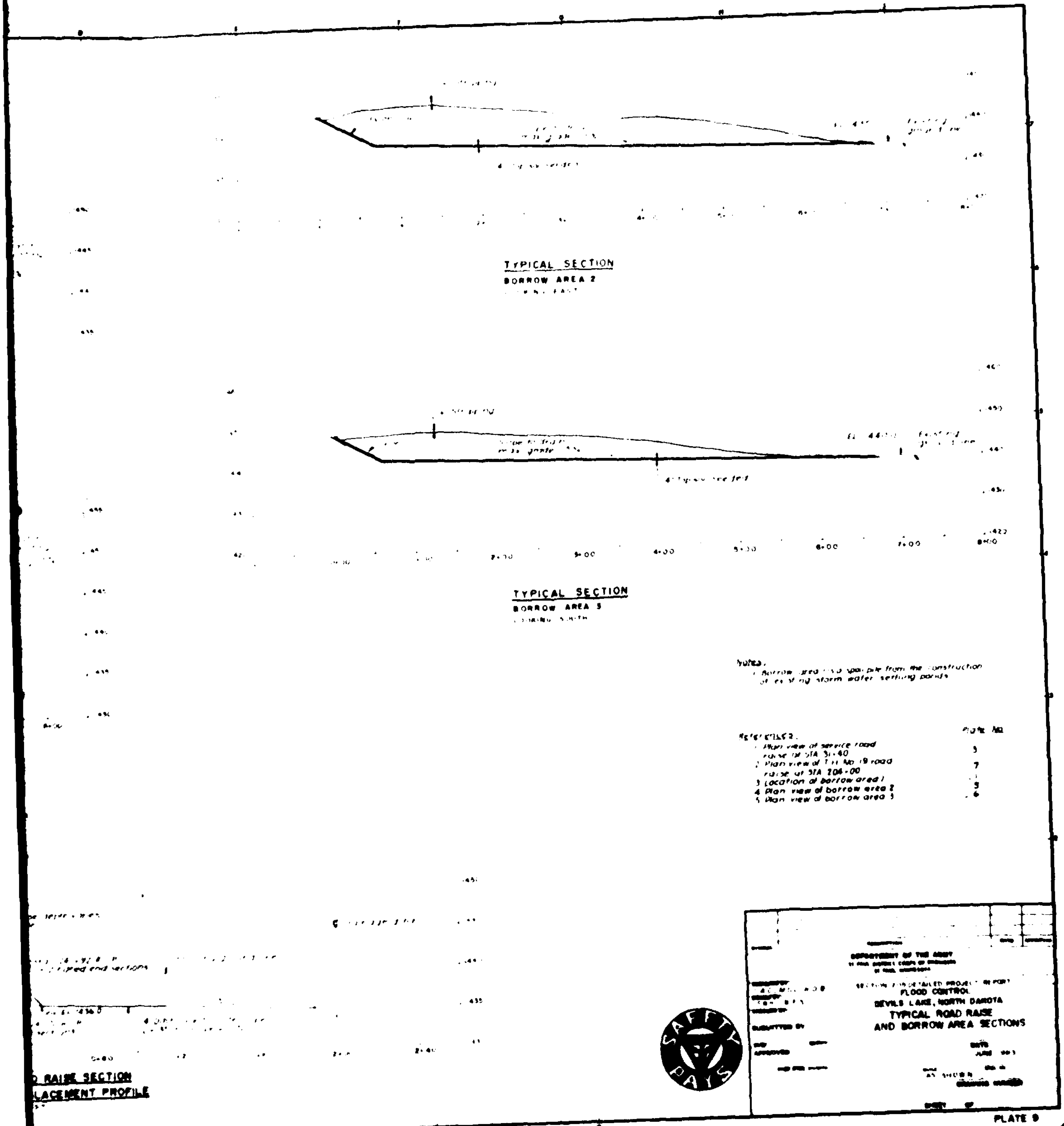




**TYPICAL T H No 19 ROAD RAISE SECTION**

**T H No 19 CULVERT REPLACEMENT PROFILE**

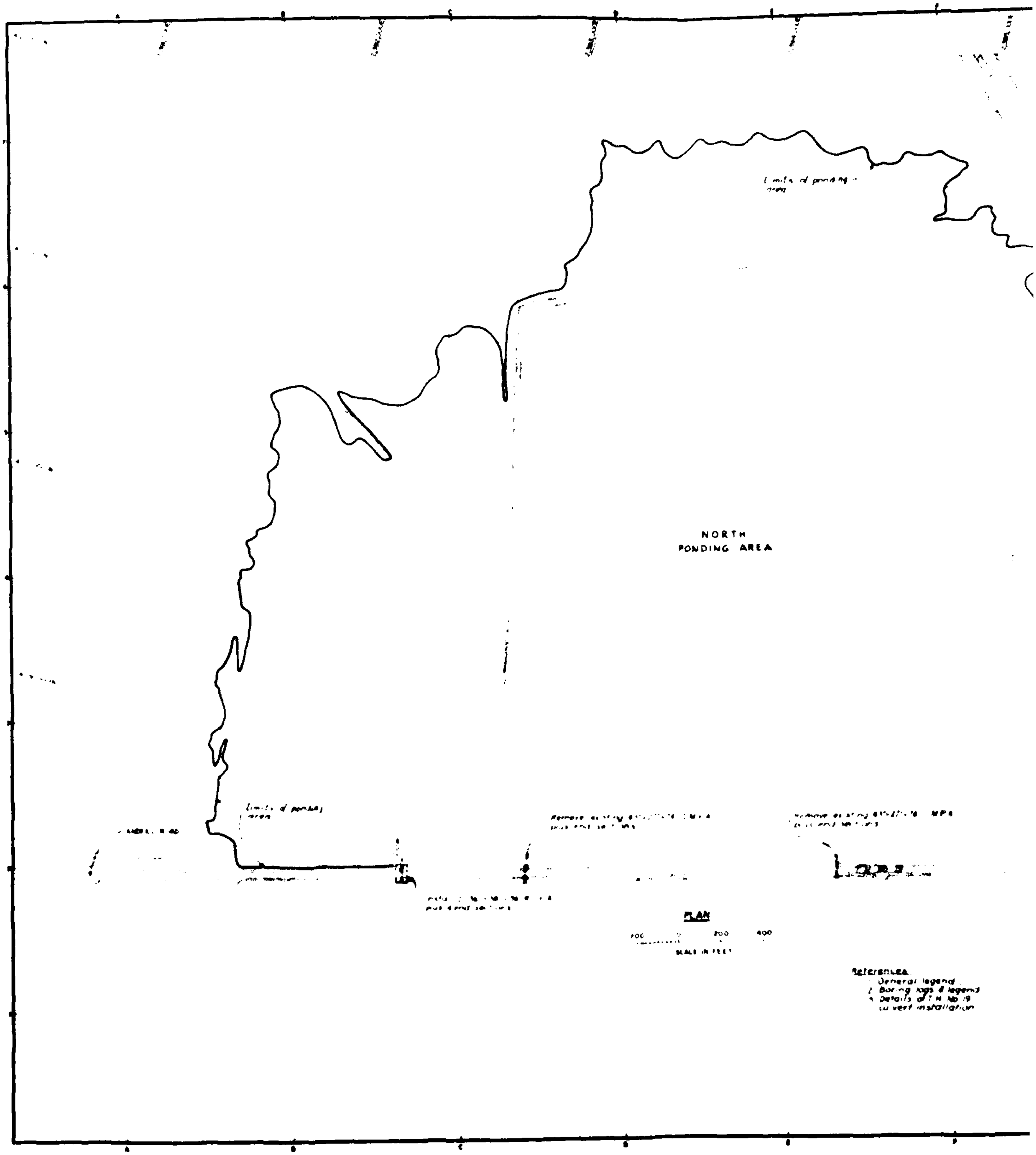
LOOKING WEST

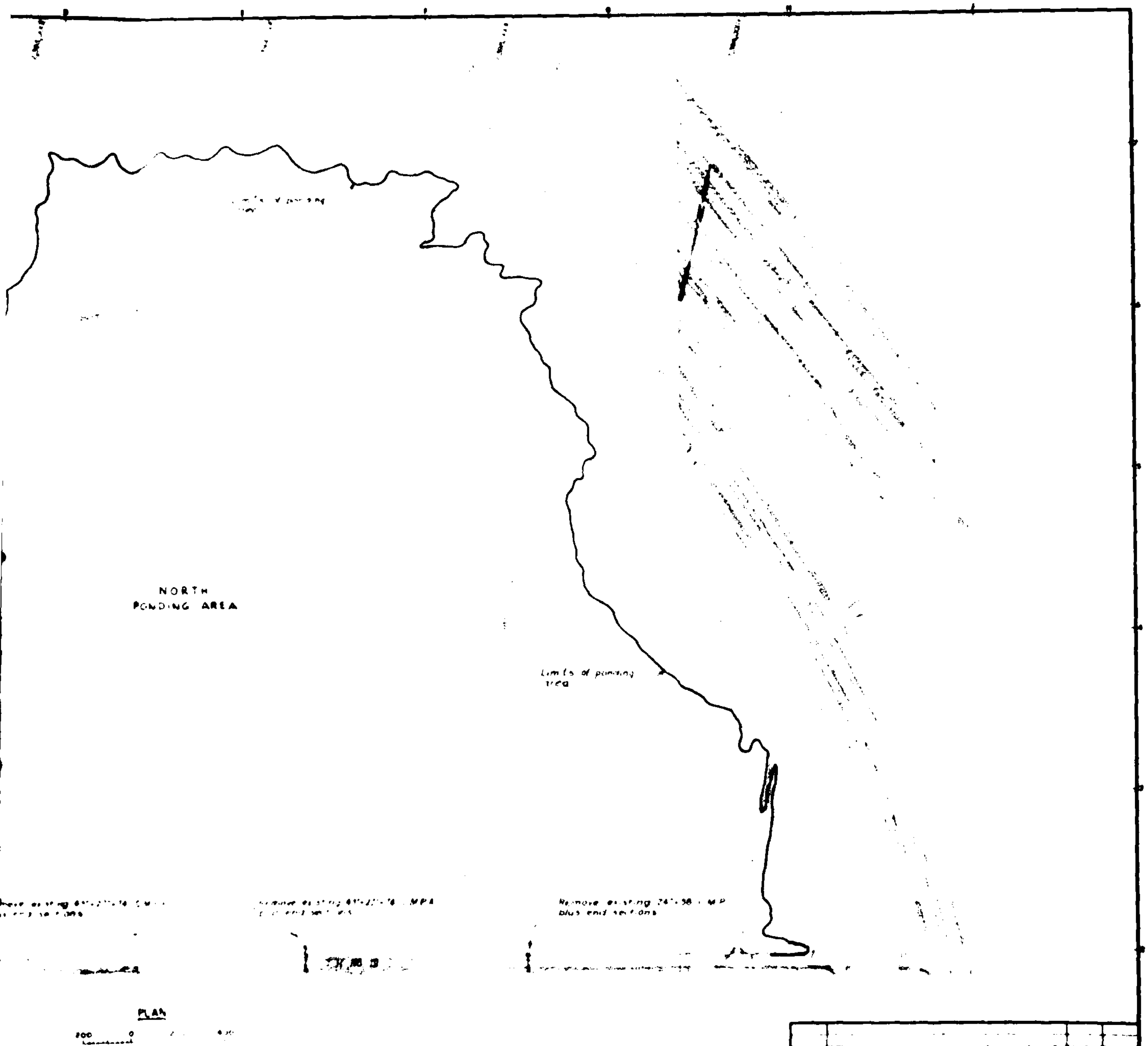


TYPICAL SECTION
BORROW AREA 2
TYPICAL SECTION
BORROW AREA 3
2+00
3+00
4+00
5+00
6+00
7+00
8+00
Notes:
Borrow area 3 is a spoil pile from the construction of existing storm water settling ponds
References:
Plate No.
Plan view of service road raise at STA 31+40
5
Plan view of T.H. No. 19 road raise at STA 206+00
7
3 Location of borrow area 1
4 Plan view of borrow area 2
5
5 Plan view of borrow area 3
6
DEPARTMENT OF THE ARMY
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
TYPICAL ROAD RAISE
AND BORROW AREA SECTIONS
SUBMITTED BY
APPROVED
AS SHOWN
SAFETY PAYS
RAISE SECTION
LACEMENT PROFILE


PLATE 9

2


Limits of ponding area
NORTH
PONDING AREA
PLAN
200 0 200 400
SCALE IN FEET
References
General legend
Boring logs & legends
Details of T H No 19
culvert installation




References | Plate No.
General legend
2. Boring logs & legend | Appendix "E"
3. Details of T.H. No. 19
culvert installation | 14

DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
NORTH PONDING AREA

SUBMITTED BY

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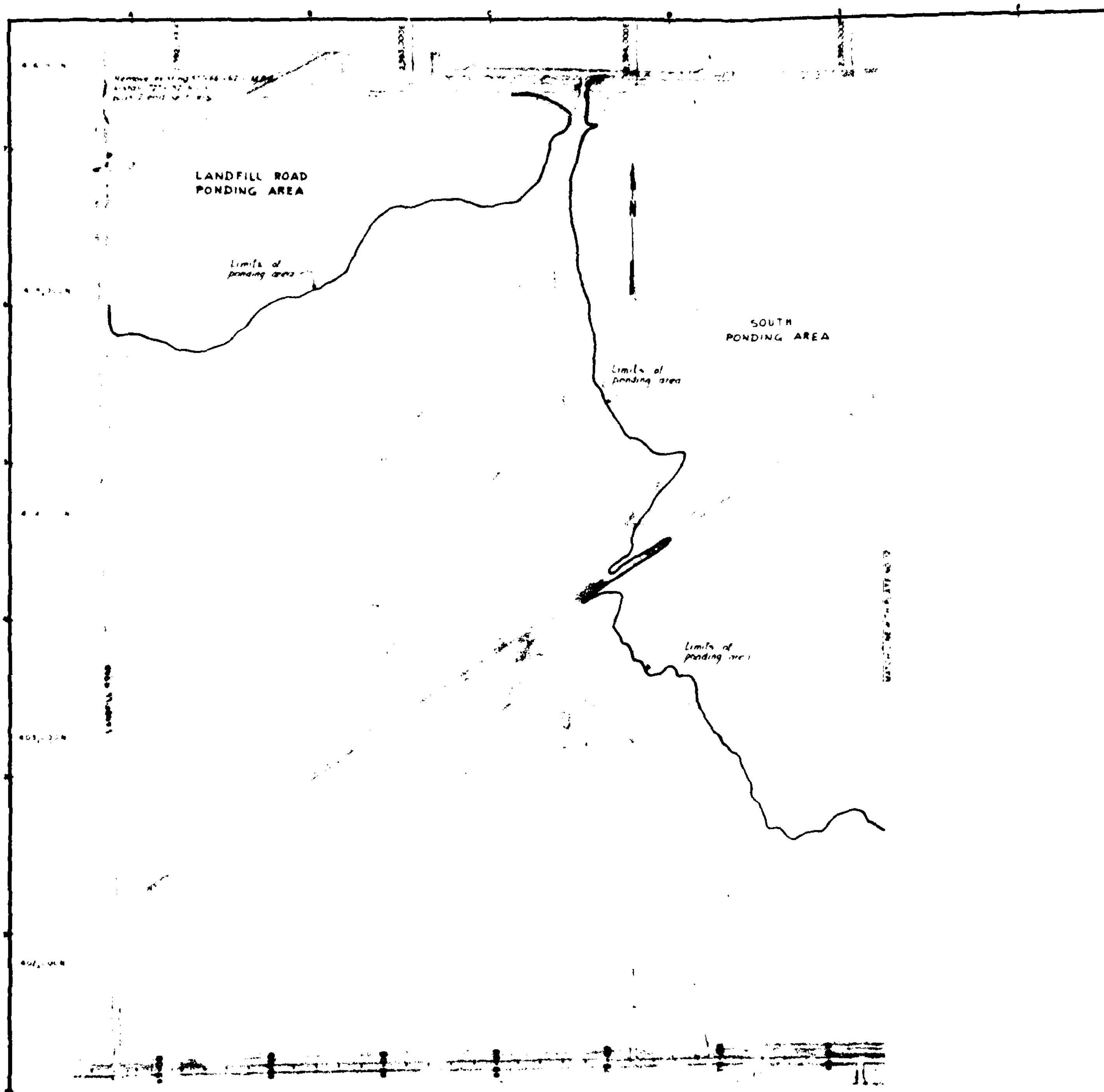
DATE
JUNE 1983

SCALE
AS SHOWN

PLATE 10

2




PLAN

200 0 200 400
SCALE IN FEET

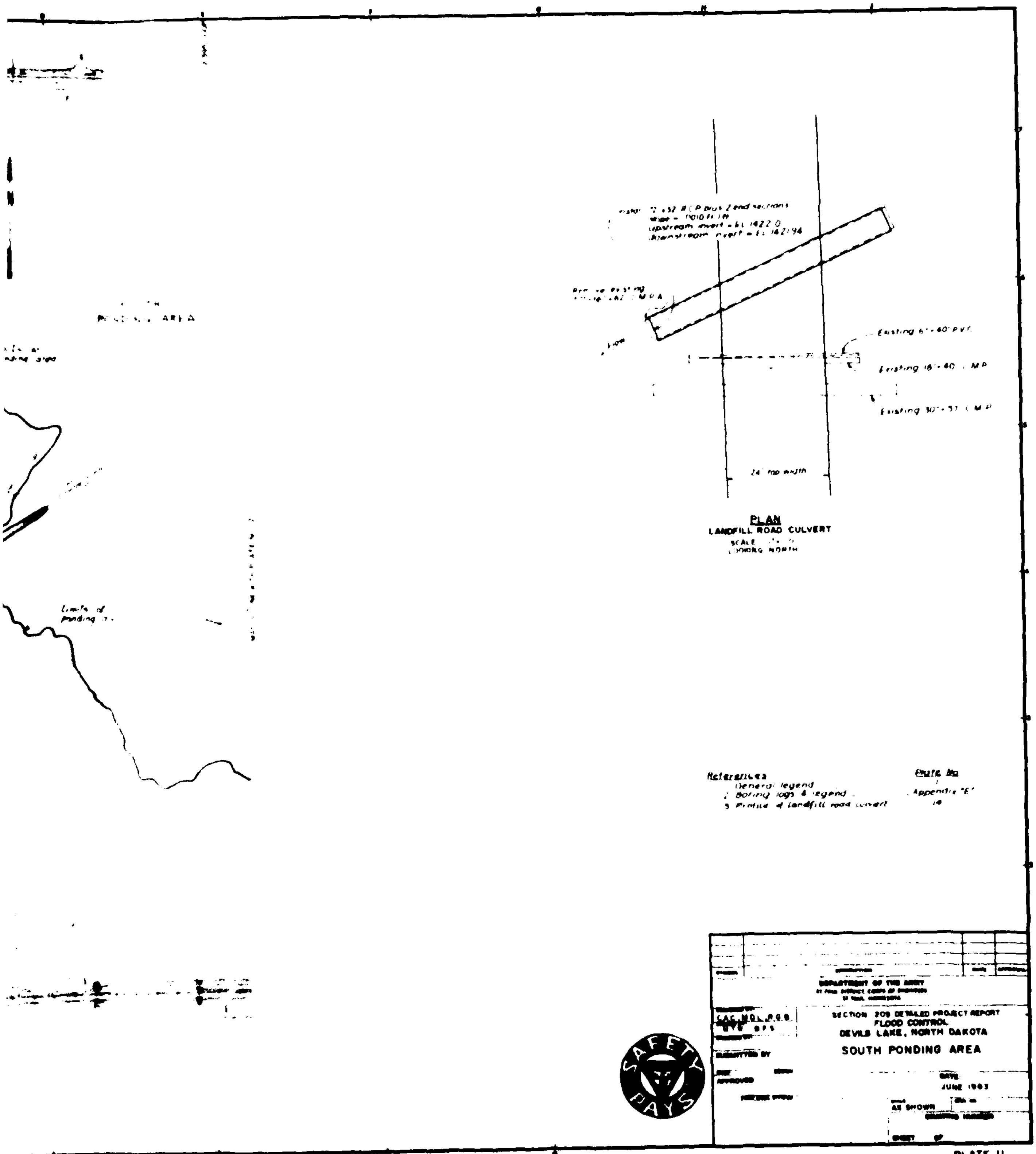
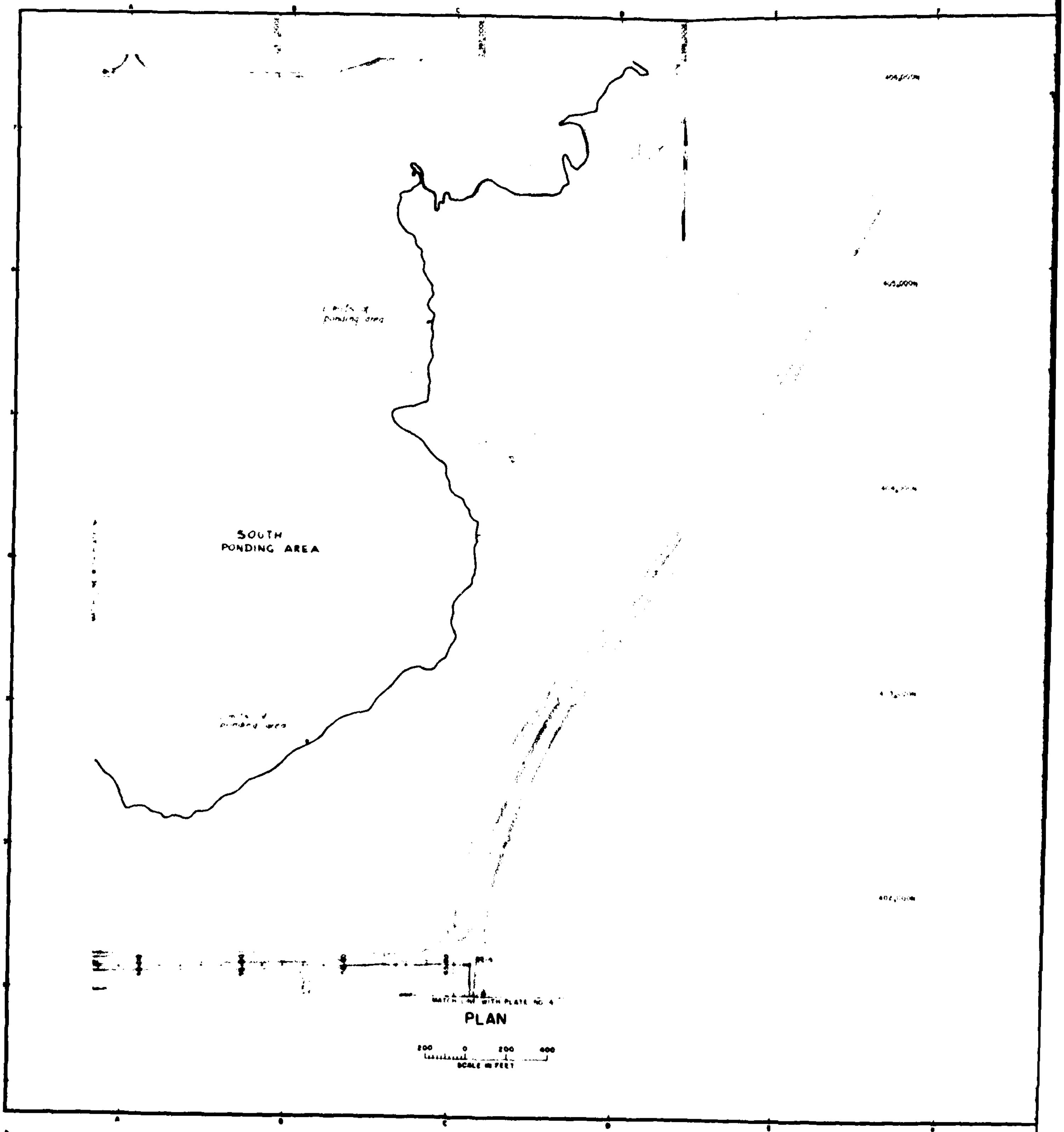

PLAN
LANDFILL ROAD CULVERT
LOOKING NORTH
24' top width
Existing 18"×40' C.M.P.
References
General legend
Boring logs & legend
Profile of landfill road culvert
Plate No.
Appendix "E"
DEPARTMENT OF THE ARMY
SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
SOUTH PONDING AREA
SUBMITTED BY
APPROVED
DATE
JUNE 1983
AS SHOWN
SAFETY PAYS

PLATE 11


SOUTH
PONDING AREA
MATCH LINE WITH PLATE NO. 4
PLAN
SCALE IN FEET

REFERENCES

PLATE No.

APPENDIX

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

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SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

SOUTH PONDING AREA

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DATE
JUNE 1981

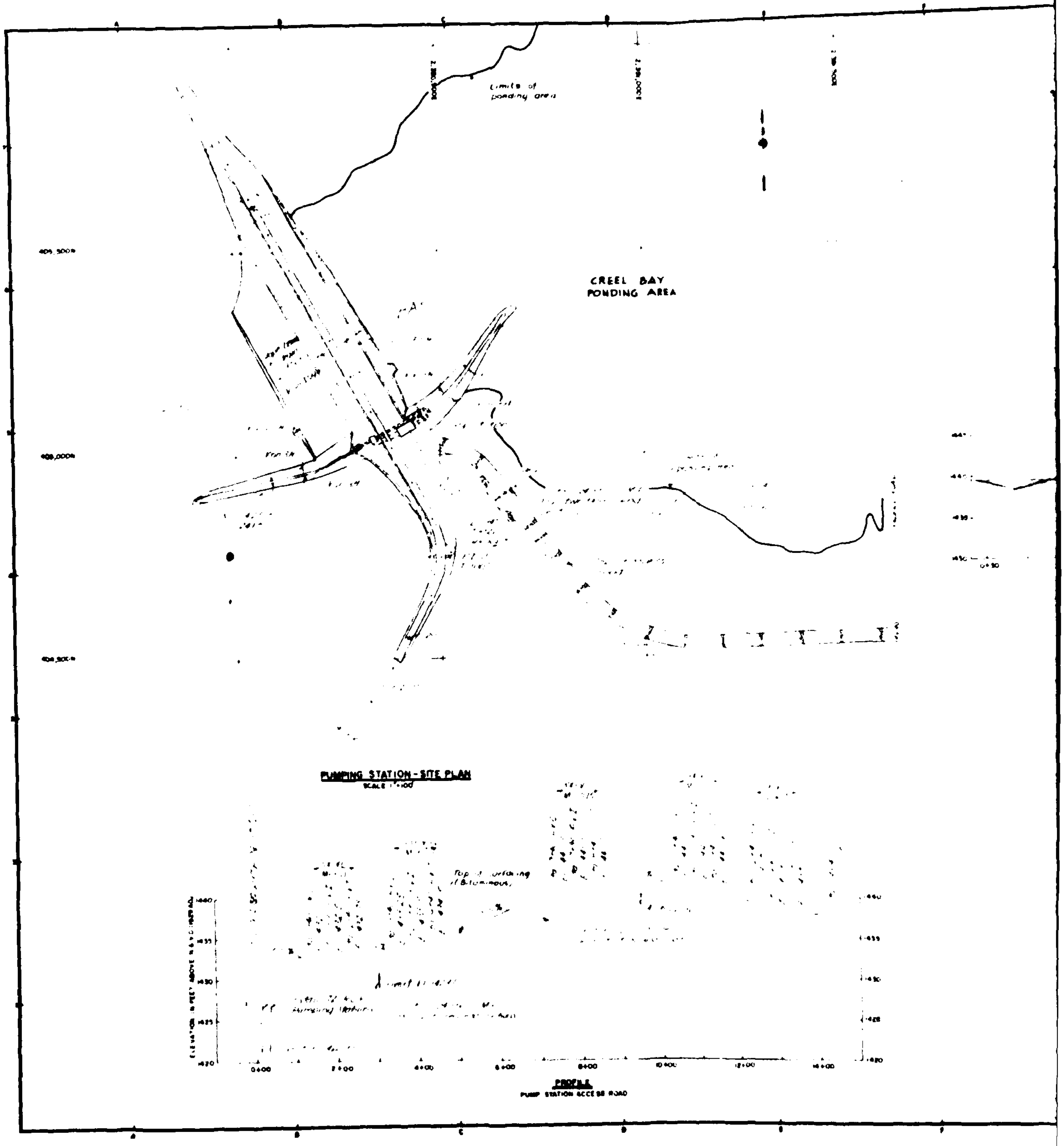
AS SHOWN

DRAWING NUMBER

SHEET OF

PLATE 12

2


Limits of ponding area
CREEL BAY
PONDING AREA
PUMPING STATION - SITE PLAN
Top of surfacing of Bituminous
PROFILE
PUMP STATION ACCESS ROAD

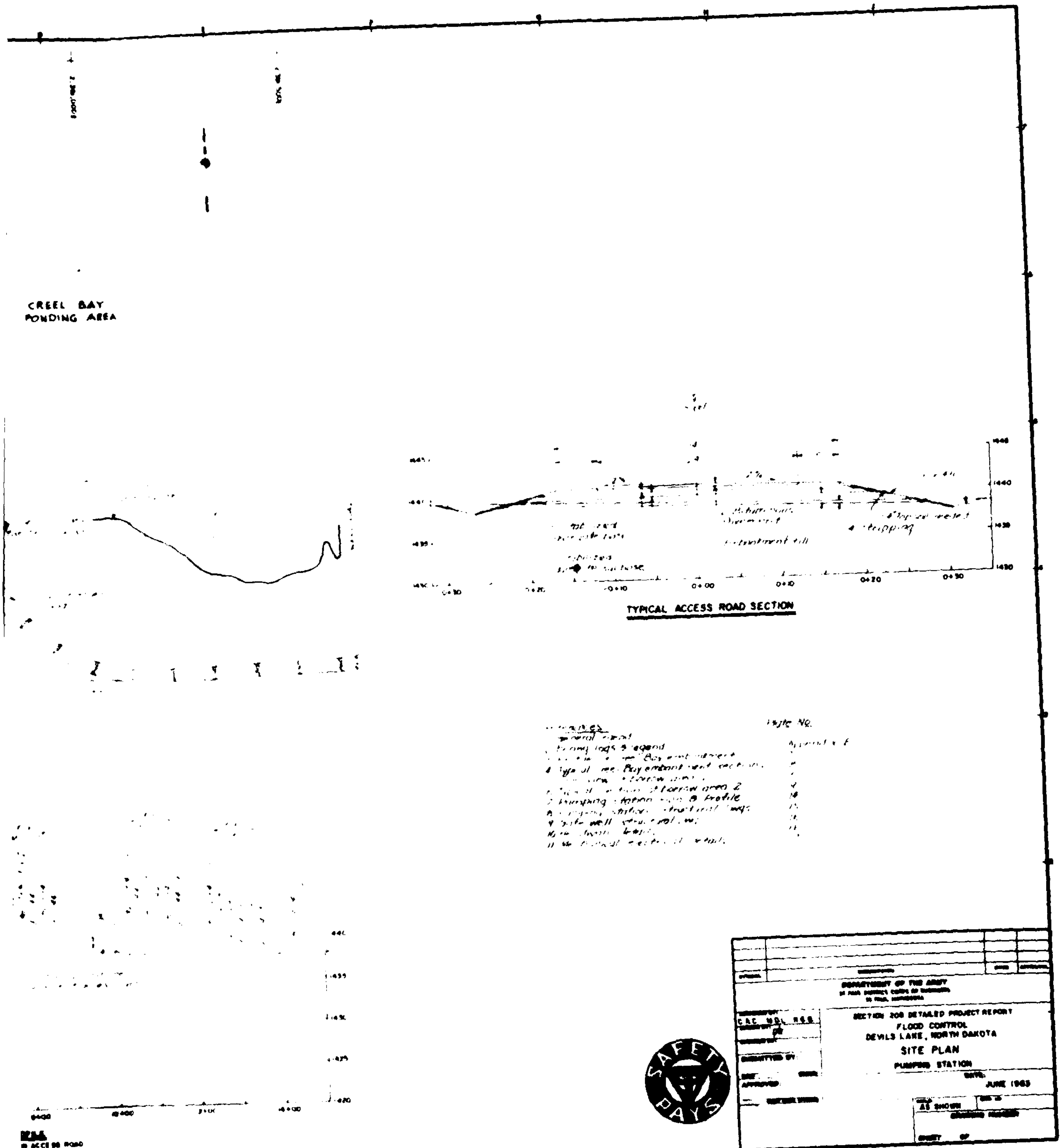
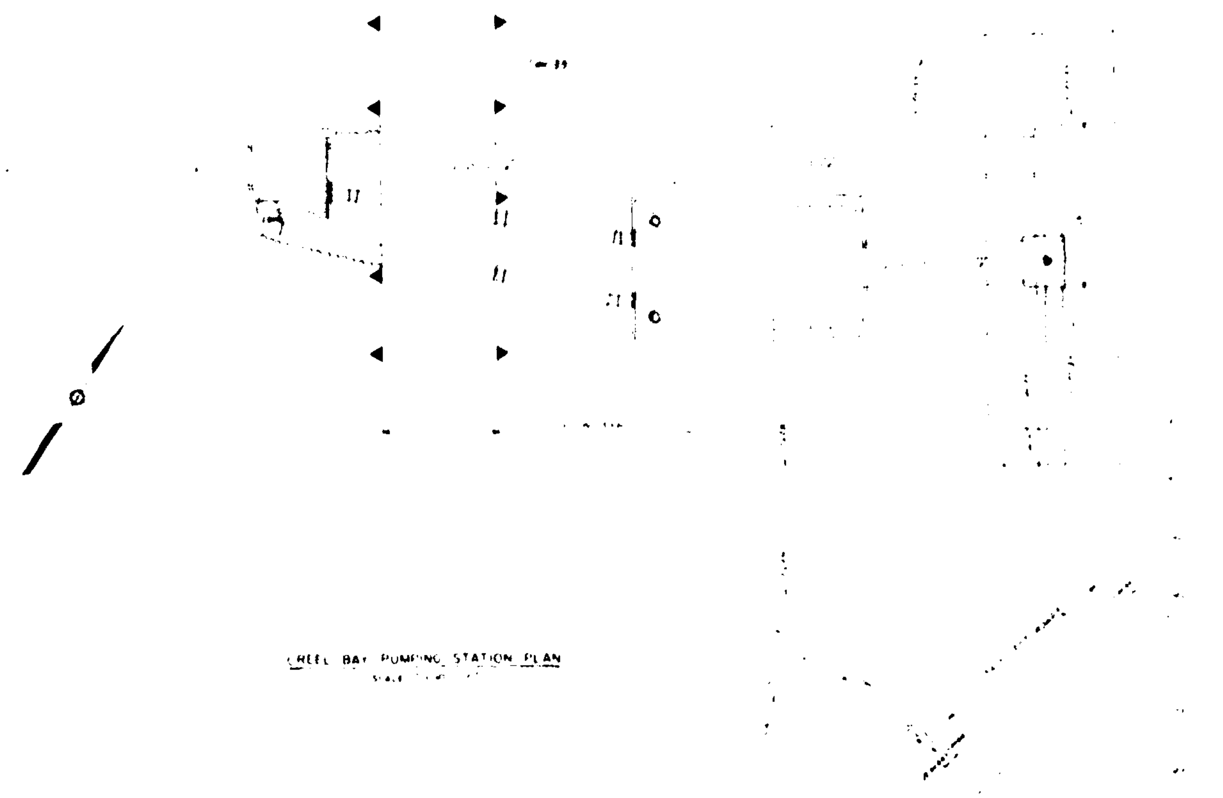
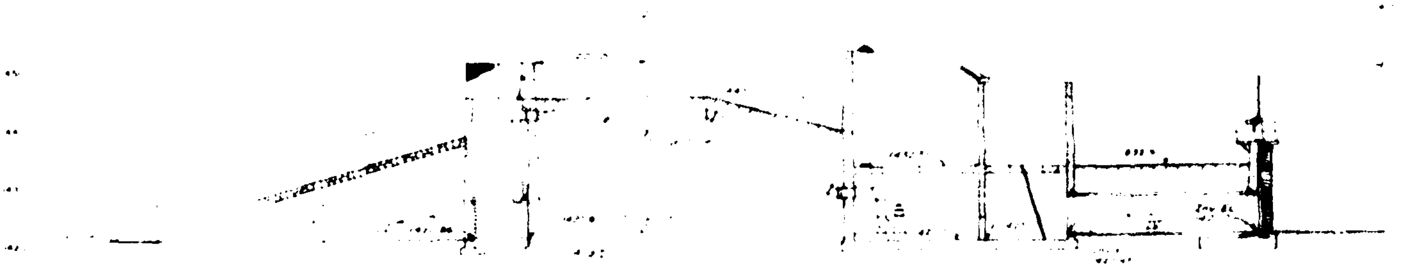

CREEL BAY
PONDING AREA
TYPICAL ACCESS ROAD SECTION
Embankment fill
DEPARTMENT OF THE ARMY
SECTION 208 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
SITE PLAN
PUMPING STATION
JUNE 1983
AS SHOWN
SAFETY PAYS

PLATE 13

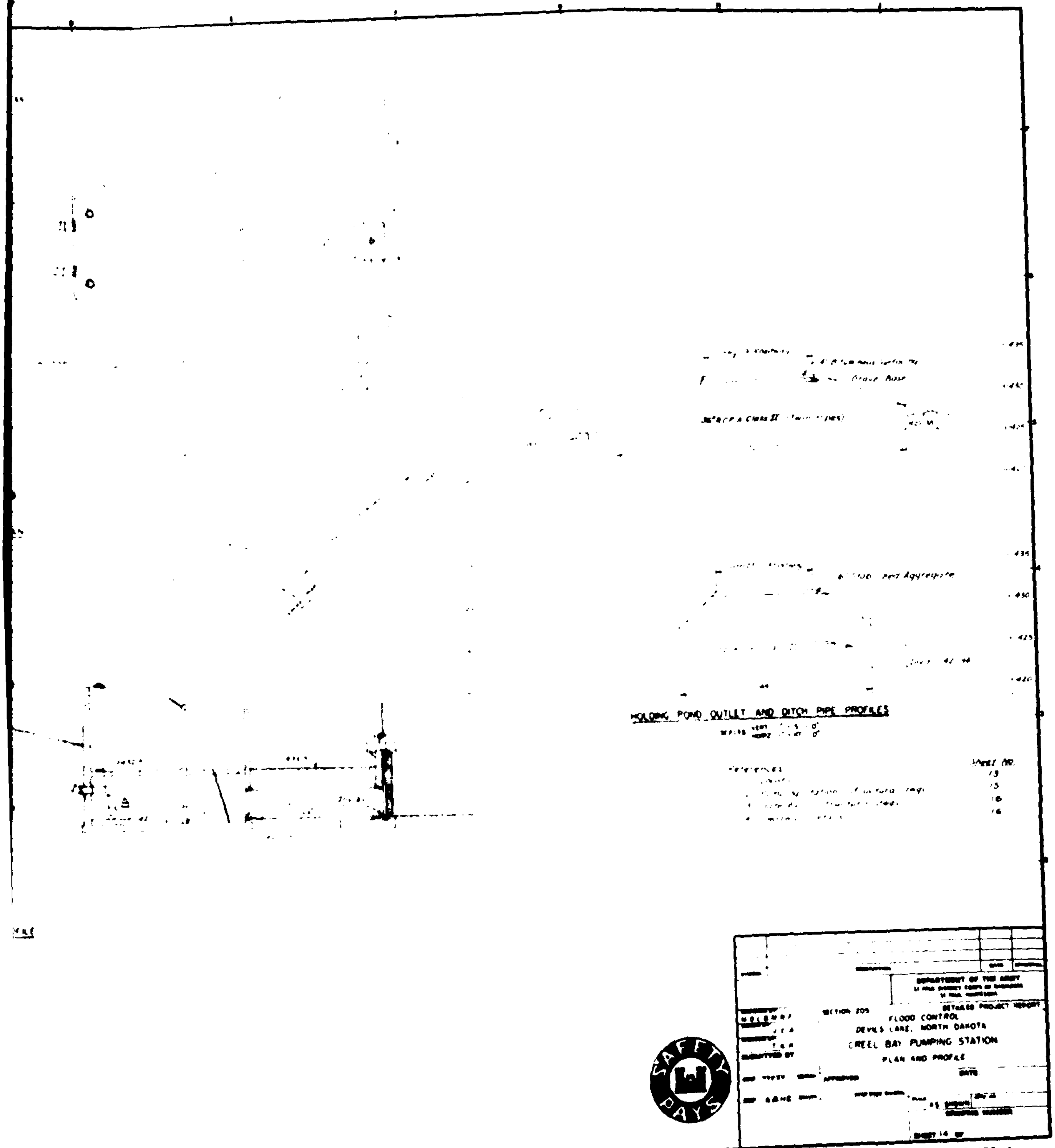
2



CREEL BAY PUMPING STATION PLAN



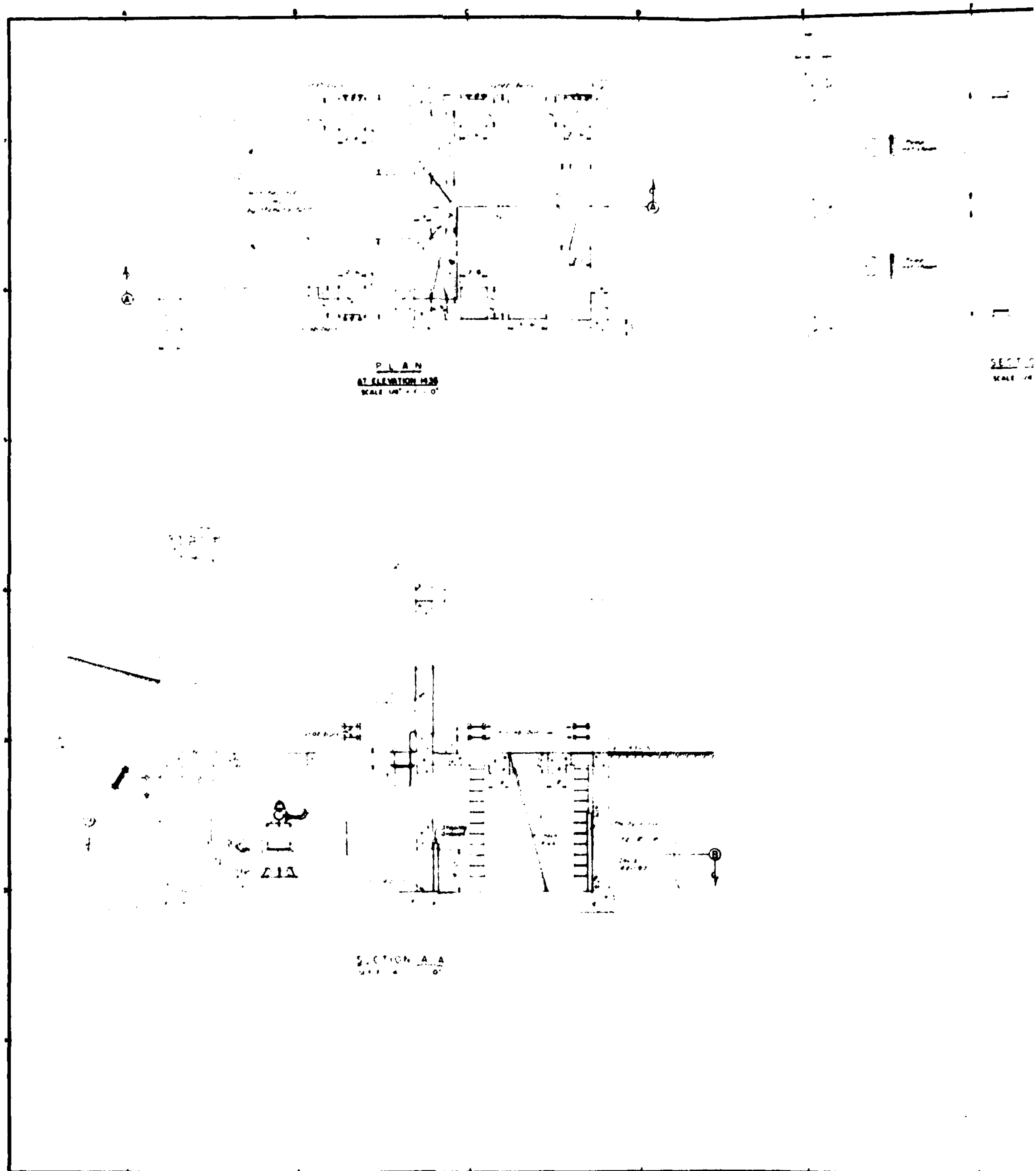
CREEL BAY PUMPING STATION PROFILE

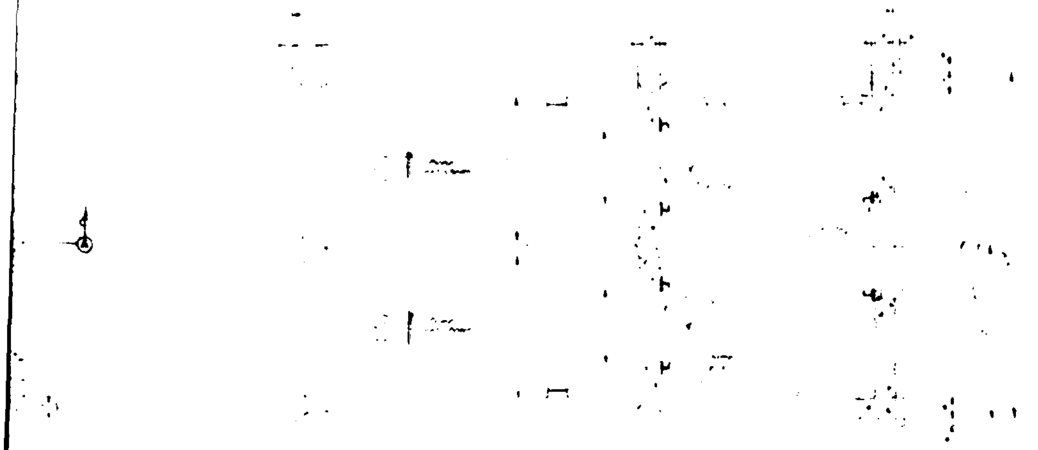


HOLDING POND OUTLET AND DITCH PIPE PROFILES
Gravel Base
Aggregate
References
Sheet No.
13
15
16
16
DEPARTMENT OF THE ARMY
DETAILED PROJECT REPORT
SECTION 205
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
CREEL BAY PUMPING STATION
PLAN AND PROFILE
DATE
APPROVED
SHEET 14 OF
SAFETY PAYS


PLATE 14

2


PLAN
AT ELEVATION 1436
SECTION A-A



SECTION B-B

References — Sheet No.
Location — 15
2 Profile — 14
3 … — 17

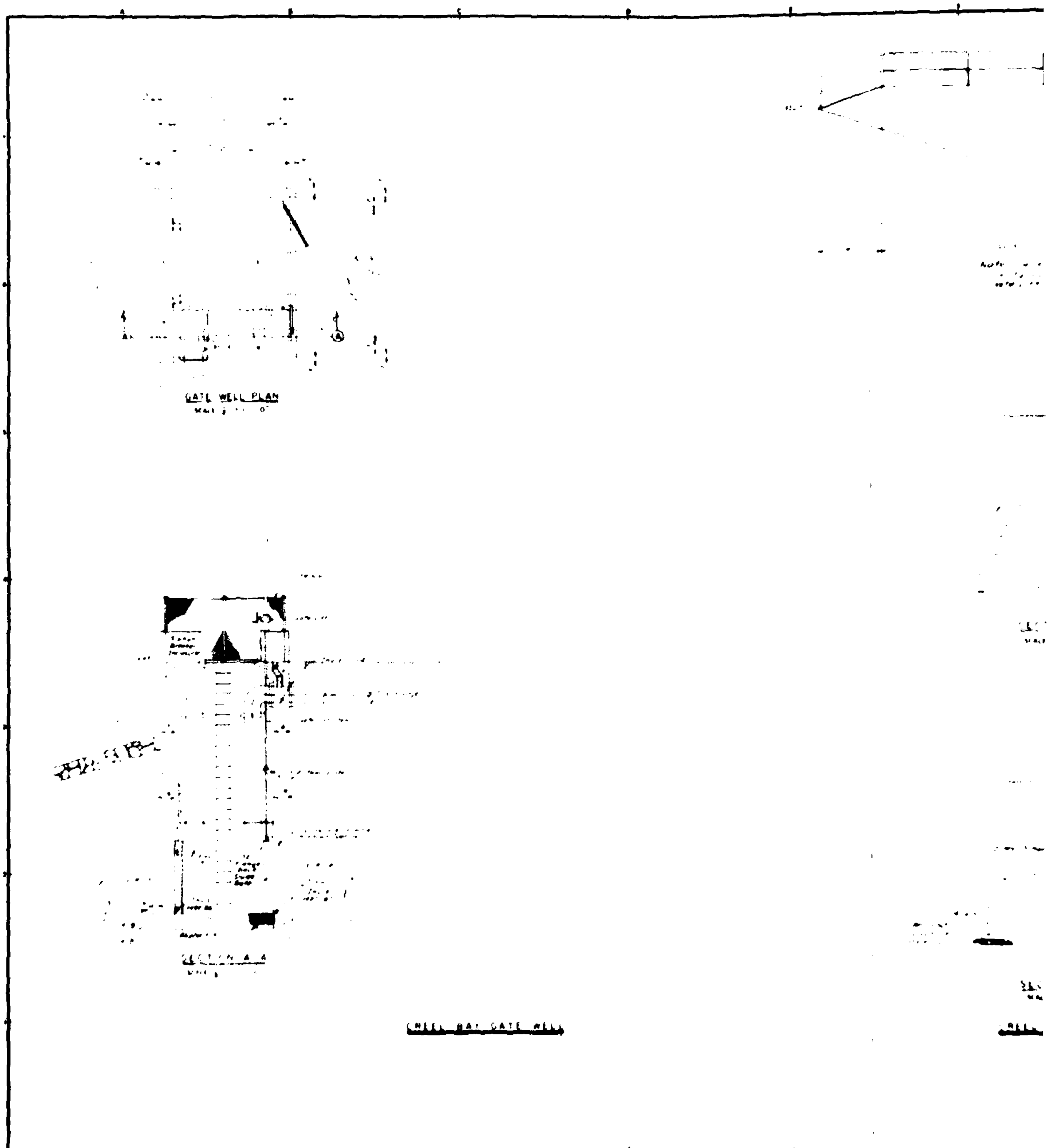
DEPARTMENT OF THE ARMY
St. Paul District, Corps of Engineers
St. Paul, Minnesota

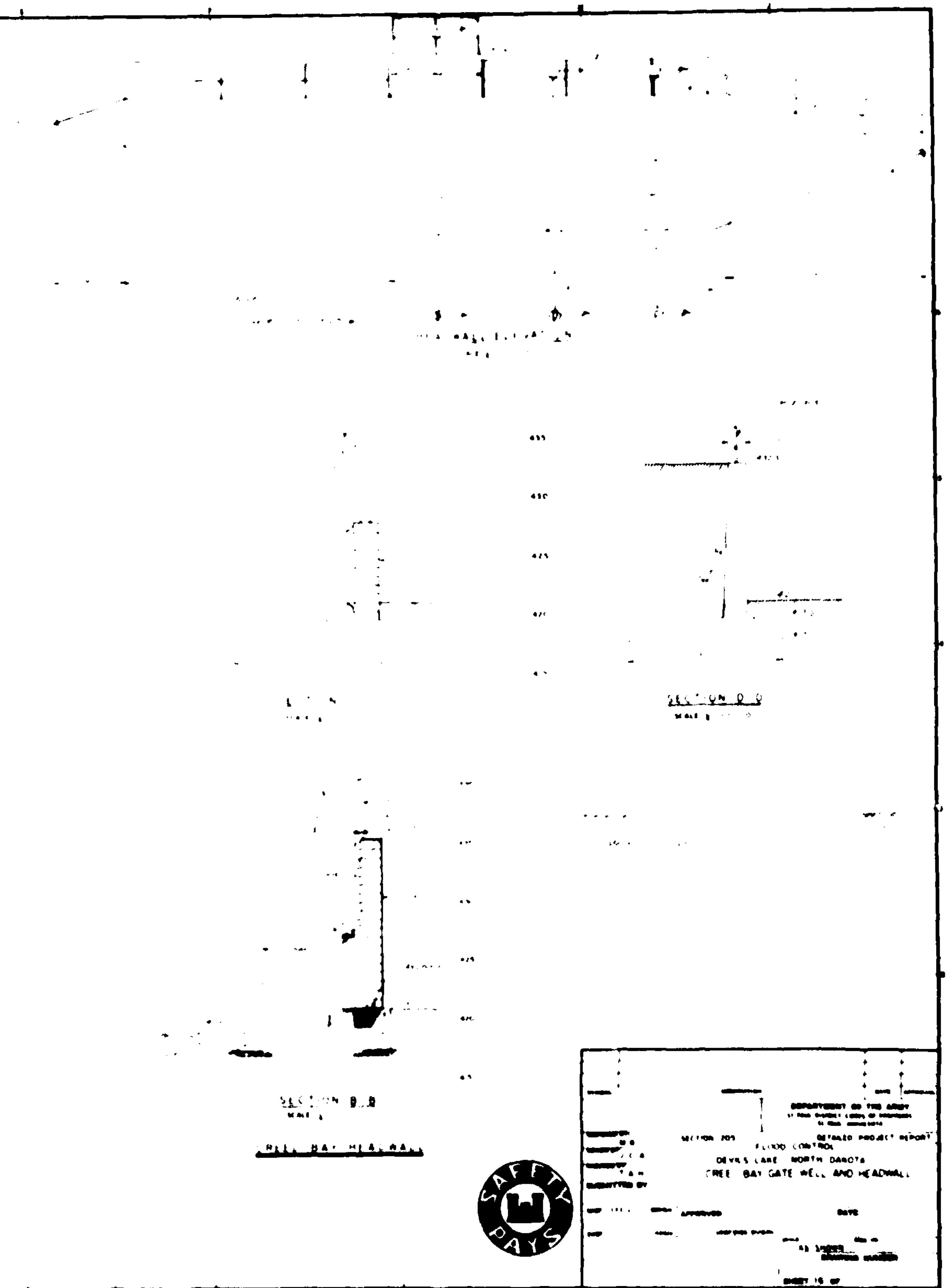
SECTION 205 — DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
CREEL BAY PUMPING STATION
STRUCTURAL DETAILS

SUBMITTED BY
APPROVED — DATE
SCALE: AS SHOWN
SHEET 15 OF

PLATE 15

2


GATE WELL PLAN
SECTION A-A
GATE WELL




DEPARTMENT OF THE ARMY

SECTION 205 FLOOD CONTROL DETAILED PROJECT REPORT

DEVILS LAKE, NORTH DAKOTA

CREEL BAY GATE WELL AND HEADWALL

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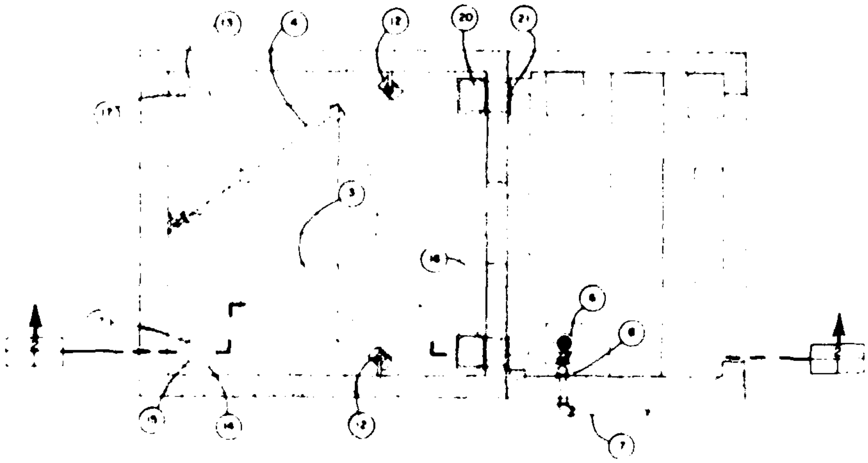
APPROVED DATE

AS SHOWN

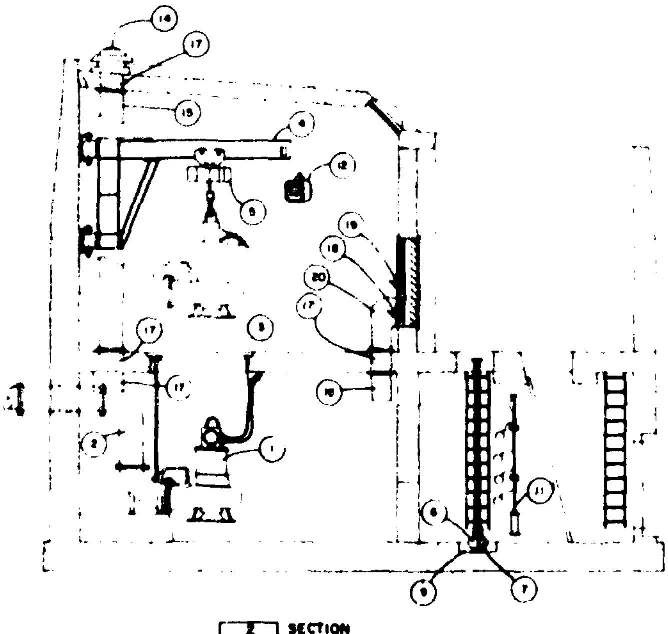
SHEET 16 OF

PLATE 16

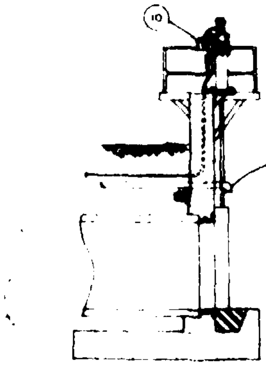
2

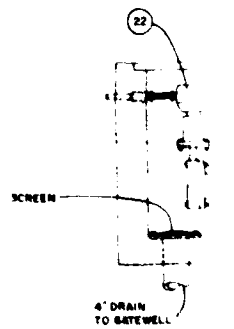


MECHANICAL PLAN
SCALE 1/4" = 1'-0"



SECTION
SCALE 1/4" = 1'-0"



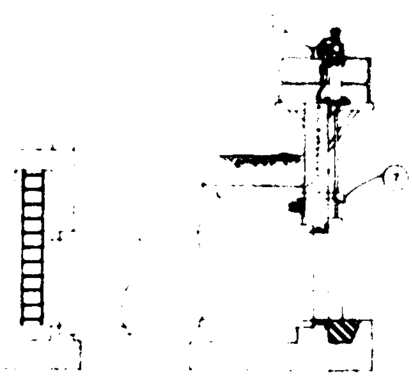


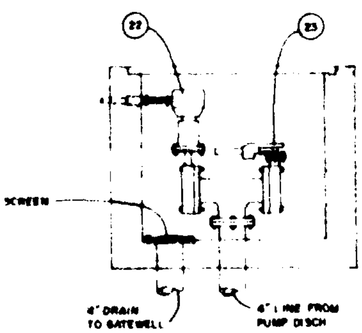

SIPHON BR
N.T.S.

| ITEM | |
|---|---|
| 1 | STORMWAT |
| 2 | STORMWAT |
| 3 | PUMP ACC |
| 4 | JIB CRANE |
| 5 | PUMP HO |
| 6 | SUMP PUM |
| 7 | SUMP PUM |
| 8 | SUMP PUM |
| 9 | SUMP P |
| 10 | GATE L |
| 11 | LEVEL TRA |
| 12 | UNIT HEAT |
| 13 | CONTROL R |
| 14 | SUMP VEN |
| 15 | 20 x 20 |
| 16 | 20 x 20 |
| 17 | 20 x 20 |
| 18 | 24 x 24 |
| 19 | 48 x 24 |
| 20 | 24 x 24 |
| 21 | 24 x 72 |
| 22 | 4" MOTOR A |
| 23 | 4" HAND AC |

## MECHANICAL ITEM LIST

| ITEM | DESCRIPTION | QTY | REMARKS |
|---|---|---|---|
| 1 | STORMWATER PUMP AND DISCHARGE [illegible] | 2 | 20" DISCHARGE |
| 2 | STORMWATER PUMP DISCHARGE PIPE | 2 | 20" DIAMETER |
| 3 | PUMP ACCESS DOOR | 2 | BY PUMP MANUFACTURER |
| 4 | JIB CRANE | 1 | WALL MOUNTED, KNEE BRACED, 5 TON CAPACITY |
| 5 | PUMP HOIST | 1 | ELECTRIC CHAIN HOIST, 5 TON CAPACITY |
| 6 | SUMP PUMP | 1 | 4" DISCHARGE |
| 7 | SUMP PUMP DISCHARGE PIPE | 2 | 4" DIAMETER |
| 8 | SUMP PUMP HOIST | 1 | SEE DETAIL, MOUNT TO WALL |
| 9 | SUMP PIT | 1 | SEE STRUCTURAL |
| 10 | GATE LIFT | 1 | ELECTRIC, FOR 72 x 72 GATE |
| 11 | LEVEL TRANSDUCER AND FLOATS | 1 | SEE ELECTRICAL |
| 12 | UNIT HEATER | 2 | SEE ELECTRICAL |
| 13 | CONTROL ROOM VENTILATION FAN | 1 | ROOF TYPE, WITH BACK DRAFT DAMPER |
| 14 | SUMP VENTILATION FAN | 1 | ROOF TYPE, W/B.D. DAMPER, DUCT TO SUMP |
| 15 | 20 x 20 RECTANGULAR DUCT | | DOWN TO SUMP |
| 16 | 20 x 20 RECTANGULAR DUCT | | OPEN ON END |
| 17 | 20 x 20 OPENING THRU WALL, FLOOR OR CEILING | 5 | SEE STRUCTURAL |
| 18 | 24 x 24 DAMPER FOR SUMP SUPPLY | 2 | W/HAND CRANK |
| 19 | 48 x 24 DAMPER FOR ROOM SUPPLY | 2 | W/HAND CRANK |
| 20 | 24 x 24 TO 20 x 20 TRANSITION | 2 | |
| 21 | 24 x 72 LOUVER | 2 | STORMPROOF BLADES, HORIZONTAL |
| 22 | 4" MOTOR ACTUATED WAFER VALVE | 2 | SEE SIPHON BREAKER ASSEMBLY |
| 23 | 4" HAND ACTUATED WAFER VALVE | 2 | SEE SIPHON BREAKER ASSEMBLY |




SIPHON BREAKER ASSEMBLY
NTS

DEPARTMENT OF THE ARMY

DRN WN
JDB

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
CREEL BAY PUMPING STATION
MECHANICAL

AS SHOWN

SHEET 17 OF

PLATE 17

2

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
1135 U.S. POST OFFICE & CUSTOM HOUSE
ST. PAUL, MINNESOTA 55101

REPLY TO
ATTENTION OF:

Environmental Resources Branch
Planning Division

## FINDING OF NO SIGNIFICANT IMPACT

In compliance with the National Environmental Policy Act of 1969, the St. Paul District, Corps of Engineers, has assessed the environmental impacts of the following project:

**SECTION 205**
**FLOOD CONTROL PROJECT**
**DEVILS LAKE, NORTH DAKOTA**

The purpose of this project is to protect the city of Devils Lake, North Dakota, from rising lake levels by constructing a series of levees and interior drainage facilities. A detailed description of the proposed action is in the main part of the detailed project report.

This finding of no significant impact is based on the following factors: (1) minor vegetation disturbances, and (2) no significant social, cultural, water quality, and biological impacts. The environmental assessment discusses the project impacts in more detail.

The environmental review process indicates that the proposed action does not constitute a major Federal action that would significantly affect the human environment. Therefore, an environmental impact statement will not be prepared for the Devils Lake, North Dakota, Section 205 flood control project.

[illegible] Aug 83
Date

[illegible signature], CE, DDE
[illegible]
[illegible] Corps of Engineers
[illegible]

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## 1.00 SUMMARY

### MAJOR FINDINGS AND CONCLUSIONS

1.01 The goal of the selected plan for the Devils Lake Section 205 flood control project is to satisfy specific needs of the study area and to show a positive contribution to the objectives of national economic development (NED) and environmental quality (EQ). Plan B has been designated as the selected, NED, and least environmentally damaging plans.

1.02 Plan B would provide flood protection up to a water surface elevation of 1440 feet msl (feet above mean sea level). Three embankment structures would be needed: at the head of Creel Bay, west of the city of Devils Lake, and south of the city. Interior drainage facilities would be located north and south of the existing city sewage lagoons. A land management plan to regulate future development is also part of the plan. Wetland areas would be created or maintained at the head of Creel Bay, the interior drainage areas, and near the south embankment. Disturbed areas would be revegetated after construction.

1.03 The selected plan has a benefit/cost ratio of 5.0 and is considered implementable. (See other sections of this detailed project report for a more complete description of the selected plan.)

1.04 The selected plan is considered to be in compliance with Executive Order 11990, Protection of Wetlands, because it does not cause unacceptable wetland impacts. Because the land management plan helps regulate future floodplain development, the selected plan is also considered to comply with Executive Order 11988 on Floodplain Management.

1.05 Discharge of fill in Devils Lake is covered by the nationwide permit program of the Corps of Engineers (33 CFR 330.4, Federal Register, July 22, 1982, Vol. 47, No. 141). Because the special conditions for the nationwide permit will be followed, a Section 404(b)(1) evaluation and State certification are not required.

RELATIONSHIP TO ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

1.06 Table 1 describes the relationship of applicable environmental regulations to the feasible alternatives that were developed in detail. (See the alternatives sections of this assessment and the main report for discussions of plans.)

Table [illegible]. Relationship of Plans to Environmental Requirements and Protection Statutes (Plan Recommended: Plan B)

| Federal Statutes | No Action | Nonstructural | Plan A | Plan B | Plan C | Plan D | Road Raise |
|---|---|---|---|---|---|---|---|
| Archeological and Historic Preservation Act, as amended, 16 USC 469, et seq | Full | Full | Full | Full | Full | Full | Full |
| Clean Air Act, as amended, 42 USC 7401, et seq | Full | Full | Full | Full | Full | Full | Full |
| Clean Water Act, as amended (Federal Water Pollution Control Act), 33 USC 1251, et seq. | Full | Full | Full | Full | Full | Full | Full |
| Coastal Zone Management Act, as amended, 16 USC 1451, et seq | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Endangered Species Act, as amended, 16 USC 1531, et seq. | Full | Full | Full | Full | Full | Full | Full |
| Estuary Protection Act, 16 USC 1221, et seq. | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Federal Water Protection Recreation Act, as amended, 16 USC 460-l(12), et seq | Full | Full | Full | Full | Full | Full | Full |
| Fish and Wildlife Coordination Act, as amended, 16 USC 661, et seq | Full | Full | Full | Full | Full | Full | Full |
| Land and Water Conservation Fund Act, as amended, 16 USC 460l-460l-11, et seq | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Marine Protection, Research and Sanctuaries Act, as amended, 33 USC 1401, et seq | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| National Historic Preservation Act, as amended, 16 USC 470a, et seq | Full | Full | Full | Full | Full | Full | Full |
| National Environmental Policy Act, as amended, 42 USC 4321, et seq | Full | Full | Full | Full | Full | Full | Full |
| Rivers and Harbors Act, 33 USC 401, et seq. | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Watershed Protection and Flood Prevention Act, as amended, 16 USC 1001, et seq. | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Wild and Scenic Rivers Act, as amended, 16 USC 1271, et seq. | Full | Full | Full | Full | Full | Full | Full |
| **Executive Orders, Memoranda, etc.** | | | | | | | |
| Floodplain Management (E.O. 11988) | Full | Full | Full | Full | Full | Full | Full |
| Protection of Wetlands (E.O. 11990) | Full | Full | Full | Full | Full | Full | Full |
| Environmental Effects Abroad of Major Federal Actions (E.O. [illegible]) | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Analysis of Impacts on Prime and Unique Farmlands (CEQ Memorandum, 30 Aug 76) | Full | Full | Full | Full | Full | Full | Full |
| Land Use Plans | Full | Full | Full | Full | Full | Full | Full |
| State and Local Policies | Full | Full | Full | Full | Full | Full | Full |
| **Required Federal Entitlements** | | | | | | | |
| Clean Water Act, Section 404 | Full | Full | Full | Full | Full | Full | Full |

NOTES: The compliance categories used in this table were assigned on the basis of the following definitions:

a. Full compliance - All requirements of the regulation have been met for current stage of planning.
b. Partial compliance - Some requirements of the regulation have not been met for current stage of planning.
c. Noncompliance - Violation of requirement of the statute, E.O., policy, etc.
d. Not applicable (N/A) - Regulation is not applicable.

## 2.00 NEED FOR AND OBJECTIVES OF ACTION

### STUDY AUTHORITY

2.01 On October 3, 1979, the Devils Lake Basin Joint Water Management Board requested that the Corps of Engineers investigate the feasibility of implementing flood control measures at Devils Lake, North Dakota. In February 1980, the St. Paul District of the Corps completed a reconnaissance report that concluded flood control measures were potentially feasible and that recommended more detailed studies. This detailed project report has been prepared in response to that recommendation under authority of Section 205 of the 1948 Flood Control Act, as amended.

### PUBLIC CONCERNS

2.02 Through meetings, reports, and correspondence, local interests and various government agencies identified the following concerns: controlling floodplain development, controlling flooding caused by rising lake levels, improving water quality, controlling wetland drainage, and preserving wildlife habitat, aesthetic values, recreation, and cultural resources.

### PLANNING OBJECTIVES

2.03 The primary planning objective of this project is to develop an implementable plan with an acceptable level of protection against rising lake levels and with minimal or no environmental impacts.

2.04 Alternative plans were developed and evaluated in terms of national economic development, environmental quality, regional development, and other social effects. The economic health of the city and the health and security of its inhabitants were also major considerations.

3.00 ALTERNATIVES

3.01 Seven alternatives were developed and studied to varying degrees of detail during the course of this study. As the study progressed, it became evident that only the embankment alternatives would be implementable. Each of the alternatives, including the no action alternative, is summarized below. More detailed discussions are in the main report.

NO ACTION (WITHOUT-PROJECT CONDITIONS)

3.02 The following is a description of the most probable future "without-project" conditions.

1. It is not possible to predict future lake levels, but the recent trend has been toward higher levels.

2. Emergency actions would be taken if necessary to protect existing developments.

3. Wetland drainage in the immediate project area would probably not be significant, but adjacent watersheds might experience substantial losses.

4. The existing sewage treatment facilities would not be relocated, but the treated wastewater may be spread on land to reduce water quality impacts at Creel Bay.

5. Both residential and industrial development would continue and possibly be located in the historic lakebed or floodplain.

6. Wildlife habitat in the area, which is primarily grassland, would continue to degrade because of grazing and urban development.

7. Impacts to cultural resources would continue to occur because of cultivation and deterioration caused by flooding of sites in the floodplain.

8. Social cohesion would continue within the community and interest groups.

PLANS NOT CONSIDERED IN DETAIL

Nonstructural Plan

3.03 The nonstructural plan would require evacuation of all structures that suffer first-floor flooding under a specific flood elevation. Depending on the elevation of protection, this plan would require acquisition of property worth between $14,000,000 and $60,000,000. The sewage treatment facilities either would have to be relocated or protected by levees. The high cost and the lack of economic feasibility made this plan unimplementable. In addition, because of the uncertainties surrounding the elevation that requires protection, this option would be socially controversial. All historic properties affected by the non-structural plan would have to be evaluated for their eligibility to the National Register of Historic Places. If any properties were determined eligible, a mitigation plan would be developed for all eligible properties affected by the plan.

Road Raise

3.04 Early in the stage 2 planning for this project, one alternative was considered that involved the raising of the road west of the existing sewage lagoons. Further investigations showed that other alternatives would be less costly and just as effective, and that they would be socially and environmentally acceptable. Therefore, the road raise alternative was dropped from further consideration.

PLANS CONSIDERED IN DETAIL

3.05 During stage 2, it become evident that the most desirable plans from the standpoint of economics and local acceptability would involve embankments at Creel Bay and various locations around the city. Four alternative levels of protection were proposed. These plans are displayed in the main report and are discussed in the following sections.

Measures Common to All Detailed Plans

3.06 All of these plans would require interior drainage facilities both north and south of the existing wastewater treatment lagoons. A pump station would be located at Creel Bay. Hydric (wet) conditions would become established in both of these ponding areas because of the operation of the ponds. A wetland with a maximum depth of about 1.6 feet would be maintained in the north holding pond. This wetland would filter the drainage/sewage water and would help improve the water quality of Creel Bay.

3.07 An existing 65-acre wetland west of the sewage lagoons is frequently used to hold treated sewage water. As part of the proposed project, notches would be cut at an elevation of about 1428 feet msl in the dike that contains the wetland. These notches would make it possible to use the wetland for ponding interior drainage water and to maintain its wetland values for waterfowl. The total area of the wetland would neither be increased nor decreased.

3.08 A land management plan would be a component of all alternatives. Because the level of flood protection provided by the project cannot be identified, it is prudent to control development in the flood-prone areas. The plan is being developed by local interests in cooperation with the State Water Commission, the Federal Emergency Management Agency, and the Corps of Engineers. The land management plan would be a part of the local cooperation agreement.

3.09 The city, in cooperation with the State Public Health Department and U.S. Environmental Protection Agency, is investigating the potential for spreading the interior drainage/sewage water on land. This land-spreading appears to be an acceptable alternative to discharge into Creel Bay and should help improve the Creel Bay water quality. This measure would be compatible with the selected plan.

3.10 The road west of the sewage lagoons would be maintained in its present condition with all of these alternatives.

Plan A

3.11 This plan would protect the city from lake levels up to 1435 feet msl. It would require a 1,100-foot-long embankment with a top elevation of 1440 feet msl at Creel Bay. Total cost of plan A would be about $1,530,000, with a benefit-cost (B/C) ratio of 4.6.

Plan B

3.12 This plan would protect the city from lake levels up to 1440 feet msl. It would require three embankments with a top-of-structure elevation of 1445 feet: a 2,400-foot-long embankment south of the airport, a 2,900-foot-long embankment at the head of Creel Bay, and a 3,100-foot-long embankment southeast of the lagoon area. An existing 40-acre wetland south of the city would require construction of a new outlet. The new outlet would be at the same elevation as the existing one. Total cost of plan B would be $1,920,000, with a B/C ratio of 5.0.

Plan C

3.13 This plan would protect the city from lake levels up to 1445 feet msl. The top elevation of the embankments would be 1450 feet. Plan C would require a 16,000-foot-long embankment at Creel Bay and a 7,200-foot-long embankment south of the lagoon area. This plan affects the same wetland area as plan B. Plans C and D require removal of a portion of small woodland area. In addition, the embankment on the west end of the city would be in a U.S. Fish and Wildlife Service wetland easement. Total cost of plan C would be about $5,097,000, with a B/C ratio of 2.0.

Plan D

3.14 This plan would protect the city from lake levels up to 1450 feet msl. The top-of-structure elevation would be 1445 feet. Plan D would require an almost continuous embankment around the south and southwest portions of the city. An additional pump station and interior drainage pond would be required south of the city. Additional wetlands and upland grassland areas would be affected south of the city. Plans C and D require removal of a portion of a small woodland area. Total cost of plan D would be about $8,800,000, with a B/C ratio of 1.2.

4.00 AFFECTED ENVIRONMENT

4.01 The 3,700-square-mile Devils Lake basin is an interior drainage basin (from which no water has flowed out in historic times) in northeast central North Dakota. Surficial deposits in the Devils Lake region are entirely glacial drift, ranging from 10 to 400 feet thick. The glacial till is predominantly ground-up Pierre shale and limestone. Many pothole depressions (formed by the melting of ice blocks) dot the landscape. Post-glacial lacustrine deposits of sand, silt, clay, and gravel form the bed of the Devils Lake system.

4.02 Agricultural activities have drastically altered the terrestrial ecology of the Devils Lake basin. The project area is in Ramsey County, which has about 80 percent of its land devoted to agricultural uses (table 2).

Table 2 - Land Use Characteristics of Ramsey County, North Dakota[1]

| Land Use | Acres | Percent |
|---|---|---|
| Cropland | 661,900 | 79.0 |
| Pasture | 83,800 | 10.0 |
| Water | 40,200 | 4.8 |
| Wetland | 23,400 | 2.7 |
| Urban | 20,100 | 2.4 |
| Woodland | 8,900 | 1.1 |
| Totals | 838,300 | 100.0 |

(1) Based on preliminary data from North Central Forest Experiment Station, U.S. Forest Service, St. Paul, Minnesota.

4.03 Land use in the project area is primarily urban, pasture, and agricultural. Wetland habitat is present in Creel Bay, at the sewage lagoons and holding ponds, and to the south and west of the city.

VEGETATON AND WILDLIFE RESOURCES

4.04 The project area is primarily upland grassland and wetland ranging from open water to emergent vegetation. The upland areas are urban, residential, and agricultural pastureland. The pastureland is vegetated with milkweed, buffaloberry, sagebrush, Canada thistle, foxtail barley, curly dock, buckbrush, sunflower, and various grasses and sedges.

4.05 Th wetland habitat in the project area consists of the sewage lagoons, holding ponds, Creel Bay, and some natural marsh areas. The vegetation of these areas includes cattail, bulrush, sedges, alkaligrass, curly dock, kockia, and prairie cordgrass.

4.06 The wildlife value of the pastureland is rather limited because of the urban surroundings and grazing. These areas provide nesting and refuge, and they therefore complement the adjacent wetlands. The wetland areas have good wildlife value, especially for waterfowl.

4.07 There are 251 species of birds in the Devils Lake basin. Of these, 128 species are associated with wetland and prairie habitats, which have been severely reduced by intensive agricultural practices. The basin is one of the most important waterfowl production areas in the State. It serves as a major staging area during duck and goose migration. Native prairie, when found in combination with wetlands, forms an ecosystem that supports diverse and abundant wildlife populations. These associations are found in the project area and provide wildlife values. But because of the urban nature of the area, these prairie-wetland associations are not equal in value to those in a more rural setting.

4.08 The bald eagle and peregrine falcon are the only Federally-listed endangered species that may occur in the project area. The presence of the falcon in the basin is very rare. However, the bald eagle migrates through the area in the spring and fall, and it can be found in and around the waters of Devils Lake. The bald eagle does not nest in the basin, however.

4.09 No federally-listed threatened or endangered plants are located in the project area, but a plant listed as rare in North Dakota, a Illinois brundleflower (Desmanthus illinoensis), is found within a mile of the embankment that would be south of town. This plant is found in sandy soil along lakes (W.T. Barker, G. Larson, and R. Williams, "Rare and Unique Plants of North Dakota," North Dakota State University).

WATER QUALITY

4.10 Analysis of Devils Lake indicates that the water generally contains excessive levels of hardness, total dissolved solids (TDS), sulfate, and pH. Metals such as barium, boron, and lithium also present occasional water quality problems. Runoff from agricultural operations is the major contributor to the metals and TDS concentrations. High levels of nitrates and phosphates, although naturally occurring, also result from livestock and cropland erosion.

4.11 The city of Devils Lake discharges stormwater runoff and treated wastewater from its sewage lagoons into Creel Bay. Although this sewage water meets State standards, it contains high levels of nutrients, particularly nitrogen and phosphorous, which further deteriorate the water quality of Creel Bay and Devils Lake. The city, in cooperation with the State Public Health Department and the U.S. Environmental Protection Agency, is currently studying the feasibility of land-spreading these wastewaters. Eliminating this discharge would improve the water quality of Creel Bay and would be more acceptable from a recreational standpoint. Elimination of the discharge would also benefit the public health and aesthetics of the area.

RECREATION RESOURCES

4.12 Devils Lake is the most important water-based recreation area in eastern North Dakota. Fishing and other water-oriented activities provide a major economic resource for the local economy and are very important to the overall well-being of the area. Major game fish species of the lake include northern pike, walleye, white bass, crappie, and yellow perch. Creel Bay provides fair spawning habitat for walleye and pike but is considered good for crappie, bass, and perch. The Devils Lake area is also one of the best waterfowl hunting areas in the State and is a valuable economic asset to the local economy.

SOCIAL ENVIRONMENT

4.13 As the largest city (1980 population 7,442) in the Devils Lake basin and the only one larger than 1,000 residents to grow in the last decade, Devils Lakes serves as an important regional center for agricultural service, retirement, and recreation.

4.14 Much of the city's recent commercial and residential growth is in the area that would be threatened by a continued rise in the lake level. Part of this area lies outside the city limits, in Creel Township.

4.15 The areas where embankments would be constructed are 1 to 2 miles beyond the developed urban area. The eastern embankment would be near a small subdivision, and the other embankments would be near only a few homes.

4.16 Although the Devils Lake Basin Joint Water Management Board requested this Corps study, the eventual local sponsor may be the city of Devils Lake. The board would continue to support this study, however, and will actively pursue a long-range solution for fluctuating lake levels. The city, Creel Township, and the board all have legal authority to finance water resource projects and to participate in floodplain management. Both the city and the township participate in the Federal Flood Insurance Program. (Since Creel Township manages its portion of the floodplain, the city does not exercise its extraterritorial authority in that area.) The State of North Dakota is also actively involved with the study. The State Water Commission is assisting in the revision of floodplain ordinances. The State also claims title to property below the meander line of the lake. The State plans to transfer title for project purposes, but the city anticipates paying private owners who believe they have legitimate claims to that land.

4.17 Although the city can use different methods to finance the project (and to allocate those costs among its taxpayers), property in Devils Lake currently (1981) has the highest mill rate levy of any city in the State.

CULTURAL RESOURCES

4.18 In compliance with Section 106 of the National Historic Preservation Act of 1966, the National Register of Historic Places has been consulted. As of May 18, 1983, the project area had no sites listed on the National Register. The project has been coordinated with the North Dakota State Historic Preservation Officer and the National Park Service.

4.19 During September 1981, a cultural resources literature and records search and review and a field reconnaissance survey of the project area were conducted. No historic or prehistoric sites were recorded. However, there is a high potential for sites in the surrounding area. At least 15 prehistoric burial mounds, 2 prehistoric occupation sites, and 5 historic cultural sites are near the project area. The location and probability of identifying sites are affected by the fluctuating lake levels.

4.20 The Devils Lake basin began filling with water around 13,500 BP (before present). The water level of glacial Devils Lake stabilized at 1453 feet msl. It may have remained at this level for a long period (800 to 4000 years). Around 12,800 BP, the water level of the lake declined because the glacial meltwater that fed it was diverted into glacial Lake Agassiz. No documentation is available on lake levels or fluctuations until historic times (Steven J. Fox, 1982, Excavations at the Irvin Nelson Site, 32BE208, draft report submitted to the U.S. Fish and Wildlife Service, Denver, Colorado).

4.21 From 1867 to the present, the varying levels of the lake have been recorded. In 1867, Devils Lake was at its highest recorded level, 1438.5 feet msl. From 1890 to 1907, the level stablized between 1428.4 and 1428.8 feet. From then until 1940, the levels declined. In 1940, the lake had its lowest recorded level, 1401.2 feet. Since 1940, the lake levels have been increasing, with the present lake level being 1428-plus feet (S. Fox 1982).

4.22 Recent excavations at the Irvin Nelson site, on the south shore of Devils Lake, revealed stratigraphic evidence that the lake had been at the maximum 1453-foot line at least once since the early Holocene times (S. Fox 1982). Evidence in core samples from the bottom of Devils Lake contrastingly determined that around 6,120 BP Devils Lake completely dried up (Callander, 1967, in S. Fox, 1982).

4.23 As long as the lake level remained at 1457.1 feet msl, Devils Lake flowed through Big Stoney Spillway into the Sheyenne River. When the lake level dropped below 1457.1 feet but remained above 1445 feet, Devils Lake flowed through the Jerusalem Outlet into Stump Lake but would not have flowed on into the Sheyenne River. So once the lake level fell below 1457.1 feet, the lake became an internal closed system fluctuating with the varying environmental conditions (Aronow, 1957, in S. Fox, 1982). Additionally, if the lake level falls below 1420.8 feet, the salinity of the water increases, with a high level of sulphate.

4.24 Periods of lake level fluctuations or stabilization and the subsequent environmental conditions associated with each change also affected the human, faunal, and floral populations that occupied the area prehistorically and historically.

4.25 Our understanding of the human occupation of the Devils Lake area from prehistoric to historic times is limited. The Devils Lake area has probably been occupied by people since Pleistocene or early Holocene times, although most occupational evidence comes from the Middle Woodland period (S. Fox, 1982). The excavations at the Irvin Nelson site (32BE208) have yielded data from these later periods.

4.26 Two prehistoric occupations are represented at 32BE208:

> The earliest cultural materials from this site are of Middle Woodland cultural ascription and suggest a seasonal big game, bison, hunting focus. The Late Woodland cultural level also contained evidence of a seasonal flood procurement pattern; however, these data indicate that a wider range of seasonally available resources were exploited. Especially noteworthy is the fact that the Late Woodland inhabitants of the site made but minimal use of the bison. Both Woodland components exhibit technologies containing lithic, ceramic, and bone artifacts. Local materials were widely used in stone tool manufacture.
>
> (S. Fox, 1982)

4.27 Knowledge of the adaptations and settlement patterns of prehistoric human groups in the Devils Lake area is just beginning to be acquired. Future research into the prehistoric occupations and seasonal use patterns of the Devils Lake area will further knowledge of changes in lake levels and environmental conditions over time, and it will increase our understanding of peoples' adaptations to a unique set of environmental conditions.

4.28 The history of the Devils Lake area was also affected by the fluctuations in lake levels. Kurt Schweigert (1977, Historic Sites Cultural Resources Inventory in the Devils Lake Region, Central North Dakota Section, Garrison Diversion Unit, North Dakota, final report submitted to the Bureau of Reclamation, Billings, Montana, Contract No. 14-06-600-1575A), briefly summed up the effects with the following statement:

> The fluctuation of Devils Lake in historic times has had a large effect on the economy and settlement of the region. When the area to the north of the lake was surveyed prior to being officially opened for homesteading in 1883, Devils Lake was a series of four connected bays twenty-four miles long and up to seven miles wide. Water up to 35 feet deep covered an estimated 60,000 acres, and was surrounded by 180 miles of shoreline (Simpson 1912:140). The lake was extensive and deep enough to support a thriving steamboat operation, and several townsites were specifically located to front on the lakeshore. Between 1880 and 1910 the lake level declined about 12 feet, and commercial navigation of the lake was no longer possible. By 1940 the lake consisted of two or three isolated pools no more than three feet deep, surrounded by sterile alkaline flats. The salinity and brackishness of the lake increased as the lake receded, and by 1932 the bathing beaches were closed at the major resort on the lake (Babcock 1952: 21, 96, 104, 142). Dessication of the lake also led to the decline of the area as a waterfowl hunting resort, an industry which plays a considerable part in the local economy.

Additional Information

4.29 Additional information about existing environmental conditions is in the main report.

5.00 ENVIRONMENTAL EFFECTS

5.01 This section discusses the environmental effects of the four major embankment alternatives considered in detail (plans A, B, C, and D). None of the impacts associated with the project would be significant. The recommended alternative is plan B. Therefore, the impacts of the proposed project are discussed in more detail in the section on plan B. The discussions of other plans cover additional impacts specific to each alternative.

PLAN A

5.02 This plan involves one embankment and a pump station at the head of Creel Bay. Ponding areas would be located both north and south of the sewage lagoons. The major impacts of this plan would occur at Creel Bay and would involve aquatic organisms. These impacts at Creel Bay are included in the discussion of plan B.

5.03 Plan A was surveyed for cultural resources during September 1981. No recorded cultural resource sites are within the areas affected by this plan.

PLAN B (SELECTED PLAN)

5.04 This plan consists of a system of embankments and ponding areas as described earlier in this report. A pumping station would be located at Creel Bay.

Vegetation and Wildlife Impacts

5.05 The upland areas where the embankments would be located are dominated by grazed and ungrazed grasslands. After construction, the disturbed areas would be reseeded. Impacts of the embankment construction would be temporary and minor. The embankment on the south side of town is near the rare Illinois brundleflower, which is listed as a rare plant species in North Dakota. However, because this flower is usually found on sandy lake shorelines, it should not be affected by plan B. An estimate of land requirements is in appendix B.

5.06 Overall, wetland habitat would be maintained in the area. A wetland on the south side of town would have to be diverted to the north, however. Water levels in this wetland would not be modified because the new outlet would be at the same elevation as the existing outlet. The ponding areas are presently semi-aquatic areas that would remain as such with the project.

5.07 A 65-acre wetland west of the sewage lagoons would be preserved because of the system of dikes that surrounds it. Notches would be cut in the dike at about elevation 1428 feet so that the wetland could be periodically replenished with ponding water and so that this area could serve as additional storage. A 35-acre wetland southwest of the sewage lagoons would be drained as a result of the project. The invert elevation of the culvert at the north holding pond would be constructed to maintain a wetland with a maximum depth of 1.6 feet.

5.08 The embankment at Creel Bay would destroy some wetland habitat that would be replaced with riprap/grassed embankment. Aquatic organisms would be destroyed, but new organisms should recolonize the new habitat quickly. This portion of Creel Bay provides good spawning habitat for bass, perch, and crappie. Because the placement of fill in water during the months of May and June would be detrimental to spawning, it therefore is desirable to prohibit fill placement during this period. If practical and if no emergency conditions exist, this prohibition would be a provision in the plans and specifications.

5.09 Two borrow areas for fill material have been identified for the project. One area consists of the excavated material from two holding ponds south of the city. No impacts would result from use of this material. The other borrow area is at Creel Bay. The surface material of this crop/grass area would be removed and replaced after subsurface material is excavated. The area would then be reseeded. The impacts of using this borrow area would be minimal.

5.10 Because it is not possible to predict how high lake levels may rise, a land management plan is part of the embankment alternatives. This land management plan would regulate future developments and would help reduce potential damages. The land management plan is being developed in cooperation with the city, the State Water Commission, and the Federal Emergency Management Agency.

5.11 Future uncontrolled wetland drainage would influence runoff, fish and wildlife resources, and the capacity of the interior drainage facilities. However, most of the potential drainage areas are to the north, and it appears to be difficult to drain these areas across the railroad and Highway 2 embankments into the ponding areas. In addition, some of these wetland areas are under U.S. Fish and Wildlife Service easements, and they are therefore regulated against drainage. In any event, wetland drainage is discouraged because it has significant fish and wildlife impacts and because it influences the time, rate, and amount of water runoff.

5.12 The impacts on terrestrial and aquatic habitat and wetlands would be minor. These impacts are discussed earlier in this section.

5.13 During construction, the contractor would be required to follow good management techniques and to avoid the contamination of surface or ground water and the disturbance of or damage to fish and wildlife resources. Solid wastes would be removed from the site and disposed of properly. Chemicals would be stored at the site and removed from the work area in accordance with existing regulations. Protection of environmental resources would be a component of the plans and specifications for project construction.

Water Quality Impacts

5.14 If the ponded wastewater and interior drainage water are spread on land, this action would be compatible with the operation of the alternative. This land-spreading would help improve the water quality of Creel Bay. No health problems appear to be associated with spreading the water on land, except that livestock use would need to be controlled immediately after spreading. Depending on the amount of wastewater involved, it may not be economical to spread the water since there may not be enough suitable land available. This feature is being coordinated with the city, EPA, and State Public Health Department. No other water quality impacts are anticipated to result from the implementation of the plan.

Recreation Impacts

5.15 Construction of trails on top of the embankments at Creel Bay is being investigated. These features are being coordinated with the local sponsor and would be finalized in later planning stages if they are incorporated in the project.

5.16 The embankments would affect the aesthetic values of the area. The embankments would be revegetated after construction, but they may obstruct views in some areas, especially at Creel Bay and near homes, and therefore may be objectionable to people. The fill material borrow area near Creel Bay would be considered for beautification features such as tree plantings. These features would be compatible with project purposes and with the desires of the local sponsors.

## Social Impacts

5.17 Significant negative social impacts (in terms of public health and safety, and of public facilities and services) would be averted by the project if the lake rises to the maximum protected elevation. Protection of specific residences and businesses will be supplemental to the primary benefit of protecting the city sewage lagoon from the lake and the lake from the lagoon.

5.18 Substantial benefits also would result from preventing numerous home and business relocations from the areas that might otherwise flood. Scarce energy resources would be conserved by preventing flooding rather than moving (or abandoning) the structural investments presently in the floodplain.

## Cultural Resource Impacts

5.19 This plan was surveyed for cultural resources during September 1981. No recorded cultural resource sites are within the areas affected by this proposed plan.

5.20 All borrow areas for the proposed selected plan will be surveyed by a St. Paul District archeologist in June 1983. If any significant cultural resource sites are discovered, the St. Paul District will initiate coordination with the North Dakota State Historic Preservation Officer to develop a mitigation plan.

## Section 122 Evaluation Categories

5.21 The evaluation categories identified in Section 122 of the River and Harbor Act of 1970 (Public Law 91-611) have been evaluated. The environmental impact assessment matrix in table 3 summarizes the impacts of plan B, including the Section 122 categories. Specific impacts are discussed in the preceding paragraphs.

Table 3
Environmental Impact Assessment Matrix

| NAME OF PARAMETER | MAGNITUDE OF PROBABLE IMPACT: INCREASING BENEFICIAL IMPACT | | | | INCREASING ADVERSE IMPACT | | |
|---|---|---|---|---|---|---|---|
| | SIGNIFICANT | SUBSTANTIAL | MINOR | NO APPRECIABLE EFFECT | MINOR | SUBSTANTIAL | SIGNIFICANT |
| **A. SOCIAL EFFECTS** | | | | | | | |
| 1. Noise Levels | | | | x | | | |
| 2. Aesthetic Values | | | | x | | | |
| 3. Recreational Opportunities | | | | x | | | |
| 4. Transportation | | | x | | | | |
| 5. Public Health and Safety | | x | | | | | |
| 6. Community Cohesion (Sense of Unity) | | | | | x | | |
| 7. Community Growth and Development | | | x | | | | |
| 8. Business and Home Relocations | | x | | | | | |
| 9. Existing/Potential Land Use | | | x | | | | |
| 10. Controversy | | | | x | | | |
| **B. ECONOMIC EFFECTS** | | | | | | | |
| 1. Property Values | | | | x | | | |
| 2. Tax Revenues | | | | x | | | |
| 3. Public Facilities and Services | | x | | | | | |
| 4. Regional Growth | | | | x | | | |
| 5. Employment | | | | x | | | |
| 6. Business Activity | | | | x | | | |
| 7. Farmland/Food Supply | | | | x | | | |
| 8. Commercial Navigation | | | | N/A | | | |
| 9. Flooding Effects | | x | | | | | |
| 10. Energy Needs and Resources | | | | x | | | |
| **C. NATURAL RESOURCE EFFECTS** | | | | | | | |
| 1. Air Quality | | | | x | | | |
| 2. Terrestrial Habitat | | | | x | | | |
| 3. Wetlands | | | | x | | | |
| 4. Aquatic Habitat | | | | | x | | |
| 5. Habitat Diversity and Interspersion | | | | x | | | |
| 6. Biological Productivity | | | | x | | | |
| 7. Surface Water Quality | | | | x | | | |
| 8. Water Supply | | | | x | | | |
| 9. Groundwater | | | | x | | | |
| 10. Soils | | | | x | | | |
| 11. Threatened or Endangered Species | | | | x | | | |
| **D. CULTURAL EFFECTS** | | | | | | | |
| 1. Historic Architectural Values | | | | x | | | |
| 2. Prehistoric and Historic Archaeological Values | | | | x | | | |

Compliance with Environmental Regulations

5.22 Public Law 96-159, Endangered Species Act of 1973, as Amended - In compliance with the Endangered Species Act, the St. Paul District, Corps of Engineers, has conducted coordination with the U.S. Fish and Wildlife Service to determine if any species on the Federal list of endangered or threatened species are in the study area and if the proposed plan could have any impact on endangered or threatened species. The Fish and Wildlife Service identified the peregrine falcon and the bald eagle, two listed species, as being in the project area. The recommended plan components would have no adverse effects on the continued existence or critical habitat of either species. (See appendix I for the endangered species correspondence).

5.23 Executive Order 11990, Protection of Wetlands, May 24, 1977 - The Devils Lake basin is in the "Prairie Pothole Region." The basin is considered significant waterfowl production habitat for the North American continent. Because of this significance, the protection and enhancement of wetlands is an important consideration. The development of alternatives tried to maintain and improve wetland habitat as much as practical.

5.24 Various features of the recommended plan would affect wetlands. However, existing habitat would be maintained or improved as much as possible, and the wetland impacts are not considered signficant.

5.25 The recommended plan is considered the most responsive to wetlands protection and enhancement. It would not result in unacceptable impacts on the environment or wetlands and therefore is considered to comply with the executive order on wetland protection.

5.26 Executive Order 11988, Floodplain Management, May 24, 1977 - The city of Devils Lake and Creel Township presently participate in the Federal Flood Insurance Program. Although a 100-year floodplain elevation is not known for this closed drainage area, the city is working with the Corps and the State Water Commission to set an arbitrary elevation that will apply to revised zoning ordinances. The intent of this effort is to comply with Executive Order 11988, as far as possible, within the limitations imposed by the uncertainty about the floodplain.

5.27 Executive Memorandum, Analysis of Impacts on Prime and Unique Farmlands, Council on Environmental Quality Memorandum, August 30, 1976 - Much of the Devils Lake basin, including the floodplain and upland areas, is classified as prime farmland. Portions of the embankments would be built in areas designated as prime farmland. However, the commitment of prime farmland to the construction of flood damage reduction structures is considered an acceptable tradeoff and use of the resource.

5.28 Clean Water Act, as Amended (33 USC 1251, et seq.), Section 404, 1977 (Public Law 95-217) - Placement of fill in the waters of Devils Lake is authorized under the Corps of Engineers nationwide permit program because Devils Lake is a closed basin and is not part of a surface tributary to interstate waters (33 CFR 330.4, Federal Register, July 22, 1982, Vol. 47, No. 141).

5.29 The special conditions of the nationwide permit will be met, and the best management practices will be followed as far as practical. The special conditions and best management practices are summarized below (33 CFR 330.5 and 330.6).

5.30 The following special conditions will be met:

1. Discharge will not occur near a public water supply intake.

2. Discharge will not occur in a shellfish harvesting area.

3. Discharge will not jeopardize a threatened or endangered species listed under the Endangered Species Act.

4. Discharge will not significantly disrupt the movement of aquatic life.

5. Discharge material will be free of toxic materials in toxic amounts.

6. Any fill will be properly maintained.

7. Activity will not occur in a component of the National Wild and Scenic River System.

8. Activity will not cause an unacceptable interference with navigation.

5.31 The following best management practices would be followed to the maximum extent practicable:

1. Discharge into waters shall be minimized.

2. Discharge in spawning areas during spawning seasons shall be avoided.

3. Discharge shall not restrict movement of aquatic species.

4. Adverse impacts on aquatic systems shall be minimized.

5. Discharge in wetlands shall be avoided.

6. Equipment working in wetlands shall be placed on mats.

7. Discharge into breeding areas for migrating waterfowl shall be avoided.

8. Temporary fills shall be removed.

5.32 Because the special conditions and best management practices listed above will be followed, as required by the nationwide permit program, a Section 404(b)(1) evaluation and State certification are not required for this project.

Fish and Wildlife Coordination Act

5.33 The Bismarck Field Office of the U.S. Fish and Wildlife Service believes that the selected plan has merit, and they have no major objections to its implementation. Their Coordination Act Report makes a number of recommendations. The complete text of this report is in appendix I of the detailed project report. A summary of the recommendations and the method of incorporating them into the selected plan is presented in appendix I and the main report.

PLAN C

5.34 This plan is similar to plan B except that plan C provides flood protection to elevation 1445 msl and therefore requires higher and longer embankments.

5.35 The impacts of plan C are basically the same as those of plan B, although with some additional impacts. The embankment south of town would require clearing some natural woodlands that may require mitigation. The embankment at Creel Bay would be one continuous structure passing through two wetland areas. The impacts on a wetland south of Creel Bay could be minimized by placing new outlet structures at existing outlet elevations. The west end of the control structure would pass through a wetland regulated by a U.S. Fish and Wildlife Service easement. Because use of this wetland is controlled by Federal law, mitigation (which could include replacement or structural modification) would be required.

5.36 Aesthetic impacts associated with plan C would be greater than those of plan B because of the increased size of the embankments.

5.37 Plan C has not been surveyed for cultural resources because it was introduced as an alternative after the initial survey work was completed. Since plan C is not considered feasible, further cultural resources work is unnecessary.

PLAN D

5.38 This plan is similar to plans B and C, except that plan D protects to an elevation of 1450 feet msl. This level of protection would require almost continuous embankments west and south of the city. An additional pump station and ponding area would be required at the south embankment.

5.39 The impacts of plan D are similar to those of plans B and C, but it would have some additional impacts. The second pump station and ponding area would change the existing vegetative cover to a more hydric (wet) composition. The type of vegetation would depend on the frequency and duration of water storage in the ponding area.

5.40 The additional embankments would affect both upland and lowland habitats. Aesthetic impacts would also increase because of the larger size of the embankments.

5.41 This alternative was not evaluated in detail because it was not seriously considered in stage 3 planning.

5.42 Like plan C, plan D has not been surveyed for cultural resources because it was introduced as an alternative after the initial survey work was completed. Since plan D is not considered feasible, future cultural resources work is unnecessary.

NATIONAL ECONOMIC DEVELOPMENT AND ENVIRONMENTAL QUALITY PLANS

5.43 The national economic development (NED) plan is the plan that has the greatest net economic benefits. Of the alternatives considered, plan B (which provides flood protection to a lake elevation of 1440 feet msl) would have the maximum benefits.

5.44 The environmental quality (EQ) plan is the alternative that makes the greatest net environmental contribution. Plans A through D are basically similar and have increasing impacts as the level of flood protection increases. Both plans C and D would adversely affect a U.S. Fish and Wildlife wetland easement; and, in general, these two plans have greater impacts on both aquatic and terrestrial resources. Plan A has the least environmental impact, but plan B includes measures to maintain wetlands, to reseed disturbed areas, to develop a land management plan, to discourage wetland rainage, and to provide for the possible land-spreading of interior drainage and sewage water. Therefore, plan B is designated the least environmentally damaging plan.

## 6.00 PUBLIC INVOLVEMENT

6.01 The St. Paul District, Corps of Engineers, has coordinated the proposed Devils Lake Section 205 flood control project with the U.S. Fish and Wildlife Service, U.S. Soil Conservation Service, U.S. Environmental Protection Agency, North Dakota Public Health Department, North Dakota Game and Fish Department, North Dakota State Water Commission, National Park Service, North Dakota Historic Preservation Office, North Dakota State Archaeologist, and other interested agencies and individuals. No significant project-related issues have been identified to date.

6.02 The draft assessment and detailed project report will be distributed to concerned agencies and the interested public for review and comment. All comments received during this review period were considered during the preparation of the final report.

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX A

ECONOMIC BENEFITS

APPENDIX A

ECONOMIC BENEFITS

FLOOD THREAT

The rising water levels in Devils Lake have created a serious flood threat to the city of Devils Lake, North Dakota. The lake fell from about 1446 feet msl (feet above mean sea level) in the year 1830 to elevation 1401 feet in the year 1940. Since the year 1940, the lake has risen in an irregular sawtooth manner to elevation 1428 feet in 1983. As discussed in the main report, there is evidence the lake has varied from nearly dry to about 1457 feet during the last several thousand years. The elevation of the natural outlet through East Devils Lake, Stump Lake, and Tolna Coulee to the Sheyenne River is 1457.1 feet (Bureau of Reclamation data).

Much of the development from 1940 through the 1970's took place on the former lakebed that became available when the water levels declined during the first half of this century. This land was flat, inexpensive, and easily developed. It was also made easily accessible by the construction of new and improved highways. There is a substantial amount of this newer development, and it would be threatened first by the rising lake levels. Much of the older development lies near or above the elevation of the natural outlet of the lake and is therefore not threatened by flooding. However, before the natural outlet elevation would be reached, access to the older parts of the city would be cut off. The Soo Line and Burlington Northern Railroad tracks and the major roads entering the city would be inundated by water levels less than the outlet elevation.

## FUTURE LAKE LEVELS

The long-term rise and fall of the lake is not well understood. Some of the possible causes include long-term changes in climate, changes in land use, drainage, and ground-water effects.

Significant evidence indicates long-term changes in climate between warm, dry periods and cool, wet periods. When the lake is below the elevation of its natural outlet, changes in climate could cause the lake level to fluctuate. Analysis of sediment samples indicate the lake has gone through several high/low water cycles in the last 6,000 years. Analysis of beach strands, cultural artifacts, and tree stumps confirms these cycles for the last 2,000 years. Evidence indicates the lake has varied from dry to between elevations 1455 and 1460 feet. This theory is consistent with the hypothesis that long-term changes in climate caused a period of frequent floods on the Red River of the North in the early 1800's, a period of infrequent floods, and then the more frequent floods in recent years.

Another possible cause for the fluctuations in lake levels is the change in land use. Much of the land was changed from prairie to cultivated land with the settlement of the late 1800's and early 1900's. Some of the land has been drained in connection with the change of land use. These changes would result in an increased run-off rate and quantity, which in turn would contribute to a rise in lake levels. Although changes in land use may be a contributing cause, it is probably not the principal cause. Changes in ground-water levels are probably another indicator of the factors causing the lake level to change rather than a cause of the lake-level changes. The geology of the area is not appropriate for the transfer of significant amounts of water into or out of the Devils Lake basin.

Because the cause of the fluctuating lake levels is not well understood and because the period of record for meteorological and hydrological data is very limited compared to the length of the trends for changing lake levels, a stage/frequency relationship is discussed in appendix D. Because this relationship could not be developed, the traditional benefit-cost ratio analysis that uses discharge or stage frequency-damage relationships was precluded.

## ECONOMIC FEASIBILITY

There is no certainty that the lake will continue to rise. However, it has risen to much higher elevations several times before. Standard project flood inflow to the lake would cause the lake to rise about 18 feet above its present elevation (see appendix D). Since the economic damages that would result from higher lake levels are significantly greater than the cost of constructing flood control measures to these levels, it appears prudent to construct the measures.

In order to increase the understanding of the economic feasibility of implementing flood control measures, economic data were collected and analyzed in terms of three scenarios for future lake levels.

This analysis shows the sensitivity of the economic feasibility to the rate of increase of the lake levels. It also shows the economic feasibility of the plans relevant to each other and is an aid for selection of a recommended plan.

An inventory of all property by 5-foot increments from elevation 1426 feet msl up to elevation 1455 feet was developed. The inventory was broken down by residential urban and non-farm rural, commercial urban and non-farm rural, and public damages. The following assumptions were made:

1. The cost of moving household goods from the residential structures in imminent danger of flooding was not included.

2. The cost of demolishing or moving abandoned structures would be offset by their salvage value.

3. The value of the land for the non-farm rural residential and commercial structures was not included.

4. The value of the land for the mobile home parks was included in the value of the commercial mobile home parks. However, not all mobile homes are located in these parks. The cost to move a mobile home was assumed to be $1,000.

5. The loss of business, loss of non-removable equipment, and moving expenses for commercial properties are for the surveyed properties only. About 64 percent of the commercial properties were surveyed.

6. Once the water level reaches the first-floor elevation of the structure, the structure and land would no longer have utility.

7. The October 1981 values were updated to October 1982 values based on the ENR building cost index.

8. Flood damages would begin at elevation 1429 feet and continue to elevation 1455 feet. The natural outlet of the hain of lakes to the Sheyenne River is at about elevation 1457 feet.

Assumptions 1, 3, 4, 5, and 6 result in conservative damage figures and were made because of lack of data. Assumptions 2, 7, and 8 represent our best estimate and are at an appropriate level of detail for the purposes of this analysis. Additional economic data collection and analysis could reduce the number of assumptions. However, this additional effort would not be cost-effective. Table A-1 and figure A-1 are summaries of flood damage data. Table A-2 lists public and commercial properties at or below elevation 1440.

Table A-1 Summary of Damages
October 82 ($1,000's)

| | Elevation less than 1429.9 No. of Structures | Damage | Elevation 1430-1434.9 No. of Structures | Damage | Elevation 1435-1439.9 No. of Structures | Damage | Elevation 1440-1444.9 No. of Structures | Damage | Elevation 1445-1449.9 No. of Structures | Damage | Elevation 1450-1454.9 No. of Structures | Damage |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Residential**[1] | | | | | | | | | | | | |
| Urban | | | | | | | | | | | | |
| House, structure | | 0 | | | 16 | 215.6 | 32 | 755.7 | 96 | 1732.7 | 21 | 470.2 |
| House, land | | 0 | | | | 75.3 | | 297.3 | | 339.7 | | 85.0 |
| Mobile homes[2] | | 0 | | | 10 | 10.9 | 39 | 42.5 | 77 | 77.3 | 11 | 12.0 |
| Total | | 0 | | | | 301.8 | | 1095.7 | | 2149.7 | | 567.2 |
| Rural | | | | | | | | | | | | |
| House, structure | | 0 | 2 | 40.7 | [illegible] | 313.4 | 33 | 1329.7 | 47 | 1708.5 | 16 | 648.1 |
| House, land[3] | | 0 | | | | | | | | | | |
| Mobile homes[2] | | 0 | | | | | | | | 6.5 | | |
| Total | | 0 | | 40.7 | | 313.4 | | 1329.7 | | 1715.0 | | 648.1 |
| Residential total | | 0 | | 40.7 | | 615.2 | | 2425.4 | | 3864.5 | | 1215.3 |
| Cumulative total | | 0 | | 40.7 | | 655.9 | | 3081.3 | | 6945.8 | | 8161.1 |
| **Commercial** | | | | | | | | | | | | |
| Urban | | | | | | | | | | | | |
| Structure | 4 | 1111.3 | 25 | 9137.5 | 17 | 1809.9 | 28 | 3993.5 | 30 | 1709.0 | 1 | 16.0 |
| Loss of business[4] | | 82.1 | | 1823.0 | | 16.9 | | | | 98.1 | | |
| Loss of nonremovables[4] | | 0 | | 440.4 | | 35.5 | | 37.3 | | 10.9 | | |
| Moving expenses[4] | | 76.3 | | 1990.9 | | 6.5 | | 119.9 | | 70.9 | | |
| Total | | 1269.7 | | 13,391.8 | | 1868.3 | | 4150.7 | | 1888.9 | | 16.0 |
| Rural | | | | | | | | | | | | |
| Structure | 1 | 130.7 | 2 | 422.4 | | | 5 | 825.4 | 6 | 436.7 | 1 | 62.6 |
| Loss of business[4] | | | | | | | | | | | | |
| Loss of nonremovables[4] | | | | | | | | | | | | |
| Moving expenses[4] | | | | | | | | | | | | |
| Total | | 130.7 | | 422.4 | | | | 825.4 | | 436.7 | | 62.6 |
| Commercial total | | 1400.4 | | 13,814.2 | | 1868.3 | | 4976.1 | | 2325.6 | | 78.6 |
| Cumulative total | | 1400.4 | | 15,214.6 | | 17,082.9 | | 22,059.0 | | 24,384.6 | | 24,463.2 |
| **Public** | | | | | | | | | | | | |
| Public damages total | 1 | 937.4 | 2 | 2507.0 | 8 | 4888.7 | 3 | 18,889.7 | 1 | 5777.0 | 2 | 10,518.5 |
| Cumulative total | | 937.4 | | 3444.4 | | 8333.1 | | 27,222.8 | | 32,999.8 | | 43,518.3 |
| **Employees affected** | 40 FT/22 PT | | 270 FT/163 PT | | 98 FT/15 PT | | 169 FT/83 PT | | 97 FT/50 PT | | 4 FT/1 PT | |
| **Total 5-foot increments** | | 2337.8 | | 16,361.9 | | 7372.2 | | 26,291.2 | | 11,967.1 | | 11,812.4 |
| **Cumulative total** | | 2337.8 | | 18,699.7 | | 26,071.9 | | 52,363.1 | | 64,330.2 | | 76,142.6 |

[1] Cost of moving household goods from the abandoned structures is not included. It was assumed the cost of demolishing abandoned structures would be approximately equal to the salvage value of the residential and commercial structure.

[2] Land for mobile homes was assumed to be included in the value of commercial mobile home parks. Based on $1,000 cost to move mobile home.

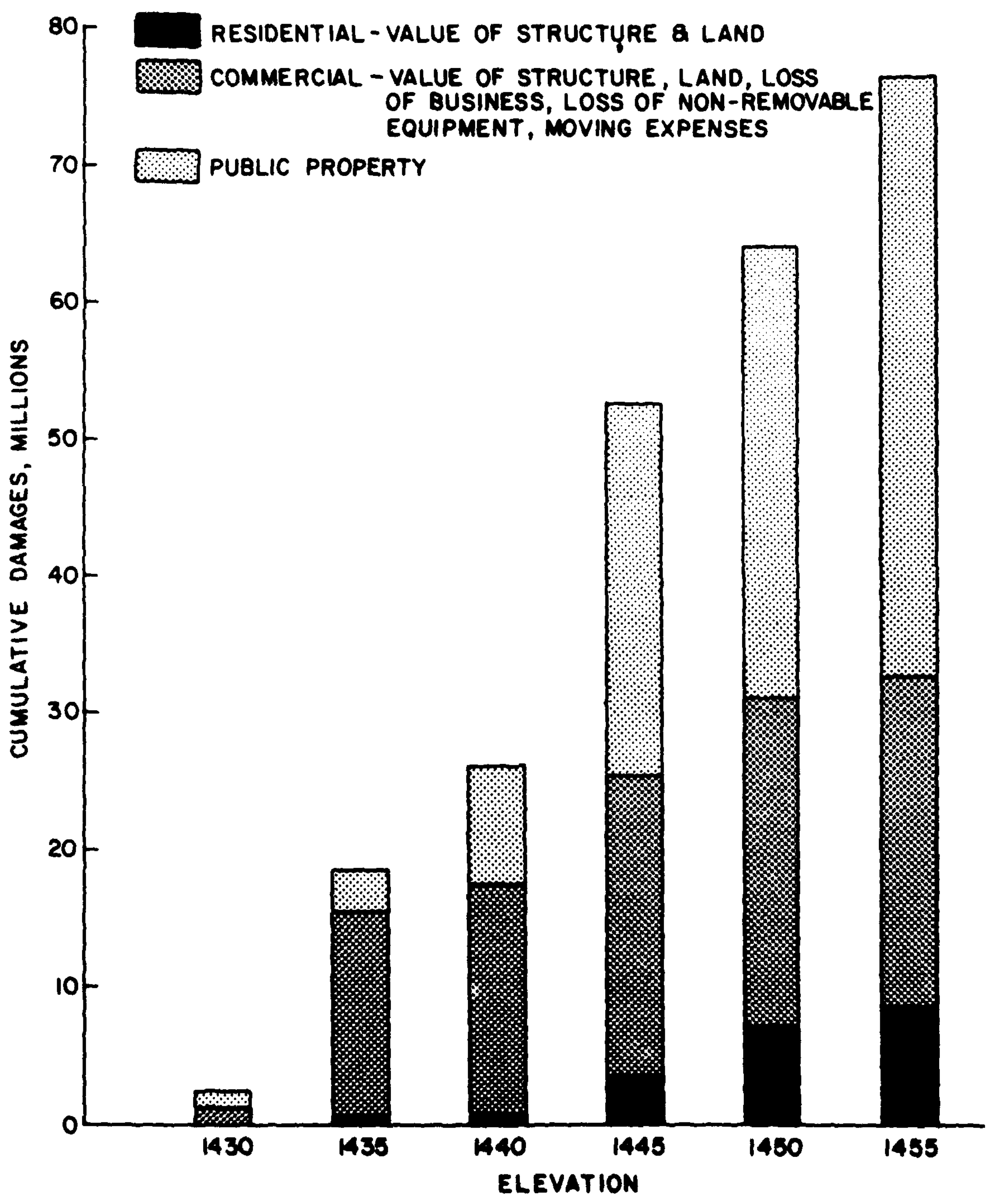
[3] Land value for rural houses was not available and therefore not included.

[4] Loss of business, loss of nonremovable equipment, and moving expense categories are for the 64 percent of the commercial property surveyed. These categories were not broken down by urban and non-farm rural.

Three scenarios of future lake levels were developed. Scenario 1 is an extrapolation of the approximate peaks on the stage hydrograph from 1940 to 1980. Scenario 2 in an extrapolation of the approximate means for this period, and scenario 3 is an extrapolation of the approximate troughs for this period. Figure A-2 shows these scenarios superimposed on the stage hydrograph for the lake. It was assumed that the damages for each 5-foot increment are uniformly distributed over that increment. For example, if it took 10 years for the lake to rise 5 feet, 10 percent of the total damages for the 5-foot rise would occur each year. The present value of the damages associated with each year's rise in lake level above the previous year's level was calculated and accumulated for each scenario. Sample calculations are shown on page A-10.

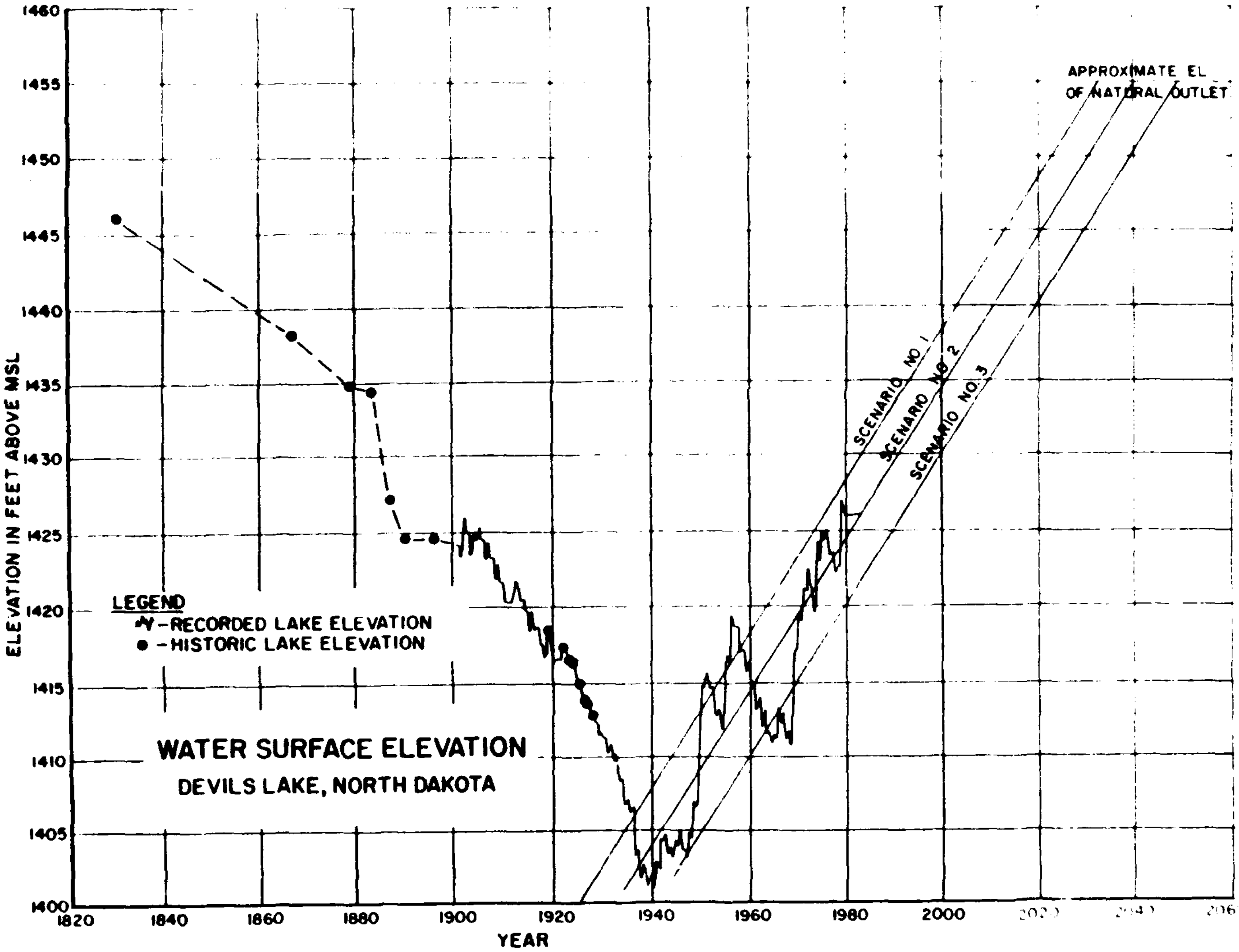
Table A-2 - Public and Commercial Properties

| Elevation | Commercial | Public |
|---|---|---|
| Less than 1430 | Auto Sales & services | Sewage Treatment Plant |
| | Grocery & gas | |
| | Auto body shop | |
| | Farm implementation sales and service | |
| 1430 to 1434.9 | Shopping center | Human Services Center |
| | Cafe/gas/trailer, truck rentals | Legal Assistance of North Dakota |
| | Lodging | Ramsey County Farm Bureau |
| | Apartments | Lake Region Law Enforcement |
| | Apartments | |
| | Apartments | |
| | Financial services | |
| | Fast food | |
| | Food and beverage | |
| | Insurance | |
| | Realty | |
| | Insurance | |
| | Construction/contractor | |
| | Retail | |
| | Food and beverage | |
| | Variety | |
| | Stereo/records | |
| | Food | |
| | Interior decorator | |
| | Grocery | |
| | Dry cleaning | |
| | Clothes | |
| | Barber services | |
| | Beautician services | |
| | Fast food | |
| | Fast food & restaurant | |
| | Clothes & western accessories | |
| | Gas & variety | |
| | Wholesale grocer | |
| | Gas sales & service | |
| | Liquor sales & tavern | |
| | Lumber, hardware and household fixtures | |
| | Sports equipment, snowmobiles | |
| | Truck, trailer, van rentals | |
| 1435 to 1440 | Gas sales & service | Sewer Department |
| | Office | Water Department |
| | Farm building construction | Street Department |
| | Financial services | USDA offices: ASCS, FCIC, North Central Planning, Farm Mgmt Assoc. |
| | Site management & rentals | Devils Lake Wetlands |
| | Bottling company | N. Dakota Employment Service |
| | Hardware | Devils Lake Motor Vehicle Bureau |
| | Auto sales & service | Devils Lake Rural Fire Department |
| | Food & transportation | Federal Land Bank Association |
| | Auto sales & service | |
| | Construction | |
| | Metal working | |
| | Construction | |
| | Auto parts sales | |
| | Grocery | |
| | Meat & deli | |
| | Electric utility | |




DEVILS LAKE 205
NED BENEFITS

FIGURE A-1


APPROXIMATE EL
OF NATURAL OUTLET
SCENARIO NO. 1
SCENARIO NO. 2
SCENARIO NO. 3
LEGEND
-RECORDED LAKE ELEVATION
-HISTORIC LAKE ELEVATION
WATER SURFACE ELEVATION
DEVILS LAKE, NORTH DAKOTA
ELEVATION IN FEET ABOVE MSL
YEAR
1460
1455
1450
1445
1440
1435
1430
1425
1420
1415
1410
1405
1400
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000

According to scenario 1, the water surface would be at elevation 1430 feet in the year 1983. Since damages begin at elevation 1429 feet and the project would not be completed until 1984, it was assumed that existing or somewhat improved emergency protection measures would protect the threatened property until the project is completed. The lake would rise from elevation 1430 feet in the year 1983 to elevation 1455 feet in 2033 in a linear manner. Figure A-3 shows the calculation of damage if the lake rises according to scenario 1.

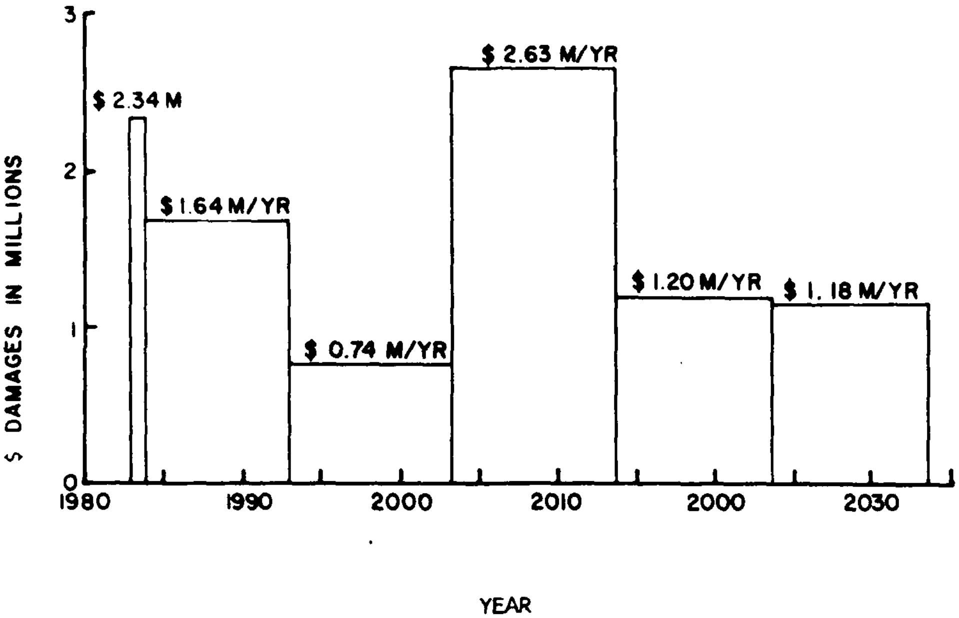
According to scenario 2, the lake would rise from elevation 1430 feet in the year 1991 to elevation 1455 in 2041. Figure A-4 shows the calculation of damages for scenario 2.

According to scenario 3, the lake would rise from elevation 1430 feet in the year 2000 to elevation 1455 in 2050. Figure A-5 shows the calculation of damages for scenario 3.

Table A-2 is a summary of the damages that would occur according to these three scenarios.

These scenarios show that constructing structural measures to protect the city would be economically feasible for a wide range in the rate of future lake level increases. Past lake levels and the standard project flood analysis indicate that these scenarios are reasonable expectations, although probabilities of their occurrence could not be calculated.

There would be no residual damages if the lake does not rise above the level of protection provided by the project. In the event that it appears the lake will rise above the level of protection, local or Federal governments probably would take action to prevent overtopping and the associated residual damages. The most probable alternatives would be construction of an outlet for the lake or (using the project levee as a base) construction of a higher levee. The lake would rise gradually over an extended period, allowing time to implement either alternative.




| PLAN | | A | B | C | D |
|---|---|---|---|---|---|
| ELEVATION | 1430 | 1435 | 1440 | 1445 | 1450 |
| YEAR | 1983 | 1993 | 2003 | 2013 | 2023 |
| CUM. P.V. DAMAGES | $ 2.17M | 12.57 | 14.82 | 18.66 | 19.50 |
| COST | — | $ 1.53M | 2.81 | 5.10 | 8.80 |
| B/C RATIO | — | 8.22 | 5.27 | 3.66 | 2.22 |

FOR AN INTEREST RATE OF 7-5/8%, COMPOUNDED ANNUALLY, BASE YEAR 1982.

DEVILS LAKE
SCENARIO NO. 1
DAMAGE DISTRIBUTION

FIGURE A-3

Table A-3

Sample Calculation, Cumulative Present Value Of Damages, Scenario 1

Year: 1983

Elevation: 1430 feet msl

Damages, el. 1426 to 1430: $2.34M (from table A-1)

Time increment: 1 year (years beyond base year at 1982)

Damages/year during this year: $2.34M/year

Present value of damages during this increment: $2.17M

Cumulative present value of damages: $2.17M

Year: 1993

Elevation: 1435

Damages, el. 1430 to 1435: $16.4M (from table A-1)

Time increment: 10 years (years to rise from 1430 to 1435)

Damages/year during this increment: $1.64M/year

Present value of damages during this increment: $10.40M

Cumulative present value of damages: $2.17M + $10.40 = $12.57M

Year: 2003

Elevation: 1440

Damages, el. 1435 to 1440: $7.37M

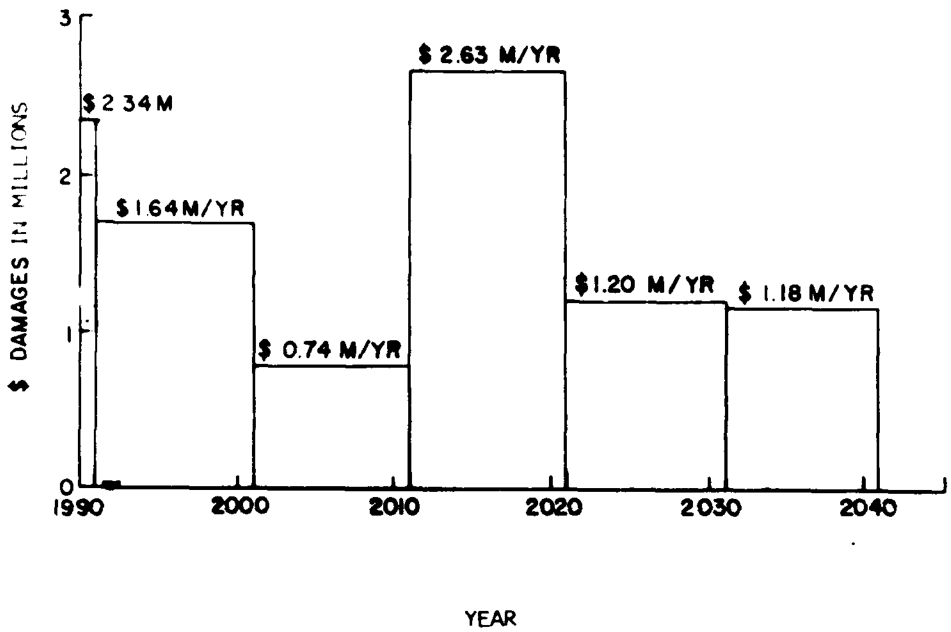
Time increment: 10 years (years to rise from 1435 to 1440)

Damages/year during this increment: $7.37M/10 years = $0.74M/year

Present value of damages during this increment: $2.25M

Cumulative present value of damages: $12.57M + $2.25M = $14.82M

M = million.

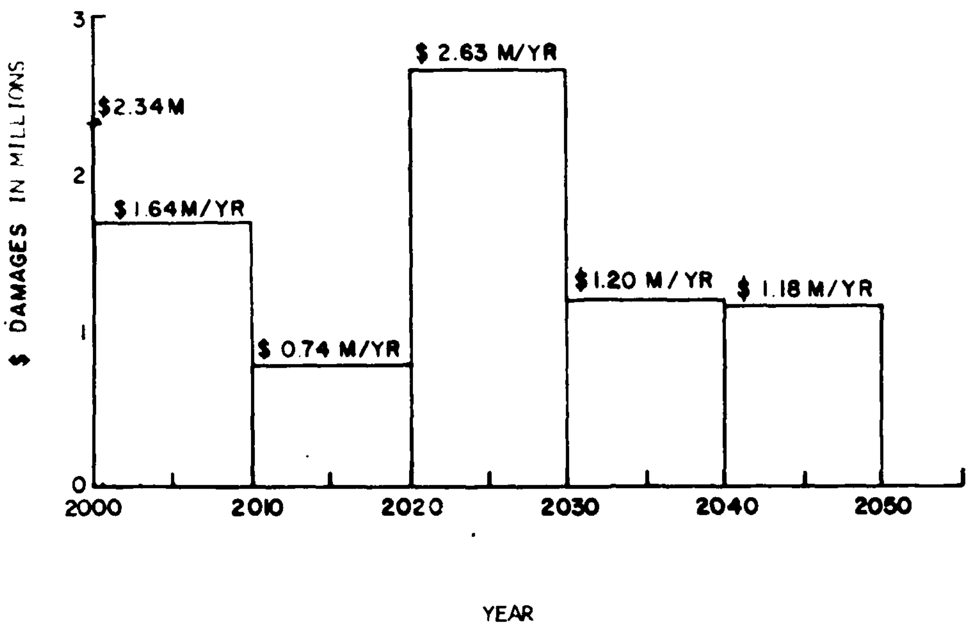



| PLAN | | A | B | C | D |
|---|---|---|---|---|---|
| ELEVATION | 1430 | 1435 | 1440 | 1445 | 1450 |
| YEAR | 1991 | 2001 | 2011 | 2021 | 2031 |
| CUM. P.V. DAMAGES | 1.21 | 6.99 | 8.24 | 10.37 | 10.84 |
| COST | — | $1.53M | 2.81 | 5.10 | 8.80 |
| B/C RATIO | — | 4.57 | 2.93 | 2.03 | 1.23 |

FOR AN INTEREST RATE OF 7-5/8%, COMPOUNDED ANNUALLY, BASE YEAR 1982.

**DEVILS LAKE**
**SCENARIO NO.2**
**DAMAGE DISTRIBUTION**

FIGURE A-4




| PLAN | | A | B | C | D |
|---|---|---|---|---|---|
| ELEVATION | 1430 | 1435 | 1440 | 1445 | 1450 |
| YEAR | 2000 | 2010 | 2020 | 2030 | 2040 |
| CUM. PV. DAMAGES | $0.62 M | 3.60 | 4.25 | 5.35 | 5.59 |
| COST | – | $1.53M | 2.81 | 5.10 | 8.80 |
| B/C RATIO | – | 2.35 | 1.51 | 1.05 | 0.64 |

FOR AN INTEREST RATE OF 7-5/8%, COMPOUNDED ANNUALLY, BASE YEAR 1982.

**DEVILS LAKE**
**SCENARIO NO. 3**
**DAMAGE DISTRIBUTION**



FIGURE A-5

Table A-4
Summary of Present Value of
Future Damages/Benefit to Cost Ratio
(In millions of dollars)

| Elevation | Plan | Scenario 1 | Scenario 2 | Scenario 3 |
|---|---|---|---|---|
| 1435 | A | 12.57/8.22 | 6.99/4.57 | 3.60/2.35 |
| 1440 | B | 14.82/5.27 | 8.24/2.93 | 4.25/1.51 |
| 1445 | C | 18.66/3.66 | 10.37/2.03 | 5.35/1.05 |
| 1450 | D | 19.50/2.22 | 10.84/1.23 | 5.59/0.64 |

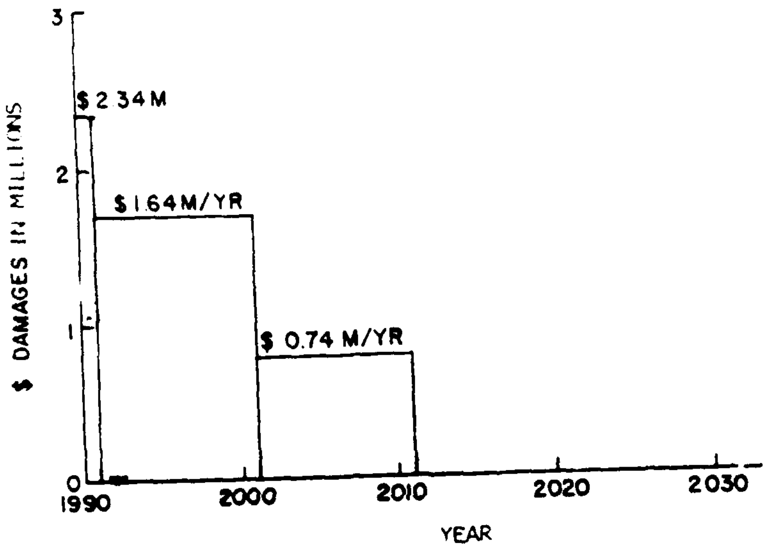
UPDATED ECONOMIC DATA
FOR THE RECOMMENDED PLAN

Table A-5 shows the updated benefits and costs and the calculations for the updated benefits of the recommended plan (plan B).

Table A-5
Updated Economic Data For
The Recommended Plan

Benefits

The following graph shows the damages for scenario 2, plan B (design water surface elevation of 1440 feet msl), 7-7/8 percent interest rate compounded annually, base year 1984.




| | | | |
|---|---|---|---|
| Elevation | 1430 | 1435 | 1440 |
| Year | 1991 | 2001 | 2011 |
| Present Value of Damages | $1.38M | $7.02M | $1.48M |
| Accumulative Present Value of Damages | $1.38M | $8.40M | $9.88M |

Costs

Updated costs are converted from May 1983 to October 1982 levels using ENR construction index (0.9566 factor).

| | | |
|---|---|---|
| May 1983 | Cost | $1,973,000 |
| October 1982 | Cost | $1,887,000 |

Calculations For Updated Benefits

1. Year: 1991

   Elevation: 1430

   Damages, elevation 1426 to 1430: $2.34M (from table A-1, Oct. 82 values)

   Present value of damages during this increment: Assumes damages occur in 1991, 7 years after project would be completed in the base year (1984).

$$P = \frac{A}{(1+i)^n} = \frac{2.34M}{(1.07875)^7} = \$1.38M$$

2. Year: 2001

Elevation: 1435

Damages, elevation 1430 to 1435: $16.4M (from table A-1, Oct. 82 values)

This increment: 10 years (years to rise from 1430 to 1435)

Damages/year during this increment: $1.64M/year

Present value of damages during this increment:

| Year | Amount | Years Past 1984 | Present Value |
|---|---|---|---|
| 1991 | $1.64M | 7 | $0.965M |
| 1992 | 1.64 | 8 | 0.894 |
| 1993 | 1.64 | 9 | 0.829 |
| 1994 | 1.64 | 10 | 0.768 |
| 1995 | 1.64 | 11 | 0.712 |
| 1996 | 1.64 | 12 | 0.660 |
| 1997 | 1.64 | 13 | 0.612 |
| 1998 | 1.64 | 14 | 0.567 |
| 1999 | 1.64 | 15 | 0.526 |
| 2000 | 1.64 | 16 | 0.488 |

Present value of damages = $7.021M

$$P = \frac{\$1.64M}{(1.07875)^n}$$

3. Year: 2011

Elevation: 1440

Damages, elevation 1435 to 1440: $7.4M (from table A-1, Oct. 82 values)

Time increment: 10 years (years to rise from 1435 to 1440)

Damages/year during this increment: $0.74M

Present value of damages during this increment:

| Year | Amount | Years Past 1984 | Present Value |
|---|---|---|---|
| 2001 | $0.74M | 17 | $0.204M |
| 2002 | 0.74 | 18 | 0.189 |
| 2003 | 0.74 | 19 | 0.175 |
| 2004 | 0.74 | 20 | 0.162 |
| 2005 | 0.74 | 21 | 0.151 |
| 2006 | 0.74 | 22 | 0.140 |
| 2007 | 0.74 | 23 | 0.129 |
| 2008 | 0.74 | 24 | 0.120 |
| 2009 | 0.74 | 25 | 0.111 |
| 2010 | 0.74 | 26 | 0.103 |

Present value of damages = $1.484M

$$P = \frac{\$0.74M}{(1.07875)^n}$$

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX B

COST ESTIMATES

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX B

COST ESTIMATES

TABLE OF CONTENTS

PRELIMINARY COST ESTIMATES
FOR ALTERNATIVE PLANS

DEVILS LAKE, NORTH DAKOTA, FLOOD CONTROL PROJECT,
MARCH 1982 PRICE LEVELS

Plan A, Design Water Surface Elevation 1435 Feet

| | |
|---|---|
| Embankment | $335,000 |
| Channels | 4,000 |
| Pumping Plant | 951,000 |
| Engineering and Design | 158,000 |
| Supervision and Administration | 91,000 |
| Real Estate | 61,000 |
| | 1,600,000 |

Plan B, Design Water Surface Elevation 1440 Feet

| | |
|---|---|
| Embankment | $1,307,000 |
| Channels | 4,000 |
| Pumping Plant | 951,000 |
| Engineering and Design | 249,000 |
| Supervision and Administration | 162,000 |
| Real Estate | 134,000 |
| | 2,807,000(1) |

Plan C, Design Water Surface Elevation 1445 Feet

| | |
|---|---|
| Embankment | $3,263,000 |
| Channels | 4,000 |
| Pumping Plant | 951,000 |
| Engineering and Design | 401,000 |
| Supervision and Administration | 290,000 |
| Real Estate | 188,000 |
| | 5,097,000 |

(1) This plan was recommended for construction. In the last stage of planning, the plan was refined, and a more detailed, revised cost estimate was prepared.

# DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

NCDRE-S

Preliminary Real Estate Cost Estimate, Section 205 Flood Control Study at Devils Lake, ND

XX THRU: NCDRE-S (Ditch)
TO: NCSED-PB (Fosberg)

FROM: NCDRE-S

DATE: 12 March 1982
ZOOK/1j1/7041

1. This is in response to your request of 5 February 1982 concerning real estate cost estimates on the above subject project. The following assumptions were made in determining the estimated right-of-way costs: 1) estimated dam/levee width of 100 feet; 2) the easterly ponding area would encompass approximately 75± acres; 3) the State has legal title to riparian lands necessary for the north and south ponding areas and any development on the riparian lands would be above the necessary ponding level.

2. Based on the maps and data furnished by you, the estimated right-of-way costs of acquisition are: $61,000 for top of dam 1440; $134,000 for top of dam 1445; $188,000 for top of dam 1450; and, $376,000 for top of dam 1455.

3. A breakdown of estimated costs is as follows:

| Top of Dam Elevation | 1440 | 1445 | 1450 | 1455 |
|---|---|---|---|---|
| Value of Part Taken and Severance | $50,500 | $111,900 | $156,400 | $313,450 |
| 20% Contingency | $10,100 | $ 22,380 | 31,280 | 62,690 |
| Total | $60,600 | $134,280 | $187,680 | $376,140 |
| Call | $61,000 | $134,000 | $188,000 | $376,000 |

4. These estimates are based on the need to acquire in fee or perpetual easement the following acreage:

| Top of Dam | 1440 | 1445 | 1450 | 1455 |
|---|---|---|---|---|
| Levee/Dam | 4.25± | 22.6± | 51.3± | 72.9± |
| Ponding | 220± | 220± | 220± | 295± |
| Total Acreage | 224.25± | 242.6± | 271.3± | 367.9± |

No structures are to be acquired or relocated.

5. The above estimates include no estimated costs for administrative, relocation of public roads, streets or highways, railroads, pipelines, or public utilities.

MICHAEL C. ZOOK
Staff Appraiser

cf: Jack Gordon

DA FORM 2496

DEVILS LAKE, N.D.
205 REPORT - SUMMARY OF CONSTRUCTION COSTS
MAY 1983 COSTS

| | | |
|---|---|---|
| **Federal First Costs:** | | |
| **Embankments** | | |
| Creel Bay Embankment | $395,000 | |
| Creel Bay Tieback Embankment | 113,000 | |
| South Embankment | 138,000 | |
| Drainage | | |
| Creel Bay | 35,000 | |
| Tieback | 8,000 | |
| South | 3,000 | |
| Pumping Plant | 22,000 | |
| Borrow Area Work | 105,000 | |
| Total Embankment Work | | $819,000 |
| **Roads** | | |
| T.H. 19 | 25,000 | |
| Service Road | 17,000 | |
| Access Road | 63,000 | |
| Total Roads | | 105,000 |
| **Pumping Station** | | 540,000 |
| Total Est. Federal First Cost (Direct) | | $1,464,000 |
| Engineering & Design | | 176,000 |
| Supervision & Administration | | |
| Inspection | | 66,000 |
| Overhead | | 61,000 |
| Total Estimated Federal First Costs (Indirect) | | 303,000 |
| Total Estimated Federal First Costs (Direct & Indirect) | | $1,767,000 |

| | Unit | Quantity | Unit Price | Total |
|---|---|---|---|---|
| **Federal First Costs** (Cont) | | | | |
| **Embankments** | | | | |
| **Creel Bay Embankment** | | | | |
| **Remove** | | | | |
| 43" x 27" C.M.P.A. | LF | 74 | 3.00 | 222 |
| 43" x 27" C.M.P.A. | LF | 74 | 3.00 | 222 |
| 24" CMP | LF | 58 | 3.00 | 174 |
| 57" x 66" C.M.P.A. | LF | 62 | 5.00 | 310 |
| **Construct** | | | | |
| Cofferdam | CY | 8,100 | 2.50 | 20,250 |
| Stripping 12" | CY | 4,460 | 5.00 | 22,300 |
| Inspection Trench | CY | 5,880 | 8.00 | 47,040 |
| Impervious Fill | CY | 36,850 | 2.00 | 73,700 |
| Riprap | CY | 4,040 | 25.00 | 101,000 |
| Bedding | CY | 2,020 | 15.00 | 30,300 |
| Sand Drain | CY | 7,560 | 5.00 | 37,800 |
| Topsoil | CY | 1,490 | 4.50 | 6,705 |
| Seeding | Acre | 3 | 900.00 | 2,700 |
| Contingencies | | | | 52,277 |
| Total Embankment Work (Creel Bay) | | | | 395,000 |
| **Drainage (Creel Bay)** | | | | |
| R.C.P.A. 36" x 58" (2 ea @ 80') | LF | 160 | 98.00 | 15,680 |
| R.C.P. 72" Class II | LF | 48 | 145.00 | 6,960 |
| Concrete Wiers (2 ea) | Job | Sum | *** | 2,000 |
| End Sections: | | | | |
| 36" x 58" | Ea | 4 | 850.00 | 3,400 |
| 72" | Ea | 2 | 1,180.00 | 2,360 |
| Contingencies | | | | 4,600 |
| Total Drainage (Creel Bay) | | | | 35,000 |
| **Creel Bay Tieback Embankment** | | | | |
| **Embankment** | | | | |
| Stripping 6" | CY | 1,990 | 3.00 | 5,970 |
| Impervious Fill | CY | 33,835 | 2.00 | 67,670 |
| Stabilize Aggregate | CY | 335 | 12.00 | 4,020 |
| 4" Topsoil | CY | 3,260 | 4.50 | 14,670 |
| Seeding | Acre | 60 | 900.00 | 5,400 |
| Remove 24" CMP | LF | 70 | 2.00 | 140 |
| Contingencies | | | | 15,130 |
| Total Embankment | | | | 113,000 |

| | Unit | Quantity | Unit Price | Total |
|---|---|---|---|---|
| **Federal First Costs** (Cont) | | | | |
| **Creel Bay Tieback Embankment** (Cont) | | | | |
| Drainage (Tieback) | | | | |
| RCP 24" | LF | 90 | 40.00 | 3,600 |
| End Section 24" | Ea | 2 | 200.00 | 400 |
| Ditch: | | | | |
| Excavate | CY | 630 | 3.00 | 1,890 |
| Topsoil | CY | 115 | 4.50 | 518 |
| Seeding | Acre | .2 | 900.00 | 180 |
| Contingencies | | | | 1,412 |
| Total Drainage (Tieback) | | | | 8,000 |
| **South Embankment** | | | | |
| Remove 42" CMP | LF | 55 | 3.00 | 165 |
| Stripping 6" | CY | 2,600 | 3.00 | 7,800 |
| Impervious Fill | CY | 41,820 | 2.00 | 83,640 |
| Topsoil 4" | CY | 4,490 | 4.50 | 20,205 |
| Seeding | Acre | 8.5 | 900.00 | 7,650 |
| Contingencies | | | | 18,540 |
| Total Embankment Work (South Embankment) | | | | 138,000 |
| Drainage | | | | |
| CMP 24" | LF | 55 | 40.00 | 2,200 |
| End Sections 24" | Ea | 2 | 200.00 | 400 |
| Contingencies | | | | 400 |
| Total Drainage (South Embankment) | | | | 3,000 |
| Roads | | | | |
| T.H. 19: | | | | |
| Granular Base | CY | 170 | 12.00 | 2,040 |
| Bituminous Material | SY | 3,970 | 5.00 | 19,850 |
| Contingencies | | | | 3,110 |
| Total T.H. 19 | | | | 25,000 |
| Service Road (East of T.H. 20) | | | | |
| Granular Base | CY | 740 | 12.00 | 8,800 |
| Bituminous Material | SY | 1,070 | 5.00 | 5,350 |
| Contingencies | | | | 2,770 |
| Total Service Road | | | | 17,000 |

| | Unit | Quantity | Unit Price | Total |
|---|---|---|---|---|
| **Borrow Area Work** | | | | |
| Area 1 | Job | Sum | *** | 5,000 |
| Area 2: | | | | |
| Stripping 12" (No Haul) | CY | 13,240 | 2.00 | 26,480 |
| Topsoil 4" (Salvaged) | CY | 4,410 | 2.00 | 8,820 |
| Seeding | Acre | 8.5 | 400.00 | 3,400 |
| Area 3: | | | | |
| Stripping 12" (No Haul) | CY | 16,100 | 2.00 | 32,200 |
| Topsoil (Salvaged) | CY | 5,370 | 2.00 | 10,740 |
| Seeding | Acre | 10 | 400.00 | 4,000 |
| Contingencies | | | | 14,360 |
| Total Borrow Area Work | | | | 105,000 |
| **Pumping Plant** | | | | |
| Pump Station (16,000 gpm) | Job | Sum | *** | 275,000 |
| 20" Steel Discharge Pipe | LF | 180 | 150.00 | 27,000 |
| Gatewell | Job | Sum | *** | 35,000 |
| 72" Sluice Gate | Ea | 1 | 25,000.00 | 25,000 |
| 72" RCP Class III | LF | 30 | 160.00 | 4,800 |
| 72" RCP Class IV | LF | 120 | 180.00 | 21,600 |
| 72" RCP Class V | LF | 60 | 220.00 | 13,700 |
| 72" End Section | Ea | 1 | 1,180.00 | 1,180 |
| Headwall | Job | Sum | *** | 44,000 |
| 72" Sluice Gate | Ea | 1 | 25,000.00 | 25,000 |
| Contingencies | | | | 68,220 |
| Total Pumping Plant | | | | 540,000 |
| **Drainage** | | | | |
| Excavation | CY | 6,400 | 3.00 | 19,200 |
| Contingencies | | | | 2,800 |
| Total Drainage, Pumping Plant | | | | 22,000 |
| **Access Road** | | | | |
| Stripping | CY | 740 | 3.00 | 2,220 |
| Excavation | CY | 360 | 3.00 | 1,080 |
| Fill | CY | 1,640 | 2.00 | 3,280 |
| Subbase | CY | 1,760 | 12.00 | 21,120 |
| 24" CMP | LF | 60 | 50.00 | 3,000 |
| Bituminous Pavement 2" | SY | 3,820 | 5.00 | 19,100 |
| Topsoil | CY | 770 | 4.50 | 3,465 |
| Seeding | Acre | 1.4 | 900.00 | 1,260 |
| Contingencies | | | | 8,475 |
| Total Access Road, Pumping Plant | | | | 63,000 |

# DISPOSITION FORM

[illegible] TAGO

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| | Real Estate [illegible] Estimate - Devils Lake, ND |

| TO | FROM | DATE | CMT 1 |
|---|---|---|---|
| P FS [illegible] | [illegible] | [illegible] May 1983 [illegible]/7041 | |

[illegible] to your request of 26 May 1983 concerning real estate costs on the [illegible] Based on the maps and data furnished by you, the estimated [illegible] [illegible] are $160,000.

[illegible] estimated costs is as follows:

| | | |
|---|---|---|
| [illegible] Part Taken and Severance | | $[illegible],000 |
| [illegible] | | 24,000 |
| Administrative | | 12,500 |
| | Total | $156,500 |
| | Call | $160,000 |

[illegible] is based on the need to acquire 32± acres for levees and [illegible]± acres for [illegible] easements for levees and ponding would be acquired. [illegible] structures are [illegible] Administrative costs are based on an estimated five [illegible].

[illegible] no estimated costs for [illegible] roads, streets [illegible] pipelines, or public utilities.

Gary A. Wh[illegible]

[illegible]
Chief, St. Paul Real
Estate Field Office

[illegible]



DA FORM AUG 60 2496 PREVIOUS EDITIONS WILL BE USED

U S G P O 1982 [illegible]

## INTEREST DURING CONSTRUCTION

(Construction and Real Estate Costs)

| Months Before Project Completion | Monthly Expenditure | SPCAF(1) | Investment Cost |
|---|---|---|---|
| 0 | $278,600 | 1.0000 | $278,600 |
| 1 | 278,600 | 1.0066 | 280,400 |
| 2 | 278,600 | 1.0132 | 282,300 |
| 3 | 278,600 | 1.0200 | 284,200 |
| 4 | 278,600 | 1.0267 | 286,000 |
| 5 | 278,600 | 1.0334 | 287,900 |
| 6 | 0 | 1.0403 | 0 |
| 7 | 0 | 1.0471 | 0 |
| 8 | 20,200 | 1.0540 | 21,300 |
| 9 | 53,500 | 1.0610 | 56,800 |
| 10 | 3,500 | 1.0680 | 57,100 |
| 11 | 53,500 | 1.0750 | 57,500 |
| 12 | 60,000 | 1.0821 | 64,900 |
| 13 | 7,500 | 1.0893 | 8,200 |
| 14 | 7,500 | 1.0965 | 8,200 |
| | 1,927,300(2) | | 1,973,400 |

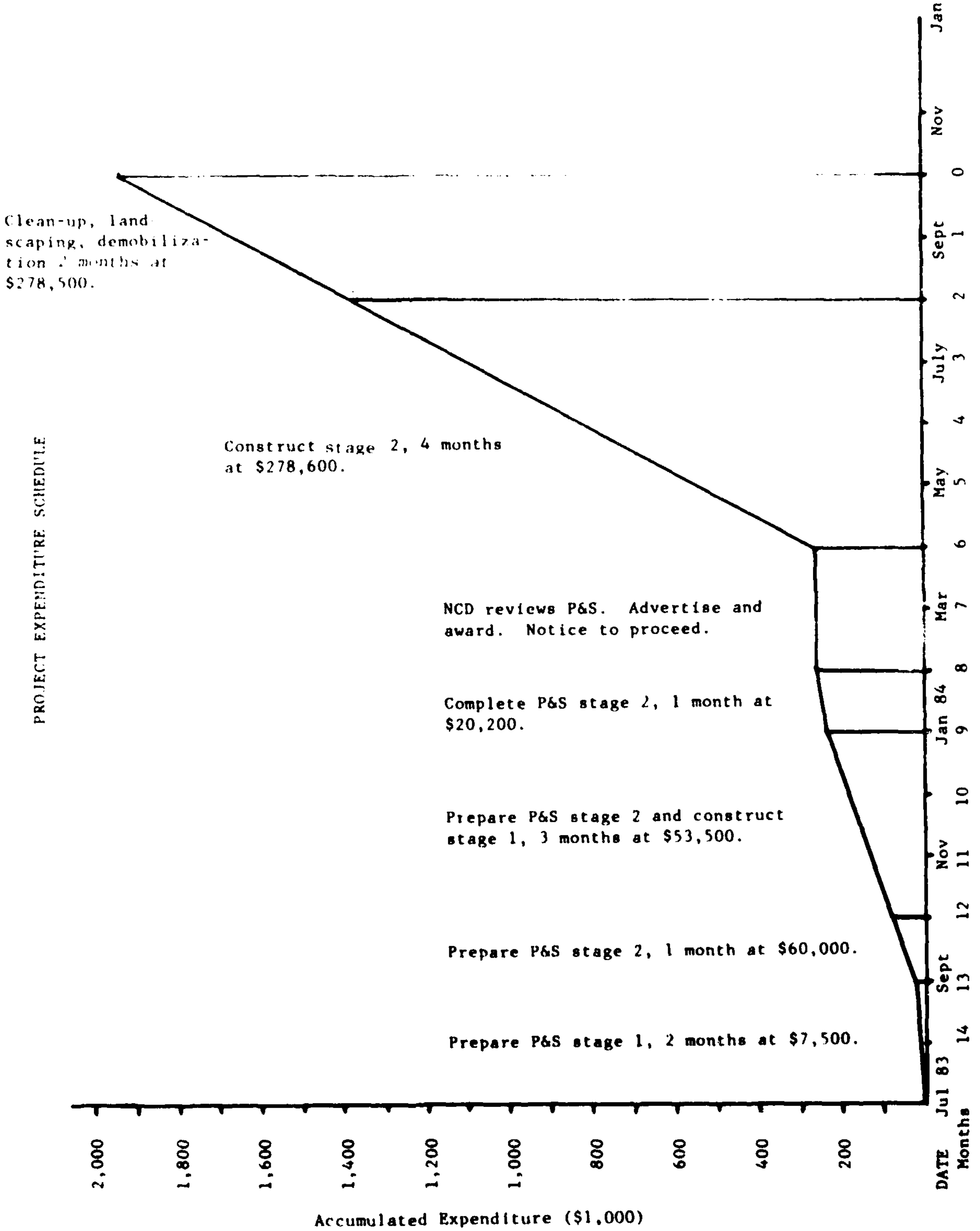
Interest during construction:

| | |
|---|---|
| Total investment cost | $1,973,400 |
| Total expenditures | 1,927,300 |
| | 46,100 |
| | Say 46,000 |

(1)Single payment compound amount factor for 1 through 14 months. 7-7/8 percent annual or 0.66 percent monthly interest rate. SPCAF=$(1+i)^n$; n=number of periods, i=interest rate for period.

(2)Does not correspond to total construction and lands cost of $1,927,000 shown in main report because of rounding-off.

PROJECT EXPENDITURE SCHEDULE



AD-A147 505 DEVILS LAKE FLOOD CONTROL PROJECT SECTION 205 DETAILED PROJECT REPORT(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT OCT 83 3/5

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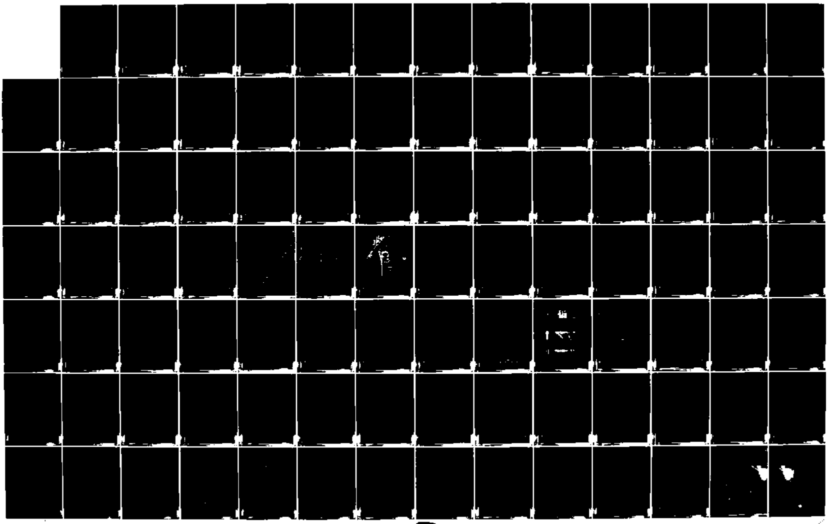

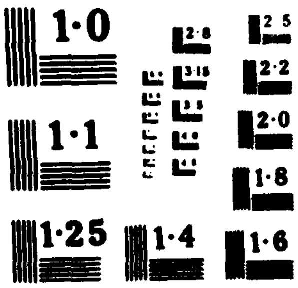
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DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

# APPENDIX C

# INTERIOR DRAINAGE

TABLE OF CONTENTS

## TABLES

## PLATES

## INTERIOR FLOOD CONTROL

## EXISTING CONDITIONS

### DESCRIPTION OF WATERSHED AND DRAINAGE PATTERNS

The five major areas, with two of them further subdivided, which contribute runoff to the proposed protected area of Devils Lake, are delineated on plate C-1 and further defined in the following paragraphs.

Area 1 consists of the 179.1-acre area north of Highway 2 about 1 1/2 miles northwest of Devils Lake. Runoff from this area is in a southwesterly direction and discharges under Highway 2 into Area 2. Area 1 is generally quite flat with a short, steeper region in the upper reaches of the watershed. Land use consists entirely of farming.

Area 2 includes the 2054.2-acre area southwest of Highway 2, north of Highway 19, and east of the gravel road just west of the airport, plus a small area just south of Highway 19 and another small area just west of the gravel road. Runoff from the area is generally to the south and east into the North ponding area.

Area 2 slopes gently from the north and west sides toward the North ponding area. Elevations in the area vary from a high around 1470 in the north end to a low of about 1426.0 in the North ponding area. Land use consists generally of farming, except for the airport in the southwest corner and a small area of development along the south side of Highway 2.

Area 3 consists of about 547.3 acres located in the city of Devils Lake itself. The area is bounded by 1st Avenue and the railroad tracks on the east, Highway 2 on the south and west and high ground along the northwest side. Runoff from this area is currently carried by storm sewer to the southwest and discharges through a 72-inch RCP into an existing stormwater pumping station located just east of the sewage lagoons. The runoff is then pumped into two stormwater detention ponds connected in series. For low flows, the runoff discharges from the first pond into the second through an 18-inch RCP. In turn, the runoff then flows from the second pond into a ditch through another 18-inch RCP. For higher flows, the runoff in the detention pond area flows through the two 18-inch RCPs as well as over a series of two riprapped overflow weirs. The runoff again follows the same sequence from the pumping station into the first pond, over the first weir into the second pond, and then over the second weir into the ditch. The ditch thence carries the runoff along the south side of the sewage treatment lagoons, through the Landfill Road and Creel Bay ponding areas into Creel Bay.

Area 3 slopes gently to the southwest with elevations ranging from about 1460 in the north end to about 1430 along Highway 2. The area is almost entirely developed with a mixture of residential, commerical and industrial property. The remaining portion of the city of Devils Lake, located to the south and east, is not included because runoff from this area is handled by a storm sewer and ditch system that carries the runoff to the south through a series of two detention ponds and on into Devils Lake.

Area 4 includes the 1289.2-acre area bounded generally by Highway 19 and the sewage lagoons on the north, Highways 2 and 20 on the east, and high ground and the proposed embankments on the south and west. This area is further subdivided as shown by the dashed lines on plate C-1. Runoff from area 4A occurs to the north and south into the Creel Bay ponding area in the center. Area 4B runoff also flows to the north and south but into the Landfill Road ponding area.

Runoff from area 4C discharges into the ditch along the sewage lagoons after flowing to the ditch from the north and south. Area 4D runoff flows from south to north into the South ponding area, thence into the ditch along the sewage lagoons.

Area 4 is relatively flat with the north portion sloping to the south and the south portion sloping to the north. Two high, steeper regions exist in the south and east parts of the area. Elevations over the area range from a high of 1495 in the south to a low around 1425 west of Landfill Road. The area is largely undeveloped or used for farming with the high regions mentioned above residentially developed.

Area 5 consists of the 366.4-acre area south of Highway 2, west of the Great Northern Railroad tracks, north of the proposed south embankment and east of Highway 20. The area is further subdivided as shown by the dashed line on plate C-1. Runoff from areas 5A and 5B flows from south to north and from east to west, respectively, and then discharges under Highway 20. The runoff from areas 5A and 5B discharges into areas 4C and 4D, respectively.

Area 5 generally slopes mildly to the northwest with elevations ranging from a high of 1465 in the middle to a low of 1430 in the north end. There is a small amount of residential development along Highway 20 and in area 5A. The remainder of area 5 is undeveloped or used for farming.

Following is a description of how runoff from the areas described above combines and flows to the line of protection. After discharging under Highway 2 through a 36-inch RCP culvert, the runoff from area 1 flows across area 2 and combines with the runoff from area 2. As the combined runoff from the two areas accumulates in the North ponding area, the runoff discharges under Highway 19 through three CMP culverts. Two of the culverts are 27-inch x 43-inch CMP arches and the third is a 24-inch CMP. The runoff discharging under Highway 19 flows into area 4B and the Landfill Road ponding area.

Runoff from area 5A discharges under Highway 20 through a 30-inch RCP culvert, flows across area 4C and combines with the runoff from area 4C. After combining, the runoff enters the ditch along the sewage lagoons and subsequently combines with the runoff from area 3. If the combined runoff exceeds the capacity of the ditch, the excess runoff temporarily ponds in the East ponding area. The runoff from area 3 enters the ditch from the stormwater detention ponds as previously explained. The ditch carries the combined runoff from the three areas along the south side of the sewage lagoons.

Runoff from area 5B discharges under Highway 20 through a 30-inch RCP culvert, flows across area 4D and combines with the runoff from area 4D. The combined runoff from the two areas accumulates in the South ponding area and discharges into the ditch along the south side of the sewage lagoons. Runoff from the five areas, 3, 4C, 4D, 5A and 5B, combines and flows to the west in this ditch. At the southwest corner of the sewage lagoons, the combined runoff discharges through a 60-inch CMP culvert under a ramp across the ditch. If the capacity of the ditch or culvert is exceeded, the excess runoff temporarily accumulates in the South and East ponding areas. After exiting the 60-inch CMP culvert, the runoff enters area 4B and the Landfill Road ponding area.

The runoff from areas 1 and 2 flows to the south in a ditch along the west end of the sewage lagoons and discharges through five 24-inch RCP culverts under a ramp across the ditch. The runoff existing the culverts combines with the runoff from areas 3, 4C, 4D, 5A and 5B and the local area 4B. The combined runoff from the eight areas flows to the west in a ditch that angles from the sewage lagoons to Landfill Road. Then the runoff discharges under Landfill Road through a 72-inch equivalent CMP arch. The excess runoff temporarily ponds in the Landfill Road ponding area if the capacity of the ditch or culvert is exceeded. Under existing conditions, the runoff exiting the culvert under Landfill Road combines with the runoff from area 4A and flows west into Creel Bay.

## PONDING AREAS

There are currently two ponding areas that are used to store treated sewage effluent. One is located north of Highway 19, and the other is between the sewage lagoons and Landfill Road. The city pumps the treated sewage effluent from the lagoons into these ponding areas and stores it there until a favorable time to release it into Devils Lake. Once the proposed Creel Bay embankment is built, three additional ponding areas will be created. Two of the new ponding areas will be located south and east of the sewage lagoons, while the third will be located between the proposed embankment and Landfill Road. All five of the ponding areas will be used to store stormwater runoff after the proposed embankment is built. Elevation-area-storage curves for each of the five ponding areas are shown individually on plates C-3 through C-7 and combined on plate C-8. Under design conditions for the North ponding area, a conservation pool at elevation 1426.75 will be maintained to mitigate the loss of wetlands in other areas. Therefore, plate C-3 has an elevation-storage curve for both existing and design conditions. Any area below elevation 1427.7 in the bermed area immediately west of the sewage lagoons is not included in the elevation-area-storage curves for the Landfill Road ponding area (plate C-6). This area will continue to be maintained as a wetland and will be used to store treated sewage effluent.

## DAMAGE-ELEVATION RELATIONSHIPS

A damage-elevation curve for the city of Devils Lake was developed for the purpose of defining flood damages from interior runoff. The curve, presented on plate C-9, was updated to October 1982 price levels and is based on October 1980 conditions. The zero damage elevation for the city of Devils Lake is 1429.0.

SANITARY SEWERAGE SYSTEM

The present sanitary sewerage system for the city of Devils Lake conveys the sewage to a lift station located southeast of the intersection of Highway 2 and 4th Street South. This lift station pumps the sewage under Highway 2 to the city's sewage treatment lagoons located about 1,500 feet to the west. Both the lift station and sewage treatment lagoons are shown on plate C-1. Under existing conditions, the treated sewage effluent is released into Devils Lake during favorable times of the year. Once the proposed project is built, the system will operate in a similar fashion except that the released effluent will have to be pumped over the embankment. The amount of sewage effluent was not included in the analysis performed to determine the pumping station size. This flow was not included because the sewage effluent can be released at a time when the ponding areas have been pumped down to a minimum elevation and when rainfall is generally not expected. In addition, the city of Devils Lake is presently developing a plan to land spread the treated sewage effluent. If this plan is implemented, the effluent will not have to be pumped over the embankment.

FUTURE DEVELOPMENT

It was assumed that relatively limited future development will occur within the interior flood control watershed. Some development may occur along Highway 2 in the north end of area 2. The city of Devils Lake itself, area 3, may experience a small smount of additional residential or commercial development and the high portions of areas 4C, 4D and 5A may also be developed; however, no other land use changes are anticipated. In areas 4C, 4D and 5A, commerical development will tend to occur along Highway 20, while the remainder will be residential. As part of the local cooperation agreement, the city of Devils Lake will be required to regulate development below the project's design water surface elevation of 1440. This will restrict development near the ponding areas and pumping station.

LAKE LEVEL INFORMATION

A lake stage hydrograph is included as figure 3 of the main report. The period of record for which lake levels have been recorded is too short to develop any stage-frequency data or show any clear pattern of variation in lake levels. A more extensive discussion of past water levels, some based on archaeological and sedimentological studies, is presented on pages 27 through 30 of the main report. Additional discussion is in ar   ix D, Hydrology.

RAINFALL INFORMATION

Both hypothetical and historical rainfall data were investigated for the design of the interior flood control facilities and are further discussed in the following paragraphs. References made in the following and subsequent paragraphs are listed at the end of this appendix.

HYPOTHETICAL RAINFALL

Hypothetical storms were developed for the 1-, 2-, 3-, 6-, 12-, 24-, 48-, and 96-hour duration rainfall depths for the 100-, 50-, 20-, 10-, 4-, 2-, 1-percent exceedence frequency and standard project storms at Devils Lake. In addition, 7- and 10-day duration rainfall depths for the 50-, 20-, 10-, 4-, 2- and 1-percent storms were also obtained for use in the pumping station probabilistic-economic analysis. Rainfall data were obtained from the United States Weather Bureau Technical Reports Nos. 40 and 49 (references a and b). Rainfall-depth-duration-frequency relations were determined from these data in accordance with criteria presented in EM-1110-2-1410 (reference c) and are presented in table C-1 and plates C-10 and C-11. The standard project storm for the Devils Lake area was developed in accordance with criteria presented in EM 1110-2-1411 (reference d) and is also shown in table C-1 and plate C-10. Incremental rainfall amounts for the seven selected hypothetical and standard project storms are presented in table C-2.

## HISTORICAL RAINFALL

Historical rainfall data were obtained from the U.S. Department of Commerce publication, "Climatological Data" (reference e). Hourly rainfall amounts, when available, were obtained for the recording station at Devils Lake. In some instances, only daily rainfall amounts were available. If so, hourly rainfall records were obtained from nearby recording stations at Cando, Leeds, Sheyenne, and Towner. Amounts of rainfall occurring in each hour of a given storm at the recording station were converted into percentages of the total rainfall occurring during that storm. These percentages were then applied to the same storm at the Devils Lake weather station. Table C-3 shows the hourly rainfall amounts for the ten most severe events at Devils Lake during the 34-year period from 1949 to 1983. Runoff hydrographs were developed only for the most severe event which occurred on 5-6 June 1956. Monthly and annual precipitation data were obtained for the 107-year period from 1870 to 1977. The average annual precipitation is 17.15 inches with a maximum annual amount of 25.39 inches in 1921.

## UNIT HYDROGRAPHS

Unit hydrographs for the interior watersheds, shown in table C-5, were developed using the HEC computer program UHCOMP. The watershed characteristics required to generate these unit hydrographs are shown in table C-4. Surface cover, watershed lengths and slopes were obtained from USGS quad sheets and detailed topography of the areas. Flow velocities in each area were obtained using figure 3-1 in Soil Conservation Service Technical Release No. 55 (reference f). Times of concentration were calculated by dividing the watershed length by the velocity. Clark's method was used to generate the unit hydrographs because some of the areas, especially areas 1, 2 and 4, have rather long times of concentration. Clark's attenuation constant, R, is based in part on data from a similar basin near Cooperstown, North Dakota. A full description of Clark's method appears in HEC's "Hydrograph Analysis," (reference g). The UHCOMP computer program also computes values of Snyder's coefficients $C_p$ and $T_p$, which are shown in table C-4.

RUNOFF HYDROGRAPHS

Runoff hydrographs for each of the nine interior watersheds were generated using the HEC computer program UHCOMP. First, the UHCOMP program takes the hypothetical hyetographs or historical rainfall values and develops rainfall excess hyetographs by applying the selected losses. An initial loss of 0.5 inch and a constant loss rate of 0.1 inch per hour were used. The runoff hydrographs are then obtained by applying the rainfall excess hyetographs to the unit hydrographs described in the preceding paragraph. Runoff hydrographs for the hypothetical 2- and 1-percent and standard project storms are presented in tables C-6 through C-8. Table C-9 presents runoff hydrographs for the selected historical event of 5-6 June 1956. Since limited future development is expected, no differentiation was made between runoff hydrographs for existing and future conditions.

SEEPAGE

Because the foundation materials are largely impervious, seepage is considered to be negligible. Seepage is further discussed on pages 68 through 69 of the main report.

## ALTERNATIVE PLANS CONSIDERED

### GENERAL

Alternate interior flood control plans were considered for two major areas, the proposed Creel Bay embankment area and the proposed South embankment area, of Devils Lake. Several alternatives of a plan, consisting of the proposed Creel Bay embankment, several culverts, a gravity outlet and a pumping station, were considered for conducting flow to, through and over the proposed embankment. Three different plans were also examined to determine the location of the proposed South embankment. The alternative plans considered in each area are further discussed in the following paragraphs.

### PROPOSED CREEL BAY EMBANKMENT

With this plan, runoff from the interior watershed will flow to the line of protection generally as described in the Existing Conditions section. After reaching the embankment, the runoff will discharge into Creel Bay either through the gravity outlet or be pumped over the embankment by the pumping station. Alternatives considered were concerned with which existing culverts, if any, could remain in place, what size the culverts under Highway 19 and Landfill Road should be and what size the gravity outlet should be. The only other alternative considered, which was just slightly different than the plan described above, involved building a dike along the north edge of the South ponding area. With this plan, a culvert would be required from the South ponding area to the Landfill Road ponding area. This plan was considered because the zero damage elevation around the South ponding area is higher and more storage could be obtained by building the dike. It was later found that sufficient storage was available without the dike; therefore, this plan was eliminated.

PROPOSED SOUTH EMBANKMENT

Three different locations were considered for this embankment. For Plan 1, the embankment would be located on or along the gravel road south of the city of Devils Lake and shown on plate C-1. A 36-inch RCP gravity outlet and a small pumping station with a capacity of about 1,000 gpm would be required with this plan.

With plan 2, the embankment would be located about 1,000 feet north of the gravel road. Once again, a 36-inch RCP gravity outlet and small pumping station, but with a capacity of 1,500 gpm, would be required. Also considered for plans 1 and 2 was a ditch and/or interceptor system that would carry runoff from this area into the South ponding area.

In plan 3, the embankment would be located about 2,650 feet north of the gravel road and would tie into Highway 20 on the west end and the railroad tracks on the east end. No gravity outlet or pumping station would be required with this plan because runoff from area 5B would flow north and discharge into area 4D through an existing culvert under Highway 20. Plan 3 was selected because it was found to be significantly cheaper than plans 1 and 2 since no outlet or pumping station is required.

## RECOMMENDED PLAN

GENERAL

The recommended interior flood control plan will consist of two interior culverts, one gated gravity outlet, five designated ponding areas, and a 16,000 gpm pumping station. Two existing culverts, one at the southwest corner of the sewage lagoons and the other along the west side of the lagoons, will have to be removed. Three existing CMP culverts under Highway 19 will have to be plugged or removed. Existing ditches along the south and west sides of the sewage lagoons, from the southwest corner of the lagoons to Landfill Road, and from Landfill Road to the gravity outlet and pumping station will have to be cleaned.

A plan view showing the location of proposed interior flood control features is presented on plate C-2 and also on plate 1 and plates 10 through 13 of the main report. A profile of culverts A and B plus the gravity outlet is presented on plate 14 of the main report. Table C-10 presents the required size, length, elevations and other design information for the proposed interior culverts and gravity outlet. The required facilities are further defined in the following paragraphs.

DESIGNATED PONDING AREAS

The designated ponding areas are defined on page C-5 and shown on plate C-2 and plates 10 through 12 of the main report.

INTERIOR CULVERTS

Twin 36" x 58" RCP arch culverts will be required under Highway 19. In order to maintain a conservation pond in the North ponding area, an overflow weir will be constructed across the culvert inlets as shown on plate 14 of the main report. A 72-inch RCP culvert will be required under Landfill Road.

GRAVITY OUTLET

The proposed gravity outlet is a 72-inch RCP outlet with a gatewell and sluice gate located in the proposed Creel Bay embankment.

PUMPING STATION

A 16,000 gpm pumping station, equipped with two 8,000 gpm pumps, will be located adjacent to the gravity outlet. The required size of pumps, number of pumps and other design and operating requirements based on standard Corps of Engineers criteria are presented in tables C-11, C-12 and C-13 and on plate C-12. A 20-inch, axial flow pump (per model curve 18), appears to meet the design criteria most satisfactorily. Although a 20-inch axial flow pump was initially selected as the prototype pump in the Devils Lake pumping station, a submersible sewage pump meeting the same design conditions and having certain operational advantages has been selected. Details of the operational advantages and a comparison of the operating cost of the submersible pump are contained in Appendix F. Each submersible pump will be equipped with a safety shutdown for motor and seal failure and automatic control equipment.

STATION LAYOUT

The Devils Lake pumping station will include the following facilities:

a. A 72-inch RCP connecting sewer from the Creel Bay ponding area to the intake chamber.

b. A manually controlled slide gate at the inlet of the 72-inch connecting sewer.

c. An intake chamber with stop log supports located at the entrance to the intake chamber.

d. Stop log supports located between the intake and pump chambers.

e. Two separate sump chambers, each housing one pump, a trash rack, raking facilities, ladders, and operating platforms to facilitate cleaning operations.

f. A superstructure housing the motors and controls and providing an operating room with a deck.

g. A stop log storage area and fireproof storage container for flammable materials above the intake chamber at the finished ground level.

h. Hoisting equipment to lower and raise the submersible pump.

i. Two pump discharge pipes which discharge directly into the gravity outlet gatewell.

j. A sump pump will be provided to drain the station during times when the station is not in use.

The pumping station layout is based on the most practical and economical plan which will provide good operating conditions. The stormwater pump chambers will be large enough to accommodate the pumps and to provide adequate cycling and good flow conditions to the pump intakes. Layout of the floors and superstructure are based on the minimum desirable working clearance required for cleanup, inspections, repair, and/or removal of the submersible pumps, and control equipment. The pump station will be accessible to service vehicles. Layout details for the Devils Lake pumping station are shown on plates 13 through 16 of the main report.

PLAN OF OPERATION

During periods when Devils Lake is low, the sluice gate in the gravity outlet will be open and runoff from the interior watersheds will discharge directly into Devils Lake. Runoff from the interior watersheds will generally follow the same drainage patterns as previously described in the Existing Conditions Section with the following exceptions. The combined runoff from areas 1 and 2 will discharge under Highway 19 through the proposed twin 36" x 58" RCP arch culverts rather than the three CMP culverts. As this runoff flows south in the ditch along the west end of the sewage lagoons, it will no longer have to pass through the five 24-inch RCP culverts under a ramp in in the ditch as the culverts will be removed. Likewise, the combined runoff from areas 3, 4C, 4D, 5A and 5B will no longer have to pass through the 60-inch CMP culvert under a ramp at the southwest corner of the sewage lagoons, as this culvert will also be removed. The combined runoff from areas 1, 2, 3, 4B, 4C, 4D, 5A and 5B will discharge under Landfill Road through the proposed 72-inch RCP culvert that will replace the existing 72-inch equivalent CMP arch culvert. The runoff exiting the culvert under Landfill Road will combine with the runoff from the local area, 4A, accumulate in the Levee ponding area and eventually discharge into Creel Bay through the proposed 72-inch RCP gravity outlet.

During periods when Devils Lake rises above elevation 1427.0, the sluice gate in the gravity outlet will be closed, the gates at the entrance to the pumping station will be opened and the pumps activated. The normal operating range of the pumps will be from elevation 1425.0 to 1424.0. Pump-on levels recommended for the two pumps are 1424.5 and 1425.0, and pump-off levels recommended are 1424.5 and 1424.0. The estimated cycle times with one or two pumps operating are 7.1 and 16.8 hours, respectively. The proposed pump station will be equipped for both automatic and manual control operations.

Should the interior pond level rise 1 foot above or more above the current lake stage, the gravity outlet will be temporarily opened. When the interior pond level recedes to the same level as the lake, the gravity outlet will then be closed again.

## PROJECT JUSTIFICATION

### PERFORMANCE OF PROPOSED STORMWATER SEWERAGE SYSTEM

Table C-14 presents the maximum interior pond levels and resulting damages which would have occurred with existing and proposed conditions during a

2-, 1-percent and standard project hypothetical storms and the largest historical storm of record (presented in table C-3). The maximum pond elevations were obtained by routing the selected rainfall events through the selected ponding areas, interior culverts and the gravity outlet. Estimated damages are based on the maximum pond elevations and were obtained from the elevation damage curve shown on plate C-9. The estimated interior ponds levels for the 1-percent and standard project storm gravity flow conditions are also presented in table C-10.

ENVIRONMENTAL REQUIREMENTS

Because excess storage is available in the north ponding area, the existing intermittent wetland would be maintained as a permanent wetland. A weir at elevation 1426.75 would be constructed across the inlet to the culvert under Highway 19 in order to maintain these wetlands. As described in the Ponding Areas paragraph on page C-5, the bermed area in the Landfill Road ponding area, immediately west of the sewage lagoons, will still be maintained as a wetland.

JUSTIFICATION OF GRAVITY DESIGN

As indicated in table C-14, culverts A and B and the gravity outlet are more than adequate to maintain 1-percent pond levels less than or equal to those with existing conditions. No damages would occur during a 1-percent flood for either existing or proposed conditions. Although damages would still occur during the standard project storm, they are significantly less than for existing conditions.

## SELECTION OF GATE CLOSURE ELEVATION

A recommended gate closure elevation of 1427.0 was selected because closure at a higher elevation would greatly reduce the volume of available storage below the zero damage elevation of 1429.0. With a gate closure elevation of 1427.0, there is about 1,106 acre-feet of storage available between elevation 1427.0 and 1429.0. At a lower gate closure elevation, the pumping station would have to operate significantly longer and the increase in available storage would be negligible.

## POND FREQUENCY INFORMATION

Pond frequency information is available directly from the probabilistic-economic analysis that was performed. Pond level and estimated damages, for the pump rates and hypothetical storms considered, are shown in table C-15. Table C-16 summarizes the required storage, pond level and estimated damages for the one-percent event.

## JUSTIFICATION OF PUMPING STATION

The recommended size of the Devils Lake pumping station is about 16,000 gpm, which based on criteria presented in EM 1110-2-3102 (reference h) for a two-pump station is equivalent to a design capacity of about 12,000 gpm. As described in the Economic Evaluation paragraphs on page C-20 and as shown on table C-16, the recommended station appears to have the maximum benefit-cost ratio. With a 16,000 gpm station capacity, the one-percent hypothetical event will result in a pond level of 1429.64 and will require an estimated 1,690 acre-feet of storage which will be removed in about 23.9 days. A pond level of 1429.64 will result in about $13,000 in damages to several commercial structures along Highway 2.

## DESIGN CRITERIA

### DEGREE OF PROTECTION

The Devils Lake area is considered to be Class II urban development, as defined in EM 1110-2-1410 (reference c). The design of the gravity outlet and culverts for the low lake level (gravity) condition is, therefore, initially based on the inflow from a 2-percent event. The required outlet or culvert size is subsequently modified, if necessary, to limit interior flood damages from the standard project storm to an acceptable level.

The selection of the required pumping station capacity is based on the most economical combination of pumping rate and storage which will also limit residual flood damages to only rare occasions and/or a small magnitude of damages and meet design criteria presented in EM 1110-2-3102 and EM 1110-2-3105 (references h and i).

### DESIGN OF CULVERTS AND GRAVITY OUTLET

Procedures outlined in EM 1110-345-283 and TM 5-820-4 (references j and k) provide the basis for the hydraulic design of the gravity outlet and culverts. The gravity outlet and culverts are to be reinforced concrete pipe with their design based on a Manning's "n" value of 0.014. $K_e$ is assumed to be 0.5 for both concrete headwall entrances and flared end sections. In the design of the gravity outlet, Devils Lake is assumed to be low enough so that it will not limit discharge from the outlet. Pipe sizes were selected to maintain the design water surface elevations near the pipe crown; however, at peak discharges, some pipes will be under slight pressure heads. The gravity outlet will be furnished with a safety guard at the inlet to improve safety and reduce debris deposition in the outlet. A sluice gate will be required in the gatewell of the gravity outlet. In accordance with criteria presented in paragraph 4-09 and chart 3 of EM 1110-2-1410 (reference c), a supplemental service gate is not required on the gravity outlet. Discharge rating curves for culverts A and B and the gravity outlet are shown on plates C-13, C-14 and C-15, respectively.

PUMPING REQUIREMENTS

The required capacity of the pumping station was determined based on a probabilistic-economic analysis using the 50-, 20-, 10-, 4-, 2-, and 1-percent hypothetical storms and pump rates of 6,000, 9,000, 12,000, 18,000, 24,000, 30,000, 36,000 and 42,000 gpm. Because Devils Lake may remain high for an extended and undetermined period of time, the probability of blocked gravity conditions was assumed to be 100 percent. Therefore, the probability of a particular maximum pond level would be equal to the probability of the rainfall event that produced it. The pumping station was assumed to have two pumps of equal capacity with the first pump starting at an elevation of 1424.5 and the second pump starting at an elevation of 1425.0. When the pond level recedes to an elevation of 1424.5, the second pump shuts off. As the pond level recedes further to the minimum sump elevation of 1424.0, the first pump shuts off. A probabilistic-economic analysis was considered because insignificant seepage is anticipated.

The need for a pumping station at Devils Lake is obvious based on the possibility that Devils Lake may remain high for an extended period of time. If no pumping station were provided, runoff would accumulate in the ponding areas behind the levee and eventually inundate the city. Table C-15 summarizes the maximum pond levels for the various hypothetical storms and pump rates considered, including no pumping.

The estimated maximum pond levels were computed using a 360-hour runoff summation curve for each of the hypothetical storms. A 360-hour (15-day) curve was used because it takes about that long for the 6-hour storms to discharge under gravity conditions. It takes 15 days because there is limited head and extensive storage available. Seven- and ten-day duration rainfall depths were obtained from the United States Weather Bureau Technical Report No. 49 (reference b). The rainfall data were further extrapolated, as shown on plate C-16, to 15 days using a common log curve fit method. Next, the rainfall was broken down into 36 ten-hour increments and re-arranged in a distribution as follows: 6, 4, 2, 1, 3, 5, etc. In this distribution, 1 is the largest ten-hour increment, 2 the second largest and so on. The rainfall was then converted to rainfall excess by multiplying by an assumed constant excess rate of 70 percent. Rainfall excess was then converted to runoff in acre-feet by multiplying by the total contributing watershed in acres and dividing by 12. The incremental runoffs were added to form the runoff S curve and then the curve was plotted. Each of the various pump rates considered were also plotted on the S curves. For a specific pump rate, the maximum vertical distance between the S-curve and the plotted pump rate equalled the storage required. Finally, the maximum pond level was determined by finding the elevation corresponding to the storage required on the combined elevation-storage for the five ponding areas (plate C-8).

The estimated damages indicated in table C-15 are based on the maximum pond level for each hypothetical storm and pump rate and the elevation-damage curve for the city of Devils Lake presented on plate C-9. The estimated benefits developed with each selected pump rate are equal to the difference between the amount of damages with and without pumping.

ECONOMIC EVALUATION

The economic evaluation consisted of determining pond level frequency relationships for each selected hypothetical storm-pump rate combination, converting the pond levels to damages, determining average annual pumping station cost and average annual benefits, and selecting the size of pumping station . Maximum net benefits were not used to select the pumping station size because no station could be justified based on net benefits.

As a secondary measure, benefit-cost ratios were used to select the recommended pumping station size. Benefit-cost ratios for the various pump rates considered are summarized in table C-16.

The pond level frequency relationships based on the hypothetical storms considered and the selected pump rates are presented on plate C-17 and summarized in table C-17. The curves were obtained by plotting the maximum pond levels in table C-15 against the frequency of the storm which produced it.

Damage-frequency curves for the selected pumping conditions are presented on plate C-18 and are based on damage-frequency relationships presented in table C-15. Average annual damages are equal to the area under each curve. Average annual benefits are equal to the difference between average annual damages with and without pumping.

Estimated average annual costs for the selected pumping station capacities were obtained from a pumping cost-capacity curve supplied by Design Branch and presented on plate C-19. Costs obtained from that curve were updated to the October 1982 level by multiplying the January 1981 cost by the ratio of the October 1982 ENR construction index (3876) divided by the January 1981 ENR construction index (3350). All average annual benefits and costs are based on an interest rate of 7 7/8 percent. Because it is assumed all stormwater runoff must be pumped and the pumps will, therefore, operate much more per year, the annual cost of pumps, motors and valves is based on a 20-year life rather than the normally used life of 35 years. The average annual cost of all other features is based on a 100-year life expectancy.

SELECTION OF PUMPS

The number and size of pumps required are based on criteria presented in EM 1110-2-1410, EM 1110-2-3101 and EM 1110-2-3105 (references c, h and i, respectively). Sample computations for sizing the pumping station are shown in table C-13. The design static head for the Devils Lake pumping station is measured from the crown of the discharge pipe at the gravity outlet gatewell to the pond level where the second pump will shut off. Dynamic heads are obtained by adding to the static heads, friction losses for the pipes, bends, and fittings and velocity head losses at the outlet of the discharge pipe. The equivalent length method was used to determine the losses in bends and fittings based on equivalent pipe lengths obtained from data published by the Crane Company. The equations used in determining the friction loss are as follows:

Cast-iron pipe and fittings:

$$H_f/100 \text{ feet of pipe} = \frac{.0595V^{1.85}}{D^{1.17}}$$

Steel pipe and fittings:

$$H_f/100 \text{ feet of pipe} = \frac{.0366V^{1.85}}{D^{1.17}}$$

Where:

$H_f$ = friction resistance of fluid in feet;

$V$ = velocity in feet per second; and

$D$ = inside diameter of pipe in feet

The equation for cast-iron pipe is comparable to a Hazen-Williams roughness coefficient of about 100, and the equation for steel is comparable to a roughness coefficient of about 130.

REFERENCES

a. National Weather Service Technical Report No. 40, "Rainfall Frequency Atlas of the United States," May 1961.

b. National Weather Service Technical Report No. 49, "Two - to Ten-Day Precipitation for Return Periods of 2 to 100 years in the Contiguous United States," 1964.

c. EM 1110-2-1410, "Interior Drainage of Leveed Urban Areas, Hydrology."

d. EM 1110-2-1411, "Standard Project Flood Determinations," (Civil Works Engineer Bulletin No. 52-8, March 1952).

e. "Climatological Data," National Oceanic and Atmospheric Administration, Environmental Data Service, U.S. Department of Commerce.

f. Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds," January 1975.

g. "Hydrologic Engineering Methods for Water Resources Development, Volume 4, Hydrograph Analysis," The Hydrologic Engineering Center, Davis, California.

h. EM 1110-2-3102, "General Principles of Pumping Station Design and Layout."

i. EM 1110-2-3105, "Mechanical and Electrical Design of Pumping Station."

j. EM 1110-345-283, "Drainage and Erosion Control Structures for Airfields and Heliports."

k. TM 5-820-4, "Drainage and Erosion Control, Drainage for Areas other than Airfields," (EM 1110-345-284).

The following references, although not specifically referred to, were also used in the development of the interior flood control plan.

l. EM 1110-2-1601, "Hydraulic Design of Flood Control Channels."

m. EM 1110-2-1602, "Hydraulic Design of Reservoir Outlet Works."

n. EM 1110-2-3101, "Pumping Stations - Local Cooperations and General Considerations."

o. TM 5-820-1, "Drainage and Erosion Control, Surface Drainage Facilities for Airfields and Heliports."

p. Standards of the Hydraulic Institute, Twelfth Edition, (1969).

q. "Hydraulic Charts for the Selection of Highway Culverts," Hydraulic Engineering Circular No. 5, U.S. Department of Transportation, Federal Highway Administration, April 1977.

Table C-1

Accumulated 96-hour hypothetical rainfall amounts

| Rainfall duration in hours | Rainfall frequency in percent 100 | 50 | 20 | 10 | 4 | 2 | 1 | SPS |
|---|---|---|---|---|---|---|---|---|
| 0.5 | 0.56 | 0.82 | 1.18 | 1.45 | 1.77 | 1.99 | 2.23 | 2.38 |
| 1.0 | 0.66 | 0.99 | 1.48 | 1.83 | 2.26 | 2.57 | 2.88 | 3.23 |
| 1.5 | 0.70 | 1.04 | 1.56 | 1.91 | 2.36 | 2.68 | 3.00 | 4.01 |
| 2.0 | 0.74 | 1.09 | 1.63 | 1.99 | 2.46 | 2.78 | 3.11 | 4.79 |
| 2.5 | 0.78 | 1.14 | 1.70 | 2.07 | 2.55 | 2.88 | 3.22 | 5.46 |
| 3.0 | 0.82 | 1.18 | 1.76 | 2.14 | 2.64 | 2.97 | 3.32 | 6.08 |
| 3.5 | 0.85 | 1.22 | 1.81 | 2.21 | 2.72 | 3.06 | 3.42 | 6.64 |
| 4.0 | 0.88 | 1.26 | 1.86 | 2.28 | 2.80 | 3.14 | 3.52 | 7.05 |
| 4.5 | 0.91 | 1.30 | 1.91 | 2.34 | 2.87 | 3.22 | 3.61 | 7.44 |
| 5.0 | 0.93 | 1.34 | 1.96 | 2.40 | 2.94 | 3.30 | 3.70 | 7.77 |
| 5.5 | 0.95 | 1.37 | 2.00 | 2.45 | 3.00 | 3.38 | 3.78 | 8.07 |
| 6.0 | 0.97 | 1.40 | 2.03 | 2.49 | 3.05 | 3.45 | 3.86 | 8.34 |
| 6.5 | | | | | | | | 8.54 |
| 7.0 | | | | | | | | 8.64 |
| 7.5 | | | | | | | | 8.72 |
| 8.0 | | | | | | | | 8.79 |
| 8.5 | | | | | | | | 8.86 |
| 9.0 | | | | | | | | 8.92 |
| 9.5 | | | | | | | | 8.97 |
| 10.0 | | | | | | | | 9.01 |
| 10.5 | | | | | | | | 9.05 |
| 11.0 | | | | | | | | 9.08 |
| 11.5 | | | | | | | | 9.11 |
| 12.0 | 1.10 | 1.60 | 2.31 | 2.83 | 3.44 | 3.89 | 4.34 | 9.14 |
| 18.0 | 1.20 | 1.71 | 2.48 | 3.05 | 3.71 | 4.20 | 4.69 | 9.53 |
| 24.0 | 1.27 | 1.80 | 2.58 | 3.16 | 3.83 | 4.33 | 4.83 | 9.68 |
| 48.0 | 1.50 | 2.11 | 3.05 | 3.76 | 4.55 | 5.12 | 5.66 | 10.82 |
| 72.0 | 1.63 | 2.31 | 3.32 | 4.07 | 4.94 | 5.57 | 6.19 | 11.40 |
| 96.0 | 1.74 | 2.49 | 3.56 | 4.33 | 5.25 | 5.93 | 6.61 | 11.56 |

Table C-2

Incremental rainfall amounts

Rainfall frequency in percent

| Rainfall distribution in hours | 100 | 50 | 20 | 10 | 4 | 2 | 1 | SPS* |
|---|---|---|---|---|---|---|---|---|
| Rainfall by 0.5-hour increments during maximum 6-hour accumulation | | | | | | | | |
| 0.0-0.5 | 0.02 | 0.03 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.03 |
| 0.5-1.0 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.08 | 0.08 | 0.03 |
| 1.0-1.5 | 0.02 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.04 |
| 1.5-2.0 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 | 0.06 |
| 2.0-2.5 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.08 | 0.10 | 0.07 |
| 2.5-3.0 | 0.03 | 0.04 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.10 |
| 3.0-3.5 | 0.04 | 0.04 | 0.06 | 0.07 | 0.09 | 0.09 | 0.10 | 0.27 |
| 3.5-4.0 | 0.04 | 0.05 | 0.07 | 0.08 | 0.09 | 0.10 | 0.11 | 0.33 |
| 4.0-4.5 | 0.04 | 0.05 | 0.07 | 0.08 | 0.10 | 0.10 | 0.11 | 0.41 |
| 4.5-5.0 | 0.04 | 0.05 | 0.08 | 0.08 | 0.10 | 0.11 | 0.12 | 0.62 |
| 5.0-5.5 | 0.10 | 0.17 | 0.30 | 0.38 | 0.49 | 0.58 | 0.65 | 0.78 |
| 5.5-6.0 | 0.56 | 0.82 | 1.18 | 1.45 | 1.77 | 1.99 | 2.23 | 0.85 |
| 6.0-6.5 | | | | | | | | 2.38 |
| 6.5-7.0 | | | | | | | | 0.78 |
| 7.0-7.5 | | | | | | | | 0.67 |
| 7.5-8.0 | | | | | | | | 0.56 |
| 8.0-8.5 | | | | | | | | 0.39 |
| 8.5-9.0 | | | | | | | | 0.30 |
| 9.0-9.5 | | | | | | | | 0.20 |
| 9.5-10.0 | | | | | | | | 0.08 |
| 10.0-10.5 | | | | | | | | 0.07 |
| 10.5-11.0 | | | | | | | | 0.05 |
| 11.0-11.5 | | | | | | | | 0.04 |
| 11.5-12.0 | | | | | | | | 0.03 |
| Rainfall by 6-hour increments during maximum 24-hour accumulation | | | | | | | | |
| 0-6 | 0.97 | 1.40 | 2.03 | 2.49 | 3.05 | 3.45 | 3.86 | 8.34 |
| 6-12 | 0.13 | 0.20 | 0.28 | 0.34 | 0.39 | 0.44 | 0.48 | 0.80 |
| 12-18 | 0.10 | 0.11 | 0.17 | 0.22 | 0.27 | 0.31 | 0.35 | 0.39 |
| 18-24 | 0.07 | 0.09 | 0.10 | 0.11 | 0.12 | 0.13 | 0.14 | 0.15 |
| Rainfall by 24-hour increments during maximum 96-hour accumulation | | | | | | | | |
| 0-24 | 1.27 | 1.80 | 2.58 | 3.16 | 3.83 | 4.33 | 4.83 | 9.68 |
| 24-48 | 0.23 | 0.31 | 0.47 | 0.60 | 0.72 | 0.79 | 0.83 | 1.14 |
| 48-72 | 0.13 | 0.20 | 0.27 | 0.31 | 0.39 | 0.45 | 0.53 | 0.58 |
| 72-96 | 0.11 | 0.18 | 0.24 | 0.26 | 0.31 | 0.36 | 0.42 | 0.16 |

*In accordance with criteria in EM 1110-2-1411, rainfall amounts for the standard project storm are rearranged and are for a maximum 12-hour accumulation.

Table C-3

Hourly rainfall amounts for historical storms of record at Devils Lake, North Dakota

Rainfall in inches

| Date | 16-17 Aug 1955 | 5-6* Jun 1956 | 11-12 Jul 1957 | 10-11 Aug 1962 | 28 Jul 1970 | 19-20 Jun 1974 | 22 Jun 1975 | 11-12 Jun 1976 | 4 Jul 1978 | 25 Aug 1978 |
|---|---|---|---|---|---|---|---|---|---|---|
| Time in hours after start of storm | | | | | | | | | | |
| 1 | 0.08 | 1.08 | 0.06 | 0.92 | 1.14 | 0.13 | 0.90 | 0.94 | 0.80 | 1.10 |
| 2 | 0.02 | 0.49 | 0 | 0.17 | 0.22 | 0.13 | 0.19 | 0.20 | 0.30 | 0.30 |
| 3 | 0 | 0.18 | 0.99 | 0.27 | 0.34 | 0.10 | 0.52 | 0.15 | 0.10 | 0.30 |
| 4 | 0.97 | 0.29 | 0.25 | 0.18 | 0.13 | 0.08 | 0.22 | 0.39 | 0 | |
| 5 | 0.44 | 0.07 | 0.08 | 0.05 | | 0.04 | 0.17 | 0.49 | 0 | |
| 6 | 0.19 | 0.23 | 0.06 | 0.02 | | 0.08 | 0.19 | 0.16 | 0 | |
| 7 | | 0.26 | 0.01 | 0 | | 0.13 | 0.13 | 0.01 | 0 | |
| 8 | | 0.29 | | 0.26 | | 1.17 | 0.05 | | 0 | |
| 9 | | 0.23 | | 0.32 | | 0.06 | 0.08 | | 0 | |
| 10 | | 0.05 | | 0.14 | | 0.06 | 0.03 | | 0 | |
| 11 | | 0.02 | | 0.01 | | 0.10 | 0.02 | | 0 | |
| 12 | | 0.01 | | 0 | | 0.01 | | | 0 | |
| 13 | | 0 | | 0 | | 0.01 | | | 0 | |
| 14 | | 0 | | 0.02 | | 0 | | | 0 | |
| 15 | | 0 | | | | 0 | | | 0 | |
| 16 | | 0 | | | | 0.20 | | | 0 | |
| 17 | | 0 | | | | 0 | | | 0.20 | |
| 18 | | 0 | | | | 0 | | | 0.40 | |
| 19 | | 0 | | | | 0 | | | | |
| 20 | | 0 | | | | 0 | | | | |
| 21 | | 0 | | | | 0.01 | | | | |
| 22 | | 0.12 | | | | | | | | |
| 23 | | 0.07 | | | | | | | | |
| Total | 1.70 | 3.39 | 1.45 | 2.36 | 1.83 | 2.31 | 2.50 | 2.34 | 1.80 | 1.70 |

*Largest historical storm of record

Table C-4

Interior watershed characteristics

| Section | Subsection | Area Acres | Area Sq. Mi. | Watershed Length Feet | Average Watershed Slope Ft./Ft. | Flow Velocity Ft./Sec. | Clark's* Coefficients $T_c$, Hrs. | Clark's* Coefficients R | Snyder's Coefficients $T_p$ | Snyder's Coefficients $C_p$ | Ratio Impervious - |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 179.1 | 0.28 | 4,000 | 0.0075 | 0.37 | 3.0 | 1.3 | 2.4 | 0.76 | 0.05 |
| 2 | | 2054.2 | 3.21 | 10,000 | 0.0035 | 0.40 | 6.9 | 3.2 | 5.6 | 0.78 | 0.10 |
| 3 | | 547.3 | 0.86 | 8,500 | 0.0041 | 0.30 | 1.8 | 1.0 | 1.4 | 0.64 | 0.35 |
| 4 | 4A | 191.9 | 0.30 | 3,500 | 0.0043 | 0.52 | 1.9 | 1.1 | 1.5 | 0.63 | 0.05 |
| | 4B | 146.0 | 0.23 | 2,300 | 0.0043 | 0.46 | 1.4 | 0.8 | 1.1 | 0.62 | 0.05 |
| | 4C | 208.4 | 0.33 | 3,000 | 0.0050 | 0.50 | 1.7 | 1.0 | 1.4 | 0.65 | 0.05 |
| | 4D | 742.9 | 1.16 | 7,500 | 0.0067 | 0.60 | 3.5 | 2.0 | 2.9 | 0.72 | 0.10 |
| 5 | 5A | 166.2 | 0.26 | 3,500 | 0.0057 | 0.53 | 1.8 | 1.0 | 1.4 | 0.64 | 0.05 |
| | 5B | 200.2 | 0.31 | 2,800 | 0.0036 | 0.42 | 1.9 | 1.0 | 1.5 | 0.65 | 0.10 |

*Based in part on data from a similar basin near Cooperstown, North Dakota.

Table C-5

30-minute unit hydrographs for interior watersheds

| Area | 1 | 2 | 3 | 4 | | | | 5 | |
|---|---|---|---|---|---|---|---|---|---|
| Subarea | | | | 4A | 4B | 4C | 4D | 5A | 5B |
| Time in hours | | | | | | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 6 | 8 | 46 | 14 | 21 | 19 | 13 | 14 | 15 |
| 1.0 | 20 | 30 | 156 | 47 | 67 | 65 | 46 | 47 | 52 |
| 1.5 | 37 | 61 | 248 | 78 | 84 | 100 | 89 | 75 | 85 |
| 2.0 | 52 | 95 | 242 | 82 | 59 | 92 | 134 | 73 | 88 |
| 2.5 | 58 | 131 | 167 | 61 | 31 | 60 | 168 | 50 | 64 |
| 3.0 | 55 | 167 | 100 | 39 | 16 | 36 | 184 | 30 | 38 |
| 3.5 | 43 | 204 | 60 | 24 | 9 | 22 | 179 | 18 | 23 |
| 4.0 | 29 | 237 | 36 | 15 | 4 | 13 | 152 | 11 | 14 |
| 4.5 | 20 | 262 | 22 | 10 | 2 | 8 | 118 | 7 | 8 |
| 5.0 | 13 | 279 | 13 | 6 | 1 | 5 | 92 | 4 | 5 |
| 5.5 | 9 | 286 | 8 | 4 | 1 | 3 | 72 | 2 | 3 |
| 6.0 | 6 | 286 | 5 | 2 | 0 | 2 | 56 | 1 | 2 |
| 6.5 | 4 | 278 | 3 | 2 | | 1 | 43 | 1 | 1 |
| 7.0 | 3 | 257 | 2 | 1 | | 1 | 34 | 1 | 1 |
| 7.5 | 2 | 226 | 0 | 1 | | 0 | 26 | 0 | 0 |
| 8.0 | 1 | 193 | | 0 | | | 20 | | |
| 8.5 | 1 | 165 | | | | | 16 | | |
| 9.0 | 1 | 141 | | | | | 12 | | |
| 9.5 | 0 | 121 | | | | | 10 | | |
| 10.0 | | 103 | | | | | 7 | | |
| 10.5 | | 88 | | | | | 6 | | |
| 11.0 | | 76 | | | | | 5 | | |
| 11.5 | | 65 | | | | | 4 | | |
| 12.0 | | 55 | | | | | 3 | | |
| 12.5 | | 47 | | | | | 2 | | |
| 13.0 | | 40 | | | | | 2 | | |
| 13.5 | | 35 | | | | | 1 | | |
| 14.0 | | 30 | | | | | 0 | | |
| 14.5 | | 25 | | | | | | | |
| 15.0 | | 22 | | | | | | | |
| 15.5 | | 18 | | | | | | | |
| 16.0 | | 16 | | | | | | | |
| 16.5 | | 13 | | | | | | | |
| 17.0 | | 12 | | | | | | | |
| 17.5 | | 10 | | | | | | | |
| 18.0 | | 8 | | | | | | | |
| 18.5 | | 7 | | | | | | | |
| 19.0 | | 6 | | | | | | | |
| 19.5 | | 5 | | | | | | | |
| 20.0 | | 5 | | | | | | | |
| 20.5 | | 4 | | | | | | | |
| 21.0 | | 3 | | | | | | | |
| 21.5 | | 3 | | | | | | | |
| 22.0 | | 2 | | | | | | | |
| 22.5 | | 0 | | | | | | | |
| 23.0 | | | | | | | | | |

Table C-6

Hypothetical runoff hydrographs

| Time in hours | Area 1 2-percent | Area 1 1-percent | Area 1 SPS | Area 2 2-percent | Area 2 1-percent | Area 2 SPS | Area 3 2-percent | Area 3 1-percent | Area 3 SPS |
|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| [illegible] | [illegible] | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| [illegible] | [illegible] | 0 | 0 | 0 | 0 | 0 | 4 | 6 | 2 |
| [illegible] | [illegible] | 0 | 0 | 1 | 1 | 0 | 11 | 13 | 4 |
| [illegible] | [illegible] | 0 | 0 | 2 | 2 | 0 | 18 | 21 | 7 |
| [illegible] | [illegible] | 0 | 0 | 3 | 3 | 0 | 24 | 26 | 11 |
| [illegible] | [illegible] | 0 | 0 | 5 | 5 | 1 | 28 | 30 | 15 |
| [illegible] | [illegible] | 1 | 1 | 7 | 8 | 3 | 31 | 36 | 25 |
| [illegible] | [illegible] | 2 | 3 | 11 | 13 | 8 | 36 | 45 | 55 |
| [illegible] | [illegible] | 4 | 11 | 16 | 19 | 21 | 45 | 57 | 115 |
| [illegible] | [illegible] | 8 | 25 | 23 | 28 | 47 | 56 | 69 | 206 |
| [illegible] | [illegible] | 14 | 49 | 35 | 44 | 91 | 87 | 103 | 324 |
| [illegible] | [illegible] | 37 | 80 | 72 | 86 | 159 | 234 | 265 | 461 |
| [illegible] | 66 | 79 | 126 | 139 | 164 | 266 | 466 | 548 | 669 |
| [illegible] | [illegible] | 124 | 186 | 226 | 262 | 421 | 647 | 728 | 947 |
| [illegible] | 139 | 158 | 245 | 318 | 367 | 615 | 553 | 655 | 1149 |
| [illegible] | 147 | 166 | 292 | 413 | 475 | 833 | 392 | 441 | 1149 |
| [illegible] | [illegible] | 150 | 312 | 507 | 580 | 1065 | 237 | 264 | 994 |
| [illegible] | [illegible] | 114 | 305 | 598 | 683 | 1299 | 141 | 159 | 813 |
| [illegible] | 64 | 77 | 272 | 675 | 769 | 1526 | 85 | 95 | 649 |
| [illegible] | [illegible] | 53 | 227 | 730 | 830 | 1726 | 52 | 58 | 501 |
| [illegible] | 31 | 35 | 184 | 762 | 866 | 1884 | 31 | 34 | 369 |
| [illegible] | 21 | 24 | 143 | 770 | 873 | 1992 | 19 | 21 | 257 |
| [illegible] | 14 | 16 | 108 | 758 | 859 | 2042 | 11 | 13 | 172 |
| [illegible] | [illegible] | 11 | 78 | 724 | 819 | 2038 | 7 | 8 | 113 |
| [illegible] | [illegible] | 6 | 54 | 659 | 746 | 1980 | 4 | 4 | 73 |
| [illegible] | [illegible] | 5 | 38 | 576 | 652 | 1868 | 3 | 3 | 46 |
| [illegible] | 3 | 3 | 26 | 492 | 557 | 1713 | 2 | 3 | 26 |
| [illegible] | [illegible] | 2 | 17 | 421 | 476 | 1539 | 2 | 2 | 15 |
| [illegible] | [illegible] | 2 | 12 | 360 | 407 | 1364 | 1 | 2 | 9 |
| [illegible] | [illegible] | 2 | 8 | 308 | 349 | 1195 | 1 | 1 | 5 |
| [illegible] | [illegible] | 1 | 4 | 263 | 297 | 1039 | 0 | 1 | 2 |
| [illegible] | [illegible] | 1 | 3 | 225 | 254 | 846 | | 0 | 1 |
| [illegible] | | 0 | 2 | 194 | 219 | 769 | | | 1 |
| [illegible] | | | 2 | 165 | 187 | 665 | | | 1 |
| [illegible] | | | 2 | 140 | 159 | 565 | | | 1 |
| [illegible] | | | 2 | 120 | 136 | 432 | | | 1 |
| [illegible] | | | 2 | 102 | 116 | 412 | | | 0 |
| [illegible] | | | 1 | 89 | 101 | 352 | | | |
| [illegible] | | | 1 | 76 | 86 | 303 | | | |
| [illegible] | | | 1 | 64 | 72 | 259 | | | |
| [illegible] | | | 1 | 56 | 63 | 220 | | | |
| [illegible] | | | 1 | 46 | 52 | 189 | | | |
| [illegible] | | | 0 | 40 | 46 | 161 | | | |
| [illegible] | | | | 34 | 38 | 134 | | | |
| [illegible] | | | | 30 | 34 | 117 | | | |
| [illegible] | | | | 25 | 28 | 101 | | | |
| [illegible] | | | | 20 | 23 | 86 | | | |
| [illegible] | | | | 18 | 20 | 73 | | | |
| [illegible] | | | | 15 | 17 | 62 | | | |
| [illegible] | | | | 13 | 15 | 53 | | | |
| 25.5 | | | | 12 | 14 | 45 | | | |
| 26.0 | | | | 10 | 11 | 39 | | | |
| 26.5 | | | | 8 | 9 | 32 | | | |
| 27.0 | | | | 7 | 8 | 26 | | | |
| 27.5 | | | | 5 | 5 | 21 | | | |
| 28.0 | | | | 3 | 3 | 15 | | | |
| 28.5 | | | | 2 | 3 | 9 | | | |
| 29.0 | | | | 2 | 2 | 6 | | | |
| 29.5 | | | | 2 | 2 | 4 | | | |
| 30.0 | | | | 1 | 1 | 2 | | | |
| 30.5 | | | | 1 | 1 | 1 | | | |
| 31.0 | | | | 0 | 0 | 1 | | | |
| 31.5 | | | | | | 1 | | | |
| 32.0 | | | | | | 1 | | | |
| 32.5 | | | | | | 1 | | | |
| 33.0 | | | | | | 0 | | | |

Table C-7

Hypothetical runoff hydrographs

| Time in hours | Area 4A 2-percent | Area 4A 1-percent | Area 4A SPS | Area 4B 2-percent | Area 4B 1-percent | Area 4B SPS | Area 4C 2-percent | Area 4C 1-percent | Area 4C SPS |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.5 | 0 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| 4.0 | 2 | 5 | 8 | 3 | 6 | 12 | 3 | 6 | 11 |
| 4.5 | 5 | 9 | 25 | 7 | 11 | 34 | 7 | 12 | 34 |
| 5.0 | 10 | 14 | 54 | 11 | 14 | 65 | 12 | 17 | 71 |
| 5.5 | 20 | 25 | 93 | 23 | 28 | 103 | 25 | 31 | 118 |
| 6.0 | 64 | 74 | 140 | 87 | 99 | 145 | 86 | 99 | 173 |
| 6.5 | 143 | 162 | 208 | 181 | 204 | 215 | 190 | 215 | 256 |
| 7.0 | 202 | 228 | 299 | 197 | 222 | 308 | 250 | 282 | 367 |
| 7.5 | 196 | 221 | 371 | 133 | 149 | 341 | 214 | 242 | 443 |
| 8.0 | 142 | 160 | 384 | 69 | 78 | 295 | 138 | 156 | 432 |
| 8.5 | 90 | 102 | 342 | 36 | 41 | 232 | 83 | 94 | 365 |
| 9.0 | 56 | 63 | 285 | 20 | 22 | 179 | 51 | 57 | 297 |
| 9.5 | 35 | 40 | 229 | 9 | 10 | 136 | 30 | 34 | 236 |
| 10.0 | 23 | 26 | 179 | 4 | 5 | 96 | 19 | 21 | 179 |
| 10.5 | 14 | 16 | 134 | 2 | 3 | 63 | 12 | 13 | 129 |
| 11.0 | 9 | 10 | 93 | 2 | 2 | 38 | 7 | 8 | 87 |
| 11.5 | 5 | 6 | 63 | 0 | 0 | 21 | 4 | 5 | 55 |
| 12.0 | 4 | 5 | 40 | | | 10 | 2 | 3 | 35 |
| 12.5 | 2 | 3 | 26 | | | 5 | 2 | 2 | 21 |
| 13.0 | 2 | 2 | 16 | | | 3 | 0 | 0 | 12 |
| 13.5 | 0 | 0 | 11 | | | 1 | | | 7 |
| 14.0 | | | 6 | | | 1 | | | 4 |
| 14.5 | | | 3 | | | 0 | | | 2 |
| 15.0 | | | 2 | | | | | | 1 |
| 15.5 | | | 1 | | | | | | 1 |
| 16.0 | | | 1 | | | | | | 0 |
| 16.5 | | | 0 | | | | | | |
| 17.0 | | | | | | | | | |
| 17.5 | | | | | | | | | |
| 18.0 | | | | | | | | | |
| 18.5 | | | | | | | | | |
| 19.0 | | | | | | | | | |
| 19.5 | | | | | | | | | |
| 20.0 | | | | | | | | | |

Table C-8

Hypothetical runoff hydrographs

| Time in hours | Area 4D | | | Area 5A | | | Area 5B | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2-percent | 1-percent | SPS | 2-percent | 1-percent | SPS | 2-percent | 1-percent | SPS |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1.0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1.5 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 2.0 | 3 | 3 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| 2.5 | 4 | 4 | 1 | 3 | 3 | 1 | 0 | 0 | 0 |
| 3.0 | 6 | 7 | 1 | 3 | 3 | 1 | 0 | 0 | 0 |
| 3.5 | 9 | 10 | 4 | 3 | 5 | 3 | 0 | 2 | 1 |
| 4.0 | 12 | 14 | 12 | 5 | 8 | 11 | 2 | 5 | 9 |
| 4.5 | 16 | 21 | 31 | 9 | 12 | 27 | 6 | 10 | 28 |
| 5.0 | 23 | 31 | 68 | 12 | 16 | 54 | 10 | 15 | 59 |
| 5.5 | 38 | 49 | 128 | 22 | 27 | 91 | 22 | 27 | 102 |
| 6.0 | 87 | 105 | 214 | 66 | 76 | 133 | 71 | 82 | 152 |
| 6.5 | 179 | 208 | 344 | 142 | 160 | 197 | 157 | 178 | 225 |
| 7.0 | 287 | 329 | 520 | 191 | 216 | 281 | 219 | 247 | 322 |
| 7.5 | 390 | 443 | 710 | 172 | 194 | 342 | 209 | 236 | 397 |
| 8.0 | 458 | 519 | 888 | 115 | 130 | 342 | 147 | 166 | 407 |
| 8.5 | 480 | 543 | 1021 | 69 | 78 | 294 | 87 | 99 | 357 |
| 9.0 | 450 | 508 | 1088 | 42 | 47 | 240 | 53 | 60 | 291 |
| 9.5 | 374 | 423 | 1083 | 26 | 29 | 191 | 32 | 36 | 232 |
| 10.0 | 391 | 329 | 1008 | 16 | 18 | 147 | 19 | 21 | 178 |
| 10.5 | 337 | 256 | 892 | 9 | 10 | 108 | 12 | 13 | 129 |
| 11.0 | 177 | 200 | 770 | 5 | 5 | 74 | 7 | 8 | 88 |
| 11.5 | 138 | 155 | 647 | 3 | 3 | 48 | 4 | 5 | 57 |
| 12.0 | 106 | 120 | 531 | 2 | 3 | 30 | 2 | 3 | 35 |
| 12.5 | 83 | 94 | 426 | 2 | 2 | 19 | 2 | 2 | 21 |
| 13.0 | 64 | 72 | 338 | 0 | 0 | 12 | 0 | 0 | 13 |
| 13.5 | 50 | 56 | 264 | | | 6 | | | 7 |
| 14.0 | 39 | 44 | 206 | | | 3 | | | 4 |
| 14.5 | 30 | 34 | 161 | | | 2 | | | 2 |
| 15.0 | 24 | 27 | 125 | | | 1 | | | 1 |
| 15.5 | 18 | 20 | 98 | | | 1 | | | 1 |
| 16.0 | 15 | 17 | 75 | | | 0 | | | 0 |
| 16.5 | 12 | 14 | 60 | | | | | | |
| 17.0 | 10 | 11 | 47 | | | | | | |
| 17.5 | 7 | 8 | 37 | | | | | | |
| 18.0 | 5 | 6 | 28 | | | | | | |
| 18.5 | 4 | 5 | 21 | | | | | | |
| 19.0 | 2 | 2 | 16 | | | | | | |
| 19.5 | 1 | 1 | 11 | | | | | | |
| 20.0 | 0 | 1 | 6 | | | | | | |
| 20.5 | | 0 | 4 | | | | | | |
| 21.0 | | | 3 | | | | | | |
| 21.5 | | | 1 | | | | | | |
| 22.0 | | | 1 | | | | | | |
| 22.5 | | | 0 | | | | | | |
| 23.0 | | | | | | | | | |
| 23.5 | | | | | | | | | |
| 24.0 | | | | | | | | | |
| 24.5 | | | | | | | | | |
| 25.0 | | | | | | | | | |
| 25.5 | | | | | | | | | |
| 26.0 | | | | | | | | | |
| 26.5 | | | | | | | | | |
| 27.0 | | | | | | | | | |

Table C-9

Runoff hydrographs for the historical storm of 5-6 June 1956

| Time in hours | Area 1 | 2 | 3 | 4A | 4B | 4C | 4D | 5A | 5B |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 11 | 17 | 112 | 26 | 37 | 36 | 27 | 26 | 30 |
| 2 | 36 | 67 | 244 | 63 | 72 | 80 | 96 | 60 | 72 |
| 3 | 54 | 138 | 193 | 58 | 48 | 65 | 164 | 50 | 62 |
| 4 | 47 | 219 | 131 | 40 | 29 | 43 | 183 | 33 | 42 |
| 5 | 37 | 291 | 96 | 28 | 20 | 30 | 158 | 23 | 30 |
| 6 | 25 | 337 | 66 | 19 | 13 | 20 | 128 | 15 | 20 |
| 7 | 21 | 356 | 85 | 24 | 23 | 29 | 109 | 21 | 26 |
| 8 | 25 | 344 | 104 | 29 | 29 | 35 | 108 | 26 | 32 |
| 9 | 28 | 327 | 108 | 31 | 28 | 36 | 116 | 27 | 34 |
| 10 | 26 | 314 | 75 | 22 | 16 | 24 | 113 | 19 | 24 |
| 11 | 17 | 298 | 34 | 10 | 3 | 9 | 92 | 7 | 10 |
| 12 | 8 | 277 | 15 | 4 | 1 | 3 | 63 | 3 | 4 |
| 13 | 4 | 243 | 5 | 1 | 0 | 1 | 39 | 1 | 1 |
| 14 | 2 | 201 | 2 | 0 | 0 | 0 | 23 | 0 | 1 |
| 15 | 2 | 156 | 2 | 0 | 0 | 0 | 13 | 0 | 0 |
| 16 | 2 | 115 | 2 | 0 | 0 | 0 | 8 | 0 | 0 |
| 17 | 2 | 85 | 2 | 0 | 0 | 0 | 5 | 0 | 0 |
| 18 | 2 | 62 | 2 | 0 | 0 | 0 | 3 | 0 | 0 |
| 19 | 2 | 45 | 2 | 0 | 0 | 0 | 2 | 0 | 0 |
| 20 | 2 | 33 | 2 | 0 | 0 | 0 | 1 | 0 | 0 |
| 21 | 2 | 25 | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| 22 | 2 | 21 | 18 | 1 | 2 | 2 | 1 | 1 | 2 |
| 23 | 2 | 18 | 13 | 2 | 3 | 3 | 4 | 2 | 3 |
| 24 | 1 | 17 | 7 | 1 | 0 | 1 | 7 | 1 | 2 |
| 25 | 1 | 16 | 3 | 0 | | 0 | 6 | 0 | 1 |
| 26 | 1 | 15 | 2 | | | | 4 | | 0 |
| 27 | 1 | 13 | 2 | | | | 3 | | |
| 28 | 0 | 10 | 2 | | | | 2 | | |
| 29 | | 7 | 2 | | | | 1 | | |
| 30 | | 5 | 2 | | | | 1 | | |
| 31 | | 3 | 1 | | | | 0 | | |
| 32 | | 2 | 1 | | | | | | |
| 33 | | 1 | 1 | | | | | | |
| 34 | | 1 | 1 | | | | | | |
| 35 | | 1 | 0 | | | | | | |
| 36 | | 1 | | | | | | | |
| 37 | | 0 | | | | | | | |

Table C-10

Design of culverts and gravity outlet

| Identification | Culvert A | Culvert B | Gravity |
|---|---|---|---|
| Location | (North ponding area) | (Landfill Road) | Outlet |
| Pipe diameter, inches | 36 x 58 arch | 72 | 72 |
| Number of pipes | 2 | 1 | 1 |
| Design discharge, cfs | 92 | 220 | 211 |
| Slope, ft./ft. | 0.0015 | 0.0010 | 0.0010 |
| Upstream invert elevation | 1425.5 | 1422.0 | 1421.0 |
| Length, ft. | 88 | 64.5 | 200 |
| Maximum design water surface elevation | | | |
| 1-percent | 1428.7 | 1428.5 | 1427.6 |
| SPS | 1431.0 | 1430.5 | 1429.5 |
| Zero damage elevation | 1429.0 | 1429.0 | - |

Table C-11

Data for stormwater pumps

| | |
|---|---|
| **Data on pumping station** | |
| Total discharge requirement at design flood stage (gpm) | 16,000 |
| Type of pump (all single stage) | Axial |
| Number of pumps | 2 |
| Size of pump nozzle (inch-nominal) | 18 |
| Size of discharge line (inch-nominal) | 24 |
| Speed RPM | 870 |
| Nominal motor horsepower (BHP) | 50 |
| Effective length in feet | 216 |
| **Water level elevations** | |
| Gravity outlet gate closure | 1427.0 |
| Design lake stage | 1440.0 |
| Maximum sump elevation | 1425.0 |
| Minimum sump elevation | 1424.0 |
| Design sump level for pump activation | 1424.5 |
| Maximum elevation of discharge line | 1445.0 |
| **Pump head capacity requirements (one pump operating)** | |
| Capacity (gpm) | 8,000 |
| Static head (ft.) | 15.5 |
| Friction head (ft.) | 0.8 |
| Velocity head (ft.) | 0.5 |
| Total dynamic head (ft.) | 16.8 |

Table C-12

**PUMP PERFORMANCE CHARACTERISTICS**

| PLATE NO. | DESIGN DISCHARGE (GPM) | DESIGN HEAD (FEET) | NOZZLE DIAMETER (IN.) | DISCHARGE PIPE DIAMETER (IN.) | STAGE | DESIGN INTERSECTION WITH SYSTEM HEAD CURVE HEAD (FT.) | DESIGN INTERSECTION WITH SYSTEM HEAD CURVE DISCHARGE (GPM), | DESIGN INTERSECTION WITH SYSTEM HEAD CURVE BHP | OTHER INTERSECTION WITH SYSTEM HEAD CURVE HEAD (FT.) | OTHER INTERSECTION WITH SYSTEM HEAD CURVE DISCHARGE (GPM) | OTHER INTERSECTION WITH SYSTEM HEAD CURVE BHP | SPECIFIC SPEED (N) (RPM) | PUMP RPM | MINIMUM SUBMERGENCE BELOW MINIMUM SUMP (FT.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 8000. | 19.77 | 18.0 | 18.0 | 1. | 25.4 | 12134. | 92.9 | 24.6 | 12289. | 91.6 | 10000. | 1170. | 9.78 |
| 19 | 8000. | 19.77 | 18.0 | 18.0 | 1. | 22.5 | 9968. | 68.6 | 21.8 | 10216. | 66.8 | 9930. | 1170. | 4.83 |
| 20 | 8000. | 19.77 | 18.0 | 18.0 | 1. | 24.8 | 11754. | 89.8 | 23.8 | 11752. | 85.7 | 10550. | 1170. | 8.84 |
| 21A | 8000. | 19.77 | 18.0 | 18.0 | 1. | 24.7 | 11657. | 104.0 | 23.9 | 11778. | 103.7 | 7400. | 1170. | 8.72 |
| 21B | 8000. | 19.77 | 18.0 | 18.0 | 1. | 24.4 | 11459. | 97.1 | 23.7 | 11686. | 97.3 | 7725. | 1170. | 8.28 |
| 21C | 8000. | 19.77 | 18.0 | 18.0 | 1. | 22.4 | 9849. | 69.4 | 21.4 | 9977. | 68.7 | 7650. | 1170. | 4.55 |
| 18 | 8000. | 18.29 | 18.0 | 20.0 | 1. | 22.5 | 12615. | 88.3 | 21.7 | 12721. | 86.8 | 10000. | 1170. | 10.84 |
| 19 | 8000. | 18.29 | 18.0 | 20.0 | 1. | 20.7 | 10521. | 64.5 | 19.8 | 10617. | 63.4 | 9930. | 1170. | 6.13 |
| 20 | 8000. | 18.29 | 18.0 | 20.0 | 1. | 22.3 | 12319. | 85.6 | 21.5 | 12479. | 83.8 | 10550. | 1170. | 10.19 |
| 21A | 8000. | 18.29 | 18.0 | 20.0 | 1. | 21.9 | 11964. | 102.2 | 21.0 | 12025. | 101.1 | 7400. | 1170. | 9.41 |
| 21B | 8000. | 18.29 | 18.0 | 20.0 | 1. | 22.0 | 12009. | 96.3 | 21.1 | 12082. | 95.1 | 7725. | 1170. | 9.51 |
| 21C | 8000. | 18.29 | 18.0 | 20.0 | 1. | 20.4 | 10113. | 67.8 | 19.4 | 10222. | 67.1 | 7650. | 1170. | 5.18 |
| 18 | 8000. | 16.84 | 18.0 | 24.0 | 1. | 17.3 | 7999. | 42.5 | 16.5 | 8530. | 41.2 | 10000. | 870. | -9.94 |
| 19 | 8000. | 16.84 | 18.0 | 24.0 | 1. | 18.3 | 10761. | 61.8 | 17.4 | 10865. | 59.8 | 9930. | 1170. | 6.68 |
| 20 | 8000. | 16.84 | 18.0 | 24.0 | 1. | 19.4 | 13038. | 81.1 | 18.5 | 13197. | 79.1 | 10550. | 1170. | 11.75 |
| 21A | 8000. | 16.84 | 18.0 | 24.0 | 1. | 17.4 | 8151. | 45.0 | 16.4 | 8276. | 44.4 | 7400. | 870. | -9.68 |
| 21B | 8000. | 16.84 | 18.0 | 24.0 | 1. | 19.1 | 12522. | 93.4 | 18.1 | 12416. | 90.4 | 7725. | 1170. | 10.64 |
| 21C | 8000. | 16.84 | 18.0 | 24.0 | 1. | 18.2 | 10355. | 66.2 | 17.2 | 10513. | 65.4 | 7650. | 1170. | 5.74 |
| 18 | | | | | | | | | | | | | | |
| 19 | 8000. | 18.26 | 20.0 | 20.0 | 1. | 19.5 | 9035. | 52.4 | 18.7 | 9333. | 51.8 | 9930. | 870. | -8.21 |
| 20 | 8000. | 18.26 | 20.0 | 20.0 | 1. | 20.0 | 9693. | 61.1 | 18.8 | 9478. | 60.8 | 10550. | 870. | -7.14 |
| 21A | 8000. | 18.26 | 20.0 | 20.0 | 1. | 21.2 | 11263. | 78.2 | 20.3 | 11345. | 75.3 | 7400. | 870. | -4.68 |
| 21B | 8000. | 18.26 | 20.0 | 20.0 | 1. | 20.8 | 10754. | 70.9 | 20.0 | 11104. | 71.3 | 7725. | 870. | -5.46 |
| 21C | 8000. | 18.26 | 20.0 | 20.0 | 1. | 19.4 | 9003. | 51.3 | 18.6 | 9239. | 51.0 | 7650. | 870. | -8.26 |
| 18 | | | | | | | | | | | | | | |
| 19 | 8000. | 16.83 | 20.0 | 24.0 | 1. | 17.9 | 9652. | 51.4 | 16.9 | 9890. | 49.6 | 9930. | 870. | -7.20 |
| 20 | 8000. | 16.83 | 20.0 | 24.0 | 1. | 18.5 | 11270. | 63.5 | 17.6 | 11534. | 62.3 | 10550. | 870. | -4.87 |
| 21A | 8000. | 16.83 | 20.0 | 24.0 | 1. | 18.7 | 11545. | 73.8 | 17.7 | 11877. | 72.5 | 7400. | 870. | -4.25 |
| 21B | 8000. | 16.83 | 20.0 | 24.0 | 1. | 18.6 | 11349. | 69.5 | 17.8 | 11780. | 69.9 | 7725. | 870. | -4.55 |
| 21C | 8000. | 16.83 | 20.0 | 24.0 | 1. | 17.7 | 9420. | 50.2 | 16.9 | 9625. | 49.3 | 7650. | 870. | -7.58 |
| 18 | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | |
| 21A | 8000. | 16.80 | 24.0 | 24.0 | 1. | 17.9 | 9744. | 54.1 | 17.2 | 10559. | 55.2 | 7400. | 575. | -17.00 |
| 21B | | | | | | | | | | | | | | |
| 21C | 8000. | 16.80 | 24.0 | 24.0 | 1. | 18.8 | 11946. | 65.3 | 17.9 | 12212. | 63.8 | 7650. | 690. | -10.78 |

Table C-13

Pump Performance Computations

```
***********************************************************************

H(QM)/(NP**0.5)=      2.407
NOZZLE DIAMETER=        18. INCHES
MODEL DISCHARGE QM=      9877. GPM
INTERSECTION COORDINATE QX=    12544. GPM
INTERSECTION COORDINATE HX=      27.2 FEET

TESTED SPEED (RPM)=      874.
SPECIFIC SPEED (RPM)=    10000.
PUMP SIZE (IN)=        20.
HC=       767.

VALUES FROM MODEL CURVES
XHM=      5.00      10.00      15.00      20.00      31.00      25.00
QM=   16800.00   16100.00   15200.00   14300.00   11200.00   13200.00
PM=      57.00      67.50      78.00      87.50     109.00      97.00

HC/HM=        0.787368
(DP/DM)**2=        0.810000
VALUES FROM MODEL CURVE BASED ON HC=  767. RPM
QP1=((DP/DM)**2)*QC      PP1=((DP/DM)**2)*PC

HC =       3.10       6.20       9.30      12.40      19.22      15.50
QC =   13227.78   12676.62   11967.99   11259.36    8818.52   10393.25
PC =      27.82      32.95      38.07      42.71      53.21      47.35
QP1=   10714.50   10268.06    9694.07    9120.08    7143.00    8418.54
PP1=      22.54      26.69      30.84      34.60      43.10      38.35

RECOMMENDED STANDARD FULL SPEED=  870. (RPM)
LINE 330.2  INSX=  1
HX=      3.23       6.46       9.69      12.93      20.03      16.16
QX=  10938.49   10483.68    9897.63    9311.59    7292.99    8595.31
PX=     23.99      28.41      32.82      36.82      45.87      40.82

CHECK SPECIFIC SPEED:     10009.
ACTUAL SPECIFIC SPEED:     10000.
RECOMMENDED STANDARD FULL SPEED=  870. (RPM)
INTERSECTION WITH SYSTEM HEAD CURVE
DESIGN    H=  17.34   Q=   7998.78   P=  42.47
OTHER     H=  16.53   Q=   8530.32   P=  41.25
    SUCITON CONDITIONS BELOW MINIMUM SUMP=  -9.94    2  ITERATIONS
***********************************************************************
```

Table C-14

Maximum interior pond levels during hypothetical and historical storms
Existing and Proposed Conditions

| | Existing Conditions | | | | Proposed Conditions | | | |
|---|---|---|---|---|---|---|---|---|
| | North ponding area | East & South ponding areas | Landfill Road ponding area | Damages in $ | Culvert A North ponding area | Culvert B South, East & Landfill Road ponding area | Gravity Outlet Creel Bay ponding area | Damages in $ |
| **2-percent storm** | 1428.5 | 1428.7 | 1427.8 | - | 1428.5 | 1428.4 | 1427.4 | - |
| **1-percent storm** | 1428.7 | 1428.8 | 1428.0 | - | 1428.7 | 1428.5 | 1427.6 | - |
| **Standard project storm** | 1431.0 | 1431.0 | 1429.2 | 46,000 | 1431.0 | 1430.5 | 1429.5 | 32,000 |
| **5-6 June 1956** | 1428.0 | 1428.2 | 1427.4 | - | 1428.0 | 1427.9 | 1427.0 | - |

Table C-15

Evaluation of pumping operations during hypothetical storms

Maximum Pond Elevation

| Hypothetical Storms | No Pumping | 6,000 gpm | 9,000 gpm | 12,000 gpm | 18,000 gpm | 24,000 gpm | 30,000 gpm | 36,000 gpm | 42,000 gpm |
|---|---|---|---|---|---|---|---|---|---|
| 50-percent | 1429.00 | 1428.45 | 1428.13 | 1427.93 | 1427.81 | 1427.75 | 1427.73 | 1427.71 | 1427.68 |
| 20-percent | 1429.37 | 1428.85 | 1428.57 | 1428.39 | 1428.23 | 1428.14 | 1428.08 | 1428.04 | 1428.00 |
| 10-percent | 1429.77 | 1429.27 | 1429.01 | 1428.74 | 1428.55 | 1428.45 | 1428.38 | 1428.33 | 1428.27 |
| 4-percent | 1430.13 | 1429.67 | 1429.42 | 1429.16 | 1428.91 | 1428.77 | 1428.69 | 1428.61 | 1428.55 |
| 2-percent | 1430.50 | 1430.06 | 1429.82 | 1429.58 | 1429.18 | 1429.02 | 1428.91 | 1428.83 | 1428.76 |
| 1-percent | 1430.86 | 1430.42 | 1430.20 | 1429.96 | 1429.50 | 1429.25 | 1429.13 | 1429.03 | 1428.96 |

| | Damages in Dollars | | | | | | | | | Benefits in Dollars | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hypothetical Storms | No Pumping | 6,000 gpm | 9,000 gpm | 12,000 gpm | 18,000 gpm | 24,000 gpm | 30,000 gpm | 36,000 gpm | 42,000 gpm | 6,000 gpm | 9,000 gpm | 12,000 gpm | 18,000 gpm | 24,000 gpm | 30,000 gpm | 36,000 gpm | 42,000 gpm |
| 50-percent | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 20-percent | 7,000 | - | - | - | - | - | - | - | - | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 | 7,000 |
| 10-percent | 16,000 | 5,000 | - | - | - | - | - | - | - | 11,000 | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 | 16,000 |
| 4-percent | 23,000 | 14,000 | 8,000 | 2,000 | - | - | - | - | - | 9,000 | 15,000 | 21,000 | 23,000 | 23,000 | 23,000 | 23,000 | 23,000 |
| 2-percent | 32,000 | 22,000 | 16,000 | 12,000 | 2,000 | - | - | - | - | 10,000 | 16,000 | 20,000 | 30,000 | 32,000 | 32,000 | 32,000 | 32,000 |
| 1-percent | 42,000 | 30,000 | 25,300 | 20,000 | 10,000 | 5,000 | 2,000 | 500 | - | 12,000 | 17,000 | 22,000 | 32,000 | 37,000 | 40,000 | 41,500 | 42,000 |

Table C-16

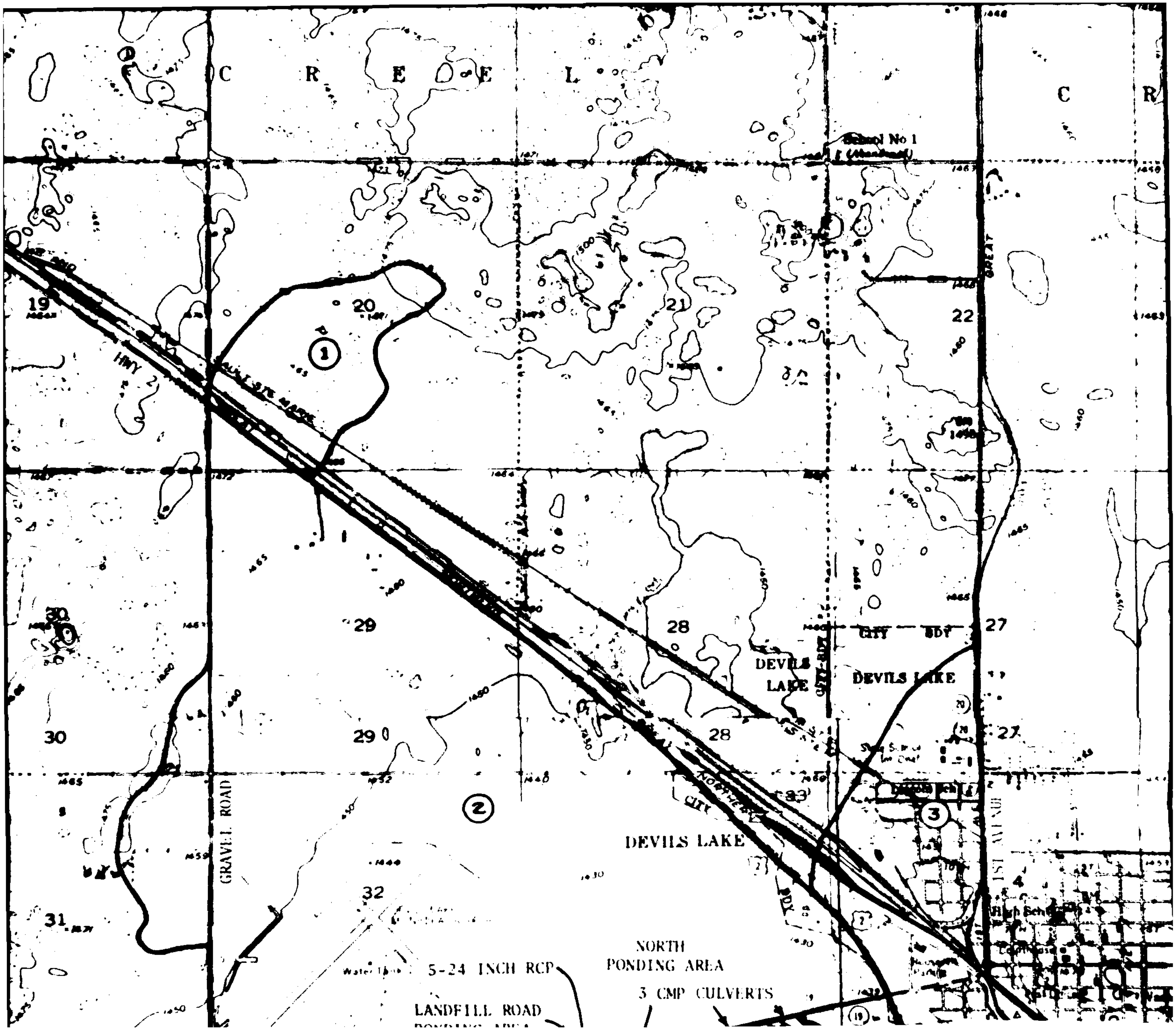
One-percent pond level, estimated damages and required storage with and without pumping

| Pumping rate in gpm | Required storage in acre-feet | One-percent pond level | Estimated damages in $ | Benefit/cost ratio |
|---|---|---|---|---|
| 0 | 2,753 | 1430.86 | 42,000 | - |
| 6,000 | 2,355 | 1430.42 | 30,000 | 0.0728 |
| 9,000 | 2,155 | 1430.20 | 25,000 | 0.0853 |
| 12,000 | 1,957 | 1429.96 | 20,000 | 0.0896 |
| 18,000 | 1,580 | 1429.50 | 10,000 | 0.0882 |
| 24,000 | 1,390 | 1429.25 | 5,000 | 0.0852 |
| 30,000 | 1,300 | 1429.13 | 2,000 | 0.0827 |
| 36,000 | 1,230 | 1429.03 | 500 | 0.0739 |
| 42,000 | 1,180 | 1428.96 | 0 | 0.0709 |

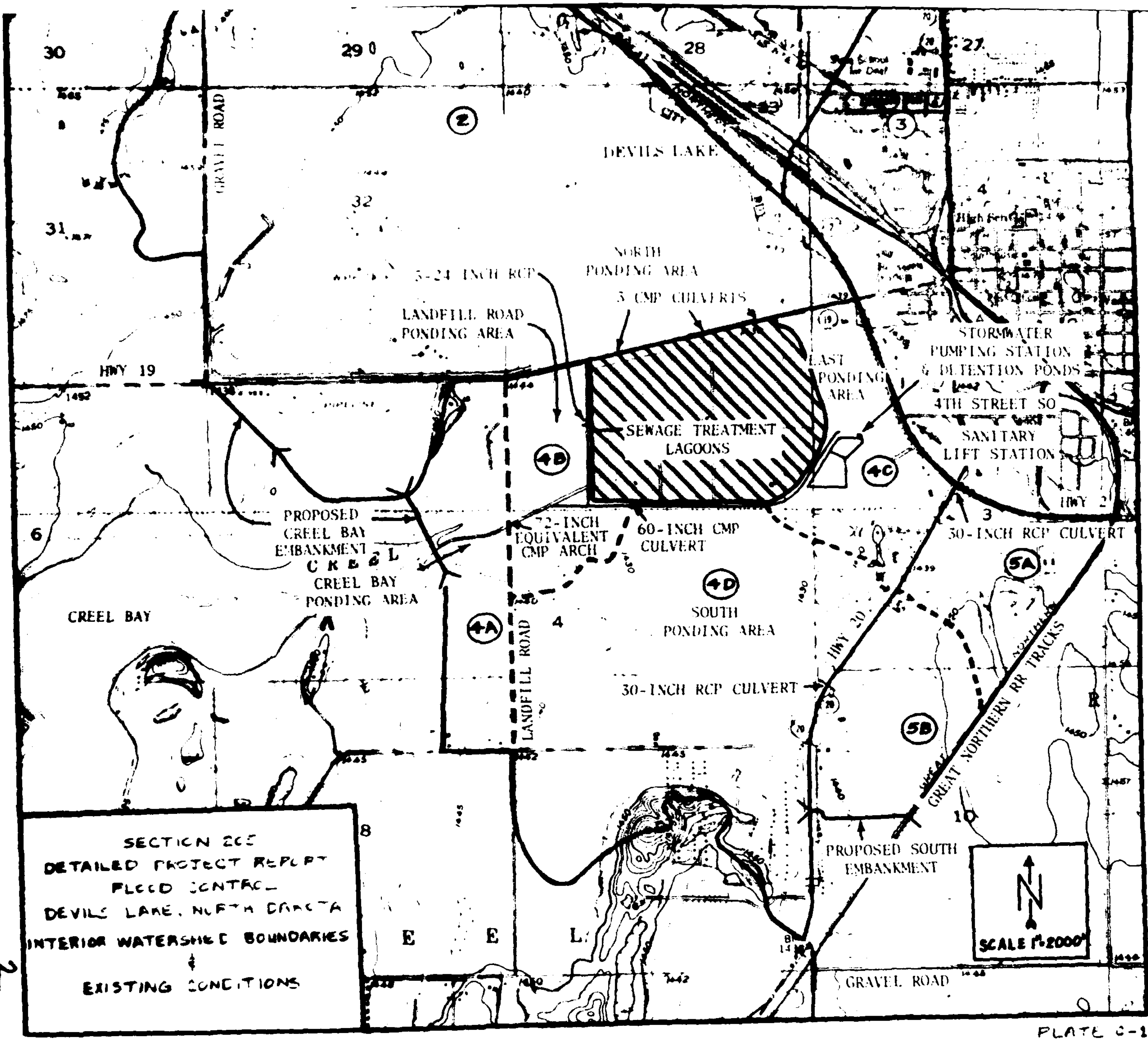
Table C-17

Pond level-frequency relationships

| Pond Level | Estimated Damages $ | Percent change of occurrence | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No Pumping | 6,000 gpm | 9,000 gpm | 12,000 gpm | 18,000 gpm | 24,000 gpm | 30,000 gpm | 36,000 gpm | 42,000 gpm |
| 1429.00 | 0 | 50.0 | 16.0 | 10.1 | 5.7 | 3.2 | 2.1 | 1.5 | 1.1 | - |
| 1429.25 | 4,800 | 24.7 | 10.5 | 6.1 | 3.5 | 1.7 | 1.0 | - | - | - |
| 1429.50 | 10,000 | 16.4 | 6.2 | 3.4 | 2.3 | 1.0 | - | - | - | - |
| 1429.75 | 15,200 | 10.4 | 3.4 | 2.3 | 1.5 | - | - | - | - | - |
| 1430.00 | 20,800 | 5.9 | 2.3 | 1.4 | - | - | - | - | - | - |
| 1430.25 | 26,600 | 3.1 | 1.4 | - | - | - | - | - | - | - |
| 1430.50 | 31,800 | 2.0 | - | - | - | - | - | - | - | - |
| 1430.75 | 39,000 | 1.2 | - | - | - | - | - | - | - | - |
| 1431.00 | 45,800 | - | - | - | - | - | - | - | - | - |



C R E E L
C R
School No 1
19
20
21
22
HWY 2
1
2
3
29
28
27
30
31
32
33
CITY BDY
DEVILS LAKE
DEVILS LAKE
GRAVEL ROAD
1ST AVENUE
High School
5-24 INCH RCP
NORTH
PONDING AREA
3 CMP CULVERTS
LANDFILL ROAD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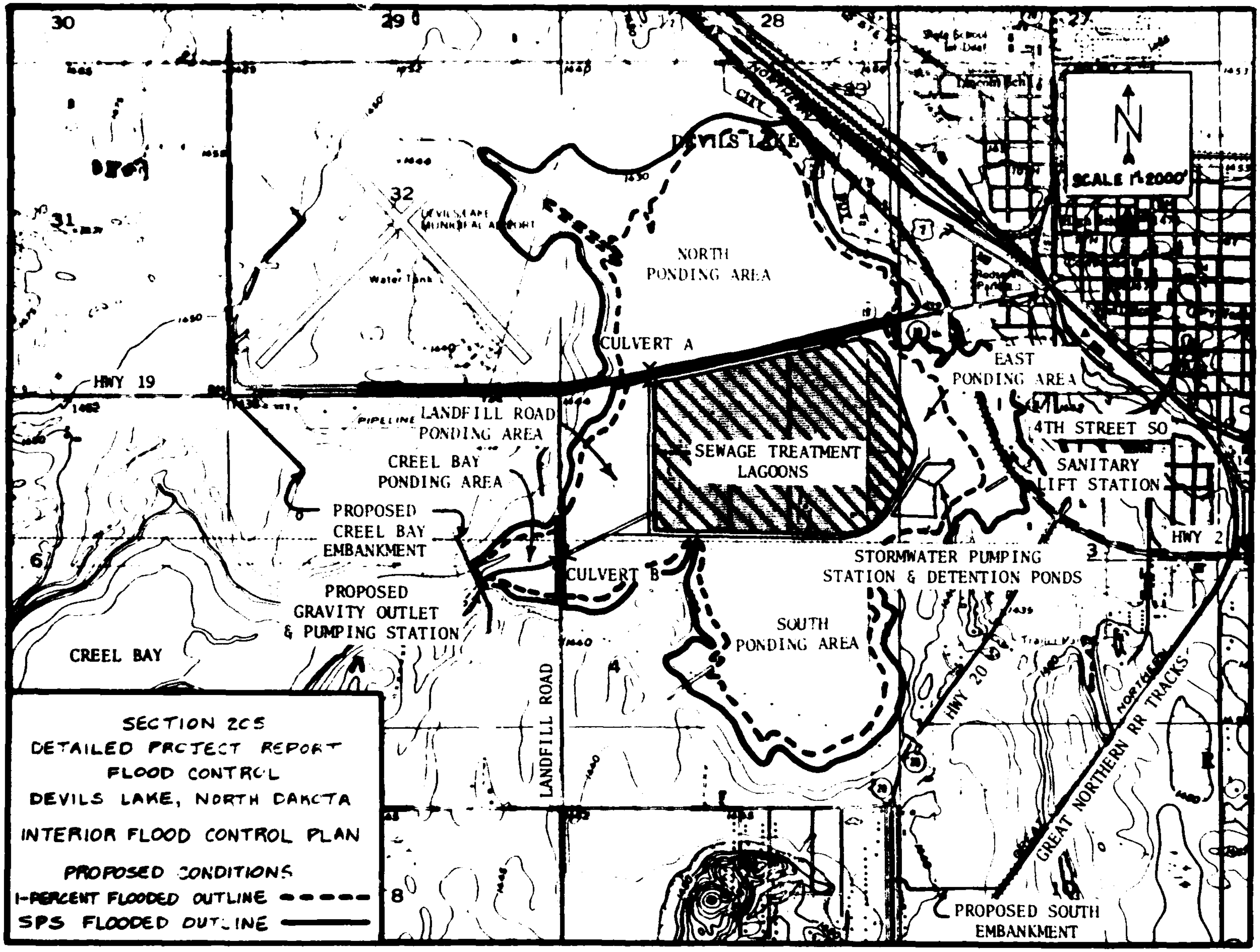
DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
INTERIOR WATERSHED BOUNDARIES
&
EXISTING CONDITIONS
DEVILS LAKE
NORTH PONDING AREA
3-24 INCH RCP
3 CMP CULVERTS
LANDFILL ROAD PONDING AREA
HWY 19
SEWAGE TREATMENT LAGOONS
EAST PONDING AREA
STORMWATER PUMPING STATION & DETENTION PONDS
4TH STREET SO
SANITARY LIFT STATION
HWY 2
30-INCH RCP CULVERT
PROPOSED CREEL BAY EMBANKMENT
72-INCH EQUIVALENT CMP ARCH
60-INCH CMP CULVERT
CREEL BAY PONDING AREA
CREEL BAY
LANDFILL ROAD
SOUTH PONDING AREA
30-INCH RCP CULVERT
HWY 20
GREAT NORTHERN RR TRACKS
PROPOSED SOUTH EMBANKMENT
GRAVEL ROAD
SCALE 1"=2000'
2
3
4A
4B
4C
4D
5A
5B

PLATE C-1


30
29
28
27
31
32
6
8
3
SCALE 1" = 2000'
N
DEVILS LAKE
NORTH PONDING AREA
CULVERT A
HWY 19
EAST PONDING AREA
4TH STREET SO
SANITARY LIFT STATION
HWY 2
LANDFILL ROAD PONDING AREA
CREEL BAY PONDING AREA
SEWAGE TREATMENT LAGOONS
PROPOSED CREEL BAY EMBANKMENT
CULVERT B
STORMWATER PUMPING STATION & DETENTION PONDS
PROPOSED GRAVITY OUTLET & PUMPING STATION
SOUTH PONDING AREA
CREEL BAY
LANDFILL ROAD
HWY 20
GREAT NORTHERN RR TRACKS
PROPOSED SOUTH EMBANKMENT
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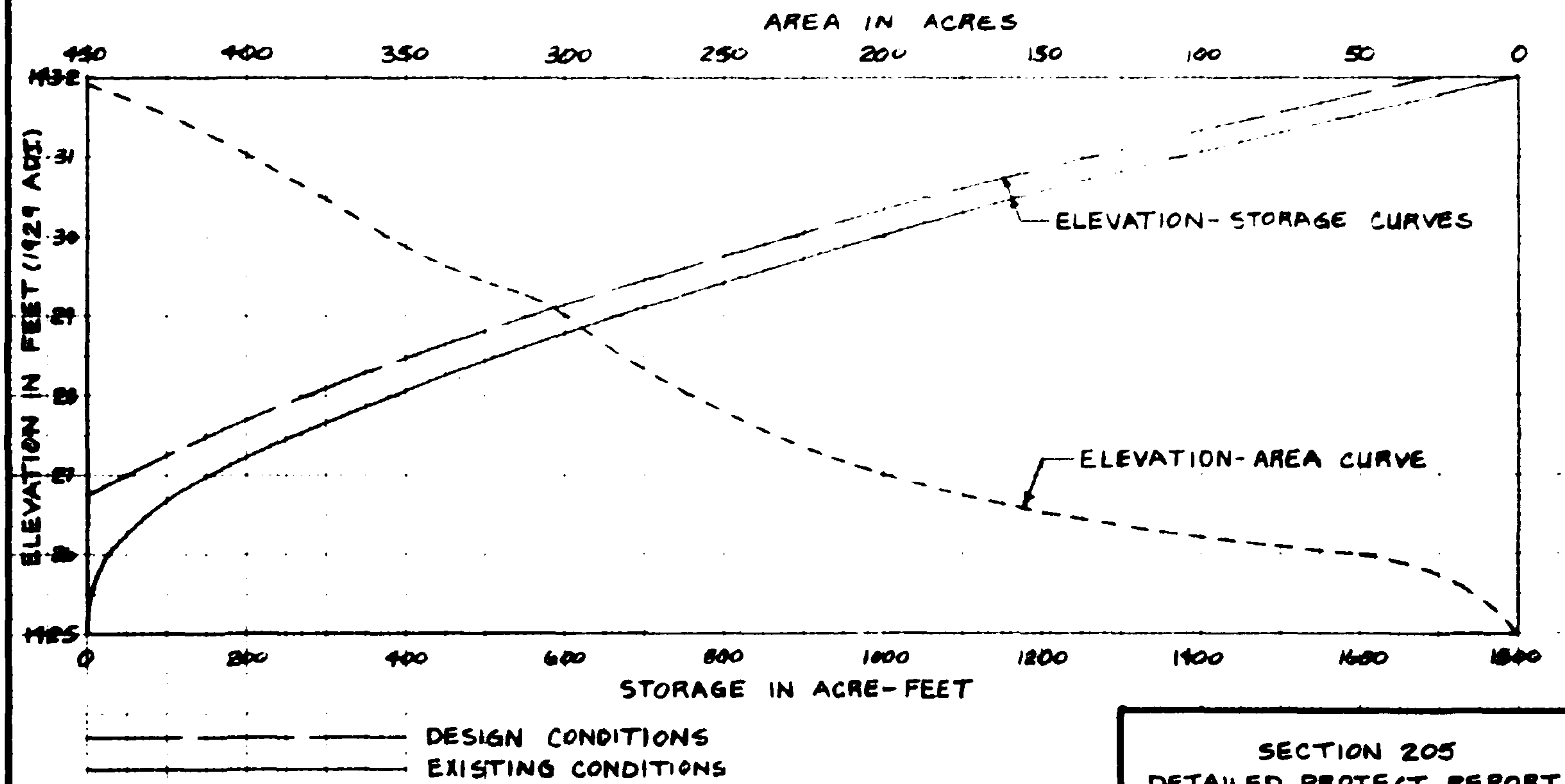
DEVILS LAKE, NORTH DAKOTA
INTERIOR FLOOD CONTROL PLAN
PROPOSED CONDITIONS
1-PERCENT FLOODED OUTLINE
SPS FLOODED OUTLINE

PLATE C-2

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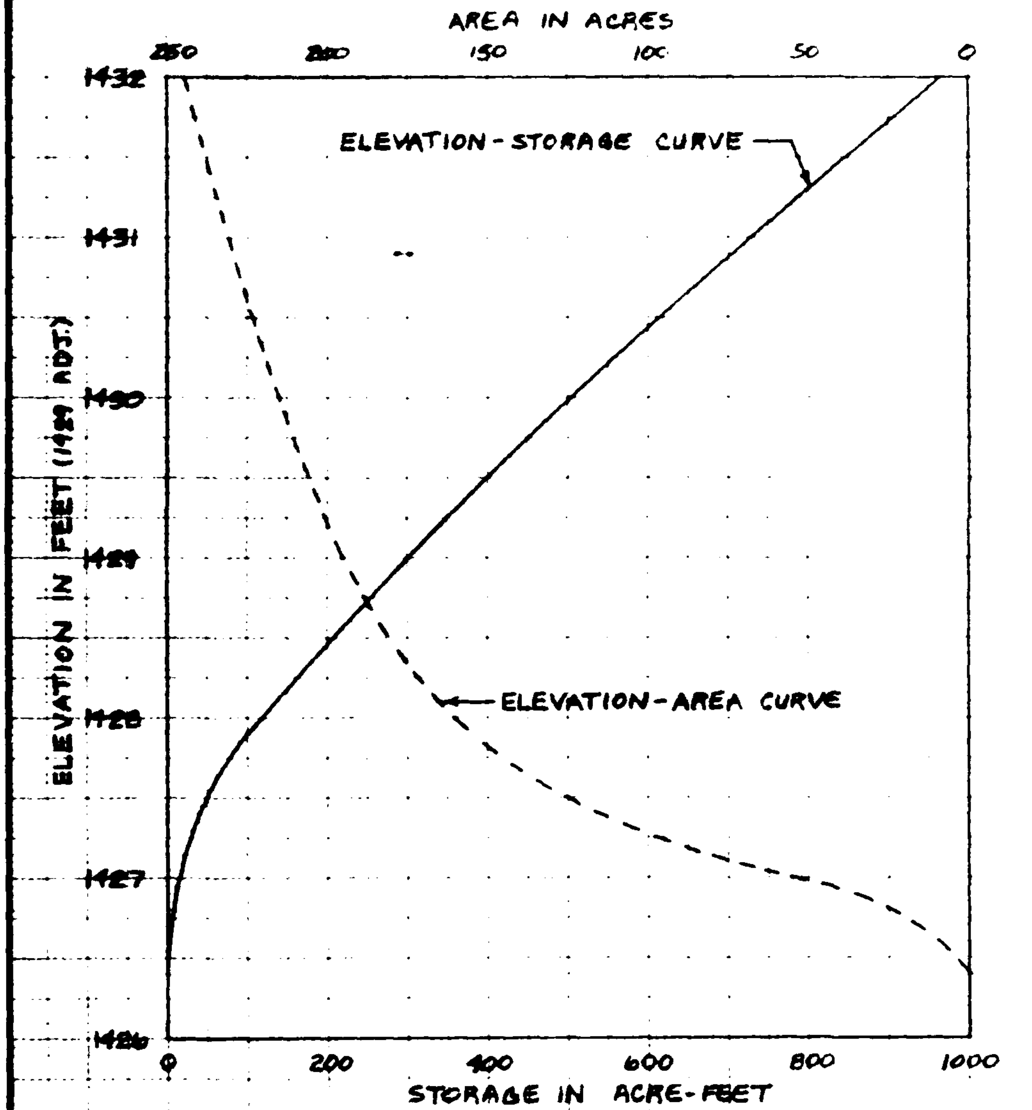
DEVILS LAKE, NORTH DAKOTA

ELEVATION-AREA-STORAGE
CURVES
NORTH PONDING AREA

PLATE C-3

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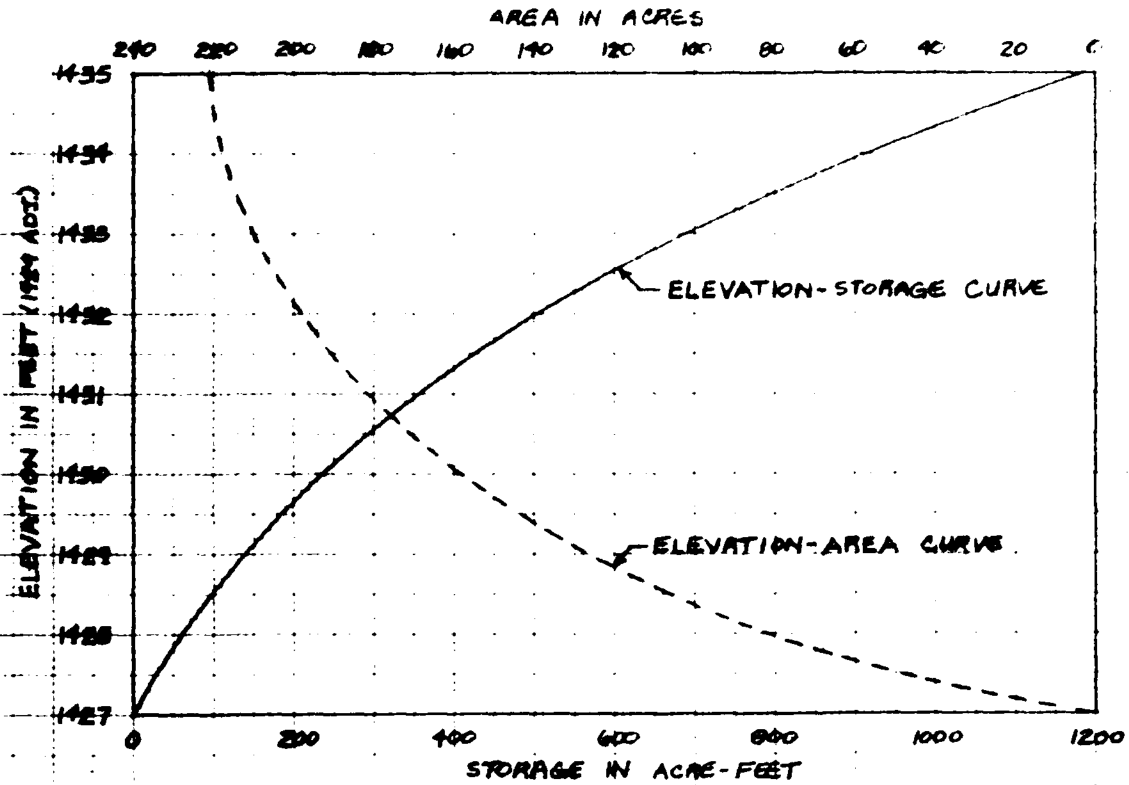
ELEVATION-AREA-STORAGE CURVES
SOUTH PONDING AREA

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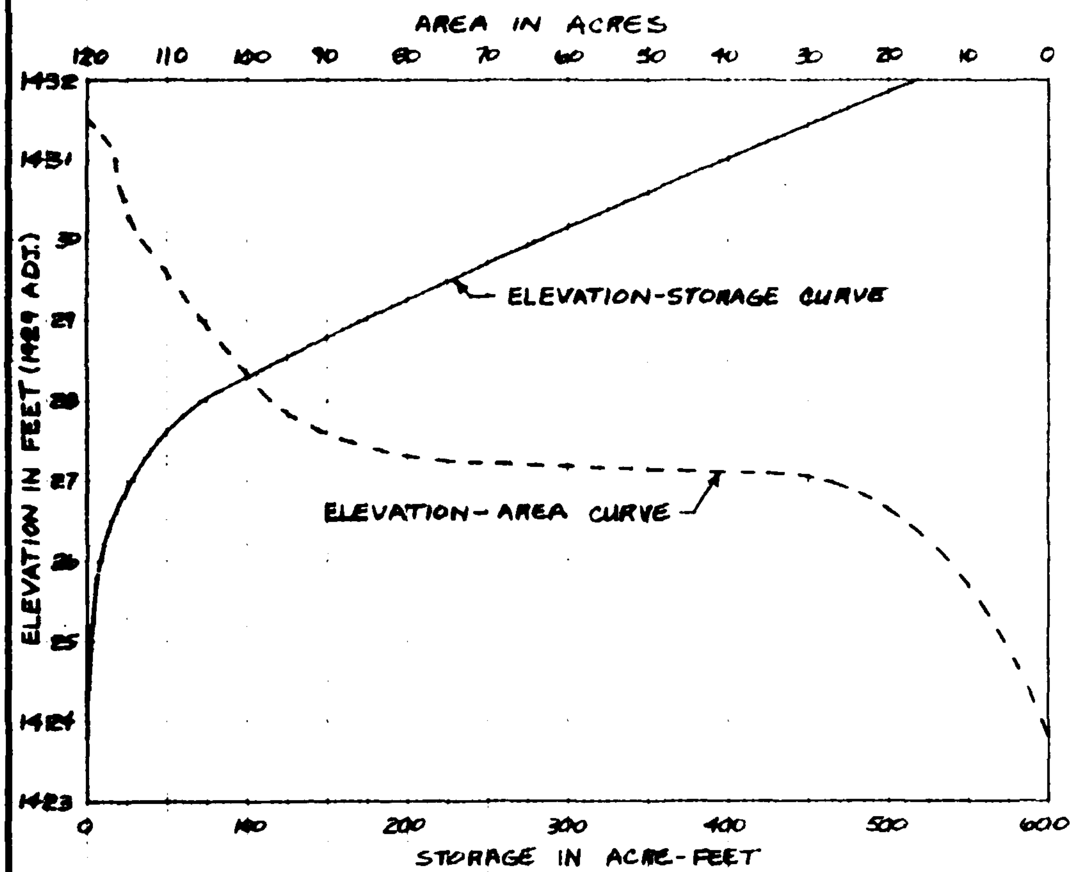
DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

ELEVATION-AREA-STORAGE CURVES
EAST PONDING AREA
EAST OF SEWAGE LAGOONS

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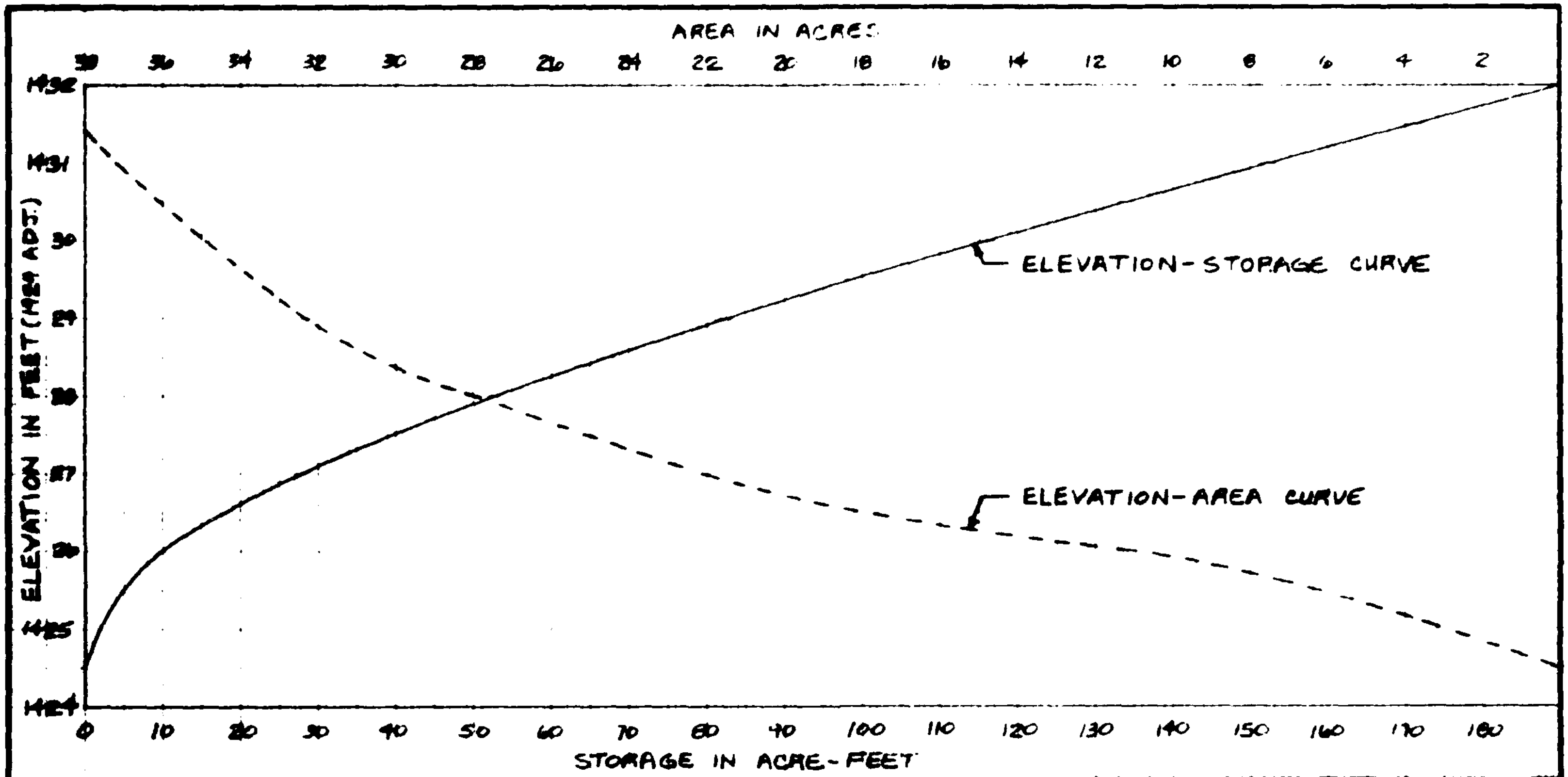
ELEVATION-AREA-STORAGE CURVES
LANDFILL ROAD PONDING AREA
BETWEEN LANDFILL ROAD & SEWAGE LAGOONS

PLATE C-6




SECTION 205
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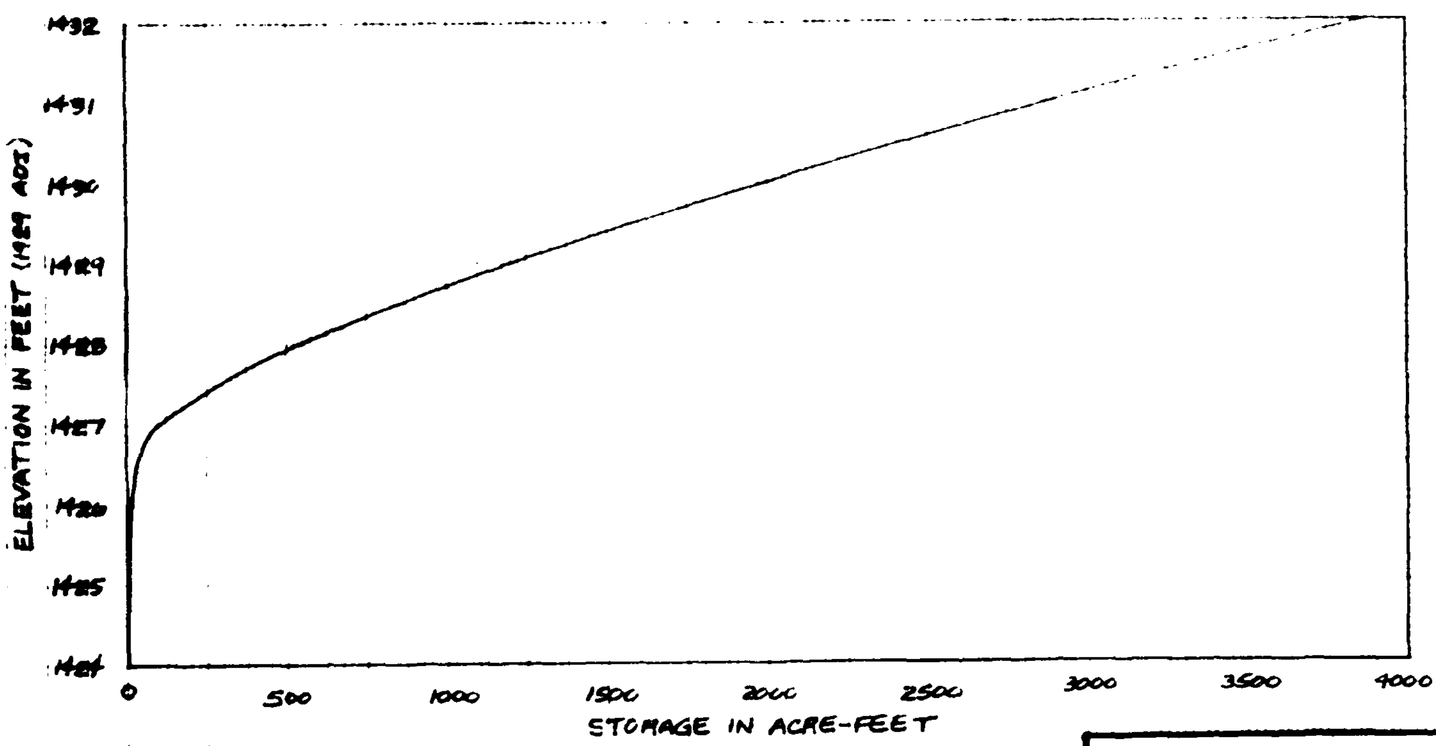
ELEVATION-AREA-STORAGE CURVES
CREEL BAY PONDING AREA
BETWEEN CREEL BAY
EMBANKMENT & LANDFILL ROAD

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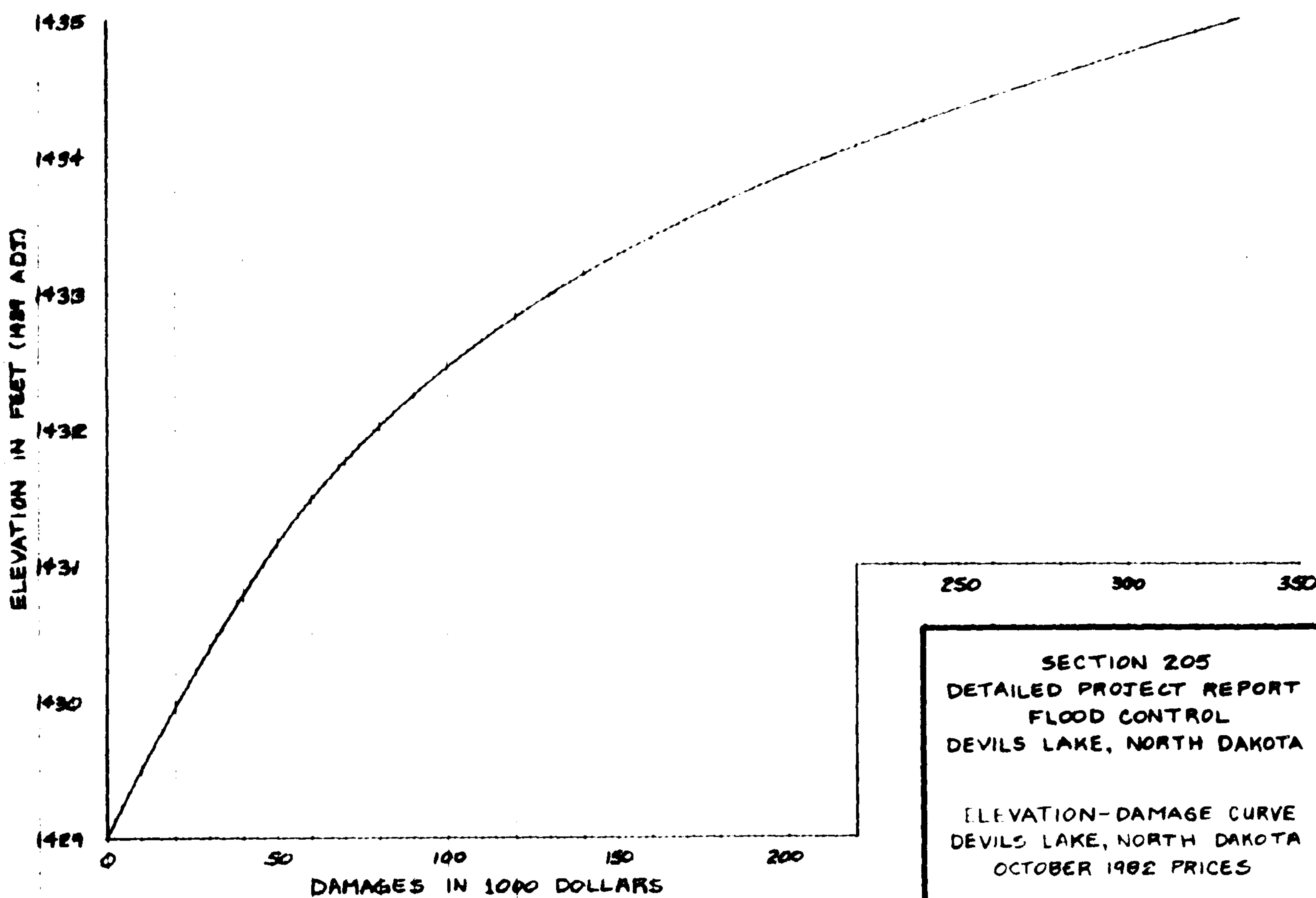
DEVILS LAKE, NORTH DAKOTA

COMBINED
ELEVATION-STORAGE CURVE

PLATE C-8

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ELEVATION-DAMAGE CURVE
DEVILS LAKE, NORTH DAKOTA
OCTOBER 1982 PRICES

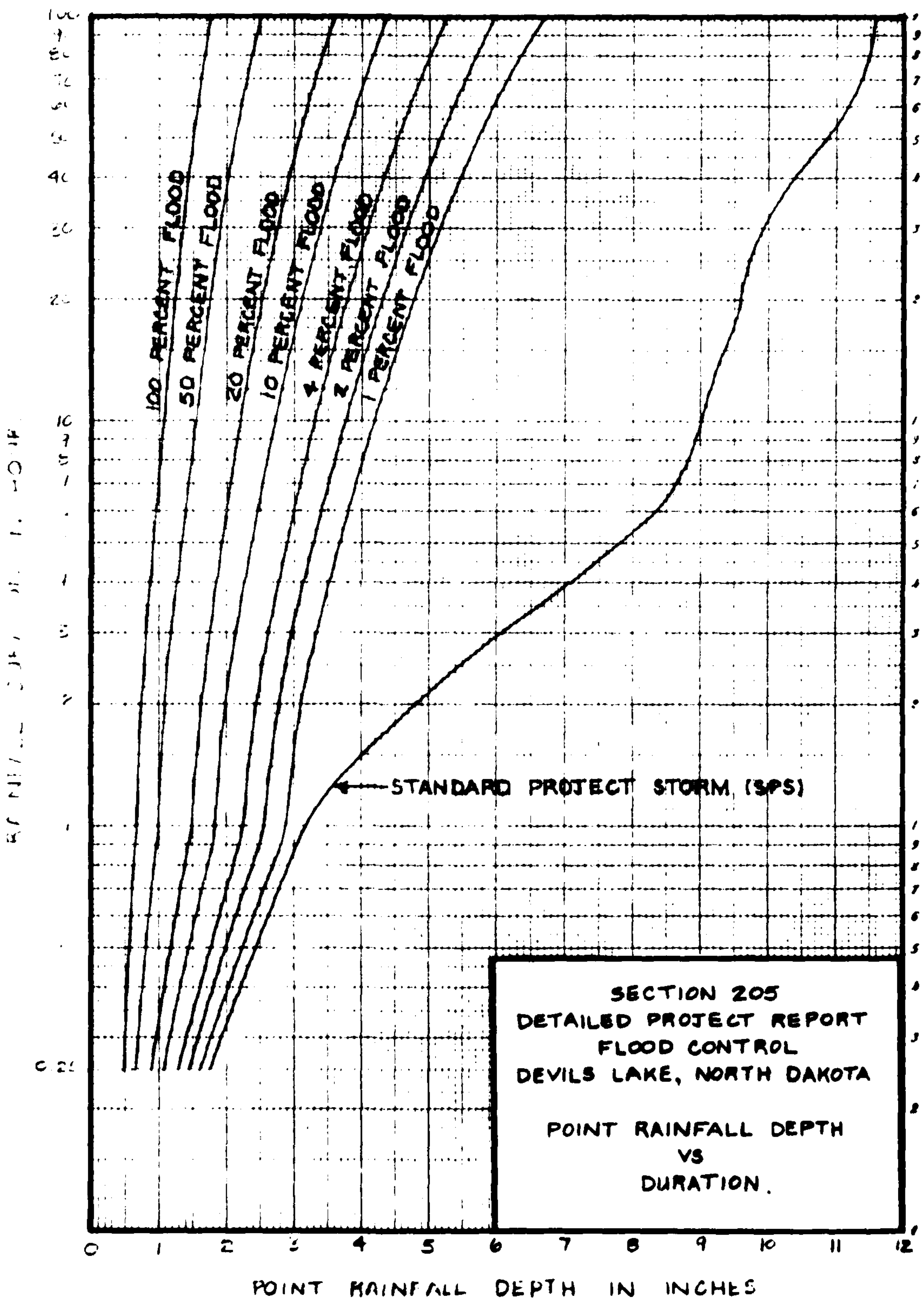
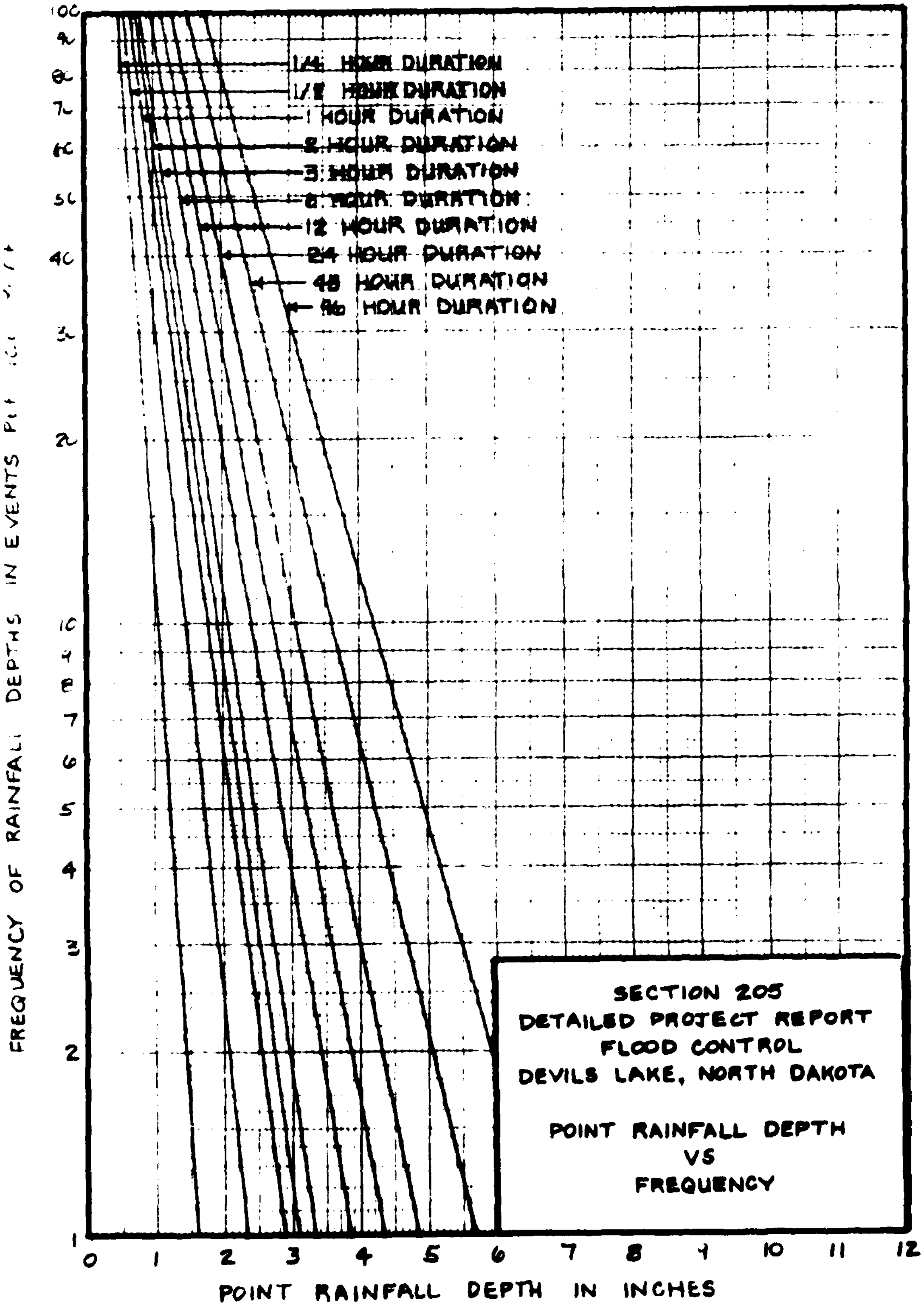

100 PERCENT FLOOD
50 PERCENT FLOOD
20 PERCENT FLOOD
10 PERCENT FLOOD
4 PERCENT FLOOD
2 PERCENT FLOOD
1 PERCENT FLOOD
STANDARD PROJECT STORM (SPS)
SECTION 205
DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
POINT RAINFALL DEPTH
VS
DURATION.
0
1
2
3
4
5
6
7
8
9
10
11
12
POINT RAINFALL DEPTH IN INCHES

PLATE C-10



1/4 HOUR DURATION
1/2 HOUR DURATION
1 HOUR DURATION
2 HOUR DURATION
3 HOUR DURATION
6 HOUR DURATION
12 HOUR DURATION
24 HOUR DURATION
48 HOUR DURATION
96 HOUR DURATION
FREQUENCY OF RAINFALL DEPTHS IN EVENTS PER 100 YRS
POINT RAINFALL DEPTH IN INCHES
0 1 2 3 4 5 6 7 8 9 10 11 12
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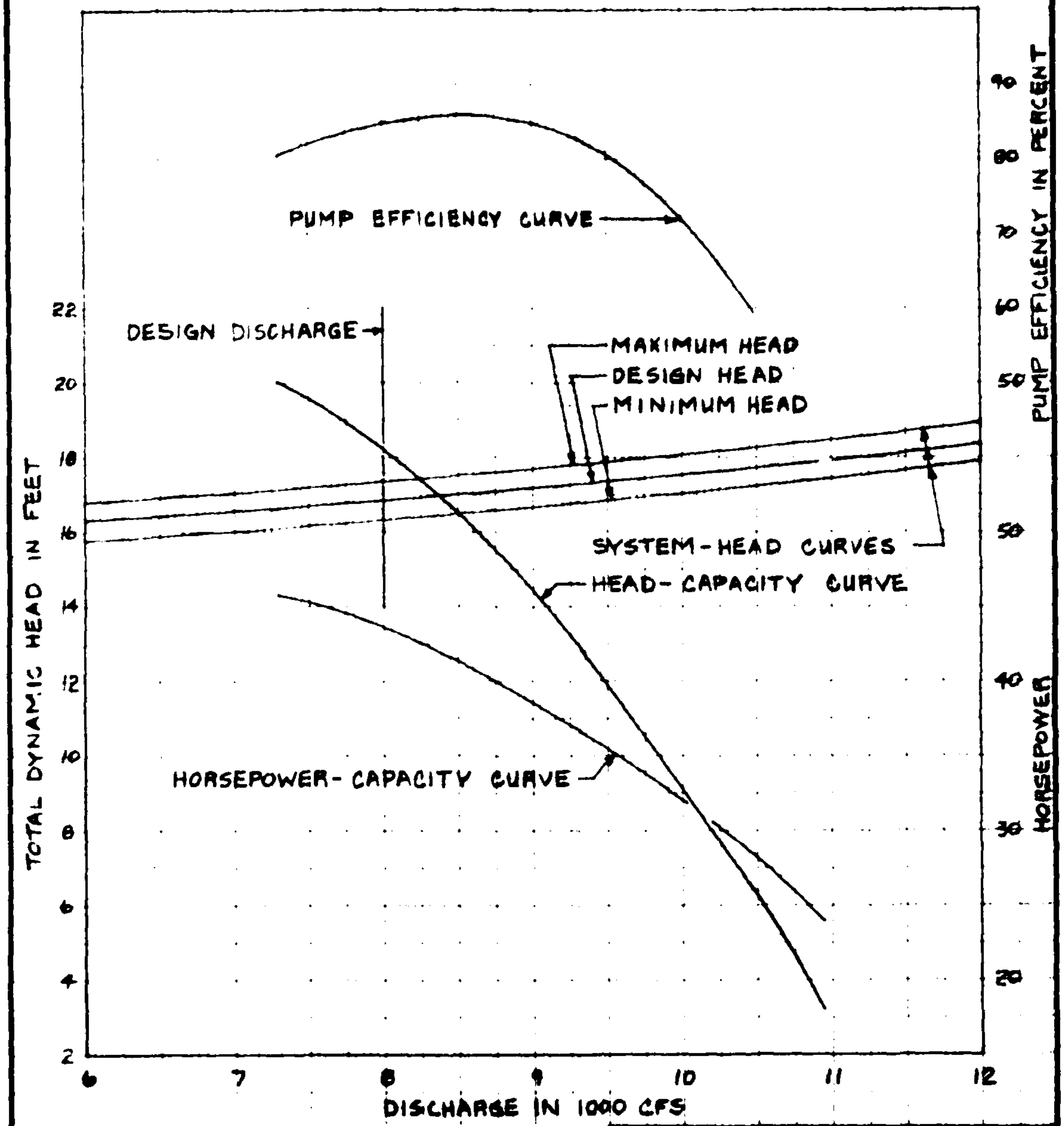
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
POINT RAINFALL DEPTH
VS
FREQUENCY


PLATE C-11

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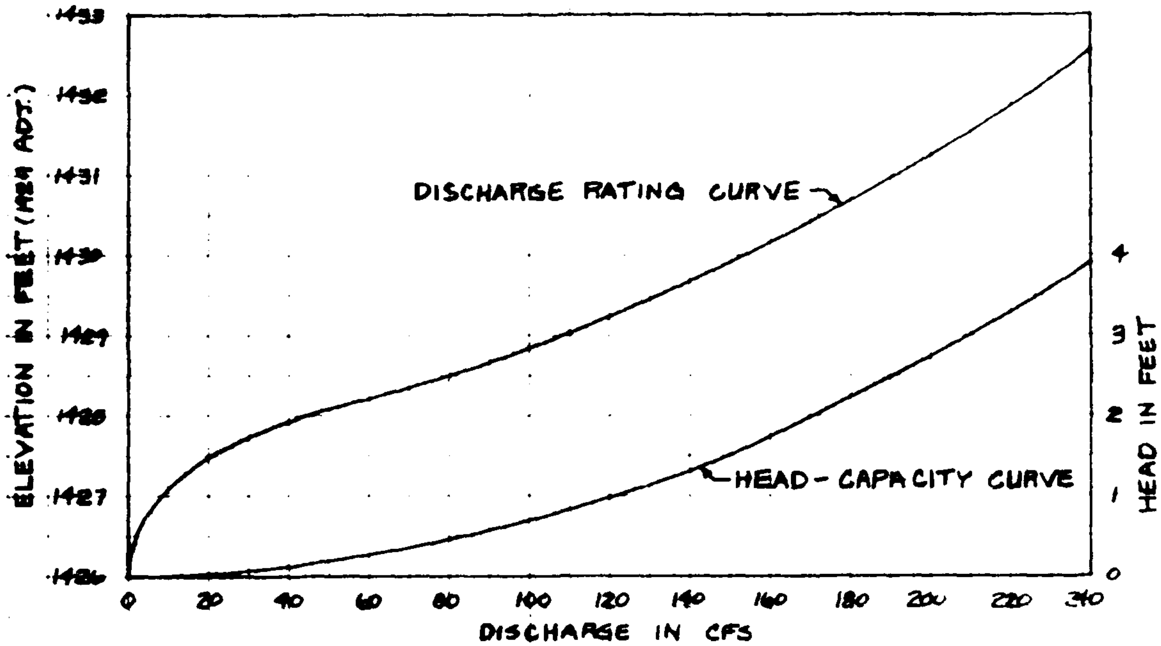
DEVILS LAKE, NORTH DAKOTA

DEVILS LAKE PUMPING STATION
SYSTEM-HEAD, HEAD-CAPACITY,
HORSEPOWER-CAPACITY & PUMP
EFFICIENCY CURVES

PLATE C-12

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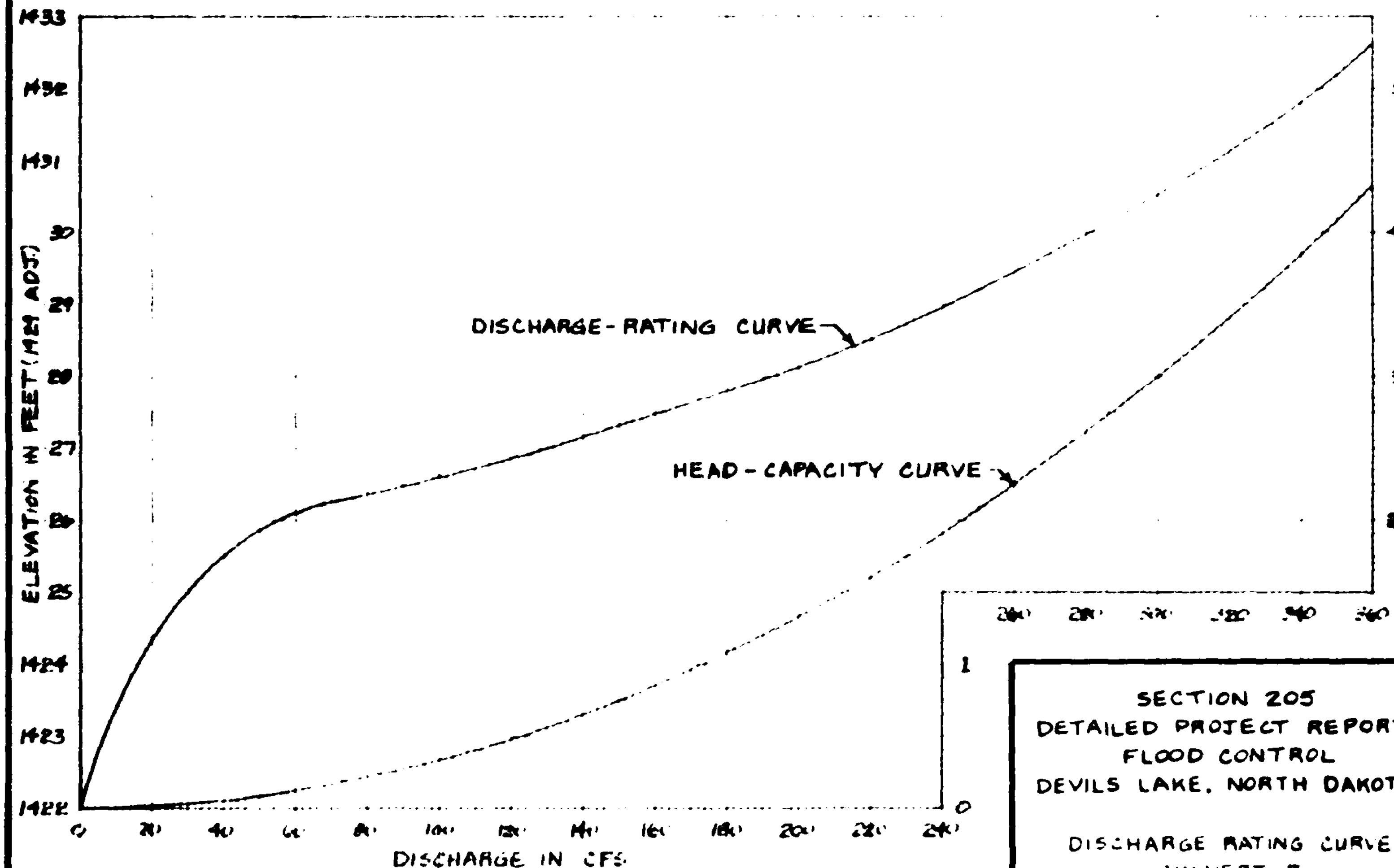
DEVILS LAKE, NORTH DAKOTA

DISCHARGE RATING CURVE
CULVERT A
2 - 36" x 58" RCP ARCH

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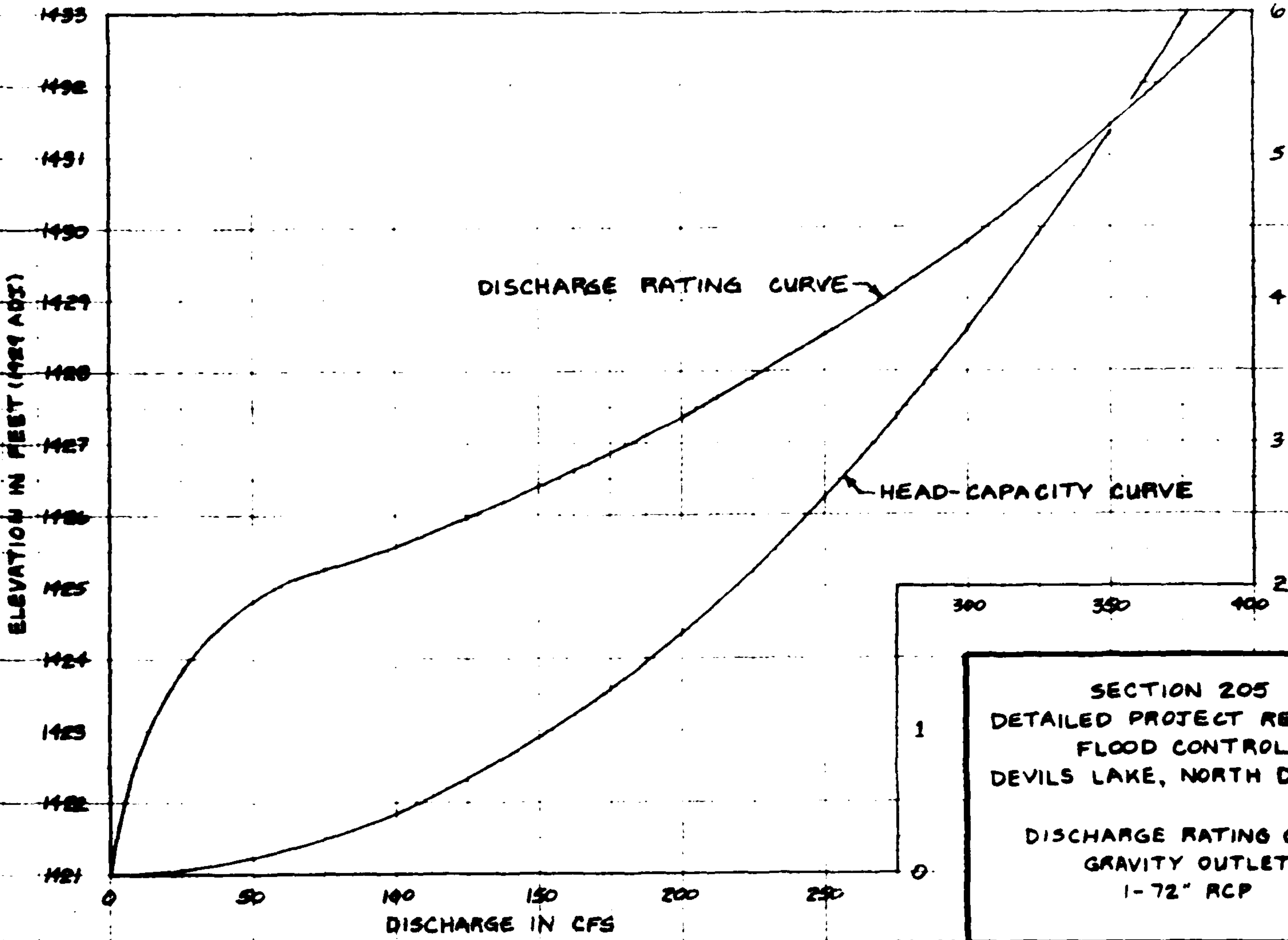
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

DISCHARGE RATING CURVE
CULVERT B
1-72 RJF

PLATE :-4




SECTION 205
DETAILED PROJECT REPORT
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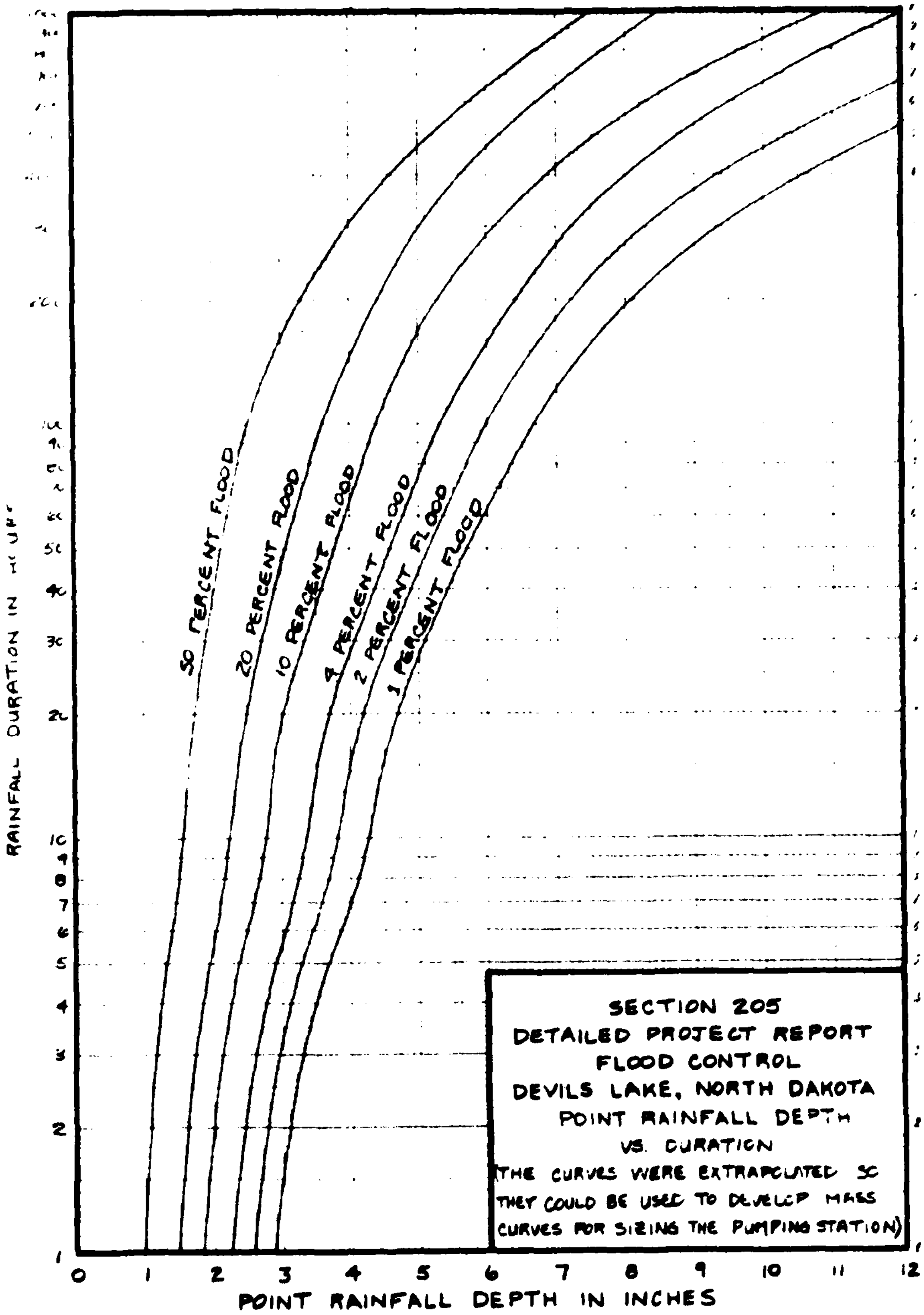
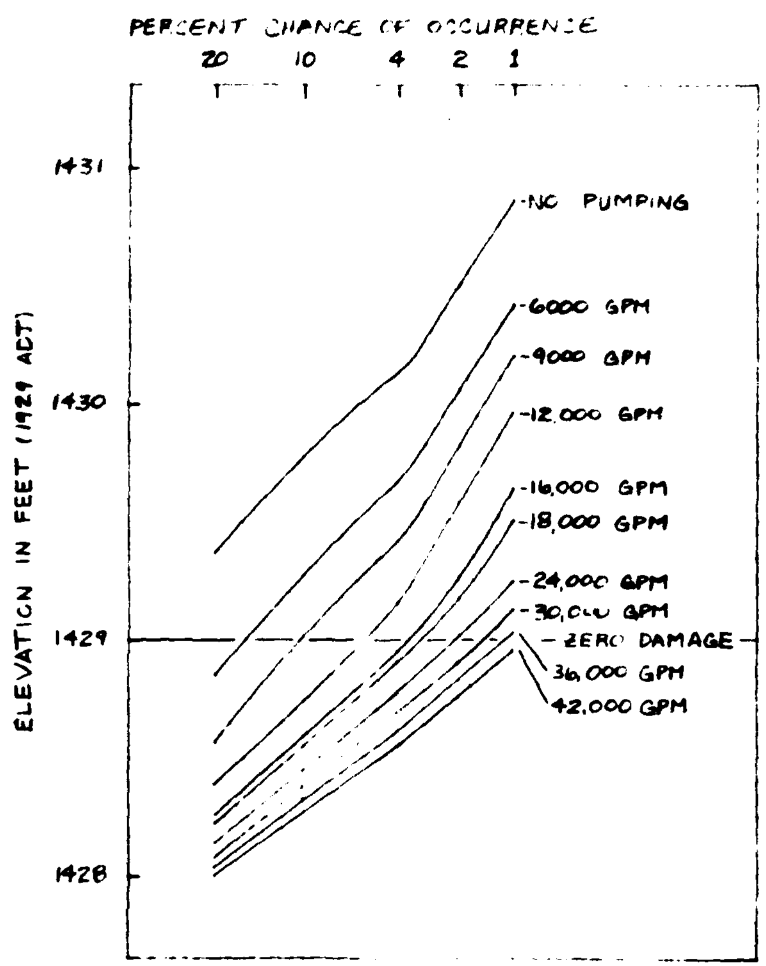
DEVILS LAKE, NORTH DAKOTA

DISCHARGE RATING CURVE
GRAVITY OUTLET
1-72" RCP


SECTION 205
DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
POINT RAINFALL DEPTH
VS. DURATION
(THE CURVES WERE EXTRAPOLATED SO
THEY COULD BE USED TO DEVELOP MASS
CURVES FOR SIZING THE PUMPING STATION)
50 PERCENT FLOOD
20 PERCENT FLOOD
10 PERCENT FLOOD
4 PERCENT FLOOD
2 PERCENT FLOOD
1 PERCENT FLOOD
RAINFALL DURATION IN HOURS
POINT RAINFALL DEPTH IN INCHES
0
1
2
3
4
5
6
7
8
9
10
11
12

PLATE

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DEVILS LAKE, NORTH DAKOTA

POND LEVEL - FREQUENCY CURVES
FOR
VARIOUS
PUMPING CAPACITIES

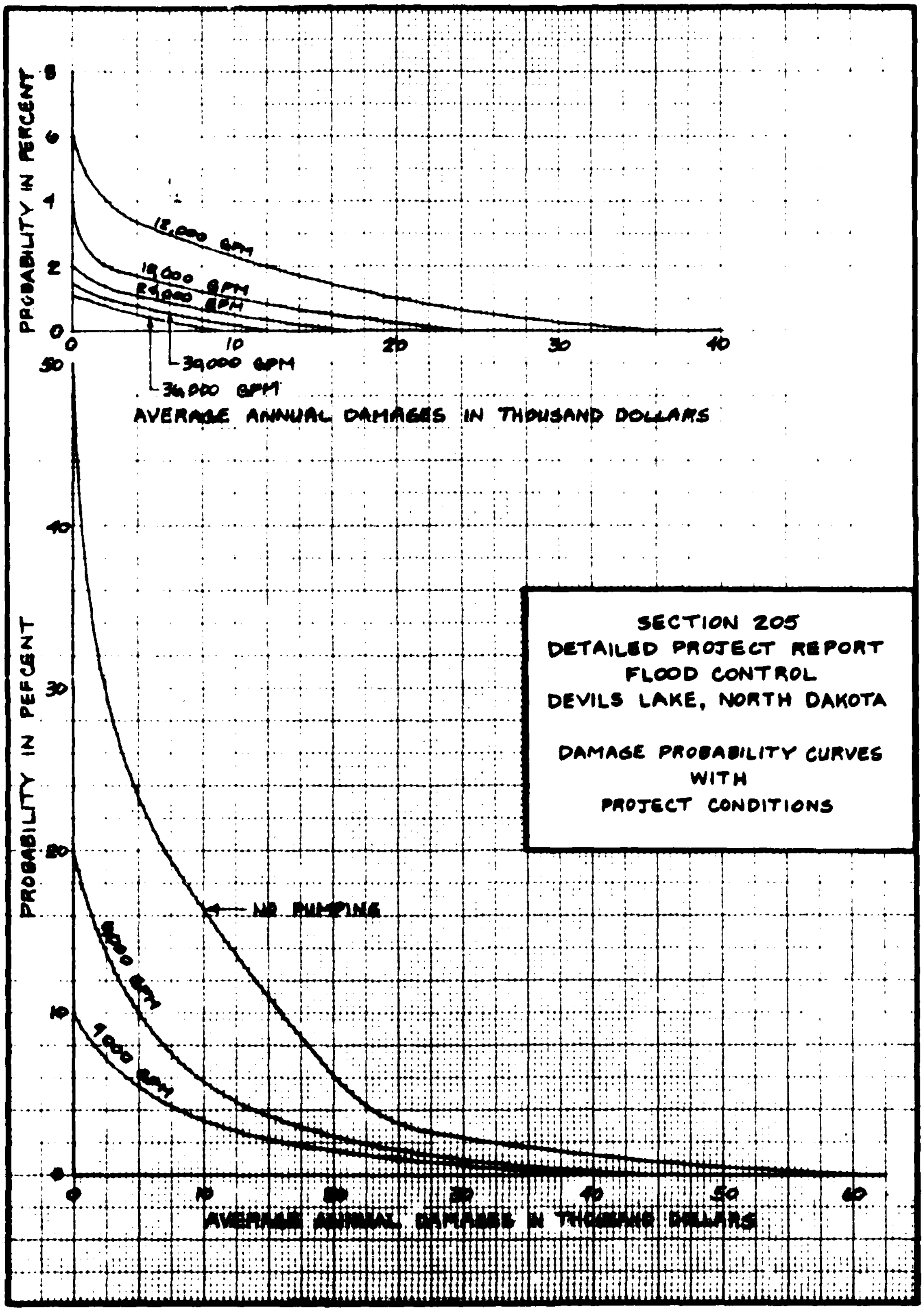
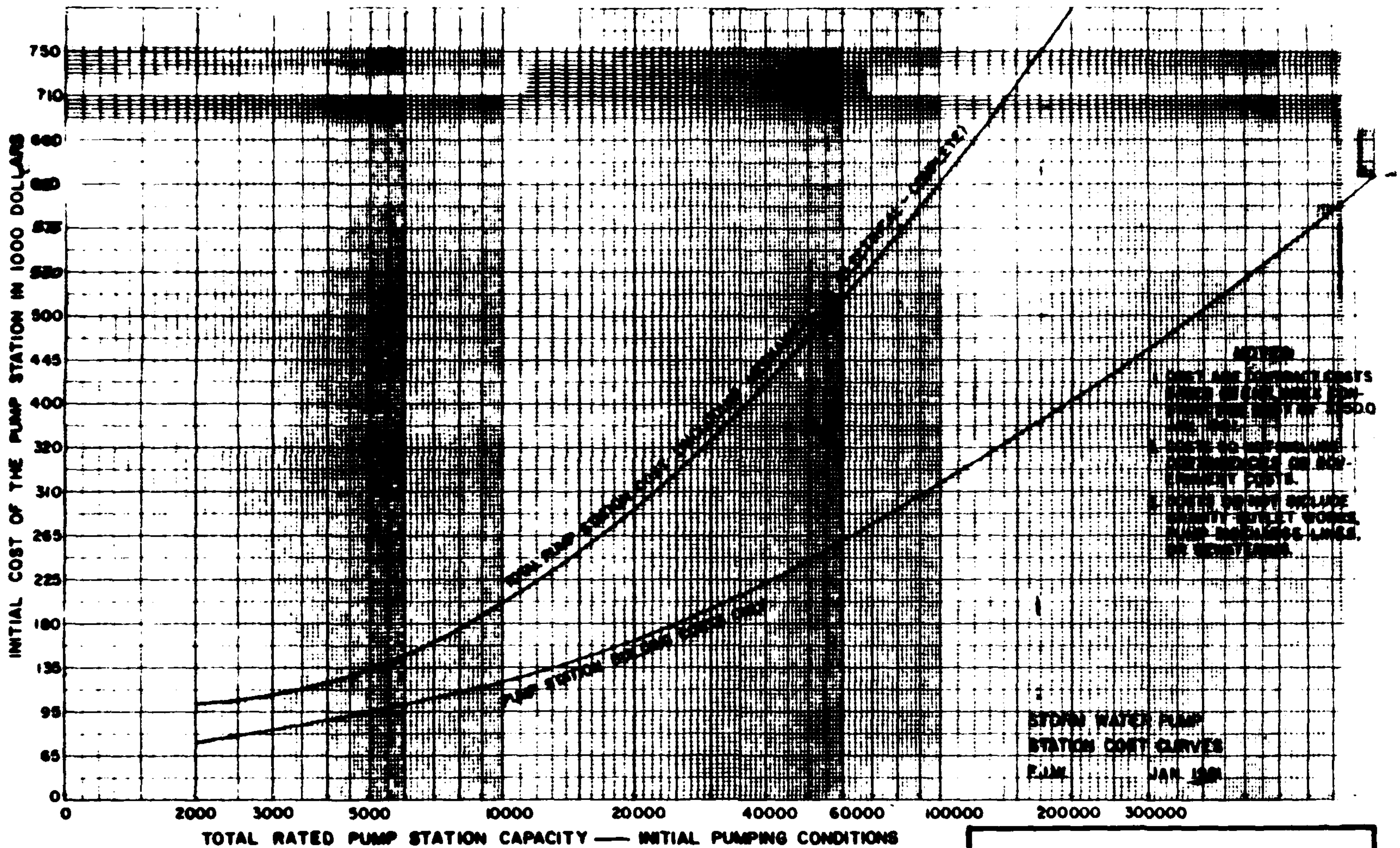

PROBABILITY IN PERCENT
12,000 GPM
18,000 GPM
24,000 GPM
30,000 GPM
36,000 GPM
AVERAGE ANNUAL DAMAGES IN THOUSAND DOLLARS
PROBABILITY IN PERCENT
NO PUMPING
SECTION 205
DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
DAMAGE PROBABILITY CURVES
WITH
PROJECT CONDITIONS

PLATE C-18

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PUMPING STATION COST-CAPACITY CURVE

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX B

HYDROLOGY

## LIST OF TABLES

## LIST OF PLATES

APPENDIX D

HYDROLOGY ANALYSIS

CLIMATOLOGY

GENERAL

The climate in the vicinity of the Devils Lake basin is typically continental characterized by cold, rather long, snowy winters and summers with warm days and cool nights. There is a variety of weather in any season due to the frequent passage of weather systems over the area. Hot humid summer days are rare, but cold waves and blizzards can be expected during the winter season due to outbreaks of arctic air from the north. Meteorological data for this area are available from a number of National Weather Service stations. Temperature and precipitation records are maintained at stations in Devils Lake, Bisbee, Edmore, Leeds and Munich. The periods of record for these stations in the basin are shown in Table D-1.

TABLE D-1

NATIONAL WEATHER SERVICE STATIONS IN DEVILS LAKE BASIN, NORTH DAKOTA

| | Precipitation Records Available | | Temperature Records Available | |
|---|---|---|---|---|
| Station | From | To | From | To |
| Devils Lake | Jan 1870 | Date | Jan 1905 | Date |
| Bisbee | Apr 1905 | Date | Apr 1905 | Date |
| Edmore | Jan 1933 | Date | Jan 1933 | Date |
| Leeds | Sep 1935 | Date | Sep 1935 | Date |
| Munich | Jan 1947 | Date | Jul 1947 | Date |

PRECIPITATION

The average annual precipitation at Devils Lake is 17.15 inches, with 77 percent falling during the growing season (April through September) and 46 percent falling during May, June and July. June is usually the wettest month of the year, averaging over 3 inches of precipitation. The average annual snowfall for the Devils Lake basin is approximately 35 inches, although the amount may vary considerably from year to year. Average monthly precipitation at the Devils Lake station is shown in Table D-2.

TABLE D-2

AVERAGE MONTHLY PRECIPITATION AT DEVILS LAKE, NORTH DAKOTA

| Month | Mean Precipitation in inches |
|---|---|
| Jan | .56 |
| Feb | .40 |
| Mar | .86 |
| Apr | 1.11 |
| May | 2.27 |
| Jun | 3.39 |
| Jul | 2.28 |
| Aug | 2.11 |
| Sep | 2.07 |
| Oct | .90 |
| Nov | .64 |
| Dec | .56 |
| Annual | 17.15 |

## TEMPERATURE

There is a considerable range in temperature from summer to winter and often from day to day. At Devils Lake the highest temperature ever recorded was 112°F and the lowest temperature ever recorded was -46°F. The average annual temperature is 38.7°F. Average monthly temperatures at the Devils Lake station are shown in Table D-3.

TABLE D-3

AVERAGE MONTHLY TEMPERATURE AT DEVILS LAKE, NORTH DAKOTA

| Month | Mean Temperature in °F |
|---|---|
| Jan | 4.2 |
| Feb | 9.1 |
| Mar | 21.6 |
| Apr | 40.1 |
| May | 52.4 |
| Jun | 62.5 |
| Jul | 68.9 |
| Aug | 67.3 |
| Sep | 55.8 |
| Oct | 45.2 |
| Nov | 26.1 |
| Dec | 11.2 |
| Annual | 38.7 |

## DRAINAGE BASIN, STREAMFLOW, AND LAKE ELEVATION DATA

### DRAINAGE BASIN

The watersheds of the Devils Lake basin are shown on Plate D-1. They represent a closed drainage basin with a total area of approximately 3,810 square miles. The cumulative drainage from eight of nine watersheds flows into Devils Lake and results in about 3,580 square miles of contributing drainage area. Stump Lake lies about 10 miles southeast of the eastern bay of Devils Lake and receives runoff from a separate area of about 230 square miles. The principle drainage patterns interconnect the five northern watersheds via the Sweetwater-Morrison Lake chain. These include the Edmore, Starkweather, Chain Lake, Mauvais and Hurricane Lake watersheds. Devils Lake is divided into several bays and separate lakes which are interconnected when the lake is at higher elevations. This chain of lakes has no outlet.

### STREAMFLOW RECORDS

The U.S. Geological Survey maintains several gaging stations throughout the Devils Lake basin for collecting streamflow data. The station at Big Coulee near Churchs Ferry records streamflow from the largest drainage area (2,510 square miles) with records since 1950. Stations at Edmore Coulee near Edmore and Mauvais Coulee near Cando measure streamflow from drainage areas of approximately 385 square miles with records since 1956. More recently installed streamflow gages exist at Little Coulee near Brinsmade (350 square miles) and Starkweather Coulee near Webster (310 square miles). Pertinent data for the gaging stations and streamflow records are given in Table D-4. The U.S. Geological Survey has also maintained gage-height records since 1979 for Webster Coulee at Webster (670 square-mile drainage area).

TABLE D-4

STREAMFLOW RECORDS AND PERTINENT DATA

| Location | Contributing drainage area (sq. mi.) | Gage zero elevation above msl (1929 adj) | Period of Record From | Period of Record To | Maximum Flow and Stage Date | Maximum Flow and Stage Discharge (cfs) Instan-taneous | Maximum Flow and Stage Discharge (cfs) Mean Daily | Maximum Flow and Stage Gage Height (ft) | Minimum Flow Date | Minimum Flow Discharge (cfs) | Average Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Big Coulee near Churchs Ferry | 1,820 | 1432.65 | 1950 | Date | 6 May 1979 | 1,420 | 1,400 | 7.59 | (2) | 0 | 42.8 |
| Little Coulee near Brinsmade | 190 | 1435.0 | 1975 | Date | 1 May 1979 | 425 | 375 | 10.43 | (2) | 0 | 9.0 |
| Starkweather Coulee near Webster | 210 | (1) | 1979 | Date | 7 Apr 1979 | 44 | (1) | 5.10 | (2) | 0 | 0.9 |
| Edmore Coulee near Edmore | 282 | (1) | 1956 | Date | 25 Apr 1979 | 1,110 | 1,090 | 7.31 | (2) | 0 | 13.7 |
| Mauvais Coulee near Cando | 377 | 1445.0 | 1956 | Date | 25 Apr 1979 | 2,660 | 2,580 | 11.18 | (2) | 0 | 19.1 |

(1) Not available
(2) No flow at times each year

LAKE ELEVATIONS

Stages at Devils Lake are available on somewhat of an irregular monthly basis from 1901 through 1959 and on a regular monthly basis from 1960 to present. One observed stage is available for each of the following six years: 1867, 1879, 1883, 1887, 1890 and 1896. The U.S. Geological Survey has also published a lake elevation of 1,446 feet for the year 1830 (and lower thereafter) based on tree growth noted from 1885 to 1889. Plate D-2 indicates the variations in water surface elevations of Devils Lake over a period of about 150 years. From 1830 to 1940, the water level has decreased from about 1,446 feet to a minimum of 1,401 feet. From 1940 to present, the water level at Devils Lake has risen to its present elevation of about 1,426 feet.

FUTURE LAKE ELEVATIONS

GENERAL

The long-term rise of water surface elevations at Devils Lake necessitated an attempt at determining an appropriate method which would yield reasonable results for predicting future stages. The following data was available for analysis:

a. Precipitation - (1870-present) on a monthly basis at Devils Lake.

b. Evaporation - (1930-present) on a monthly basis for the Devils Lake area derived from a previous study for the Red River basin. The evaporation record was extended to 1910 by use of the Thornwaite method of estimating potential evapotranspiration using temperature values.

c. Temperature - (1910-present) on a monthly basis at Devils Lake.

d. Stages - (1901-present) on a monthly basis at Devils Lake. Incomplete records necessitate graphical approximation of a few monthly stages. One observed stage is available for each of the following years: 1867, 1879, 1883, 1887, 1890 and 1896.

These data were analyzed to identify any long-term trends in evaporation, precipitation, or inflow to the lake. Both evaporation and precipitation were plotted against time on a monthly basis for the period of record. This graphical analysis revealed no obvious long-term trend for precipitation or evaporation; thus, there appears to be no correlation of either evaporation or precipitation with stages on Devils Lake.

No streamflow gages are representative of total inflow to Devils Lake. Therefore, the hydrologic budget equation (inflow + precipitation over the lake = evaporation over the lake + storage) was used to calculate monthly inflow values. Based upon information obtained from the U.S. Geological Survey, groundwater flow was considered to be insignificant. A graphical representation of Devils Lake inflow versus time indicated a fairly high degree of correlation between inflow and change in stage.

Several methods were considered for projecting future water elevations of Devils Lake. Attempts to develop a method using both the HEC-4 computer model and statistical analysis were pursued.

HEC-4

The computer program HEC-4 (Monthly Streamflow Simulation) was used to analyze monthly data to determine their statistical characteristics and to generate a sequence of hypothetical values for 400 years having those same characteristics. Since monthly elevations on a lake without an outlet are not independent of one another, a statistical analysis of Devils Lake stages was not performed. Instead HEC-4 runs were made for statistical analysis of evaporation, precipitation, and inflow; 400 years of hypothetical values were generated on a monthly basis for all three variables.

The standard version of HEC-4 internally performs a logarithmic transformation of incremental monthly values and will only generate values in integer form. It was necessary for the Hydrologic Engineering Center to revise the program for statistical analysis of evaporation and precipitation so that no logarithmic transformation would be made of the data and values would be generated to two decimal places. The standard HEC-4 version was used for monthly inflow data.

The values generated by HEC-4 for all three parameters were combined so that monthly changes in storage could be computed from the hydrologic budget equation. Using the storage-capacity curve at Devils Lake, 400 years of lake elevations were tabulated on a monthly basis.

It was recognized at the start of this study that HEC-4 would not be capable of generating large lake elevation cycles similar to the one observed over the last 114 years at Devils Lake. However, by statisically analyzing the three parameters that have accounted for this long-term change in stage, it was hoped that HEC-4 would generate values that, in combination, would produce reasonable lake stages that were somewhat cyclic in nature. The HEC-4 analysis did not, however, produce this cyclic trend. Lake elevations projected for the next 400 years appeared to fluctuate on a random basis between a minimum elevation of 1,412 feet and a maximum elevation of 1,423 feet (3 feet below the current elevation of Devils Lake) on a 1-foot to 2-foot change per year. Based on an observed low of 1,401 feet, a historic high of 1,446 feet (observed high of 1,438 feet), and changes in stage as great as 7 feet per year, the HEC-4 study projections do not appear to be realistic. Although HEC-4 was considered to be an appropriate method for indirectly predicting Devils Lake elevations, it cannot be accepted because of the generation of unreasonable results.

STATISTICAL ANALYSIS: PROBABILITY VERSUS STAGE

For any statistical analysis, it is necessary to assume that the available flood data constitute a reliable and representative time sample of random homogeneous events. A frequency analysis contains the following basic assumptions:

a. Climatic trends - Any hydrologic analysis assumes that the variable is not affected by climatic trends or cycles. In the analysis of climatological data that affect Devils Lake stages, no obvious trend was evident in evaporation or precipitation.

b. Randomness of events - A group of data must be considered a sample of random and independent events. For a closed basin such as Devils Lake, lake stages can be considered neither random nor independent since stages are directly influeced by the previous year's lake elevation.

c. Watershed changes - The only data that should be used for frequency analysis are those that represent relatively constant watershed conditions. A significant amount of channelization has apparently occurred over several years in the Devils Lake watershed and has probably resulted in nonhomogeneous data.

d. Reliability of data - The possibility of measurement errors must be recognized. However, measurement errors are usually random, and the variance introduced from stage errors is probably small in comparison to the year-to-year variance in Devils Lake stages.

Devils Lake stage data do not meet all of the basic assumptions for performing a statistical analysis. Specifically, lake stages are not independent events. The occurrence of any event is dependent on or related to previous lake elevations because of the absence of an outlet. Since lake elevations are neither random nor independent, a stage-frequency analysis cannot be considered an appropriate method for determining the likelihood of stages on Devils Lake.

## PROBABLE MAXIMUM FLOOD

A probable maximum flood (PMF) was computed for the Devils Lake basin for the purpose of developing the standard project flood. Results of detailed PMF studies conducted for the Goose River at Portland, Wild Rice River at Twin Valley, and the Sheyenne River at both Baldhill Dam and Kindred were used to establish the peak discharge and duration of the Devils Lake PMF. A relationship was developed between peak discharge per square mile of drainage area versus total drainage area based on the four known PMF sites. Linear regression analysis produced a correlation coefficient of 0.99 for this relationship. Using the Devils Lake drainage area of 3,580 square miles yielded a PMF peak discharge of 110,000 cfs.

Relationships were also developed for duration of discharge versus drainage area for 25, 50, 75 and 90 percent of the peak discharges of each of the four known PMF hydrographs. Again linear regression analysis indicated high correlation. From these relationships, durations were determined for discharges equivalent to 25, 50, 75 and 90 percent of the PMF peak discharge at Devils Lake.

The U.S. Geological Survey gaging station at Big Coulee at Churchs Ferry represents approximately 70 percent of inflow to Devils Lake. Gaged streamflow data at this location was used to establish the rising limb of the PMF hydrograph at Devils Lake. This information along with the peak discharge and duration data was utilized in developing the probable maximum flood hydrograph at Devils Lake as shown on Plate D-3.

## STANDARD PROJECT FLOOD

The standard project flood (SPF) for Devils Lake was developed using guidelines contained in EM 1110-2-1411 which states that the SPF usually is equivalent of 40 to 60 percent of the PMF flow values. Because of the large amount of wetland area available for storage of runoff, the SPF was selected as being equal to 40 percent of the PMF. The standard project flood hydrograph at Devils Lake is shown on Plate D-4.

Standard project flood routings into Devils Lake were done for three different initial water surface elevations - 1,405 feet, 1,415 feet and 1,428 feet. Elevation 1,405 feet was selected as being fairly representative of one of the lowest observed water surface elevations. Elevation 1,415 feet was considered to be an approximate mean annual water surface elevation and 1,428 feet is representative of the current water surface elevation at Devils Lake. Routings were done in 12-hour increments and results are indicated in Table D-5. Differences of 10 feet and 20 feet in starting water surface elevations did not result in corresponding 10-foot and 20-foot differences in final water surface elevations due to the increased storage capacity available at the higher elevations at Devils Lake. Standard project flood stage hydrographs at Devils Lake are shown on Plate D-5 for the three different starting water surface elevations.

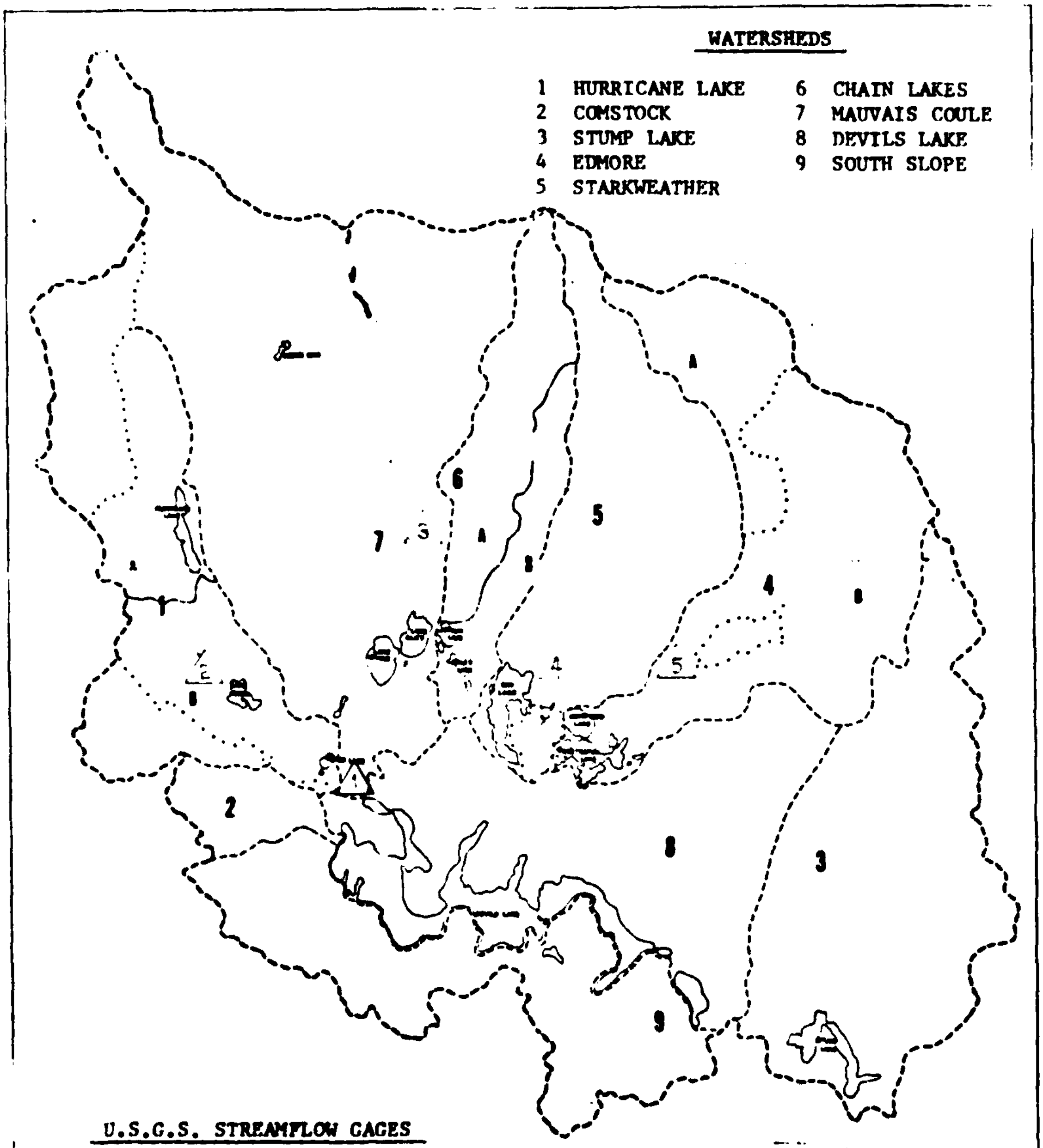
TABLE D-5

STANDARD PROJECT FLOOD ROUTING AT DEVILS LAKE, NORTH DAKOTA

| Initial water surface elevation in feet above msl | Final water surface elevation in feet above msl |
|---|---|
| 1,405 | 1,435.5 |
| 1,415 | 1,438.2 |
| 1,428 | 1,446.0 |

1 PERCENT EXCEEDENCE FREQUENCY FLOOD

A volume-frequency curve was developed for spring inflow to Devils Lake for determining the water surface elevation resulting from a flood with an exceedence frequency of 1 percent (based upon the current elevation of 1428.0). The volume-frequency curve was based on the change in water surface elevation between the fall and spring seasons for 54 years of data. The 1 percent exceedence frequency flood having a volume of 270,000 acre-feet would produce a water surface elevation of 1432.5 feet at Devils Lake based upon an initial (current) elevation of 1428.0 feet.




U.S.G.S. STREAMFLOW GAGES

1 Big Coule near Churchs Ferry

2 Little Coule near Brinsmade

3 Mauvais Coule near Cando

4 Starkweather Coule Near Webster

5 Edmore Coule near Edmore

FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA
SECTION 205 DETAILED PROJECT REPORT

DEVILS LAKE BASIN MAP

ST. PAUL DISTRICT

PLATE D-1

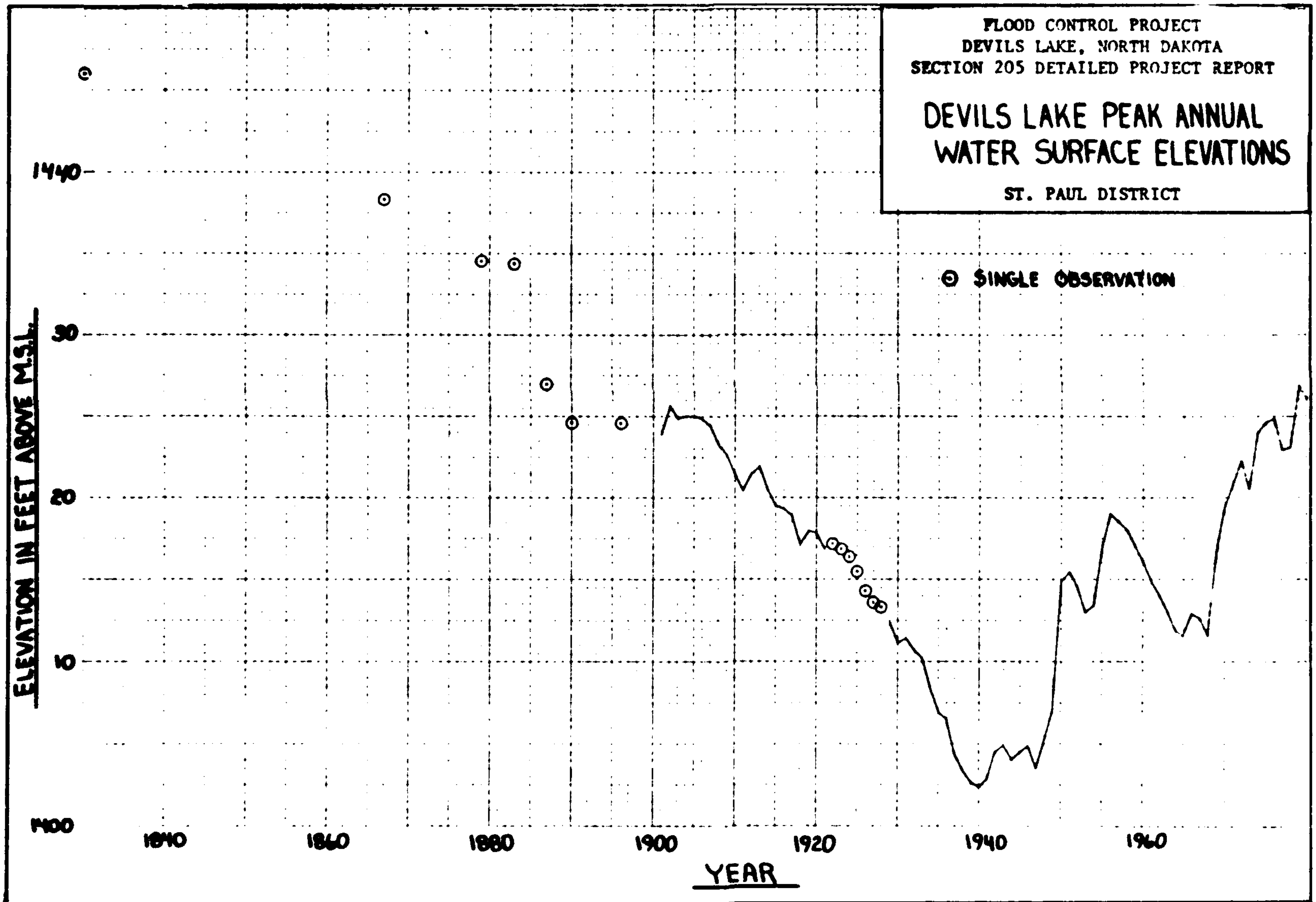
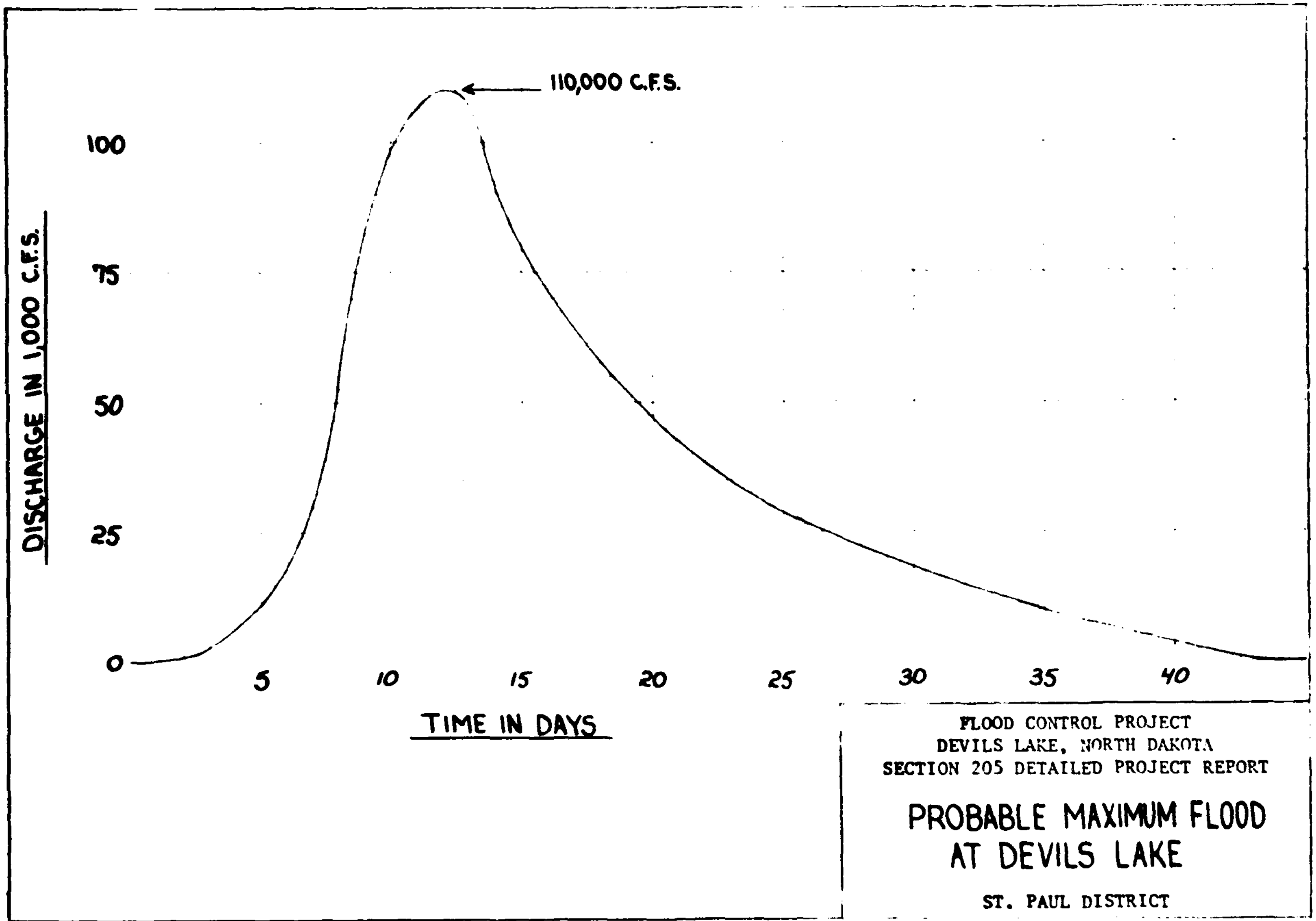

FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA
SECTION 205 DETAILED PROJECT REPORT
DEVILS LAKE PEAK ANNUAL WATER SURFACE ELEVATIONS
ST. PAUL DISTRICT
⊙ SINGLE OBSERVATION
ELEVATION IN FEET ABOVE M.S.L.
1440
30
20
10
1400
1840
1860
1880
1900
1920
1940
1960
YEAR

PLATE D-2




FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA
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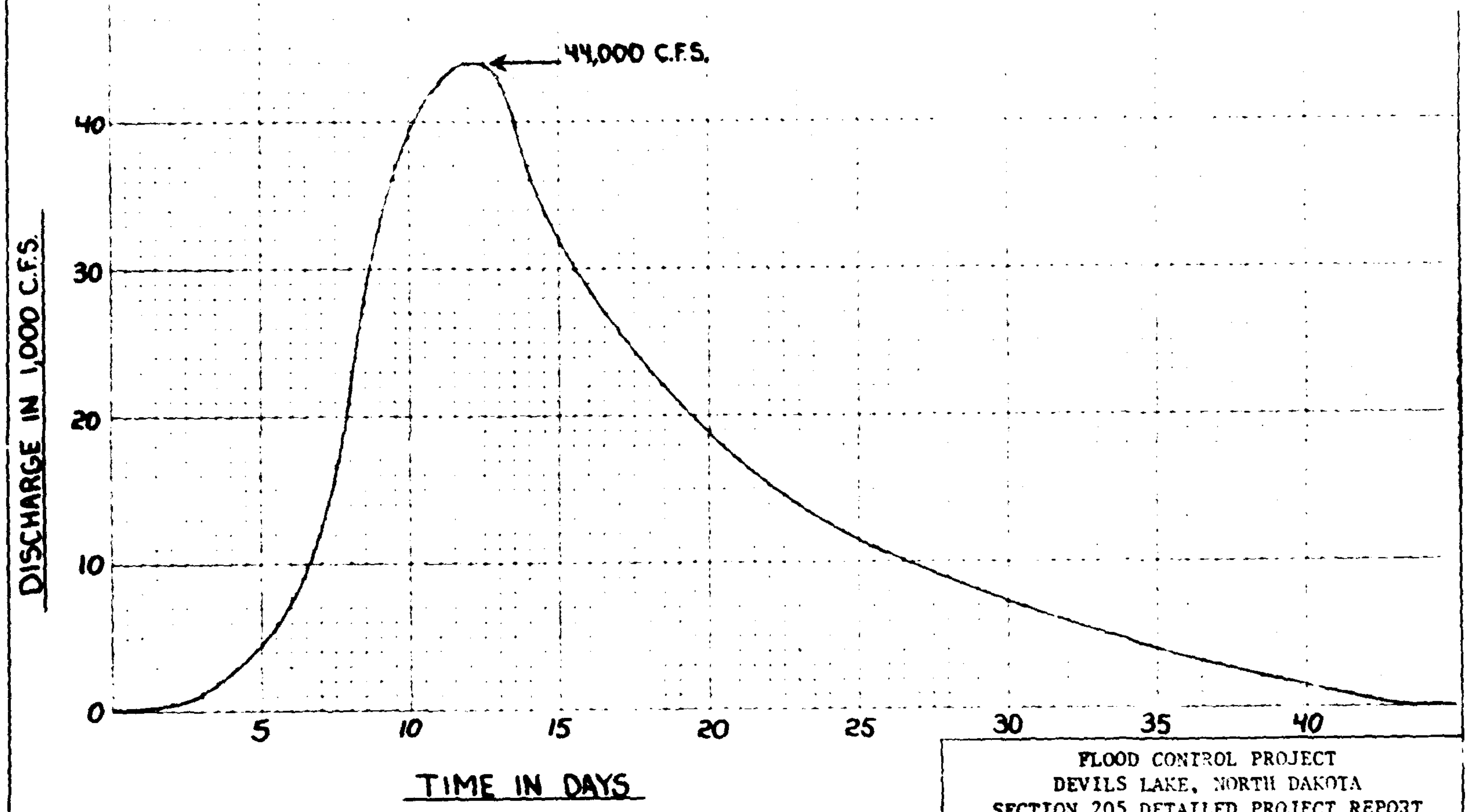
## PROBABLE MAXIMUM FLOOD AT DEVILS LAKE

ST. PAUL DISTRICT

PLATE D-3




FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA
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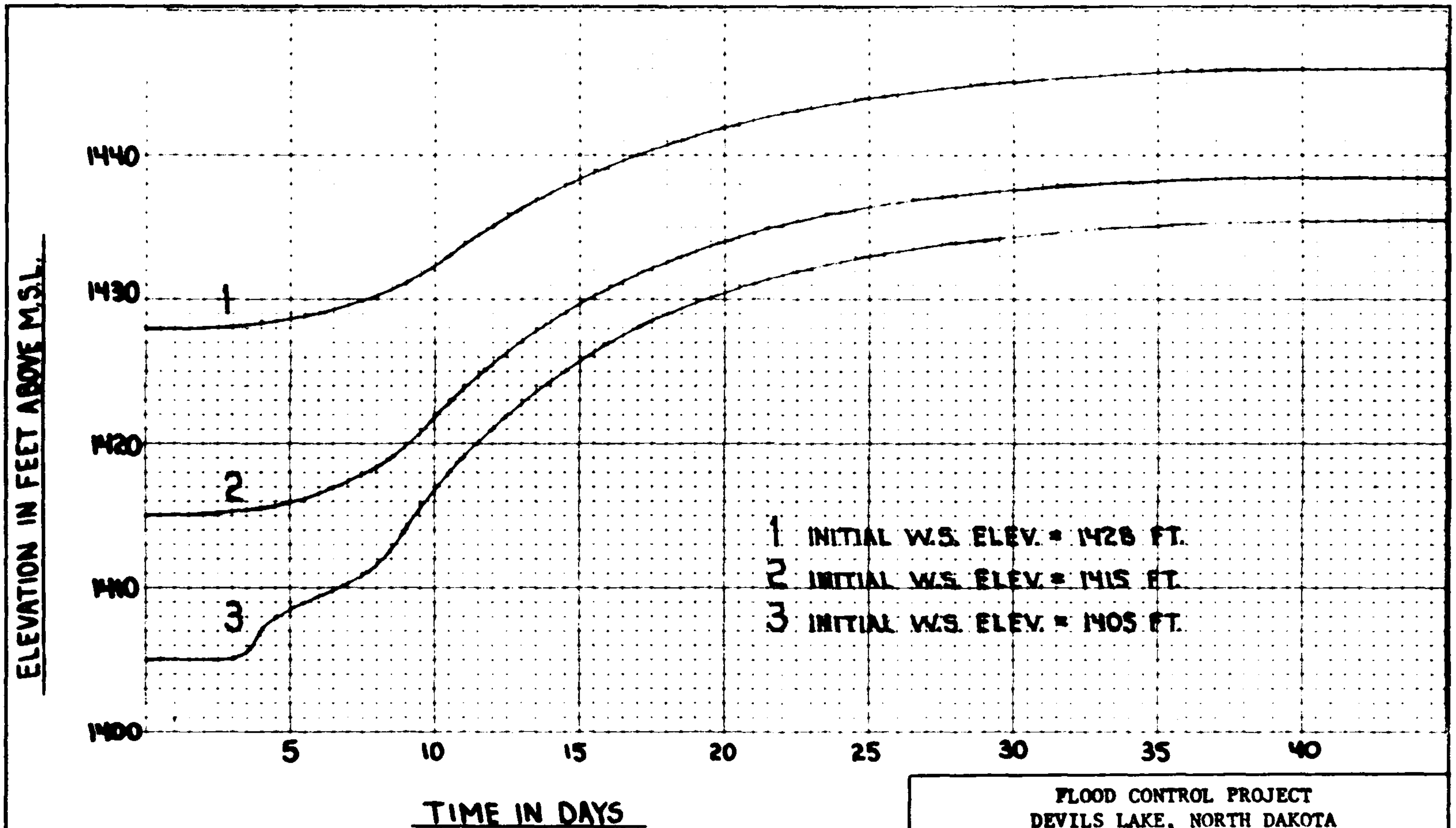
STANDARD PROJECT FLOOD
AT DEVILS LAKE

ST. PAUL DISTRICT

PLATE D-4




FLOOD CONTROL PROJECT
DEVILS LAKE, NORTH DAKOTA
SECTION 205 DETAILED PROJECT REPORT

## S.P.F. STAGE HYDROGRAPHS AT DEVILS LAKE

ST. PAUL DISTRICT

PLATE D-5

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX E

GEOLOGY, SOILS DATA, AND ANALYSIS

## APPENDIX B

## TABLE OF CONTENTS

# PLATES

## TOPOGRAPHY

The Devils Lake basin is located entirely in the Drift Prairie section of the Central Lowlands physiographic province. It is a large closed drainage basin that extends from the edge of the Turtle Mountains to the northwest to a series of prominent hills south of Devils Lake. The land surface is a rolling glacial plain characterized by numerous prairie pot holes, sloughs and occasional morainic ridges. Maximum relief in the basin is about 315 feet with Devils Lake occupying the lowest area at roughly elevation 1425 feet above N.G.V.D. of 1929 and a high elevation of 1740 occurring at the crest of hills immediately south of Devils Lake.

The land surface in the area of the proposed embankments was smoothed by sedimentation in and wave action of Devils Lake when it was at a level much higher than present. At the Creel Bay, or main, embankment the ground surface rises gently from a low elevation of 1425 to a high elevation of 1445 in a distance of 600 to 700 feet. Total relief at the smaller embankments near Highways 19 and 20 is less than 10 feet in a distance of 2500 to 3000 feet.

## GENERAL GEOLOGY

The geology of the Devils Lake basin is uncomplicated and consists essentially of a mantle of glacial drift resting on an unevenly eroded Cretaceous bedrock surface. Sandy clay till comprises most of the drift, but beds, lenses and channels of sand and gravel are common in the till. The thickness of glacial drift varies from only a few feet in areas of bedrock highs to more than 350 feet in buried bedrock valleys. Little or no modification of the drift by erosion has occurred except in areas previously inundated by lakes. In those areas, surface irregularities were smoothed by wave action, low areas filled with fine-grained lacustrine sediments and coarse-grained beach ridges developed along old shorelines.

Bedrock underlying the drift is the Cretaceous Pierre Formation which has a maximum thickness of 600 feet. The formation is a dark gray clay shale of which the upper 50 to 200 feet below the contact with the drift are badly fractured. A thick sequence of Mesozoic and Palezoic sedimentary beds underlies the Pierre Formation but is well below the influence of the proposed work and is not discussed.

## SITE GEOLOGY

In contrast to the simple overview presented for the regional geology, detailed site-specific stratigraphy in glacial drift is commonly complex. Such is the case at the Creel Bay embankment where overburden materials have been classified into four units based on time and mode of deposition. Two glacial tills separated by glacioaqueous sediments are recognized along with lacustrine sediments laid down in post-glacial Devils Lake. Correlation of the units is shown graphically for the Creel Bay embankment on Plate E-4, and the units are discussed in the following paragraphs along with discussion of the underlying bedrock.

RECENT LACUSTRINE SEDIMENTS

Sediments classified as Recent Lacustrine are those materials deposited in Devils Lake since the last glacier receded from the area. The materials are primarily clays with minor amounts of silt and fine sand. They have never been consolidated by an overlying load of sediments or ice and exhibit a penetration resistance of 3 to 10 blows per foot (bpf) to standard penetration tests. A maximum of 17.4 feet of this material was encountered at the Creel Bay embankment, 12.4 feet at the Highway 20 embankment and 10.9 feet at the Highway 19 embankment.

YOUNGER GLACIAL TILL

Sediments classified as Younger Glacial till are those deposited directly by the ice during the last glacial event. The material is predominantly sandy gravelly clay with occasional thin beds of sand and gravel. It has a penetration resistance of 5 to 25 bpf to standard penetration tests. Zones with a penetration resistance less than 10 bpf are confined to areas immediately below a former surface inundated by the post-glacial lake and now mantled by Recent Lacustrine sediments. This lower penetration resistance is interpreted to be due partially to reworking of the till by wave action but primarily to a residual high water content.

GLACIOAQUEOUS SEDIMENTS

Glacioaqueous sediments consist of lacustrine and possibly some fluvial sediments composed predominantly of clay with some silt and sand. These sediments are intepreted to have been consolidated by an overlying mass of ice after deposition and exhibit a penetration resistance to standard penetration tests between 40 and 150 bpf. They are easily differentiated from Younger Till by their uniform texture and high penetration resistance. Their stratigraphic position and high penetration resistance allow easy differentiation from Recent Lacustrine sediments.

OLDER GLACIAL TILL

Sediments classified as Older Glacial till were encountered only on the abutments for the Creel Bay embankment and consist of gravelly sandy clay and clayey sand. The material is characterized by low water content and a high penetration resistance ranging from 53 to 280 bpf to standard penetration tests. This material is differentiated from Glacioaqueous Sediments by its heterogeneous texture and from Younger Till by its lower water content and higher penetration resistance. The Older Till is interpreted to have been deposited by an early glaciation and to have been consolidated by subsequent ice and overburden loads.

BEDROCK

Bedrock is the Pierre Formation which underlies glacial drift throughout most of the region. The formation is a soft to moderately hard, dark gray clay shale. In the Devils Lake basin the upper 50 to 200 feet are sufficiently fractured to serve as an aquifer. The shale was penetrated to a maximum depth of 14 feet in borings for the Creel Bay embankment. At that location the shale is badly weathered and fractured at the overburden contact and is more like a soil than a rock for 1 to 3 feet below the contact. The shale improves in quality with depth, but it is badly fractured and characterized by a high water content to the depth penetrated. Samples of shale were obtained by drive sampling. Resistance to standard penetration tests ranged from 55 bpf at the overburden contact to over 100 blows within a few feet. The light loading proposed for the site and thick cover of impervious material make more detailed evaluation of the strength and water bearing characteristics of the shale unnecessary.

## GROUND WATER AND SEEPAGE

The foundation materials at all of the embankment sites are predominantly impervious. Out of 546.2 linear feet of overburden sampled for the project only 31.2 feet were evaluated as pervious and occurred as beds less than 5 feet thick in an impervious soil mass. A total of 97.4 linear feet of fractured shale was sampled which in all cases was mantled by an impervious soil cover. Although not verified by borings for this project, glacial till is normally weathered and occasionally fissured to a depth of 5 to 10 feet. In areas of poor surface drainage, water is frequently stored in fissures in this zone and may seep into shallow excavations. Migration of water through these fissures is, however, generally not significant. Movement of water is, therefore, interpreted to be limited to thin sandy beds in the overburden and the fractured shale. Based on this interpretation, seepage under the embankments is evaluated to not be a problem due to a limited ability of the foundation to receive and transmit water. The water table was poorly defined for this study due to the low permeability of the soils and short observation time allowed for water levels in boreholes to become static. Based on the simple definition of the water table as the surface of the zone of saturation, it is interpreted to be fairly shallow at all sites. Free water is, however, not readily available.

## SUBSURFACE INFORMATION, SOIL AND LABORATORY TEST DATA

### BORINGS

A total of 23 borings and 2 test pits were taken during 1980 and 1981 by the Corps of Engineers at anticipated construction locations for the project. The locations of the borings and test pits are shown on Plate E-[illegible]. The boring logs are presented in order of increasing boring number on Plates E-12 through E-14.

### SOILS DATA

The soils in the project area generally consist of impervious clays and sandy clays underlain by a highly fractured cretaceous shale. The soil strata can be divided into an upper strata of normally consolidated lacustrine clays underlain by normally and overconsolidated glacial clays.

LABORATORY TEST DATA

Laboratory tests performed include: insitu moisture contents, Atterberg limits, mechanical analyses, undisturbed and remolded strengths, compaction and consolidation. The insitu moisture contents and Atterberg limits are shown on the boring logs. Other individual lab test results are presented on Plates E-15 through E-28. The individual strength test results were used to develop summary strength plots whenever sufficient data were available. The summary plots for a given structure are grouped with other plates pertaining to that structure.

The undisturbed samples for strength and consolidation testing were frequently obtained from a boring offset slightly from a pilot boring. This sampling procedure permits preselection of sampling depths based on information obtained from the pilot boring and, therefore, provides samples that are more representative of the foundation material. Where this procedure was used, the offset boring number appears on the individual laboratory test results, with the subsurface conditions shown by a detailed log of the pilot boring. The location of the pilot boring is used to designate the location of both borings in plan. It is important that the reader recognize that boring numbers ending in the letters MU (81-22MU) represent borings offset slightly from the pilot boring having the same prefix number but ending in the letter M (81-22M).

DESIGN CONSIDERATIONS AT INDIVIDUAL STRUCTURE LOCATIONS

A discussion of design considerations at each structure location is presented in the following paragraphs.

CREEL BAY

The plan of the Creel Bay Dam is shown on Plate E-2. Foundation conditions at the site are shown on the geologic profile on Plate E-4.

Embankment Design

The typical embankment design is shown on Plate E-3. The embankment has a top width of 20 feet to provide access for maintenance vehicles and for constructability. The lakeward slope of the embankment will be 1V on 3.5H to satisfy partial pool criteria and will be protected with 18 inches of riprap placed on 9 inches of bedding. The landward slope of the embankment will be 1V on 3.5H to satisfy steady seepage criteria and will be protected from erosion from 2 feet above the top of the sand drain to elevation 1445 by 4 inches of topsoil and seeding. The remainder of the slope will be protected by 12 inches of riprap with 6 inches of bedding. The berm located on the lakeward slope of the dam is to be constructed from the material used to build the cofferdam. The berm shall be protected from erosion by 4 inches of topsoil and seeding, if it is above the lake elevation at the time of construction.

Stripping to a depth of 12 inches will be required beneath the embankment where the existing ground surface is below elevation 1430. Above elevation 1430, stripping to a depth of 6 inches will be required. No stripping will be required beneath the lakeside berm.

The construction sequence for the project will be altered if the emergency cofferdam is built before construction of the pump station and main embankment begins. The impact will be that part of the emergency cofferdam will have to be removed when the discharge channel from the pump station is excavated.

Seepage Control

Seepage through the embankment will be controlled by the impervious embankment fill and the sand drain. Existing borings indicate that, in general, the foundation soils are relatively impervious. On the abutments and across the valley floor, a 6-foot deep inspection trench will be excavated in the foundation soil and backfilled with impervious fill.

Stability

The strength data for the materials at the Creel Bay Dam site have been summarized on Plates E-8 through E-11. These design strengths were used to perform stability analyses of the embankment section. The cases analyzed were End of Construction, Partial Pool, and Steady Seepage at Maximum Storage Pool. The three cases were analyzed with and without a seismic coefficient of 0.025. Results of the analyses are shown on Plates E-5, E-6, and E-7. A 1V on 3H lakeward and 1V on 3H landward slope were analyzed but did not satisfy minimum design criteria. The sudden drawdown cases were not analyzed because Devils Lake has no outlet and, therefore, sudden drawdown is not applicable.

Settlement of the Embankment Foundation Soils

The materials underlying the embankment at the center of Creel Bay consist of normally consolidated lacustrine and overconsolidated glacial clays as shown on Plate E-4. The expected ultimate settlement of the embankment due to consolidation of the foundation soils is 1.5 feet. Assuming that one-third of the settlement will occur during construction, an overbuild section having a maximum height of 1 foot is required. Because of the expected embankment settlement, the sand drainage blanket will be placed on a 1.5% slope so that it will be nearly horizontal after complete consolidation.

Pump Station

Foundation conditions favor placing the pump station in the south abutment. Founding the pump station on the overconsolidated material in this abutment minimizes settlement and bearing capacity problems and also minimizes inlet and discharge channel excavation.

Proposed Distribution of Required Excavation and Borrow

A total of 44,950 cubic yards of embankment and berm fill will be required to construct the dam as designed. Essentially all of the material excavated from the inlet channel can be used in the embankment. The remaining embankment material will be obtained from borrow area 3.

REMAINING EMBANKMENT AREAS

The plans for the remaining areas are shown on Plates 2 through 7 of the Main Report.

Embankment Design

A typical embankment section is shown on Plate E-3. The embankment has a 15-foot top width, 1V on 15H lakeward slope, and 1V on 3H landward slope. Both slopes and the top of the embankment will be protected from erosion by 4 inches of topsoil and seeding. The 1V on 15H lakeward slope proved to be less expensive than a steeper slope protected with riprap and bedding. The existing ground will be stripped to a depth of 6 inches beneath the embankment in the area delineated by a 15-foot top width and 1V on 3H side slopes as shown on Plate E-3.

The abandoned Great Northern Railroad embankment will be used for part of the south embankment. The existing embankment top width varies from 10 to 12 feet in width and has 1V on 2H side slopes.

The existing embankment will be modified by placing impervious fill on a 1V on 15H lakeward slope and 1V on 3H landward slope up to elevation 1445.0. Above elevation 1445, the existing embankment will not be modified. The embankment side slopes and the foundation areas delineated by 1V on 3H side slopes shall be stripped to a depth of 6 inches, as shown on Plate E-3. A 16-inch CIP waterline is located approximately 70 feet west of the existing railroad centerline. Before a treatment for this pipe will be recommended, additional boring, testing and analysis will be scheduled to determine settlement problems.

Seepage Control

Embankment seepage control other than that provided by the impervious embankment fill will not be required because of the long seepage path and the low hydraulic head that will be maintained against the structure at the design lake elevation. Because the alignment of the south embankment was recently shifted, no borings have been taken along the new alignment. Borings will be required prior to plans and specifications to verify that no foundation stability, settlement, or seepage problems exist along the new alignment.

Stability and Settlement

Stability of the embankment slopes and settlement of the embankment are not expected to be problems because of the relatively low embankment height.

PONDING AREA LEVEE

The locations of the ponding areas are shown on Plate 2 of the Main Report.

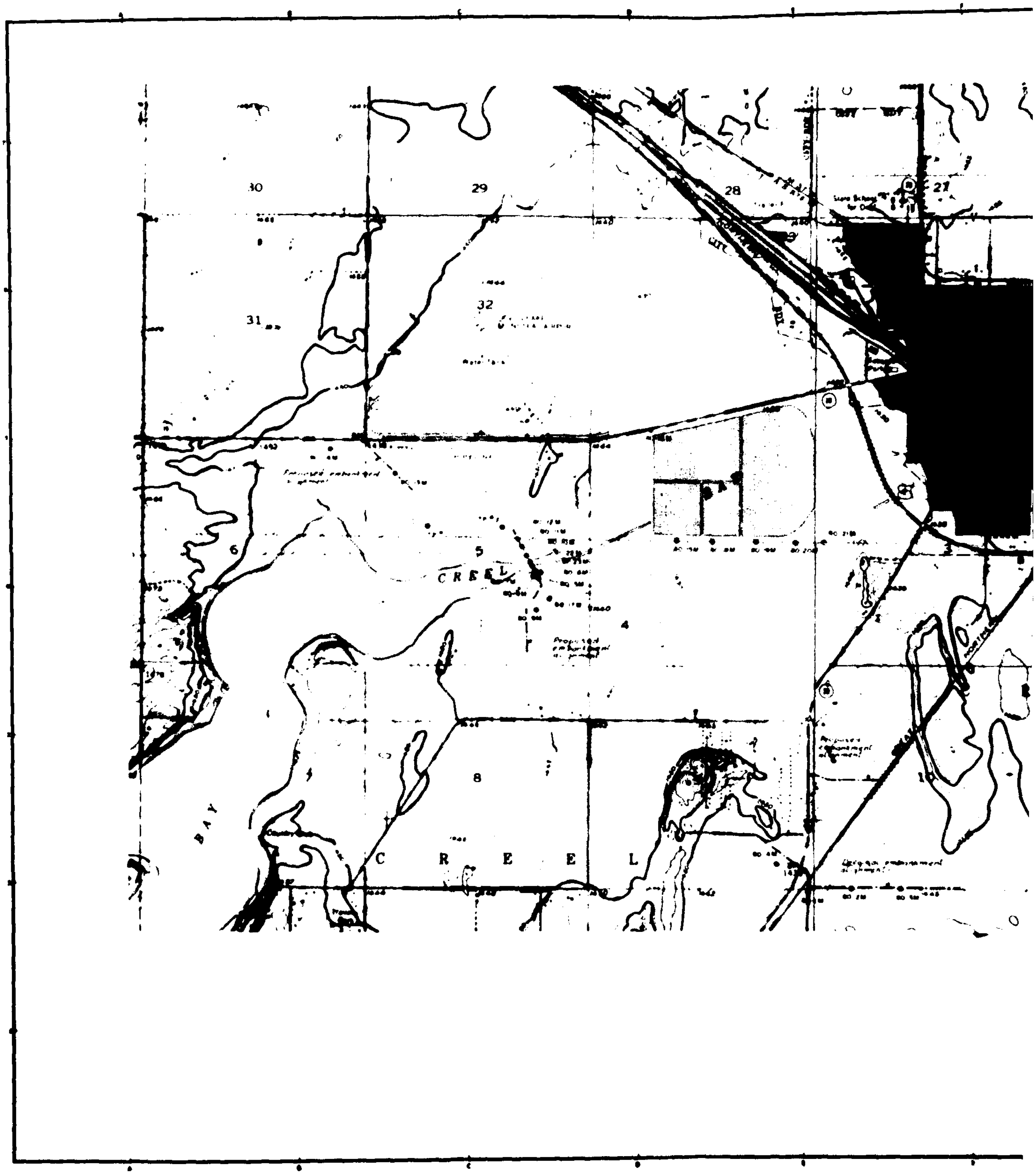
North Ponding Area

The design water surface elevation of 1429.6 for Pond 2 will pond approximately 3.5 feet of water against the existing Highway 19 embankment. The embankment has a minimum elevation of approximately 1432.5, thereby providing adequate freeboard at its present height. The existing roadway has three culverts connecting the proposed ponding area with the drainage ditch south of Highway 19. The three culverts will be removed and a control structure installed. The existing road embankment has a 38-foot wide graded roadbed with 1V on 4H side slopes. No erosion control other than that provided by the existing grassed slopes will be required as the embankment will only retain water for short periods of time. Seepage should not be a problem as Boring Number 80-16M indicates the embankment fill is a clay soil underlain by a clay foundation. No significant settlement is expected under the control structure as there will be little or no increase in loading.

## SOURCES OF STONE AND AGGREGATE CONSTRUCTION MATERIALS

The closest source of concrete aggregate previously approved for work on a Corps of Engineers' project is at Fordville, North Dakota, a distance of approximately 60 miles. Any alternative source would have to be sampled and tested prior to approval.

Riprap and bedding is not readily available locally. The closest source of fieldstone is in the area surrounding Fordville, North Dakota. Bedding material is also available in the Fordville area. The closest reliable source of quarried stone is Ortonville, Minnesota, a distance of 350 miles.

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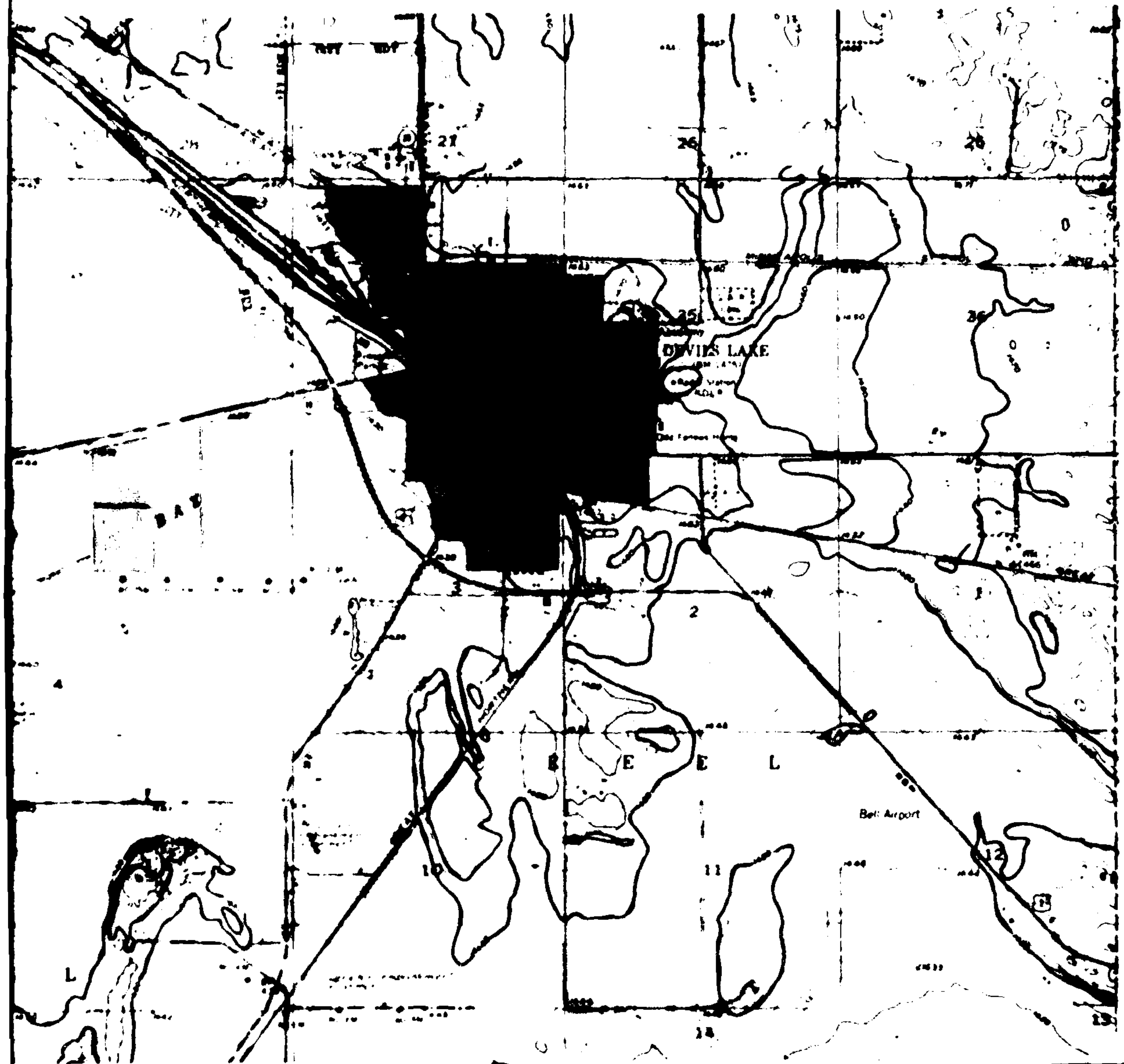



SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL

DEVILS LAKE NORTH DAKOTA

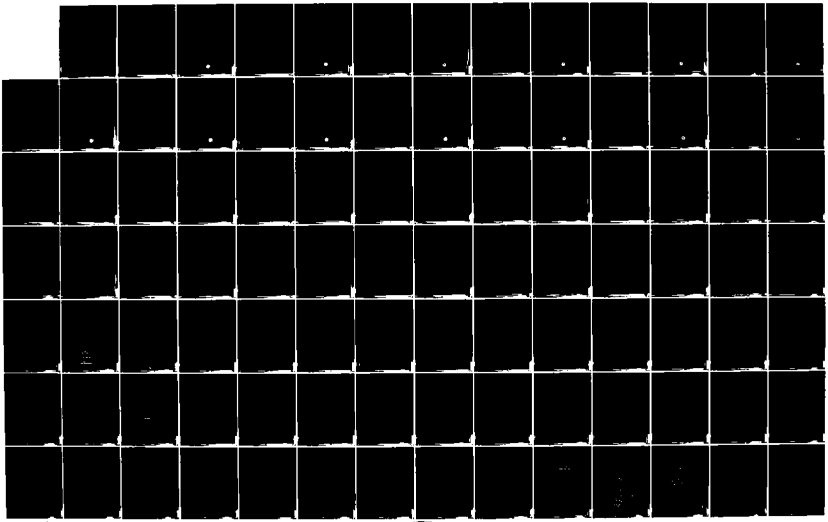
GENERAL BORING LOCATIONS

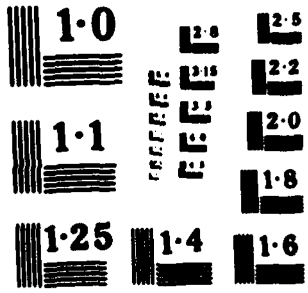
PLATE E 1

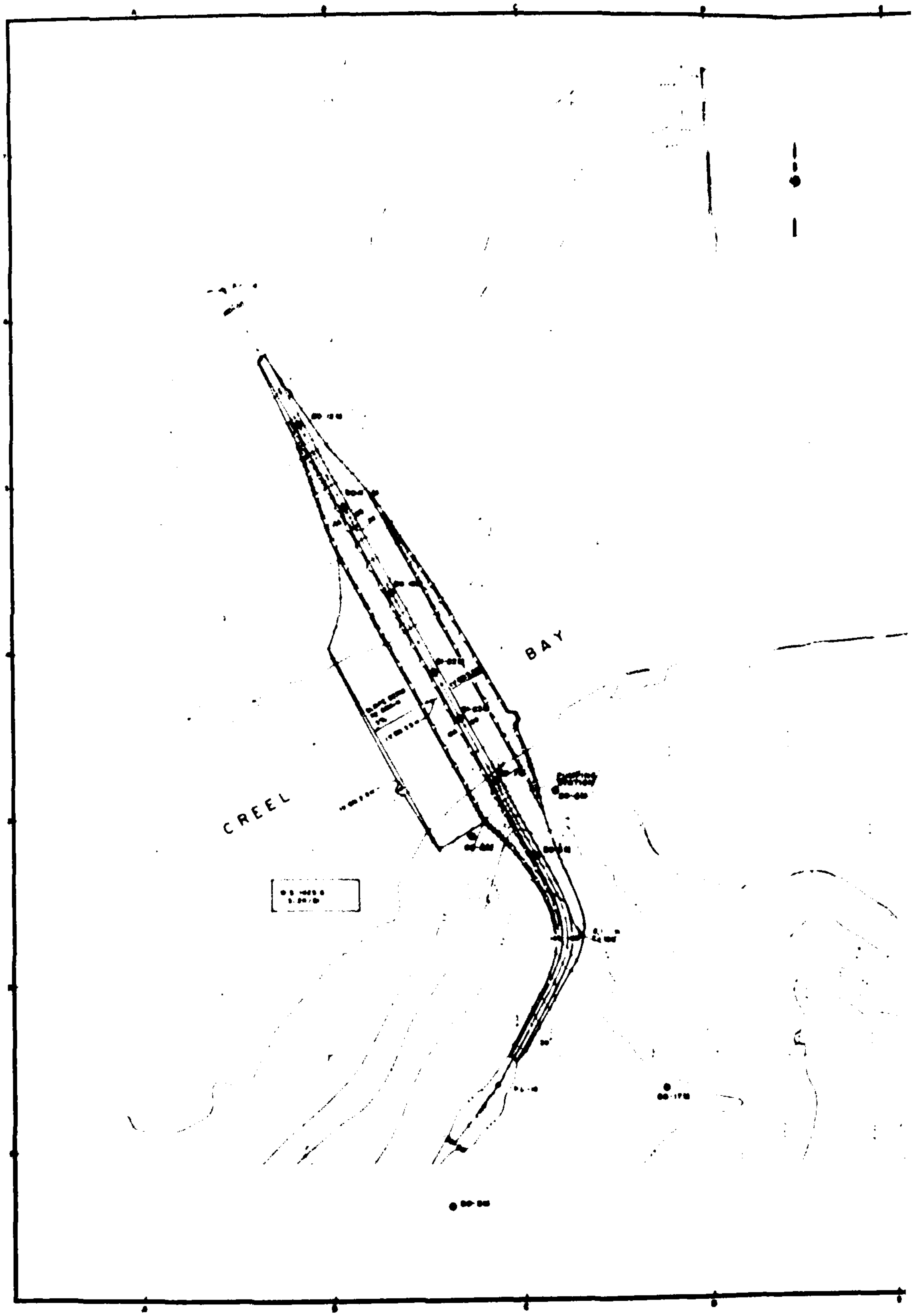
2

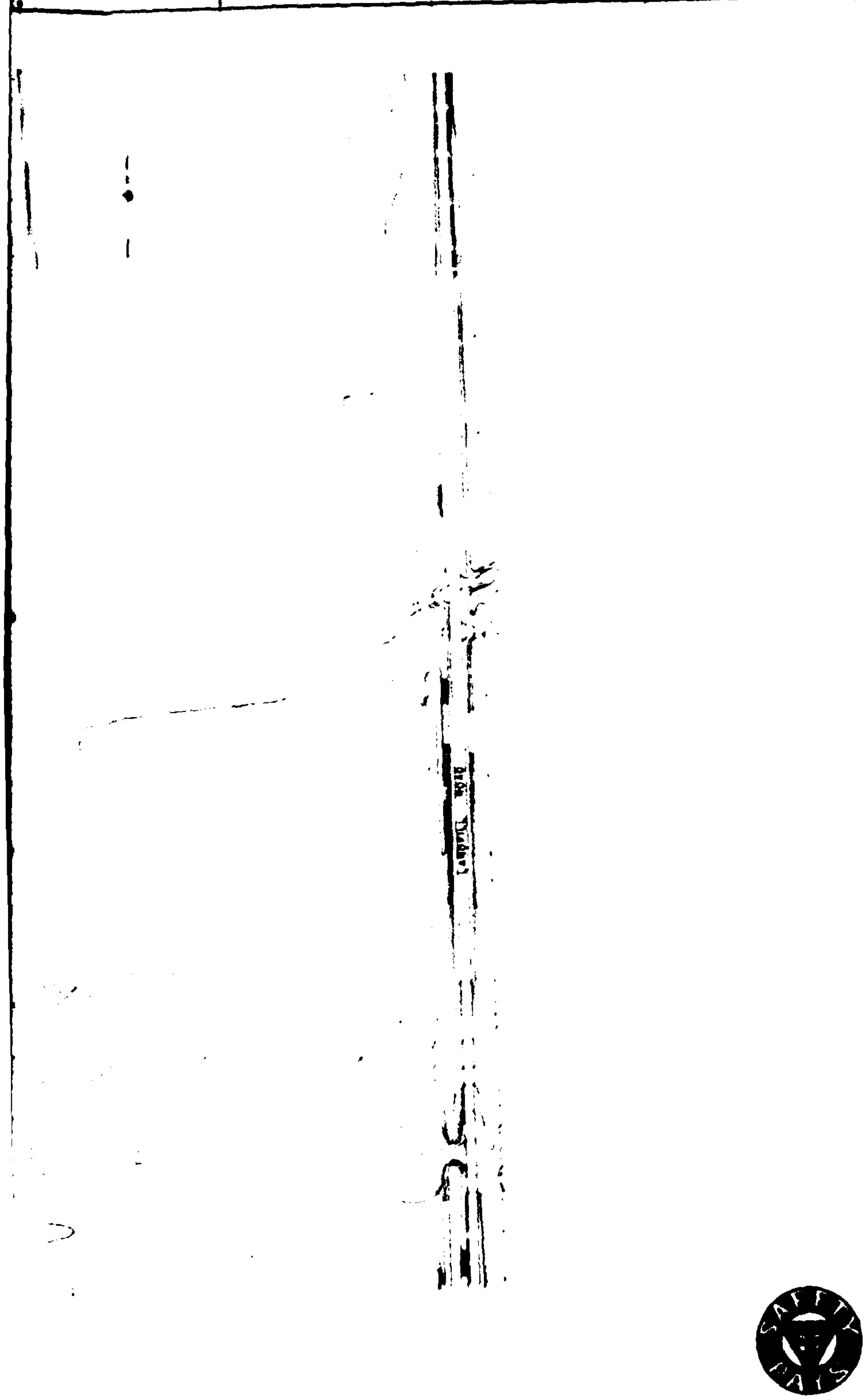
AD A147 505 DEVILS LAKE FLOOD CONTROL PROJECT SECTION 205 DETAILED PROJECT REPORT(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT OCT 83 4/5

UNCLASSIFIED F/G 13/2 NL




1·0
1·1
1·25
1·4
1·6
1·8
2·0
2·2
2·5


CREEL
BAY



DEPARTMENT OF THE ARMY

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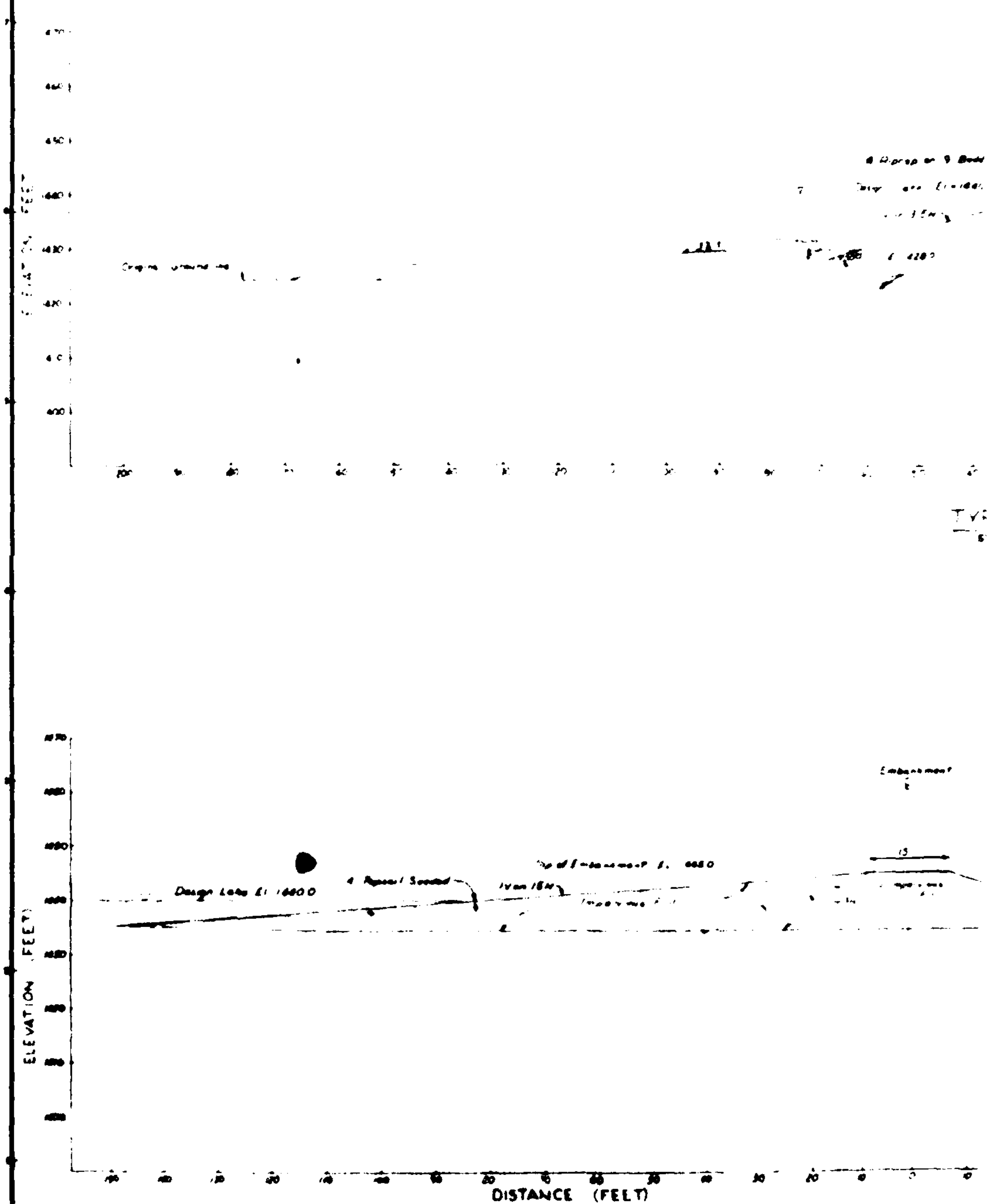
SECTION 205 DETAILED PROJECT REPORT

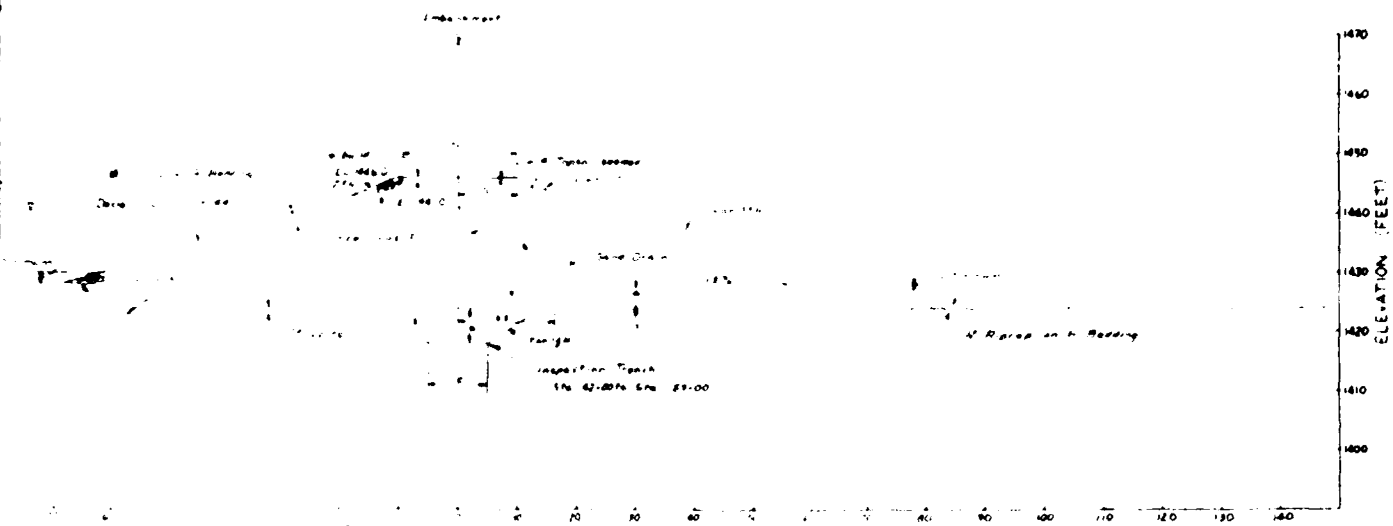
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

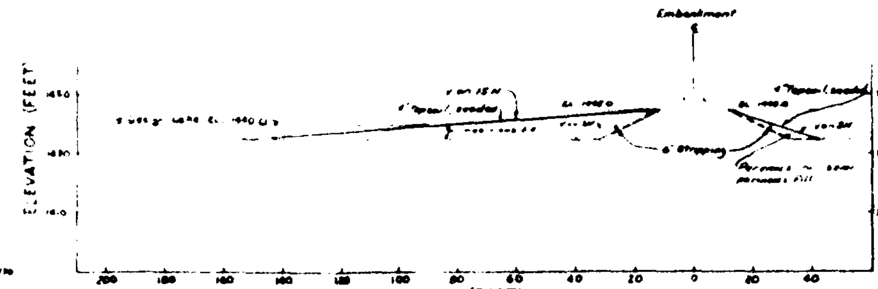
CREEL BAY BORING LOCATIONS

PLATE E-2



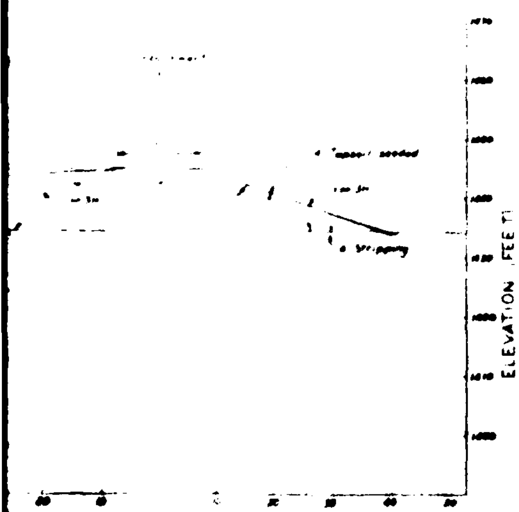

TYPICAL SECTION




DISTANCE (FEET)

TYPICAL SECTION

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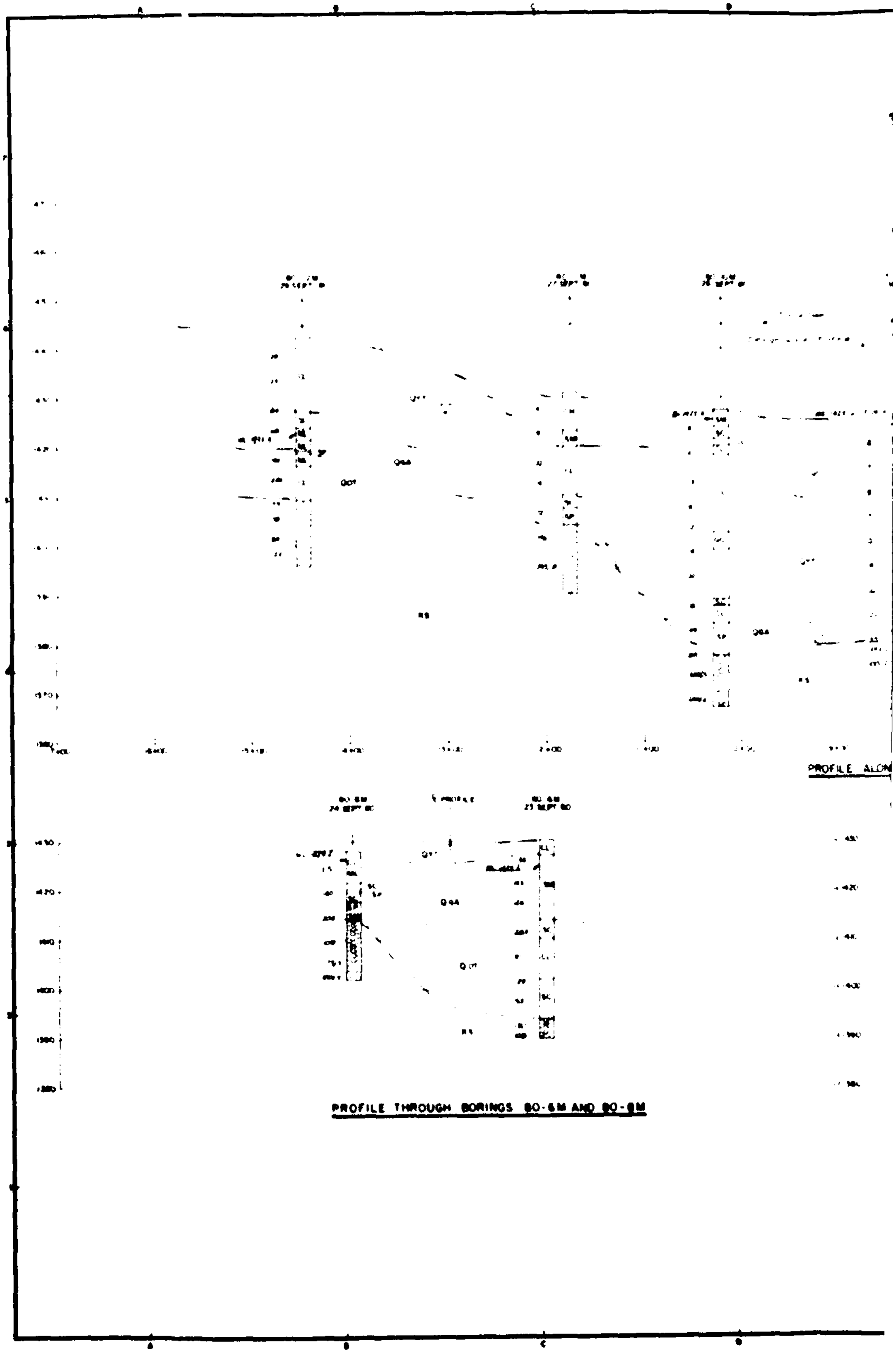
SECTION ___ DETAILED PROJECT REPORT

FLOOD CONTROL

DEVILS LAKE, NORTH DAKOTA

TYPICAL EMBANKMENT SECTIONS

PLATE E-3


PROFILE THROUGH BORINGS 80-6M AND 80-8M

PROFILE ALONG THE EMBANKMENT CENTER LINE

LEGEND

NOTES

DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

CREEL BAY BORING PROFILES

SCALE AS SHOWN

PLATE E 4

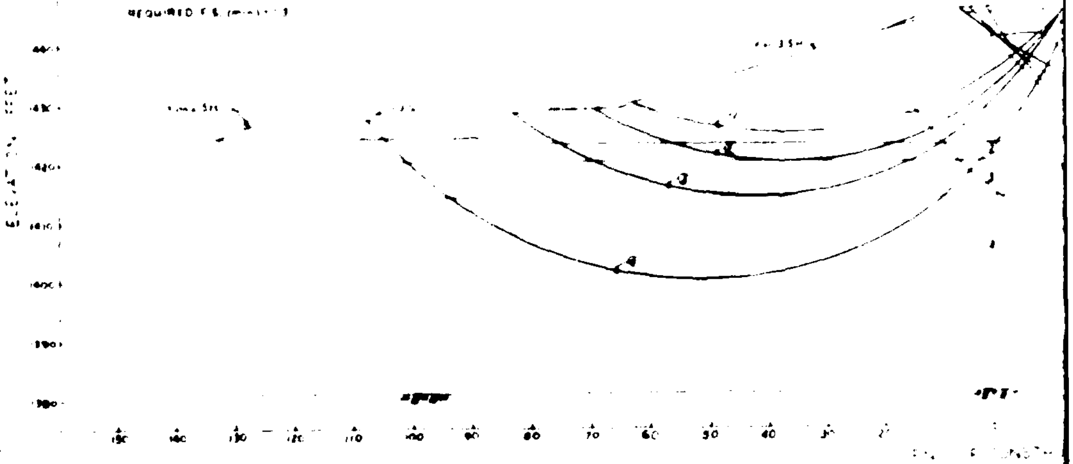
## TABULATION OF TYPICAL TRIAL ARCS

| ARC NO. | TANGENT ELEV. | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| 1 | 42[illegible] | 36.?0 | 1497.9? | 72.3? | 5.86? |
| 2 | 420[illegible] | 37.02 | 1488.10 | 63.10 | 4.?17 |
| 3 | [illegible] | 4?.47 | 1479.4? | 65.6? | 2.?6* |
| 4 | [illegible] | 5?.60 | 1471.85 | 7?.85 | 2.0?? |
| 5 | 425[illegible] | 51.0? | 1520.?? | 95.?? | 3.05? |
| 6 | 1420.0 | 56.00 | 1500.00 | 80.00 | 3.?10 |
| 7 | [illegible] | 55.00 | 14?8.46 | 6?.96 | 1.69?** |
| 8 | 400.0 | 45.?? | [illegible] | 77.42 | 2.6?6 |

* ARC NO. 3 IS THE CRITICAL ARC FOR THE LAKEWARD SLOPE. F.S.=2.?26 TAN. EL.=148[illegible]

** ARC NO. 7 IS THE CRITICAL ARC FOR THE LANDSIDE SLOPE. F.S.=1.69? TAN. EL.=[illegible]

REQUIRED F.S. (min.)=[illegible]



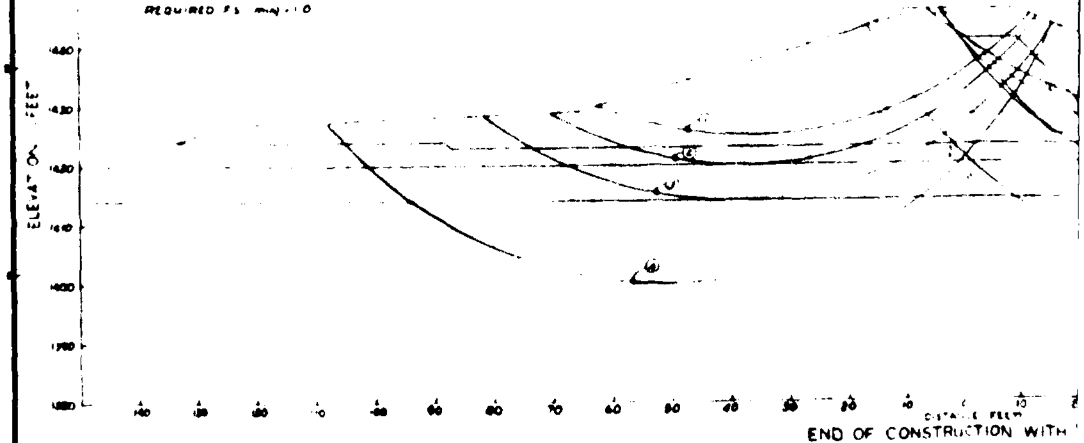
## TABULATION OF TYPICAL TRIAL ARCS

| ARC NO. | TANGENT ELEV. | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| 1 | 1425.0 | 36.27 | 1495.84 | 70.54 | 5.221 |
| 2 | 1420.0 | 37.64 | 1488.99 | 65.59 | 3.780 |
| 3 | [illegible] | 4?.55 | 1482.46 | 6?.86 | 2.209* |
| 4 | 1400.0 | 50.8? | 1473.78 | 73.78 | 2.540 |
| 5 | 1425.0 | 53.?? | 1520.?? | 95.?? | 2.864 |
| 6 | 1420.0 | 56.00 | 1500.00 | 80.00 | 2.9?9 |
| 7 | [illegible] | 52.80 | 1479.80 | 6?.83 | 1.902** |
| 8 | 1400.0 | 56.00 | 1486.00 | 86.00 | 2.?10 |

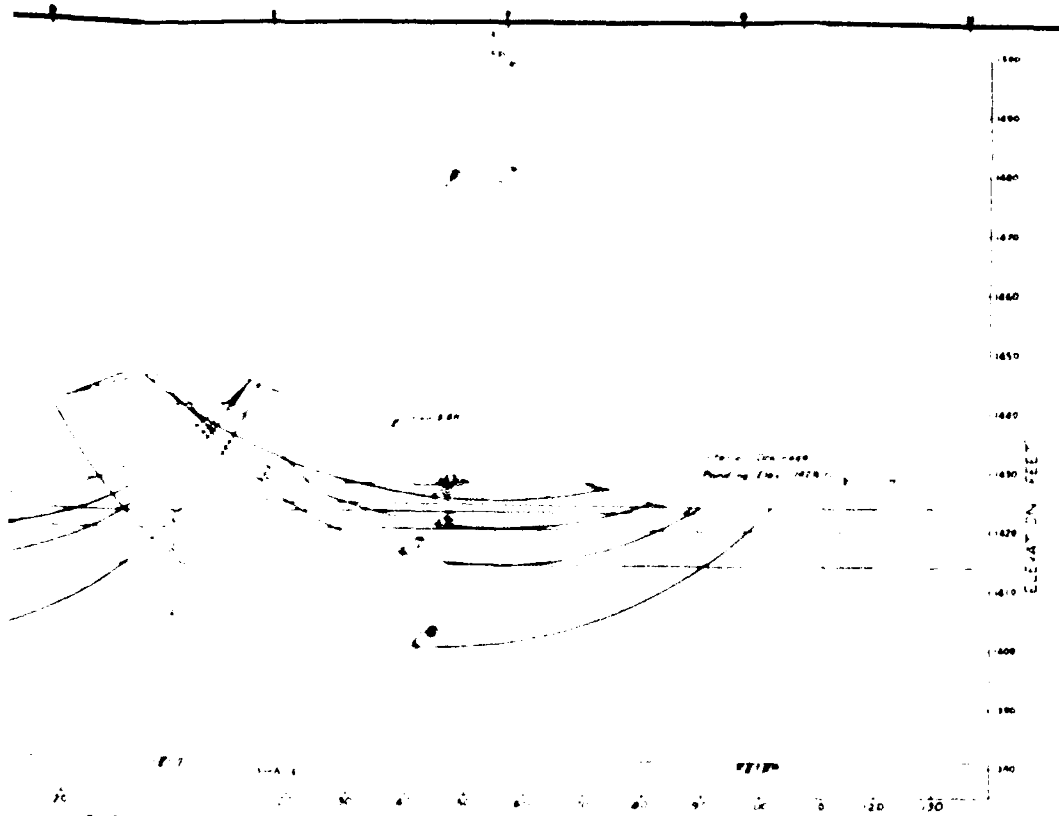
* ARC NO. 3 IS THE CRITICAL ARC FOR THE LAKEWARD SLOPE. F.S.=2.209 TAN. EL.=[illegible]

** ARC NO. 7 IS THE CRITICAL ARC FOR THE LANDSIDE SLOPE. F.S.=1.902 TAN. EL.=1414

REQUIRED F.S. (min.)=1.0

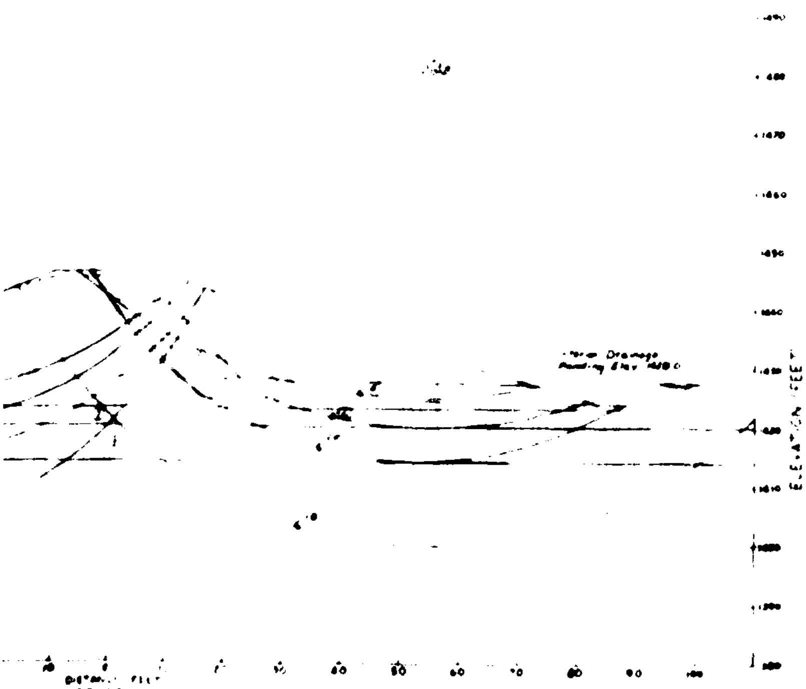


END OF CONSTRUCTION WITH




END OF CONSTRUCTION

| NO | TYPE OF SOIL | $\gamma$ (pcf) | $\gamma$ (pcf) | Q Strength c (psf) | Q Strength $\phi$ (Deg) |
|---|---|---|---|---|---|
| 1 | Impervious Embankment | 117.5 | 124.3 | 1150.0 | 11.9 |
| 2 | Foundation Material | 123.6 | 124.2 | 950.0 | 0.7 |
| 3 | Foundation Material | 22.3 | 123.2 | 330.0 | 0.0 |
| 4 | Sand Drain | 125.0 | 118.0 | 0.0 | 30.0 |




F CONSTRUCTION WITH EARTHQUAKE

DEPARTMENT OF THE ARMY

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CAC

SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

CREEL BAY EMBANKMENT

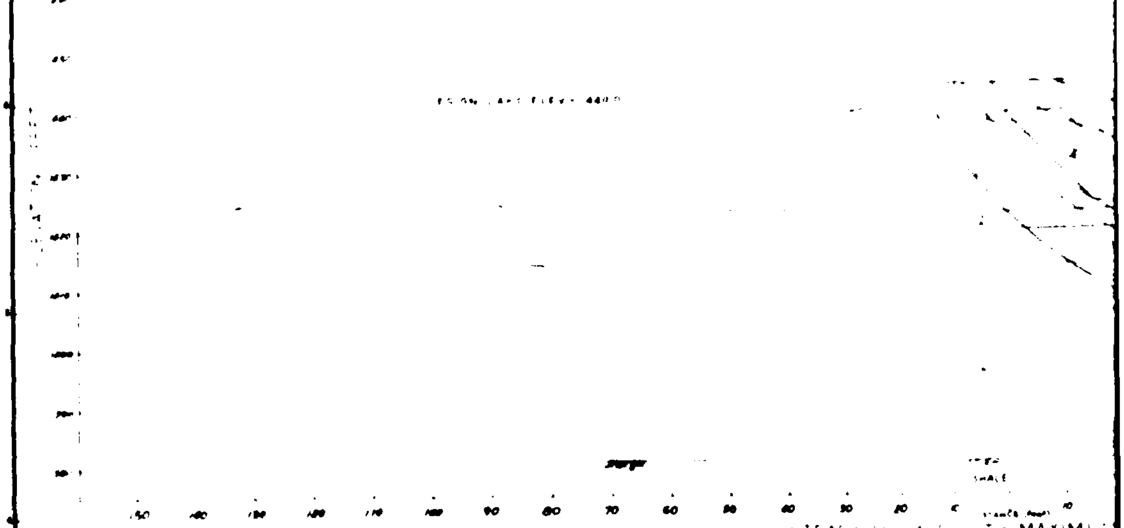
STABILITY SUMMARY

AS SHOWN

PLATE E-5

| ARC NO | TANGENT ELEV | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| [illegible] | 4[illegible] | [illegible] | [illegible] | [illegible] | 800 |
| [illegible] | 4250 | 85.01 | 570.0 | 56.0 | [illegible] |
| 3 | 4,2[illegible] | 70.86 | 5[illegible] | 90.1 | 856 |
| 4 | 4.4 | 66.5 | 1491.7 | 77.6 | 1.566* |
| 5 | 4[illegible] | 76.01 | 1489.2 | 79.2 | 2.018 |
| 6 | 4[illegible] | [illegible] | 1479.8 | 76.8 | 2.630 |

*ARC NO 4 IS THE CRITICAL ARC, F.S.=1.566 TAN EL 14.4
REQUIRED F.S.=1.5

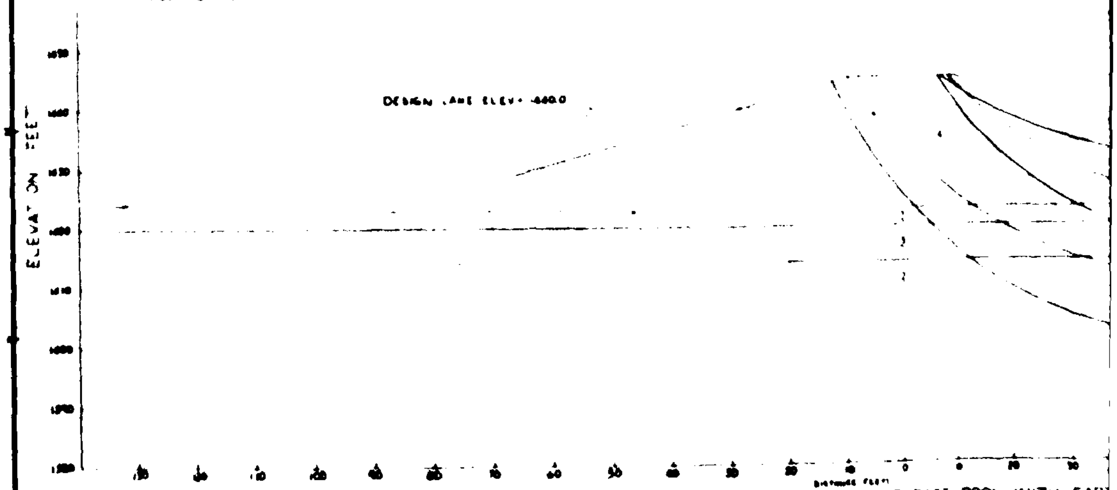



STEADY SEEPAGE WITH MAXIM...

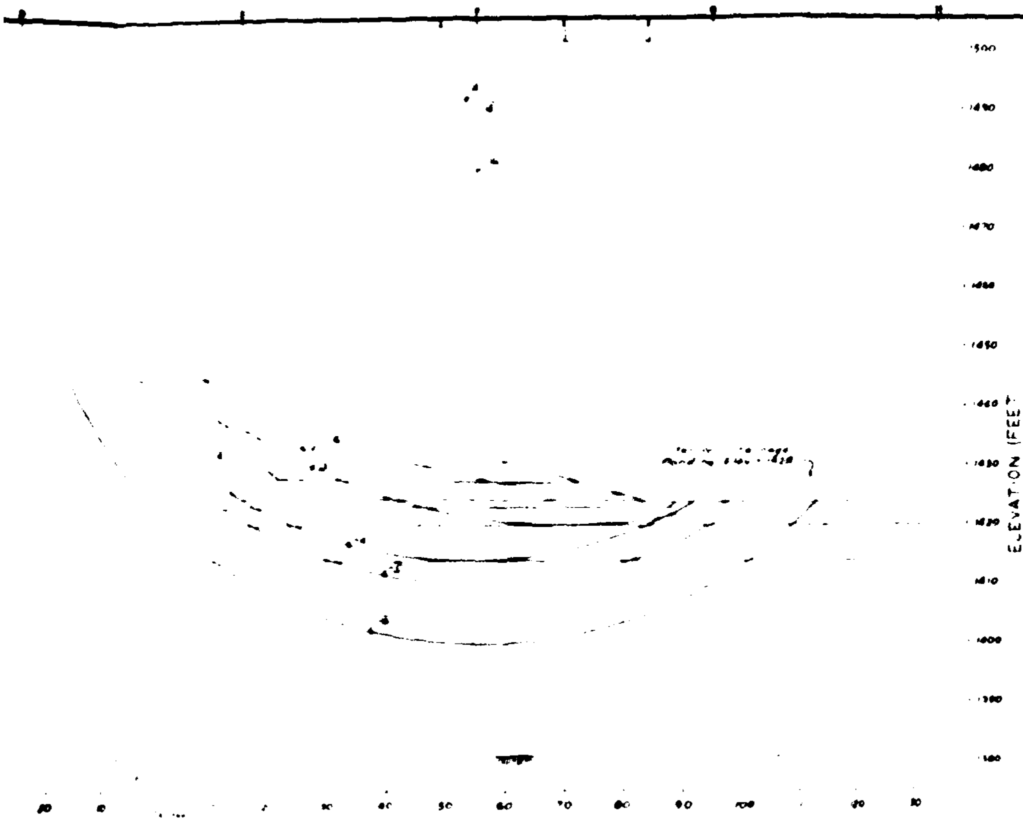
TABULATION OF TYPICAL TRIAL ARCS

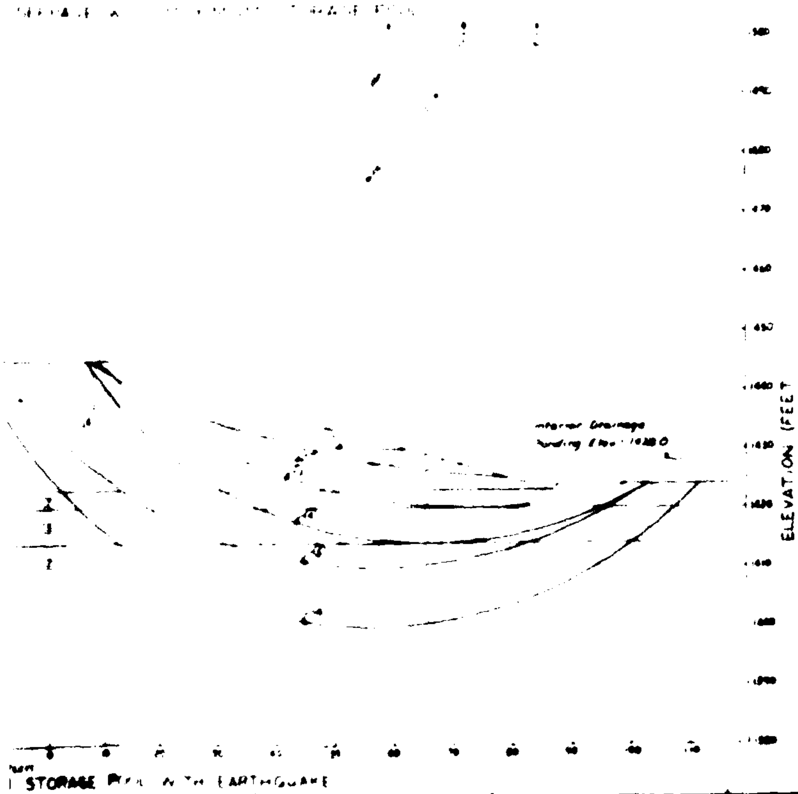
| ARC NO | TANGENT ELEV | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| 1 | 1430.0 | [illegible] | 1530.0 | 00.0 | 1.641 |
| 2 | 1425.0 | 88.00 | 1505.0 | 60.0 | 1.560 |
| 3 | 1420.0 | 72.67 | 1516.9 | 94.9 | 1.703 |
| 4 | 1414.1 | 66.40 | 1497.1 | 13.0 | 1.458* |
| 5 | 1410.0 | 57.50 | 1491.8 | 81.8 | 1.867 |
| 6 | 1400.0 | 54.31 | 1475.6 | 75.6 | 2.308 |

*ARC NO 4 IS THE CRITICAL ARC, F.S.=1.458 TAN EL = 1414.1
SEISMIC COEFFICIENT = 0.050
REQUIRED F.S. = 1.0




STEADY SEEPAGE WITH MAXIMUM STORAGE POOL WITH EART




| NO | TYPE OF SOIL | $\gamma$ (pcf) | $\gamma_{sat}$ (pcf) | Q STRENGTH c (psf) | Q STRENGTH $\phi$ (Deg) | S STRENGTH c (psf) | S STRENGTH $\phi$ (Deg) | (R+S)/2 c (psf) | (R+S)/2 $\phi$ (Deg) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Impervious Embankment | 117.5 | 126.5 | 50.0 | 14.9 | 0.0 | 30.8 | 25.0 | 22.8 |
| 2 | Foundation Material | 123.6 | 124.2 | 1980.0 | 14.6 | 0.0 | 32.7 | 1475.0 | 23.6 |
| 3 | Foundation Material | 122.3 | 123.2 | 1118.0 | 12.2 | 0.0 | 28.4 | 50.0 | 20.3 |
| 4 | Sand Drain | 125.0 | 126.0 | 0.0 | 30.0 | 0.0 | 30.0 | 0.0 | 30.0 |

DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT

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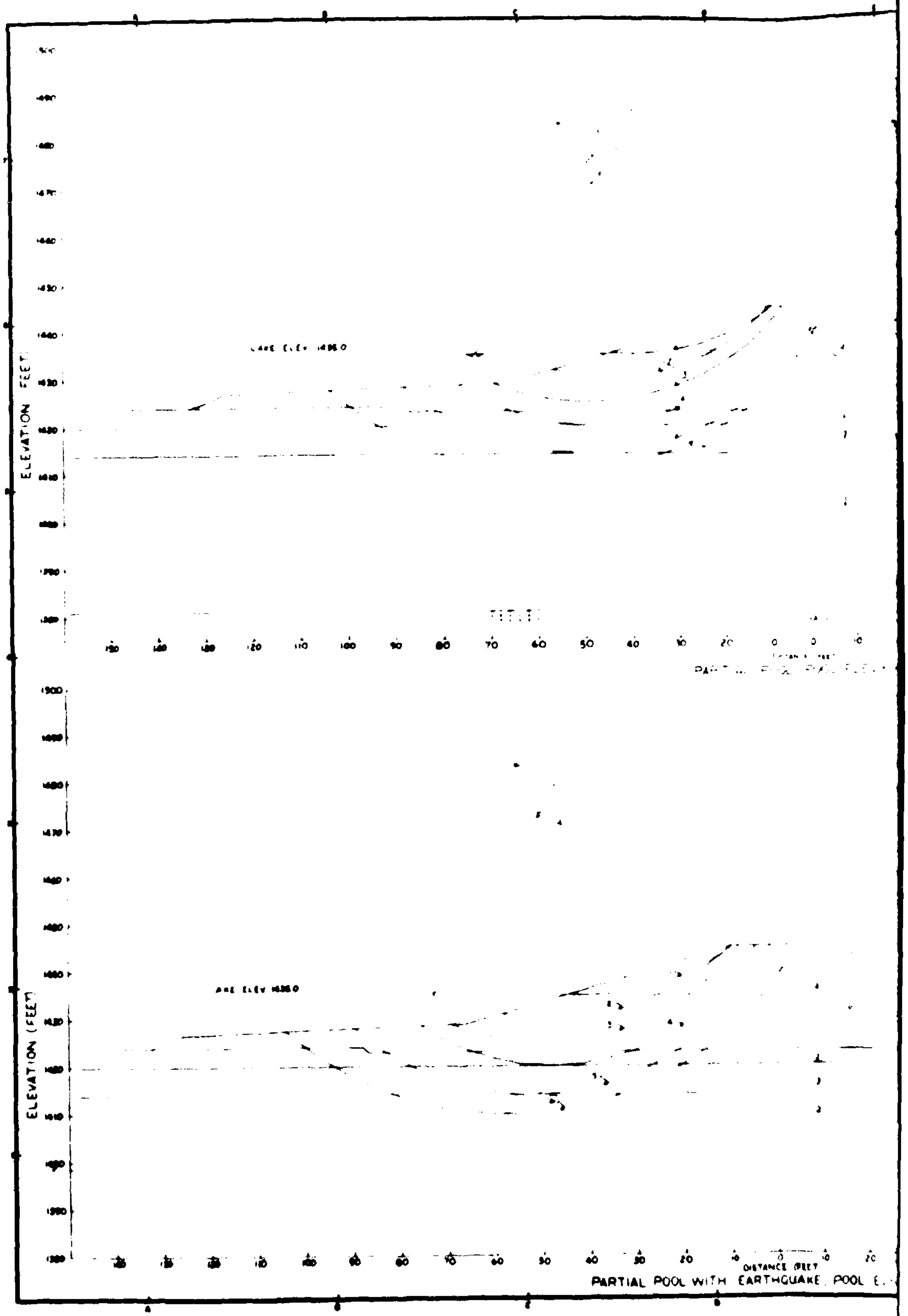
DEVILS LAKE, NORTH DAKOTA

CREEL BAY EMBANKMENT

STABILITY SUMMARY

PLATE E-6

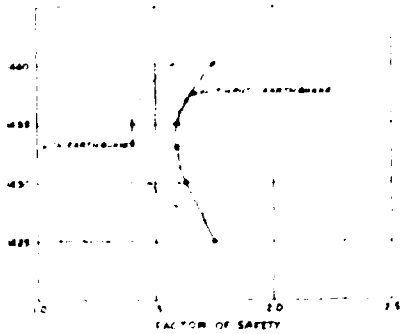

ELEVATION (FEET)
LAKE ELEV 1435.0
ELEVATION (FEET)
DISTANCE (FEET)
PARTIAL POOL WITH EARTHQUAKE, POOL E

TABULATION OF TYPICAL TRIAL ARCS

| ARC NO. | TANGENT ELEV. | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| [illegible] | 435[illegible] | 39.61 | 1486.0[illegible] | [illegible] | .89 |
| [illegible] | 1480.0 | 44.[illegible] | [illegible] | 46.[illegible] | [illegible] |
| [illegible] | [illegible] | 48.9[illegible] | 1479.00 | 54.[illegible] | .884* |
| 4 | 1420.0 | 48.[illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | 61.00 | [illegible] |
| 6 | 1410.0 | 56.8[illegible] | [illegible] | [illegible] | 2.826 |

*ARC NO. [illegible] IS THE CRITICAL ARC F.S. = .884 TAN. EL. = 1425.0
REQ. [illegible] F.S. = [illegible]

Interior [illegible]
Ponding Elev. 1420.0




FACTOR OF SAFETY VS
POOL ELEVATION FOR ARCS
WITH TANGENT EL = 1425.0
FOR PARTIAL POOL CONDITION

TABULATION OF TYPICAL TRIAL ARCS

| ARC NO. | TANGENT ELEV. | CENTER POINT X | CENTER POINT Y | RADIUS | FACTOR OF SAFETY |
|---|---|---|---|---|---|
| [illegible] | [illegible] | 39.4 | 1485.00 | 50.00 | .725 |
| [illegible] | [illegible] | 48.04 | 1488.99 | 55.99 | .41 |
| 3 | [illegible] | 49.51 | 1477.84 | [illegible] | [illegible]* |
| 4 | [illegible] | 48.00 | 1470.00 | [illegible] | .884 |
| 5 | [illegible] | [illegible] | [illegible] | [illegible] | .980 |
| 6 | [illegible] | 57.22 | 1481.46 | 46 | 2.372 |

*ARC NO. 3 IS THE CRITICAL ARC F.S. = .406, TAN. EL. = 1425.0
EARTHQUAKE COEFFICIENT = 0.025
REQUIRED F.S. = [illegible]

Interior Drainage
Ponding Elev. 1420.0

| NO. | TYPE OF SOIL | $\gamma_{sat}$ (pcf) | $\gamma_{m}$ (pcf) | R STRENGTH c (psf) | R STRENGTH $\phi$ Deg | S STRENGTH c (psf) | S STRENGTH $\phi$ Deg | (R+S)/2 c (psf) | (R+S)/2 $\phi$ Deg |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Impervious Embankment | [illegible] | 24.5 | 50.0 | 14.9 | 0.0 | 30.8 | 25.0 | 23.0 |
| 2 | Foundation Material | 73.6 | 124.2 | 950.0 | 14.6 | 0.0 | 32.7 | 475.0 | 23.6 |
| 3 | Foundation Material | 127.3 | 123.2 | 100.0 | 12.2 | 0.0 | 28.4 | 50.0 | 20.3 |
| 4 | Sand Drain | 75.0 | 110.0 | 0.0 | 30.0 | 0.0 | 30.0 | 0.0 | 30.0 |

DISTANCE (FEET)

[illegible] WITH EARTHQUAKE POOL ELEV. 1450

SAFETY PAYS

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

CAC
CAC
MB

SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
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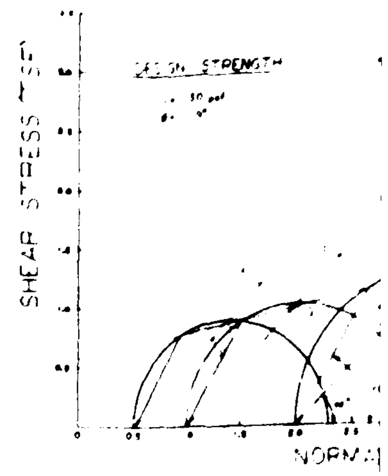
CREEL BAY EMBANKMENT
STABILITY SUMMARY

AS SHOWN

PLATE E-7

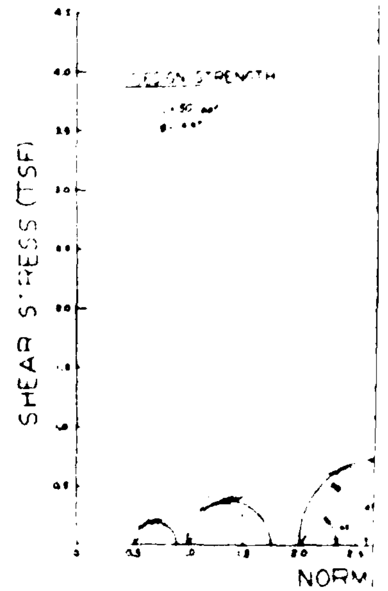
[illegible]

| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lb/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| | TP | COMP 3&4 | 39 | 15 | [illegible] | 98.4 | .72 | 76 |
| 2 | TP-2 | COMP 2&4 | 42 | 17 | [illegible] | 99.2 | .71 | 73 |
| 3 | STOCK PILE | COMP 1-4 | 40 | 21 | [illegible] | 98.6 | .70 | 75 |



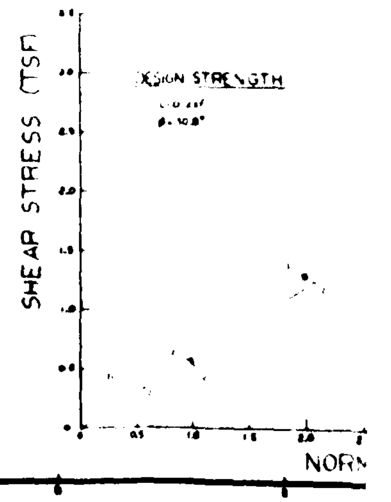

TESTS

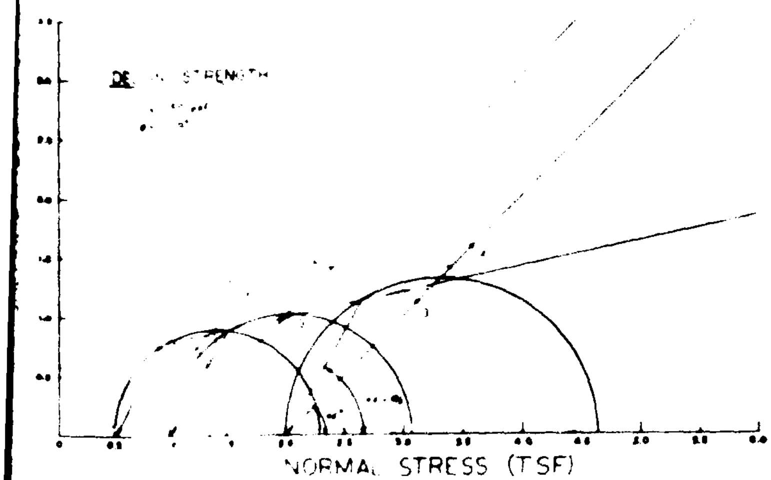
| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lb/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| | TP-1 | COMP 3&4 | 39 | 15 | 25.9 | 102.3 | .64 | 100 |
| 2 | TP-2 | COMP 2&4 | 42 | 17 | 25.4 | 100.7 | .69 | 99.7 |
| 3 | STOCK PILE | COMP 1-4 | 40 | 21 | 24.6 | 100 | .67 | 100 |

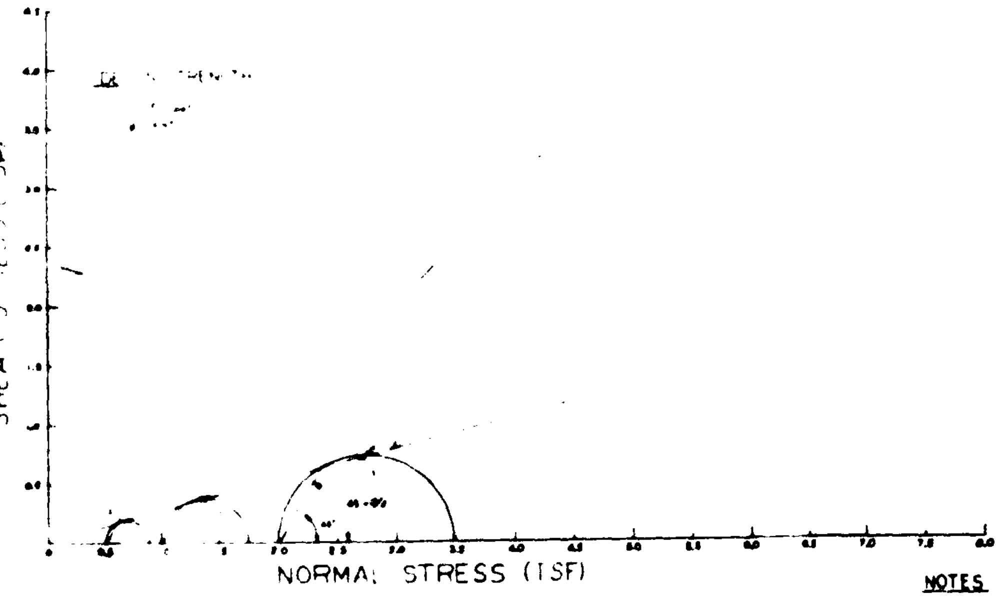


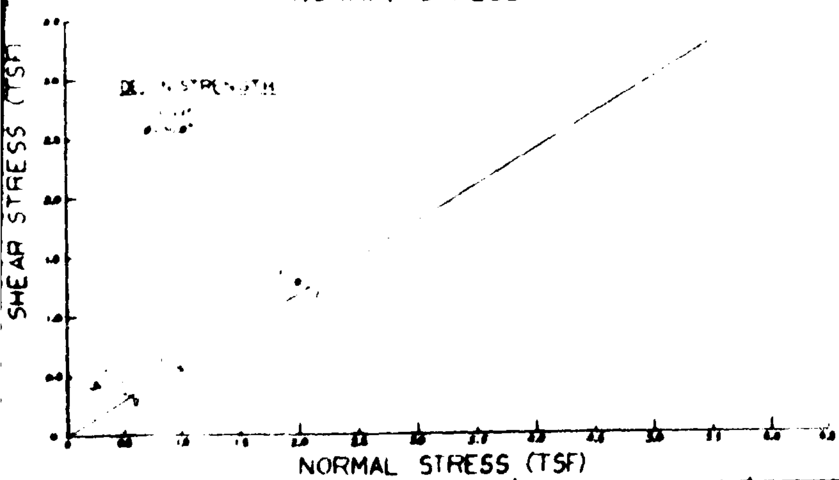

S-TESTS

| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lb/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| | TP-1 | COMP 3&4 | 39 | 15 | 23.3 | 98.7 | .62 | 95.0 |
| 2 | TP-2 | COMP 2&4 | 42 | 17 | 24.0 | 98.3 | .60 | 70.0 |
| 3 | STOCK PILE | COMP 1-4 | 40 | 21 | 22.0 | 98.3 | .64 | 77.0 |






## NOTES

1 Soil Strengths shown are presented as soil type on plates E-2 through E-7

SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL
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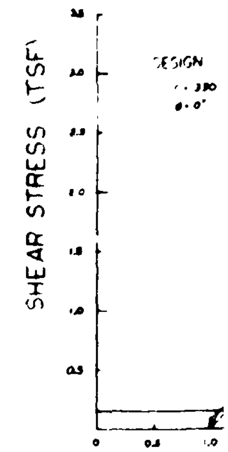
CREEL BAY EMBANKMENT

EMBANKMENT STRENGTHS

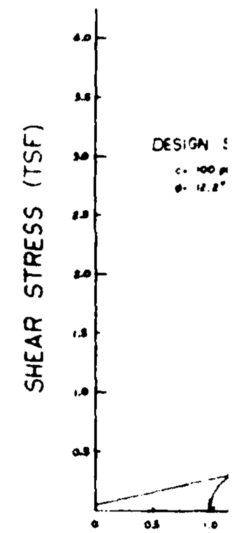
## Q TESTS

| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| | [illegible] | [illegible] | [illegible] | 13 | [illegible] | 96.7 | .74 | 96.7 |




## R-TESTS

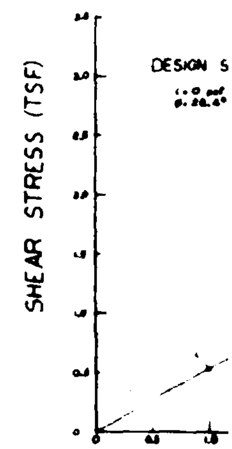
| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | [illegible] | 1 | [illegible] | 13 | [illegible] | 96.7 | .74 | 100.0 |

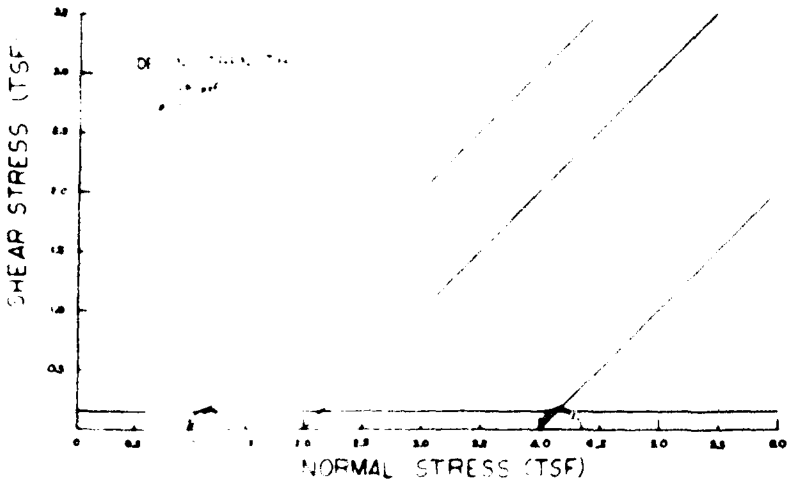


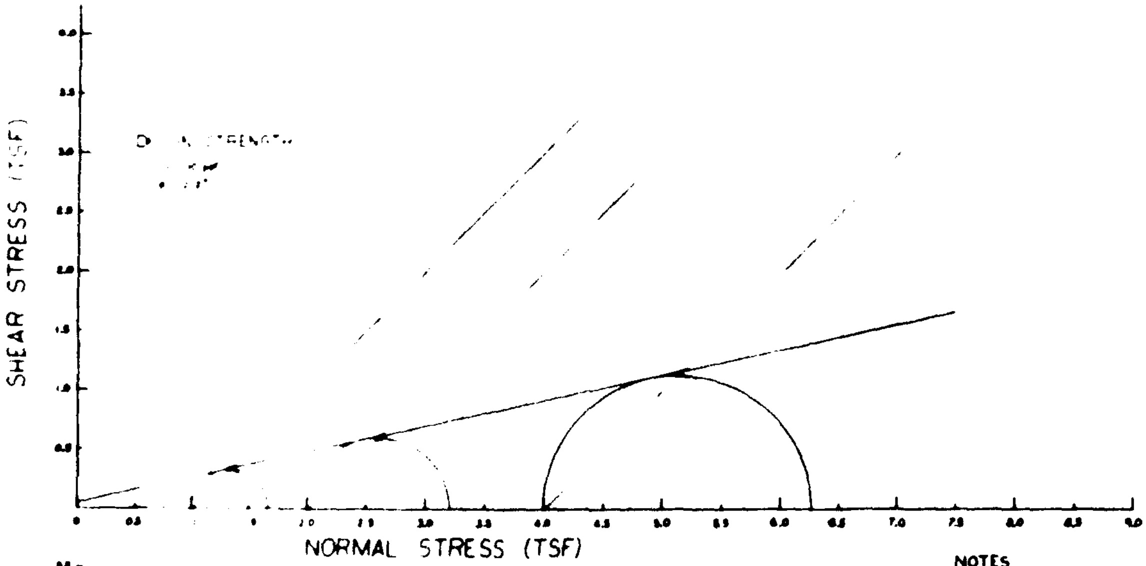

## S-TESTS

[illegible]

| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | [illegible] | 1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

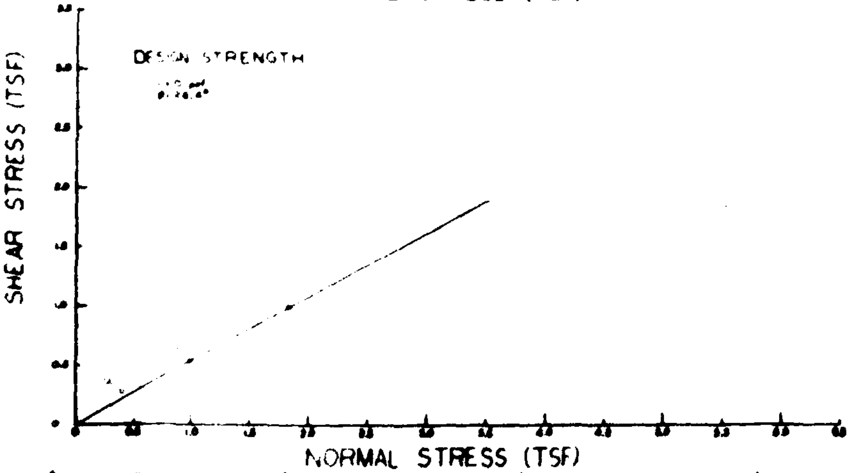





**NOTES**

1. Soil strengths shown are presented as soil type 3 on plates E-5 through E-7.

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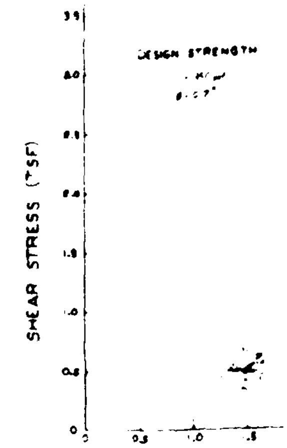
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

CREEL BAY EMBANKMENT

FOUNDATION STRENGTHS

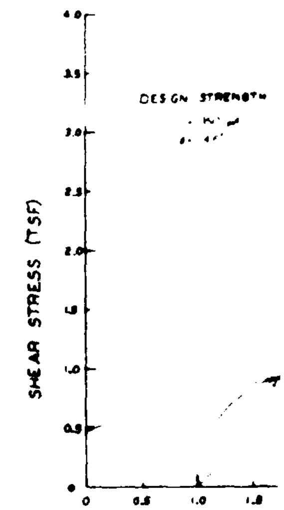
## Q TESTS

| TEST NO | BORING NO | SAMPLE NO | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | 80-10M | 2 | 40 | 17 | 24.3 | 101.2 | .67 | 99.3 |
| 2 | 80-10M | 3 | 38 | 17 | 22.4 | 103.3 | .62 | 97.0 |
| 3 | 80-11MU | 1 | — | — | 40.8 | 80.6 | 1.16 | 98.4 |
| 4 | 81-22M | 2 | 41 | 14 | 28.7 | 96.6 | .70 | 99.7 |
| 5 | 81-22M | 3 | 38 | 15 | [illegible] | 104.2 | .61 | 96.9 |




## R-TESTS

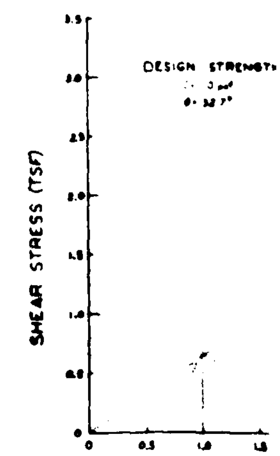
| TEST NO | BORING NO | SAMPLE NO | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | 80-10M | 2 | 40 | 17 | 24.1 | 100.7 | .60 | 98.7 |
| 2 | 80-10M | 3 | 38 | 17 | 21.4 | 102.0 | .60 | 98.7 |
| 3 | 81-22M | 2 | 41 | 14 | 13.6 | 110.3 | .48 | 100 |

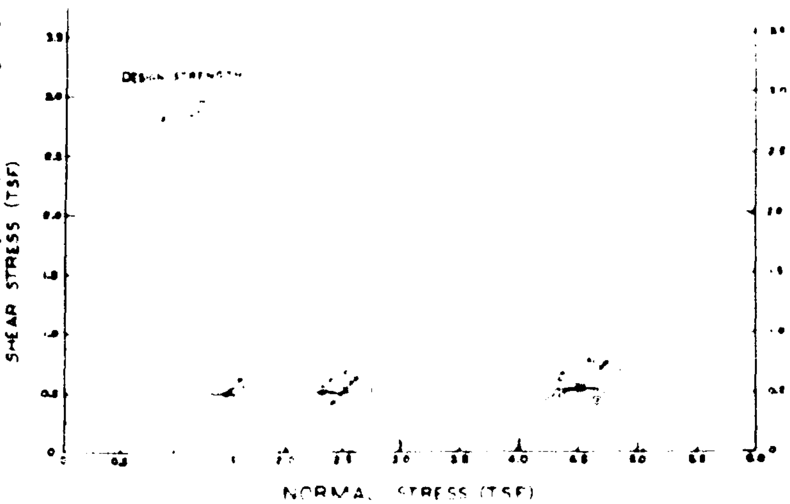


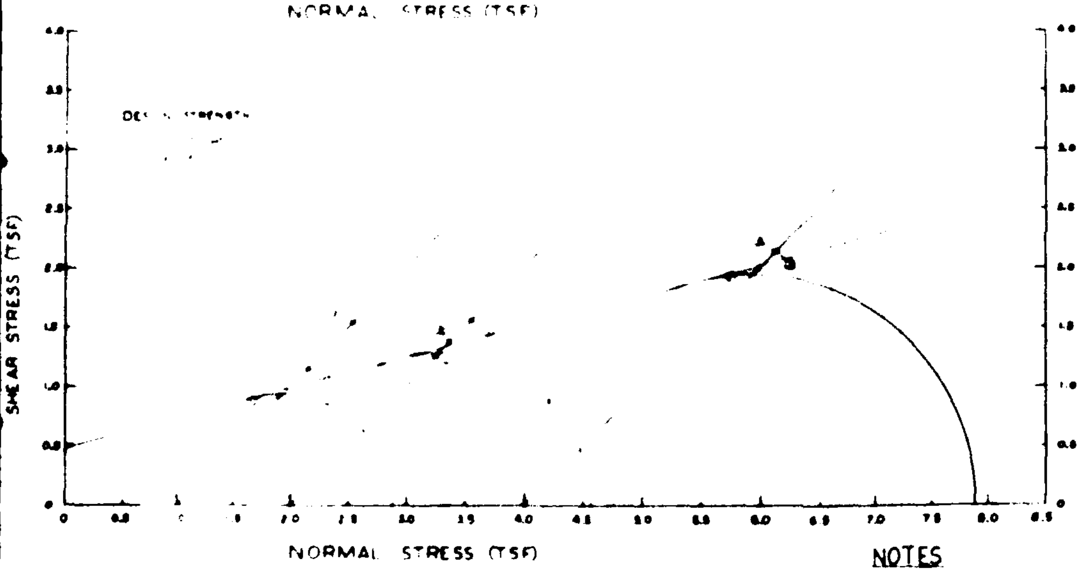

## S-TESTS

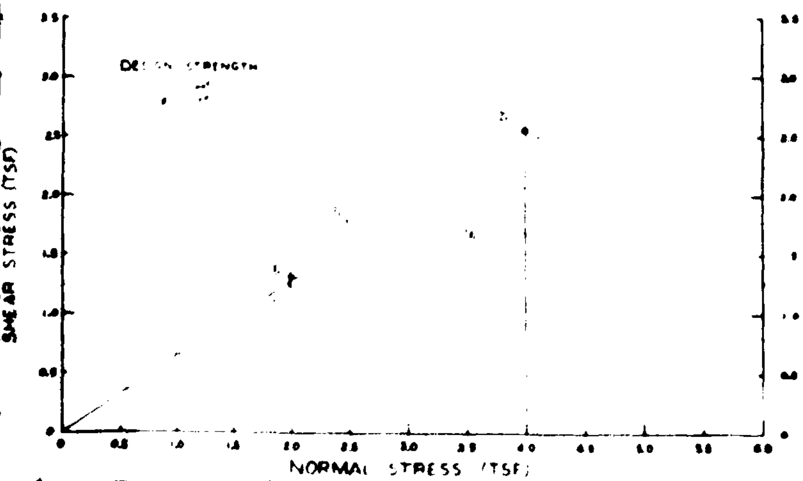
(FROM R TESTS)

| TEST NO. | BORING NO. | SAMPLE NO. | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lbs/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | 80-10M | 2 | 40 | 17 | 25.4 | 96.4 | .75 | 91.7 |
| 2 | 80-10M | 3 | 38 | 17 | 21.6 | 103.1 | .64 | 88.0 |
| 3 | 81-22M | 2 | 41 | 14 | 13.9 | 110.2 | .46 | 88.1 |






## NOTES

1. Soil strengths shown are presented as soil type 2 on plates E-5 through E-7.

SECTION ___ DETAILED PROJECT REPORT

FLOOD CONTROL
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CREEL BAY EMBANKMENT

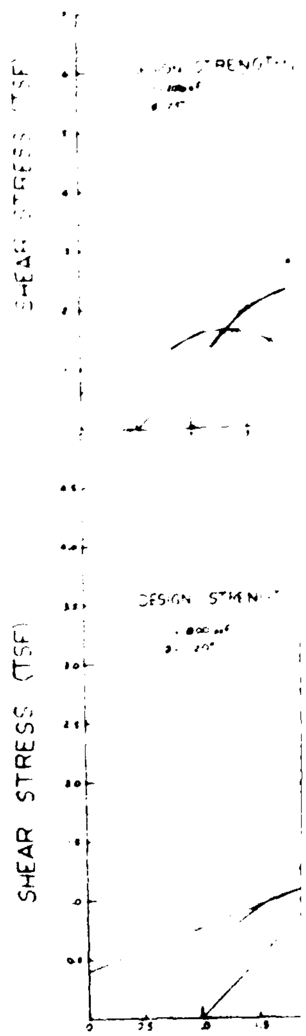
FOUNDATION STRENGTHS

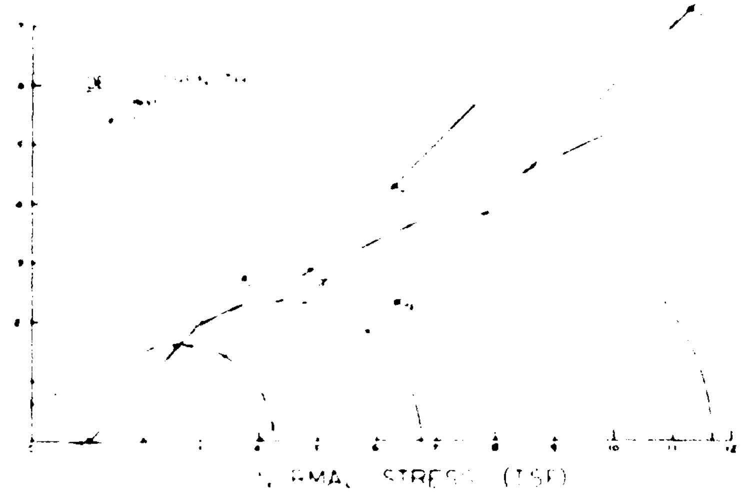
Q TESTS

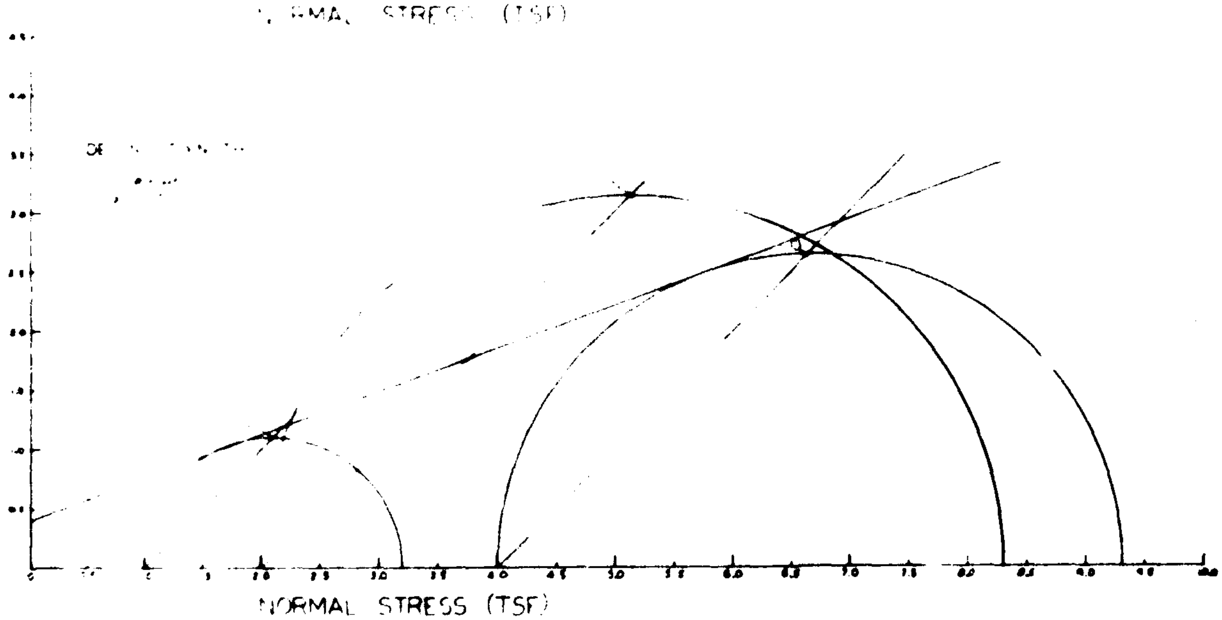
| TEST NO | BORING NO | SAMPLE NO | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY lb/ft³ | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| | 80-7MU | 1 | – | – | 19.8 | 111.0 | .52 | 100 |
| 2 | 80-7MU | 2 | 63 | [illegible] | 28.6 | 94.2 | .82 | 95.7 |

R-TESTS

| TEST NO | BORING NO | SAMPLE NO | LIQUID LIMIT | PLASTIC LIMIT | WATER CONTENT % | DRY DENSITY | VOID RATIO | SATURATION % |
|---|---|---|---|---|---|---|---|---|
| 1 | 80-7MU | 1 | 29 | 15 | [illegible] | 109.8 | .55 | [illegible] |






DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT

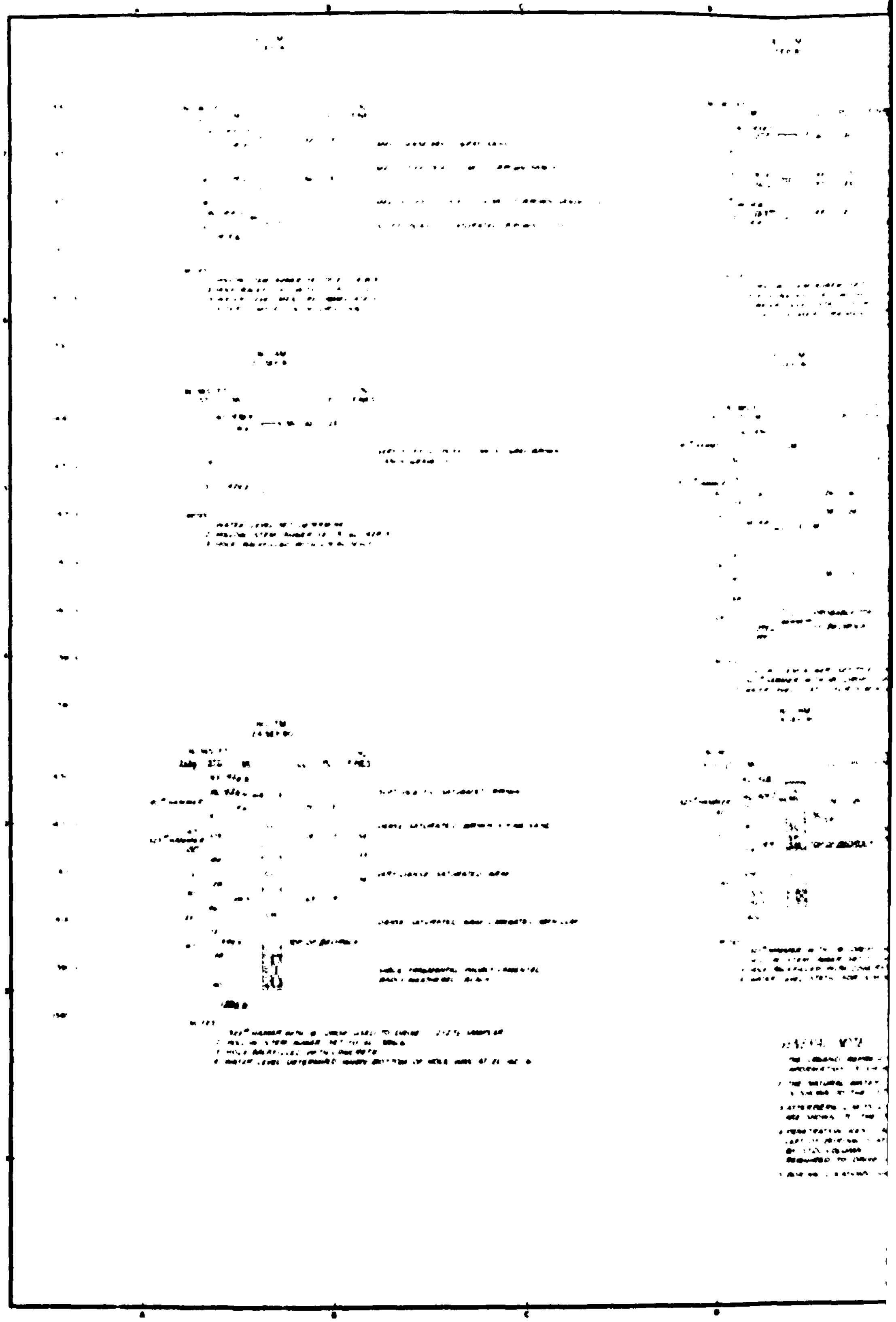
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

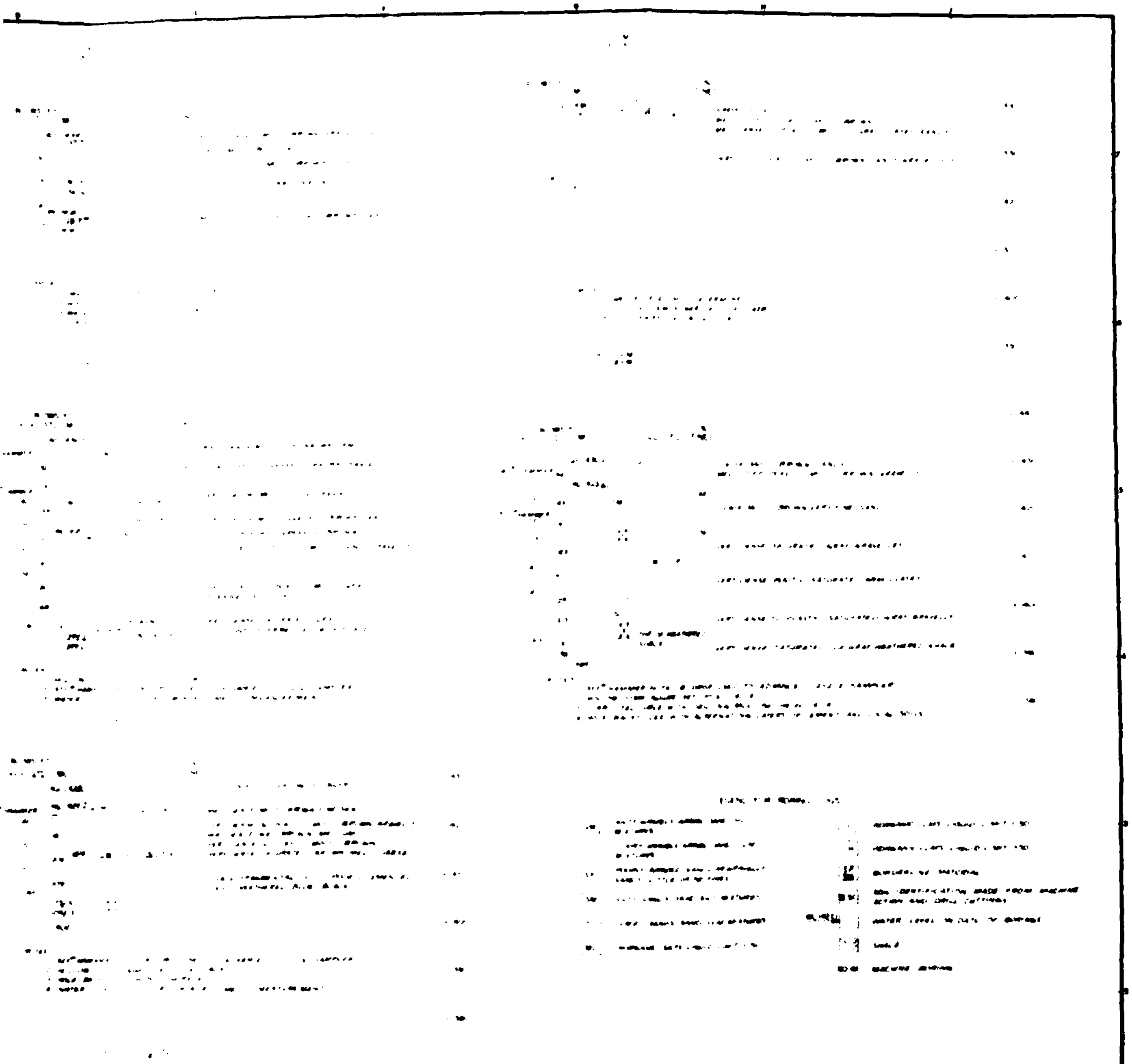
CREEL BAY EMBANKMENT

FOUNDATION STRENGTHS

AS SHOWN

PLATE E-11





DEPARTMENT OF THE ARMY

SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL

DEVILS LAKE, NORTH DAKOTA

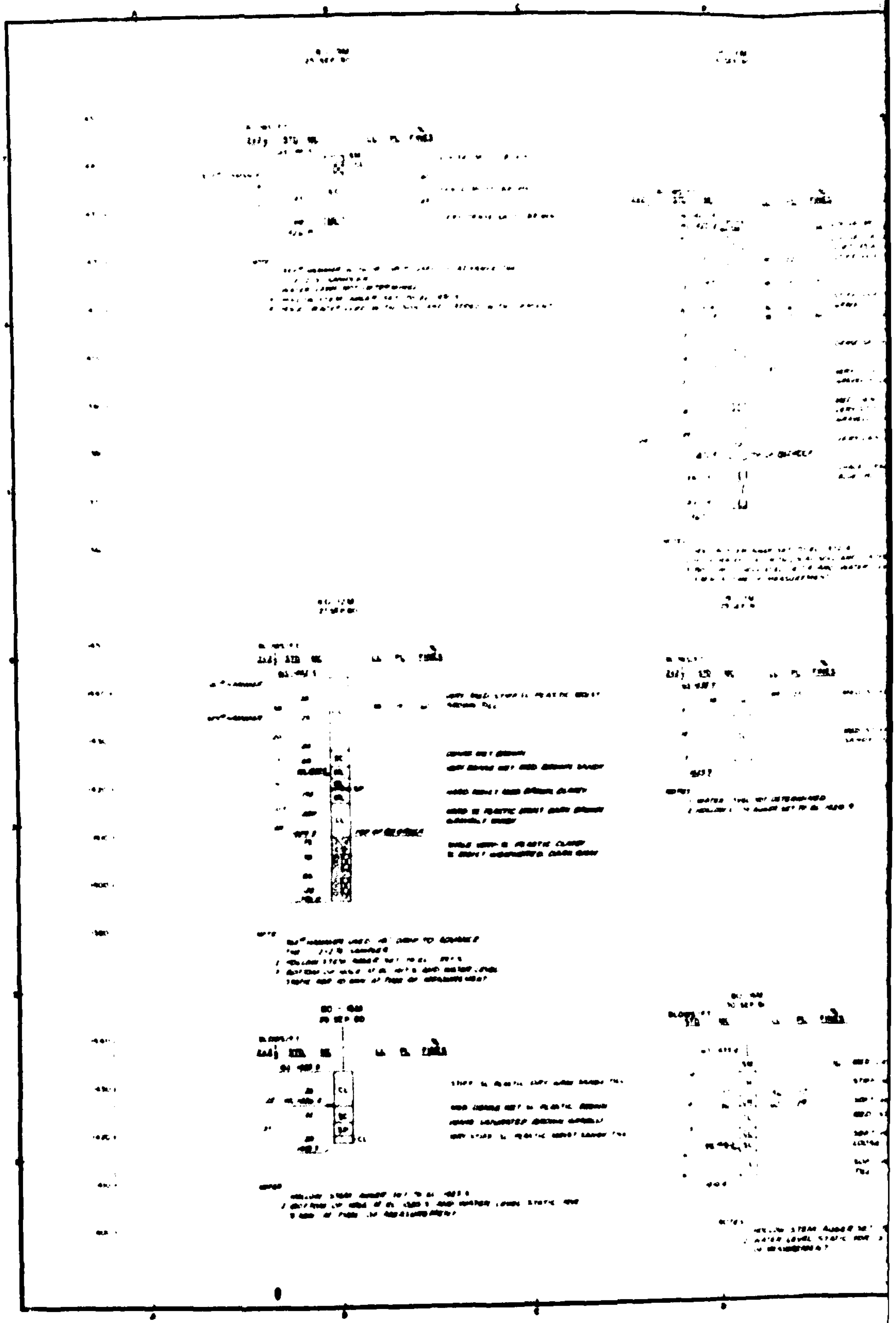
BORING BO-1M TO BORING BO-8M

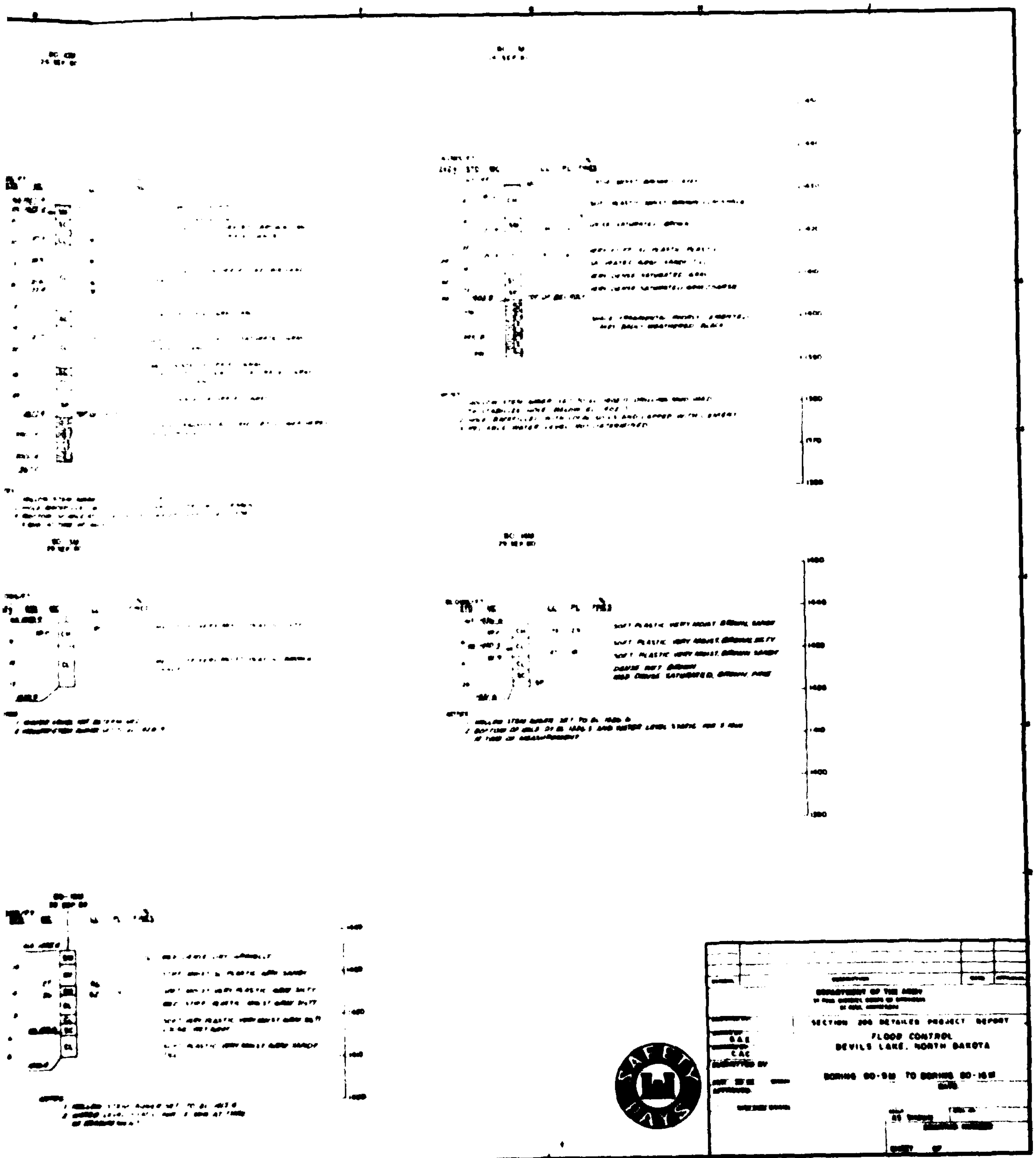
B.A.E.

L.A.C.

AS SHOWN

PLATE E-12



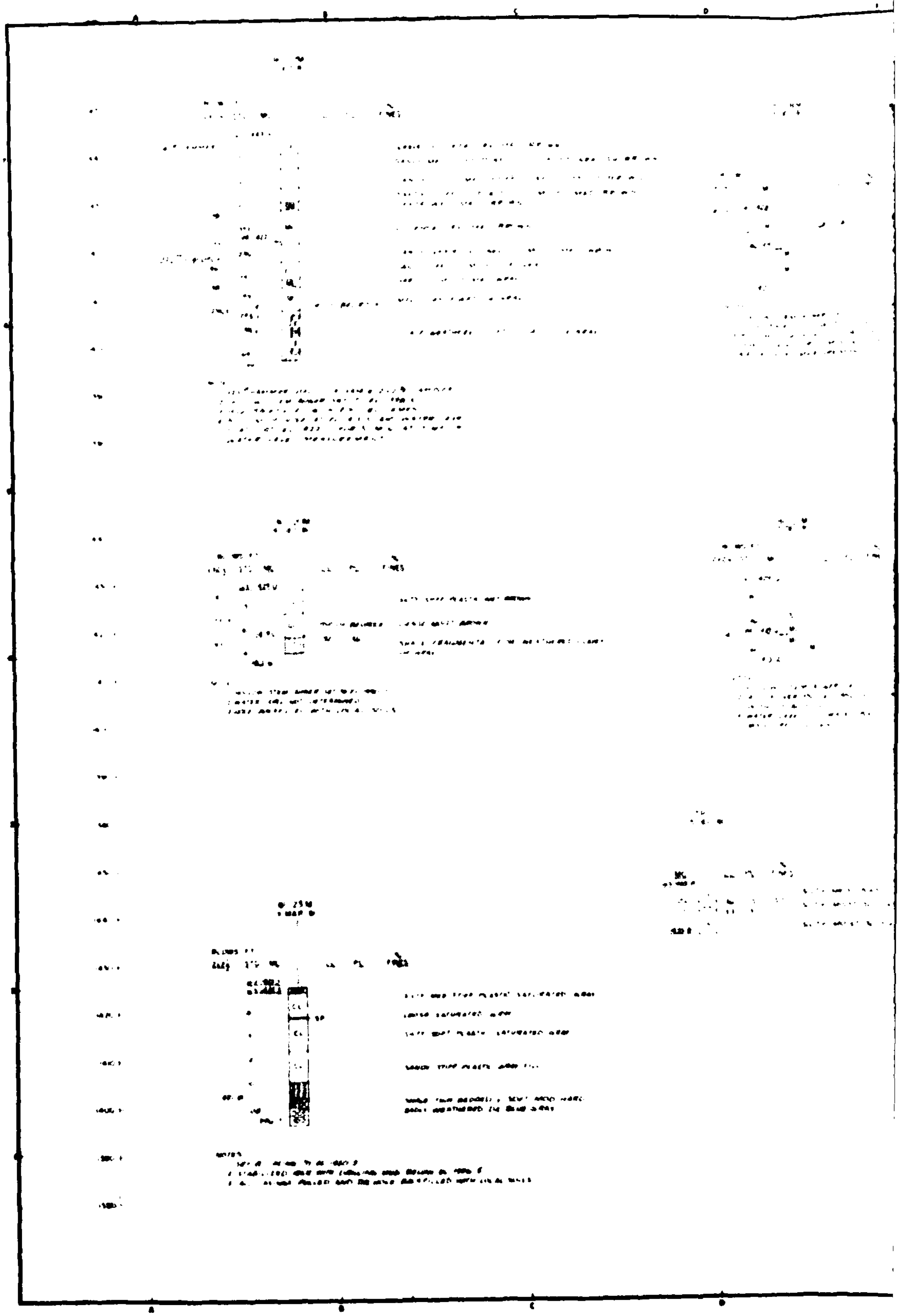


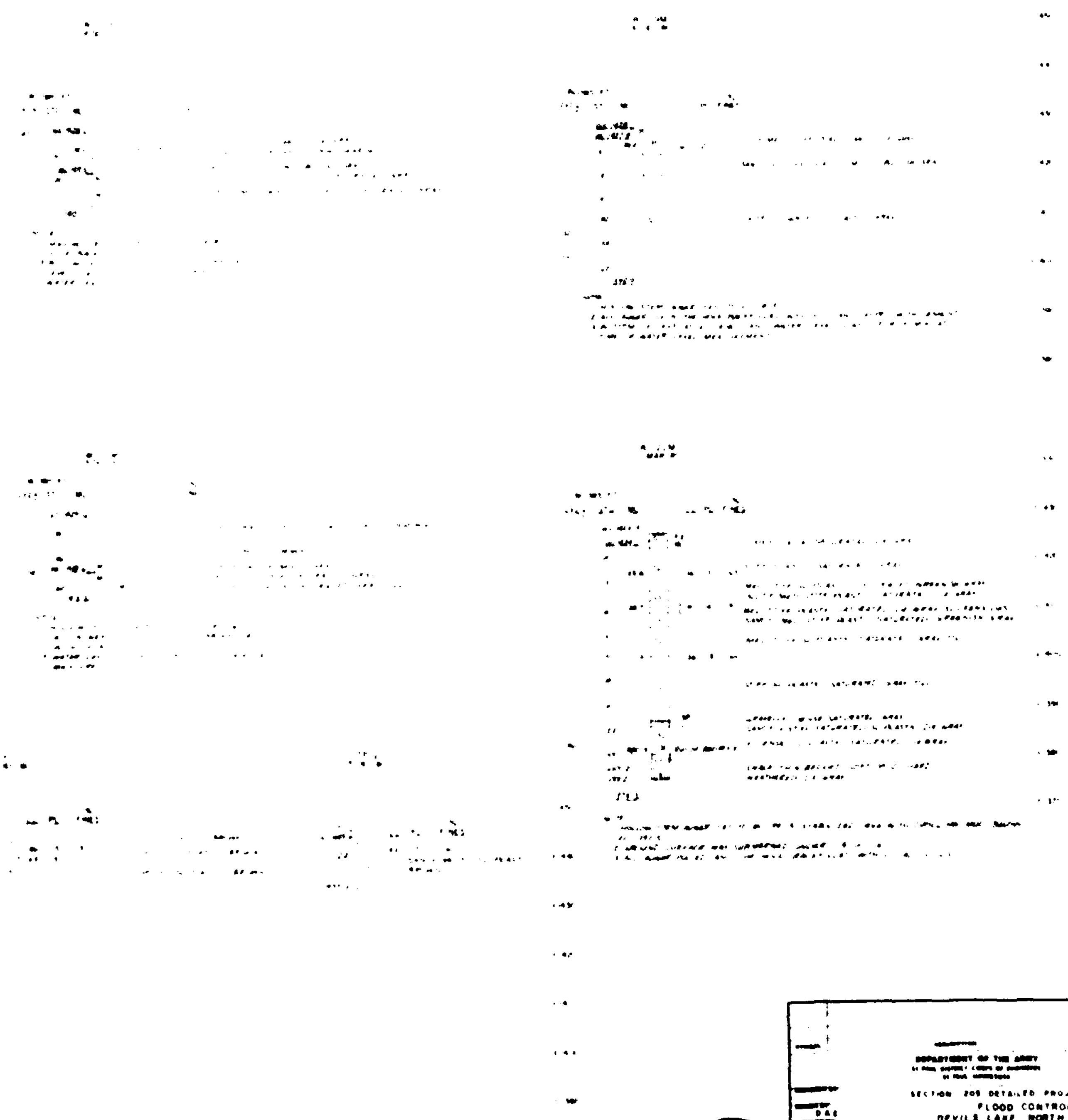
SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

BORING 80-9M TO BORING 80-16M

PLATE E-13





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SECTION 205 DETAILED PROJECT REPORT

FLOOD CONTROL

DEVILS LAKE, NORTH DAKOTA

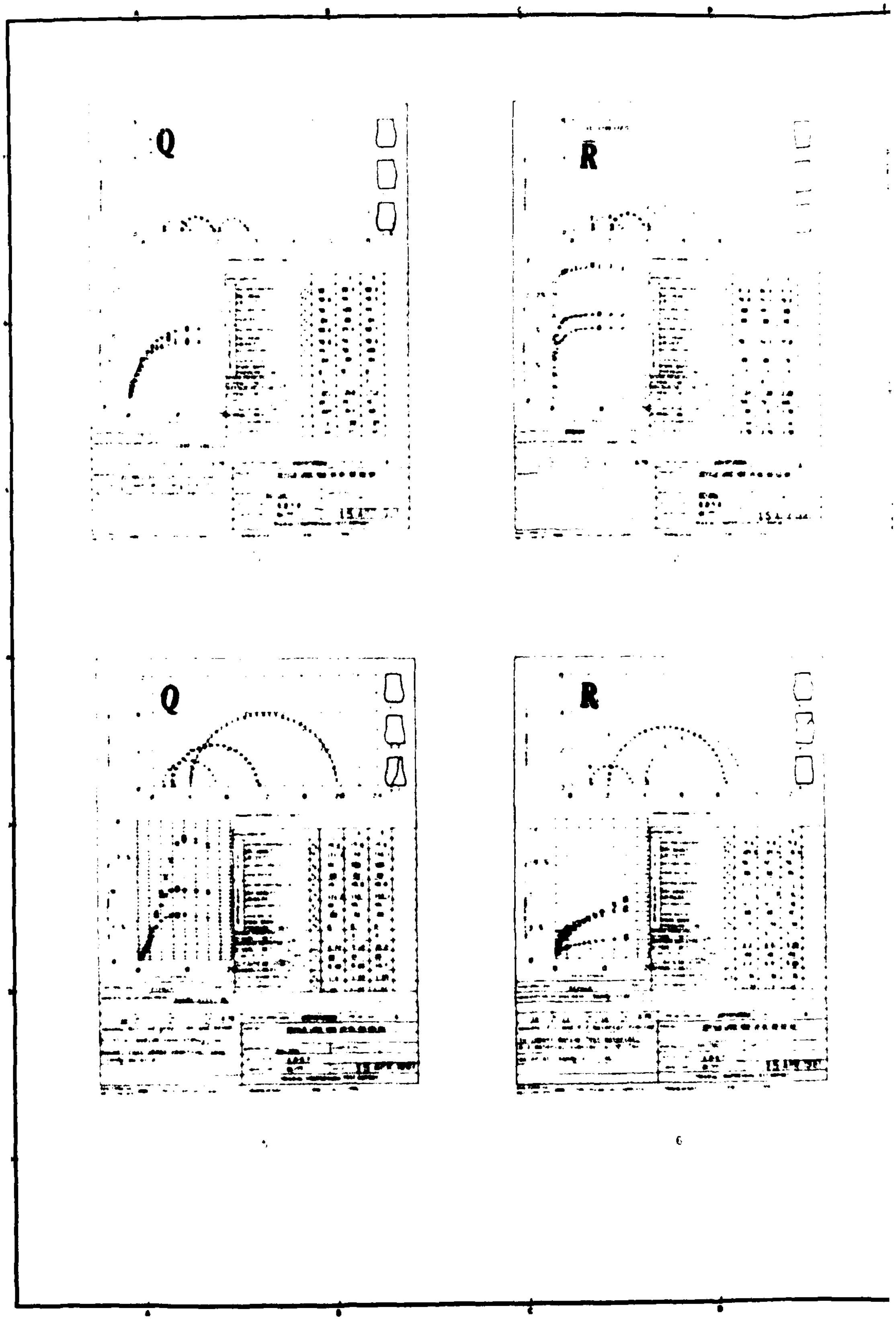
BORING 80-17M TO BORING 81-23M, TP 1 & TP 2

D.A.E.

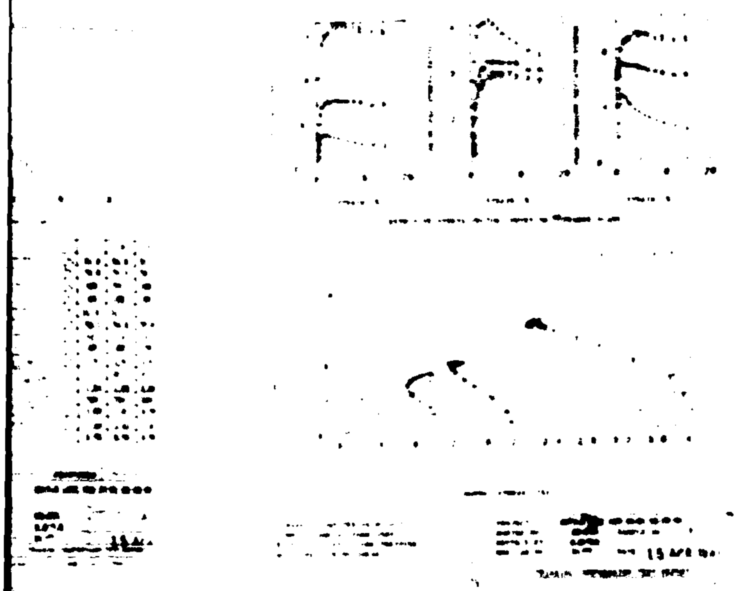
L.A.L.

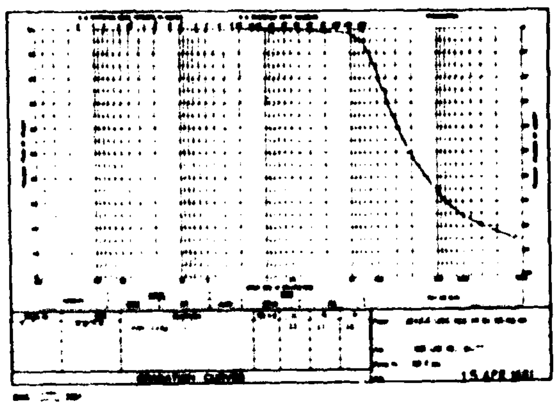
SCALE AS SHOWN

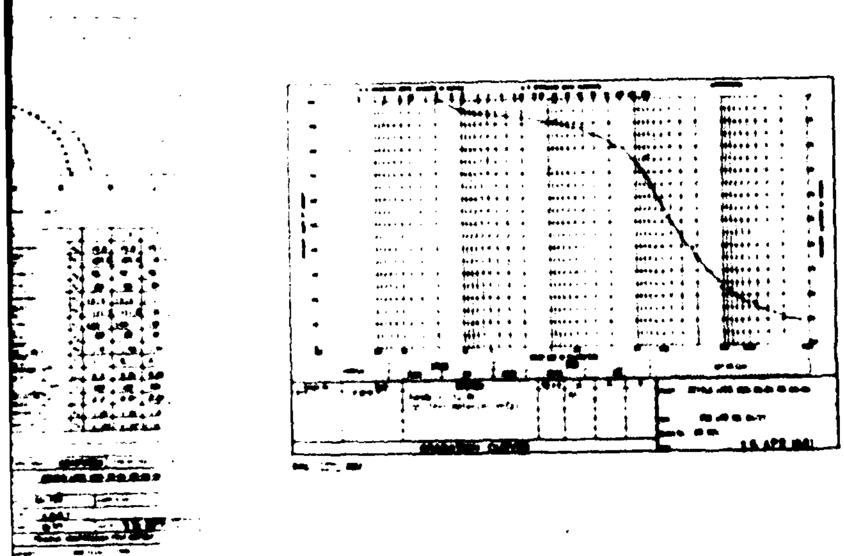
PLATE E-14




6







SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

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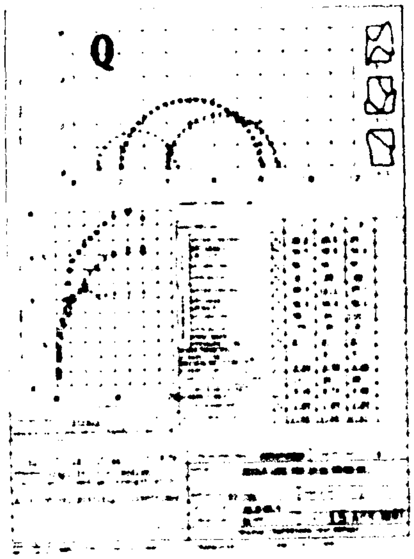
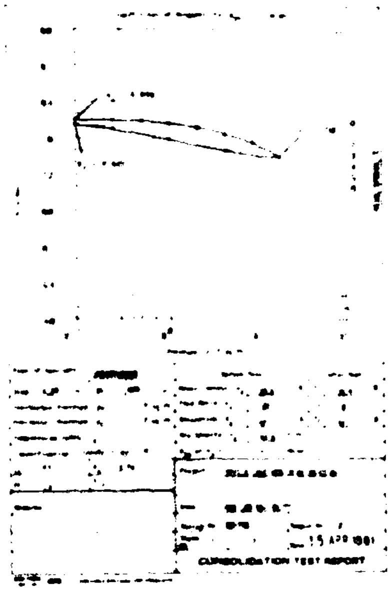
ST PAUL DISTRICT

DRAWING NO [illegible] DATE [illegible]

PLATE [illegible] 15



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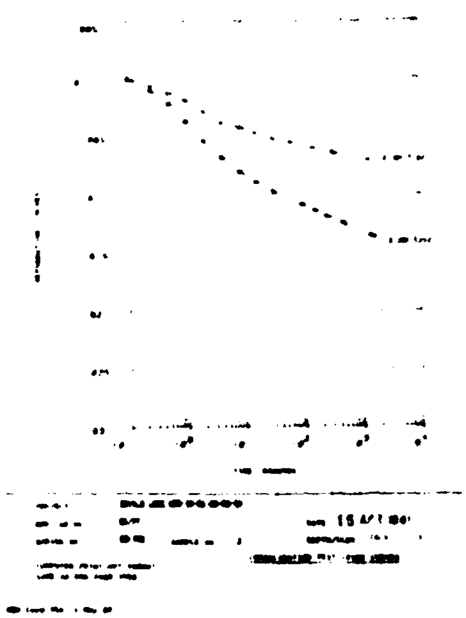

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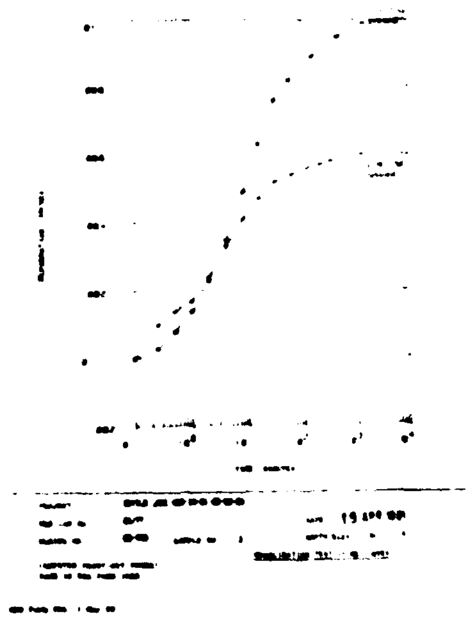

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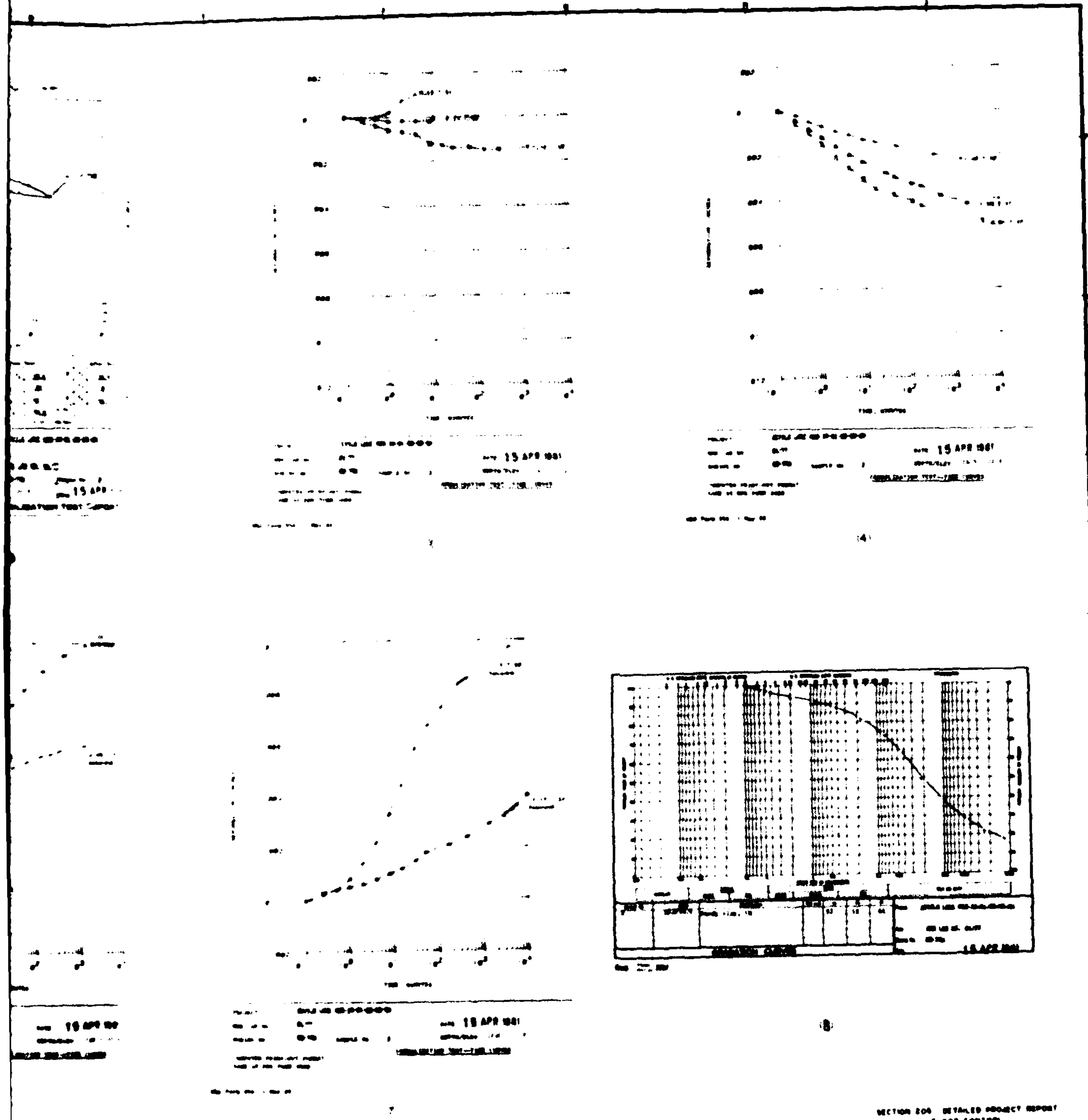



SECTION 206 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

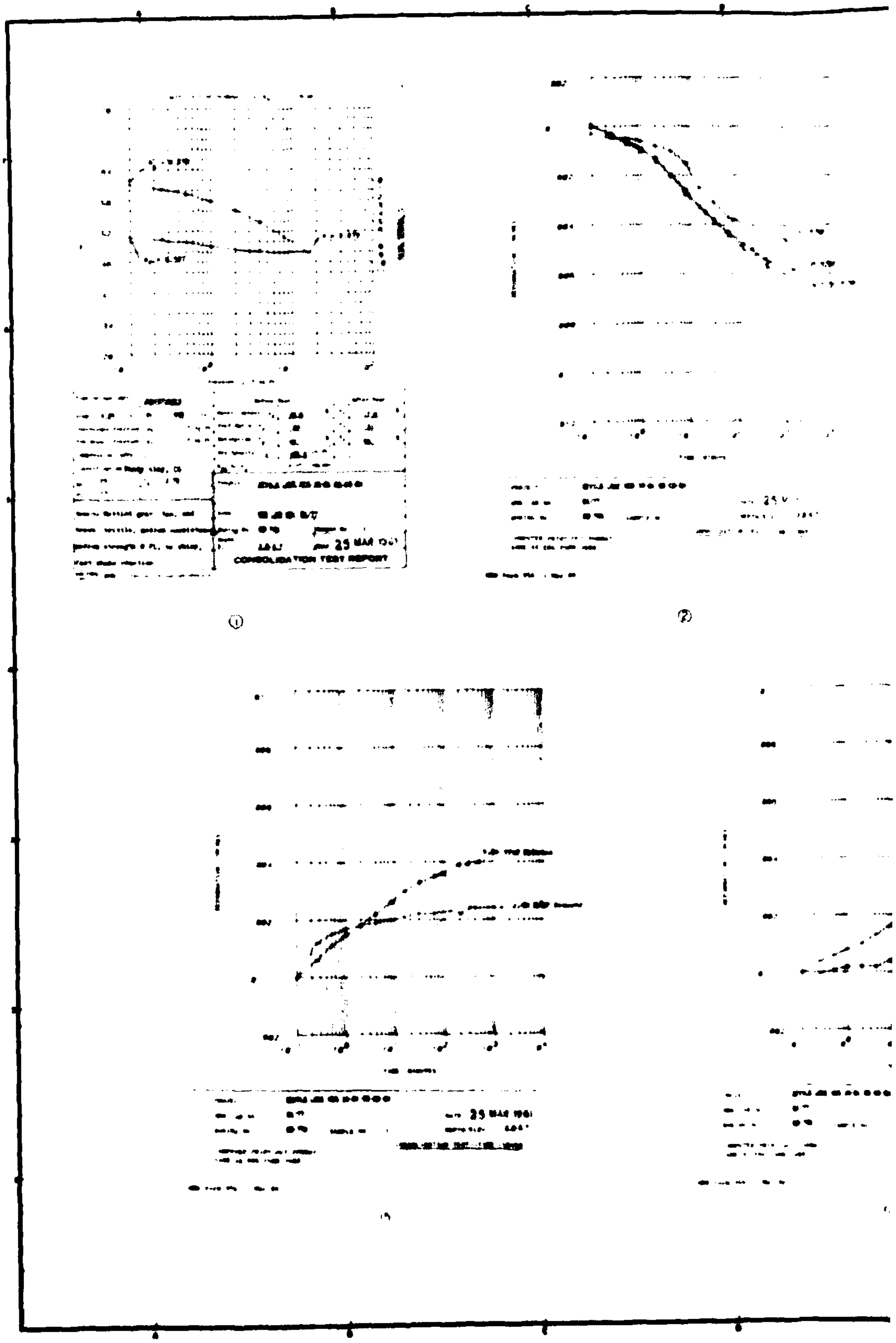
BORING

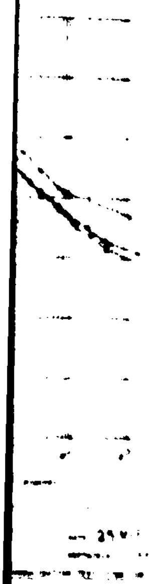
ST PAUL DISTRICT

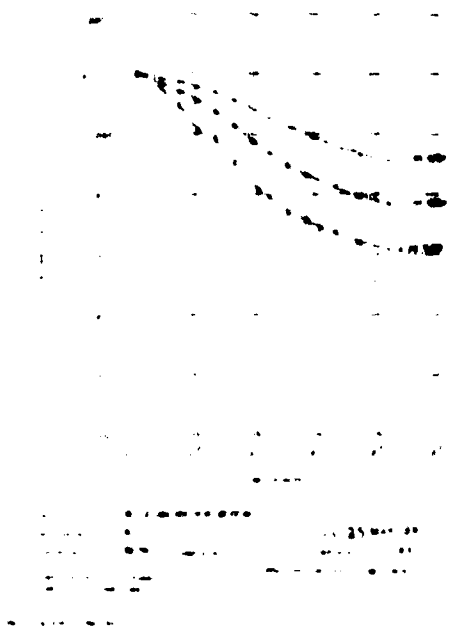
DRAWING NO

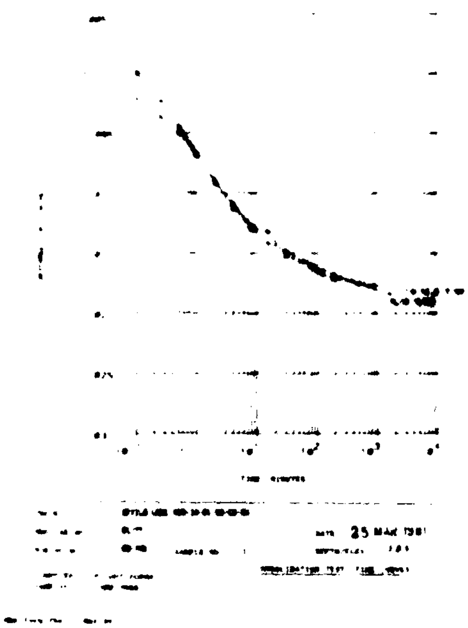
DATE

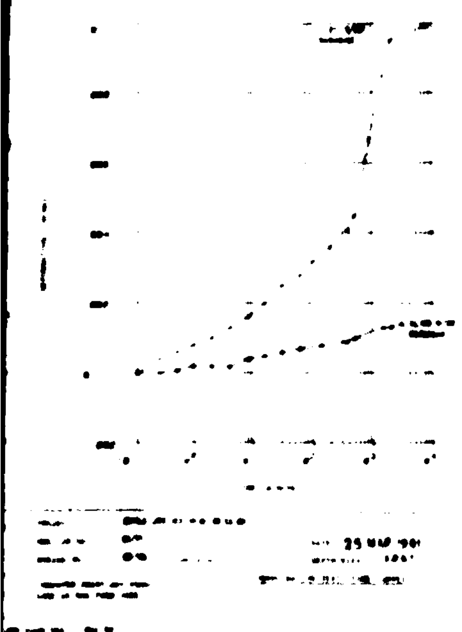
PLATE

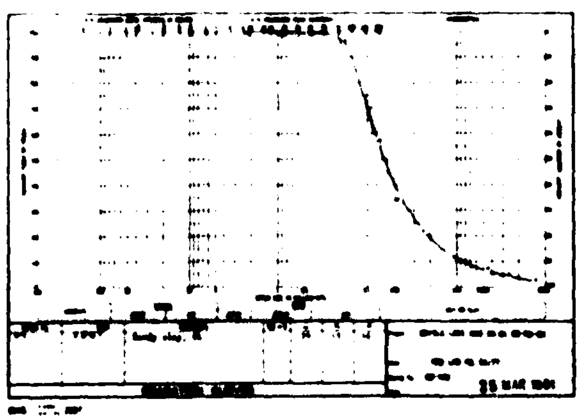

CONSOLIDATION TEST REPORT
25 MAR 1961








SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

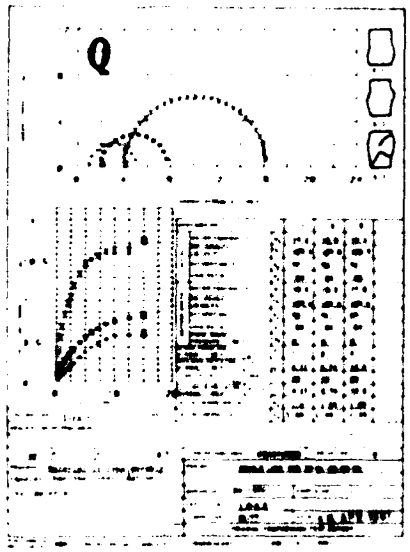
**SOILS TEST DATA**

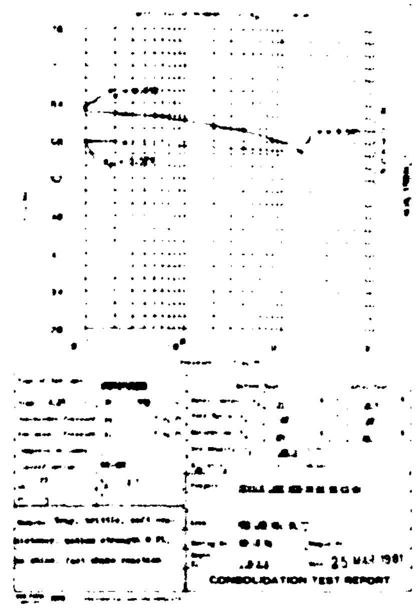
BORING 7MU

ST PAUL DISTRICT

DRAWING NO | DATE

PLATE I



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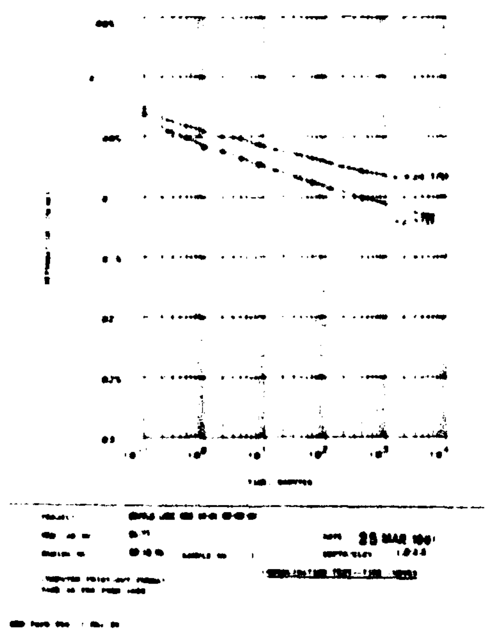


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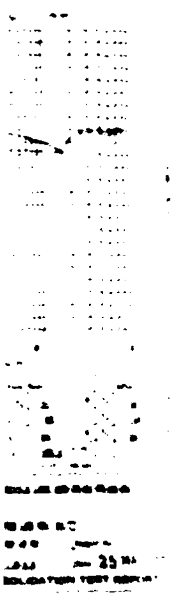

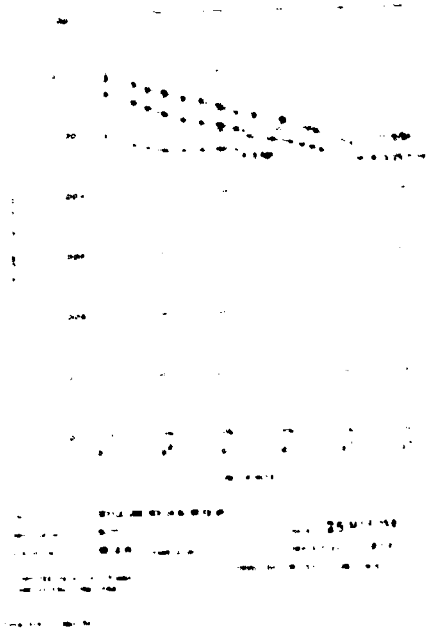

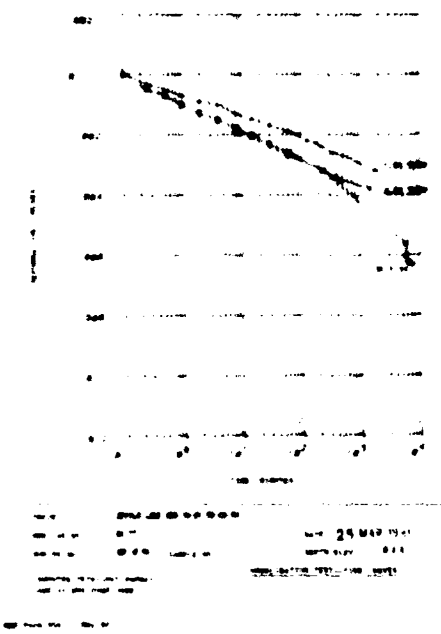

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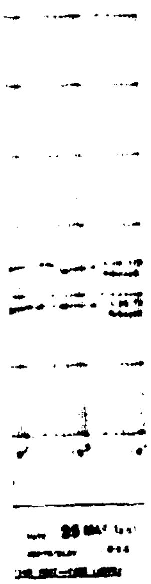

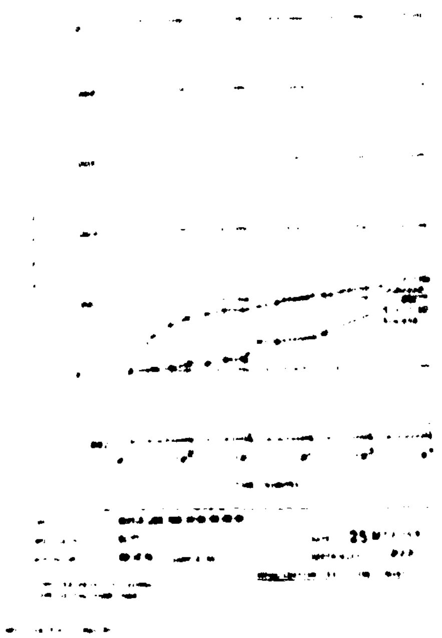

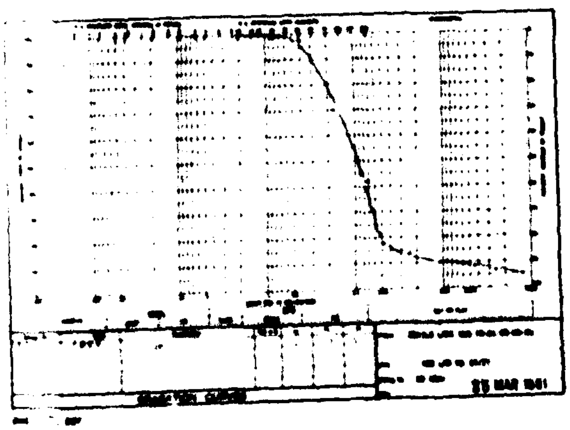


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SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

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ST PAUL DISTRICT

DRAWING NO [illegible] DATE [illegible]

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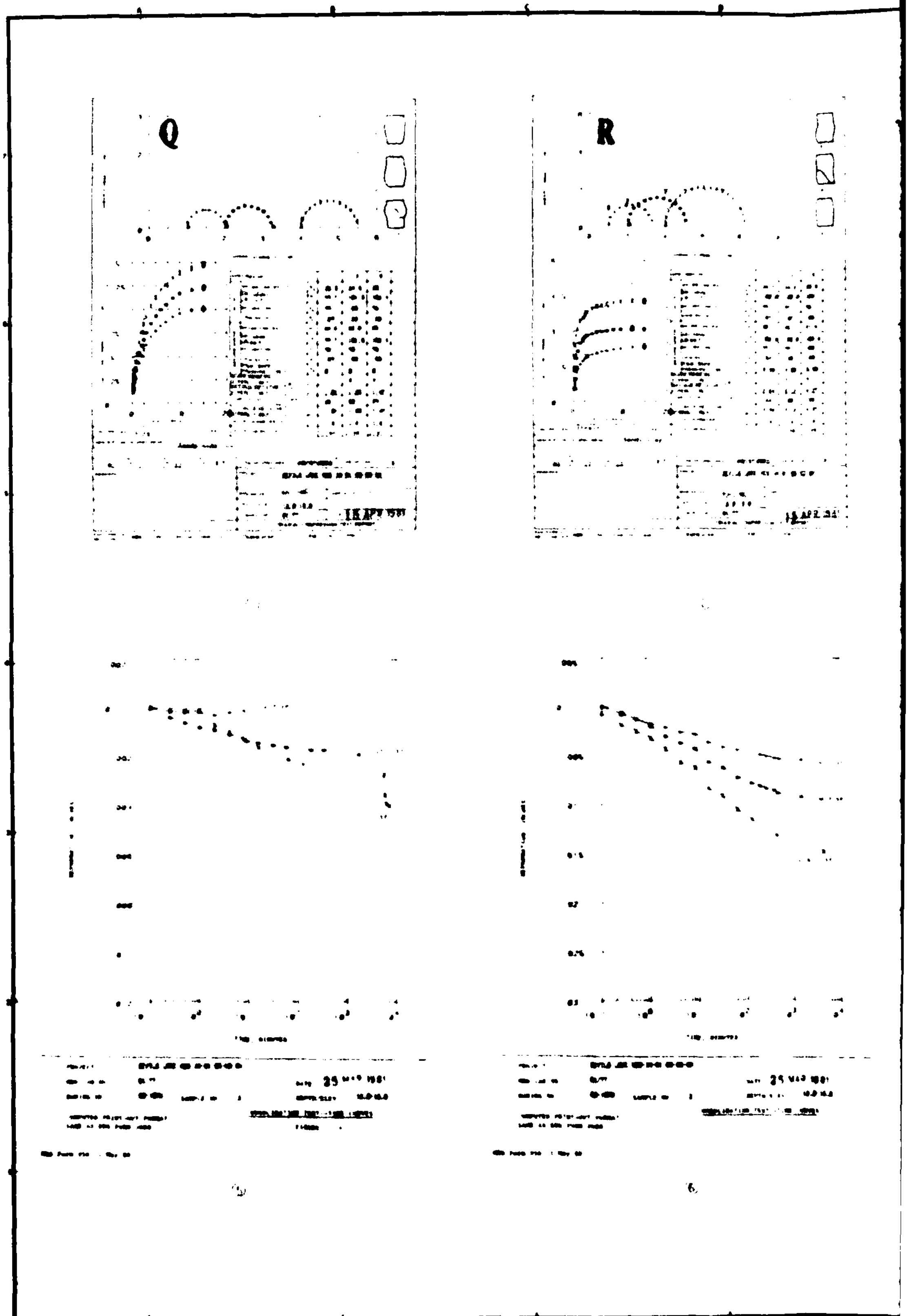

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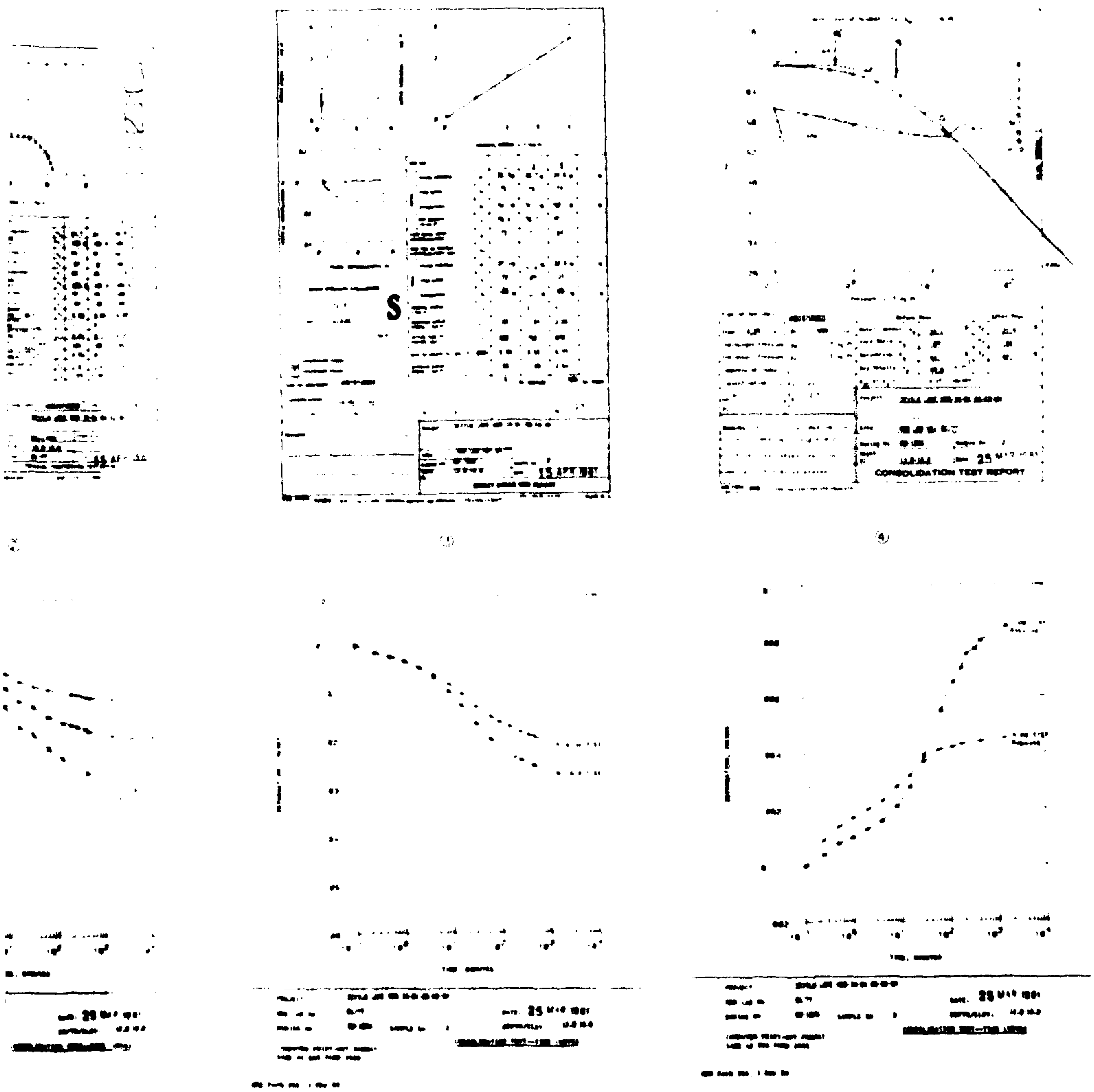


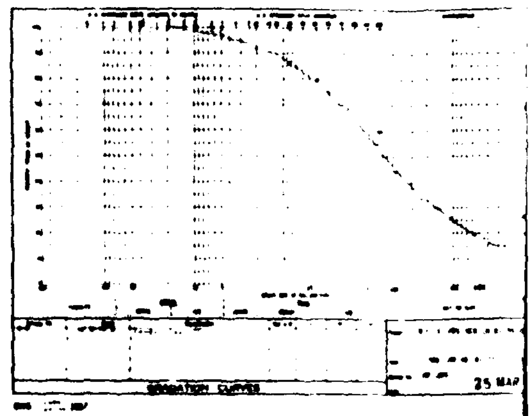

SECTION 206 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

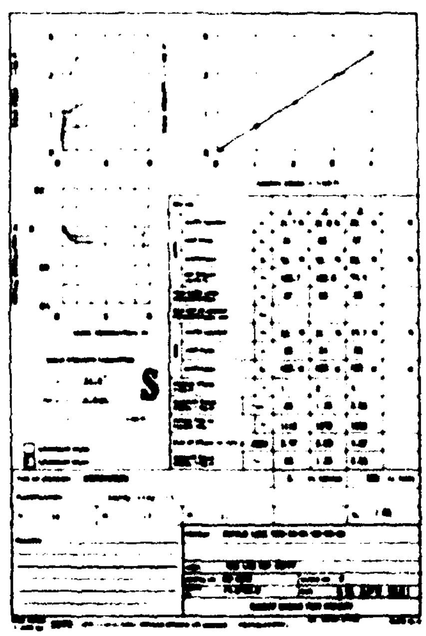
**SOILS TEST DATA**

BORING RI 10MU

ST PAUL DISTRICT

DRAWING NO | DATE
JAN 1983



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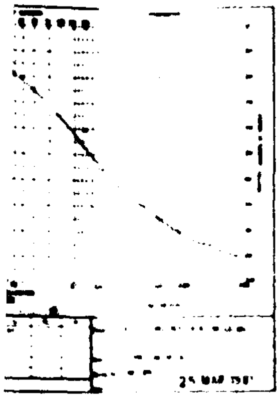
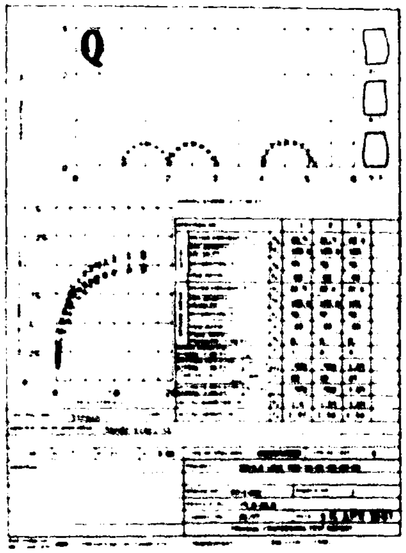
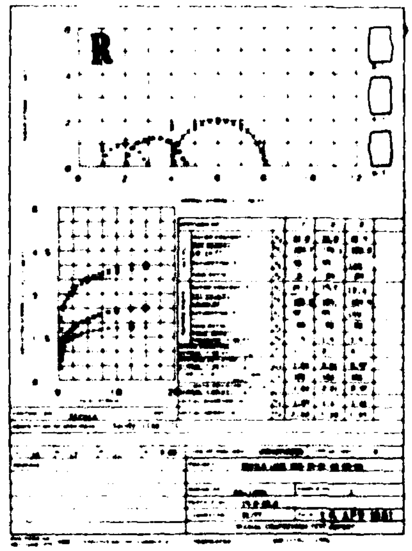
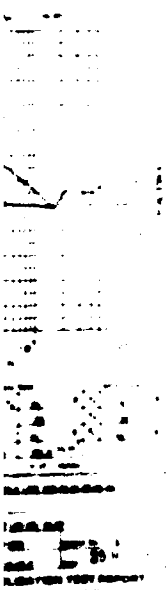
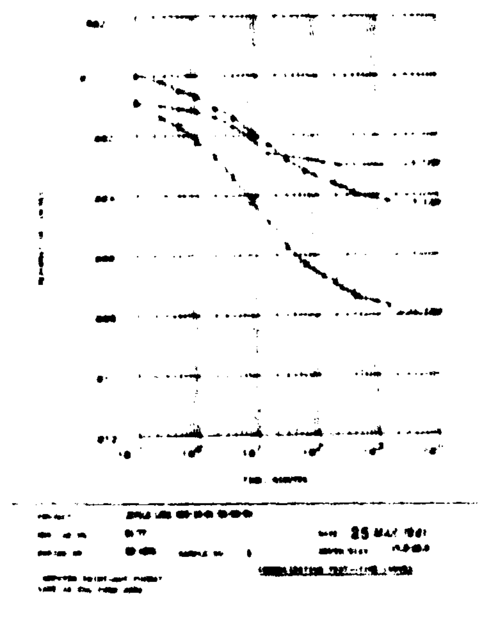
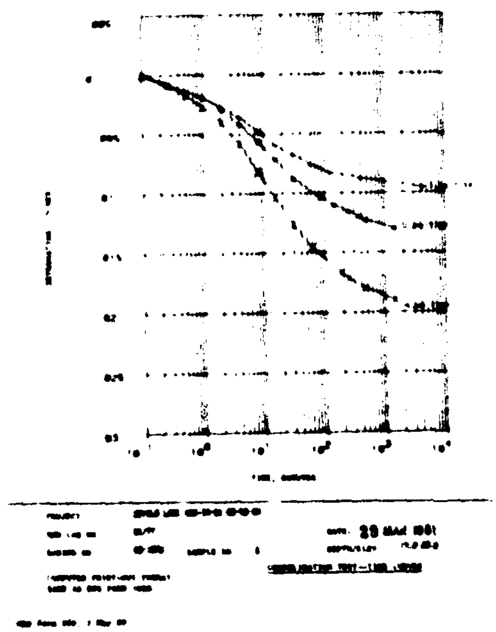





SECTION 208 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

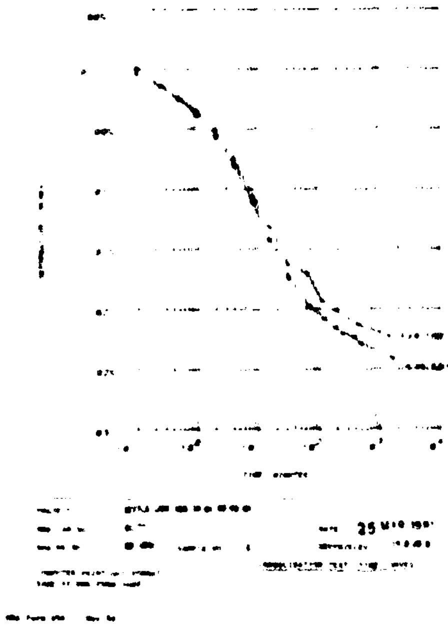
**SOILS TEST DATA**

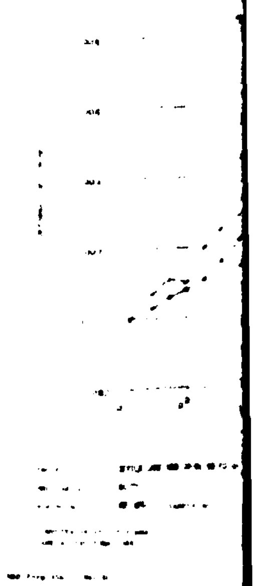
BORING RI-10MU

ST PAUL DISTRICT

DRAWING NO | DATE JAN 1983

PLATE I 70



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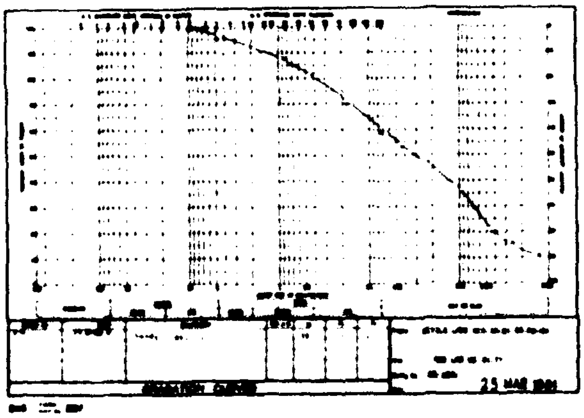


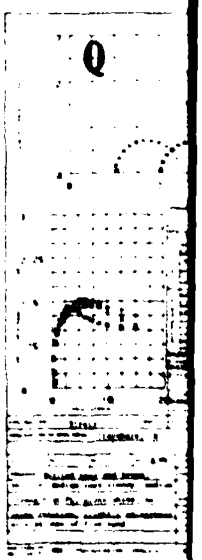

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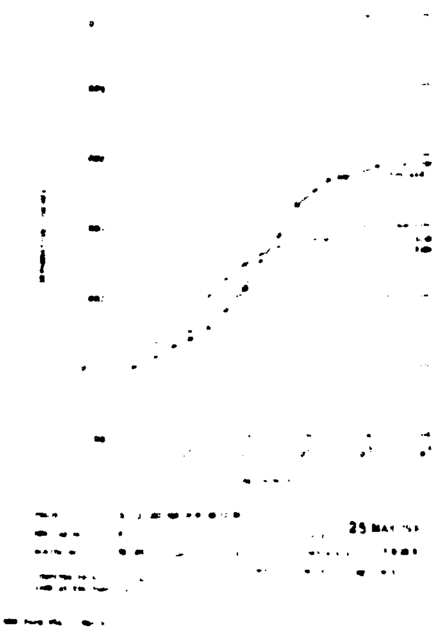


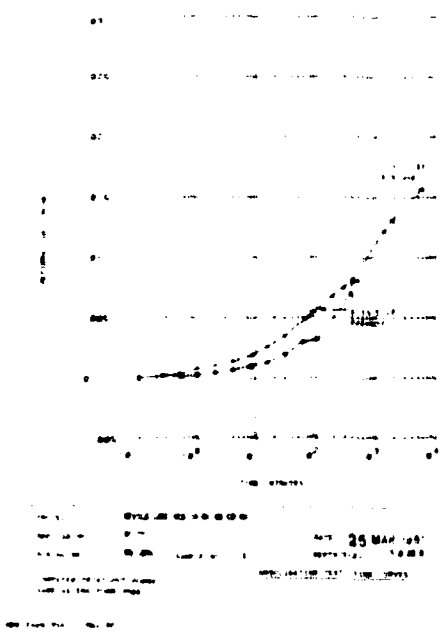


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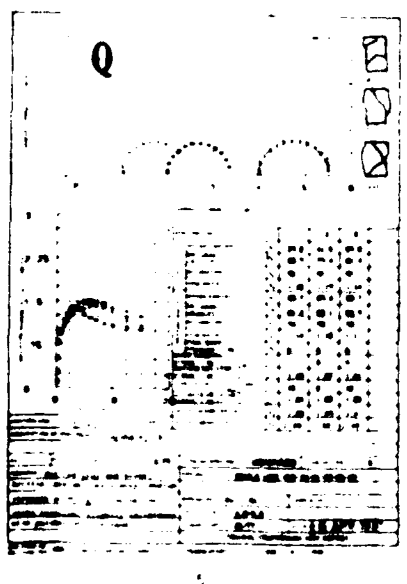


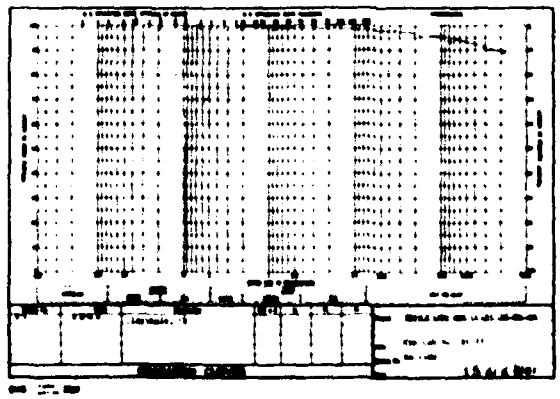

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SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

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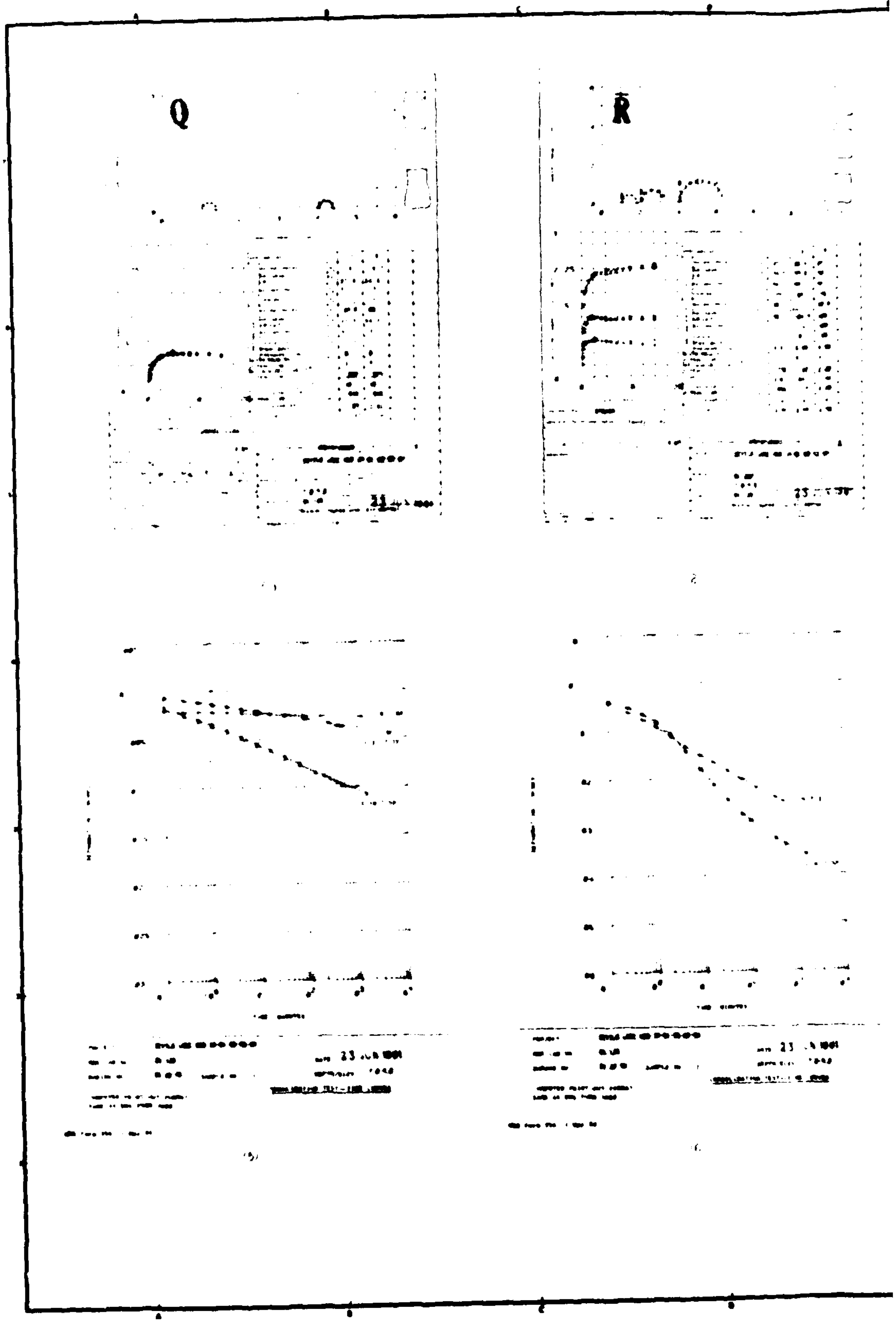
ST PAUL DISTRICT

DRAWING NO

DATE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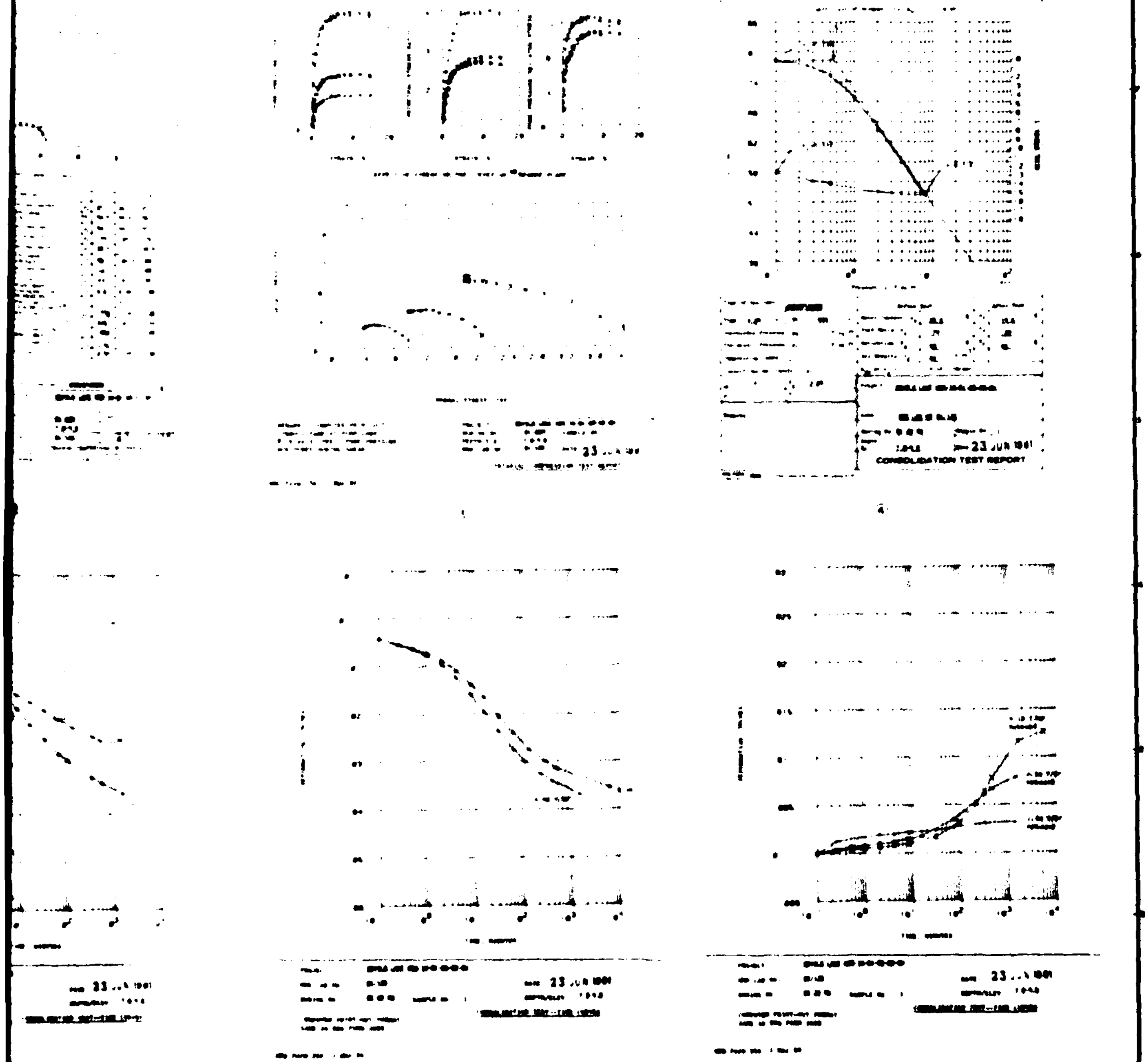


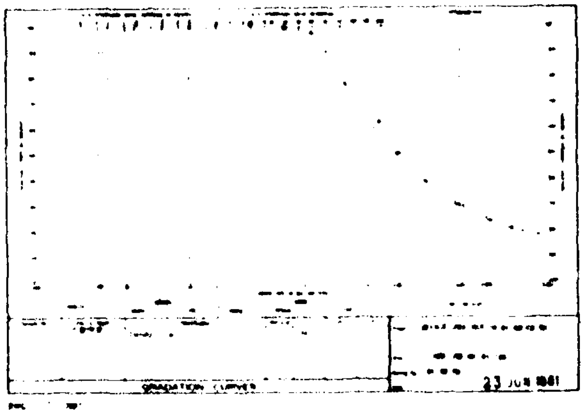

SECTION 206 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

BORING BI 22M & BI 22MU

ST PAUL DISTRICT

PLATE E 22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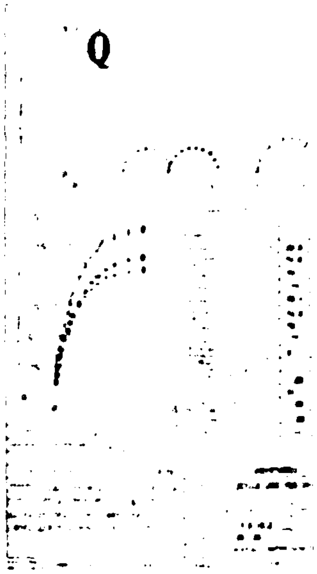

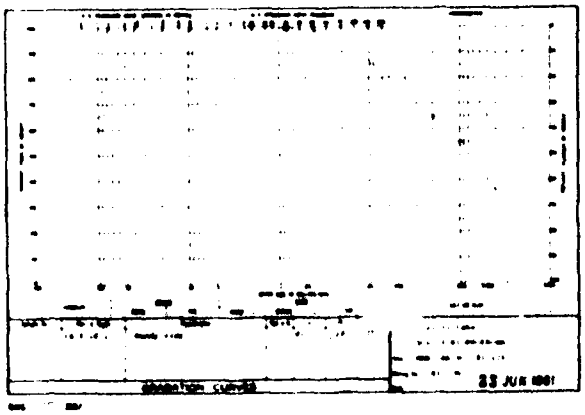
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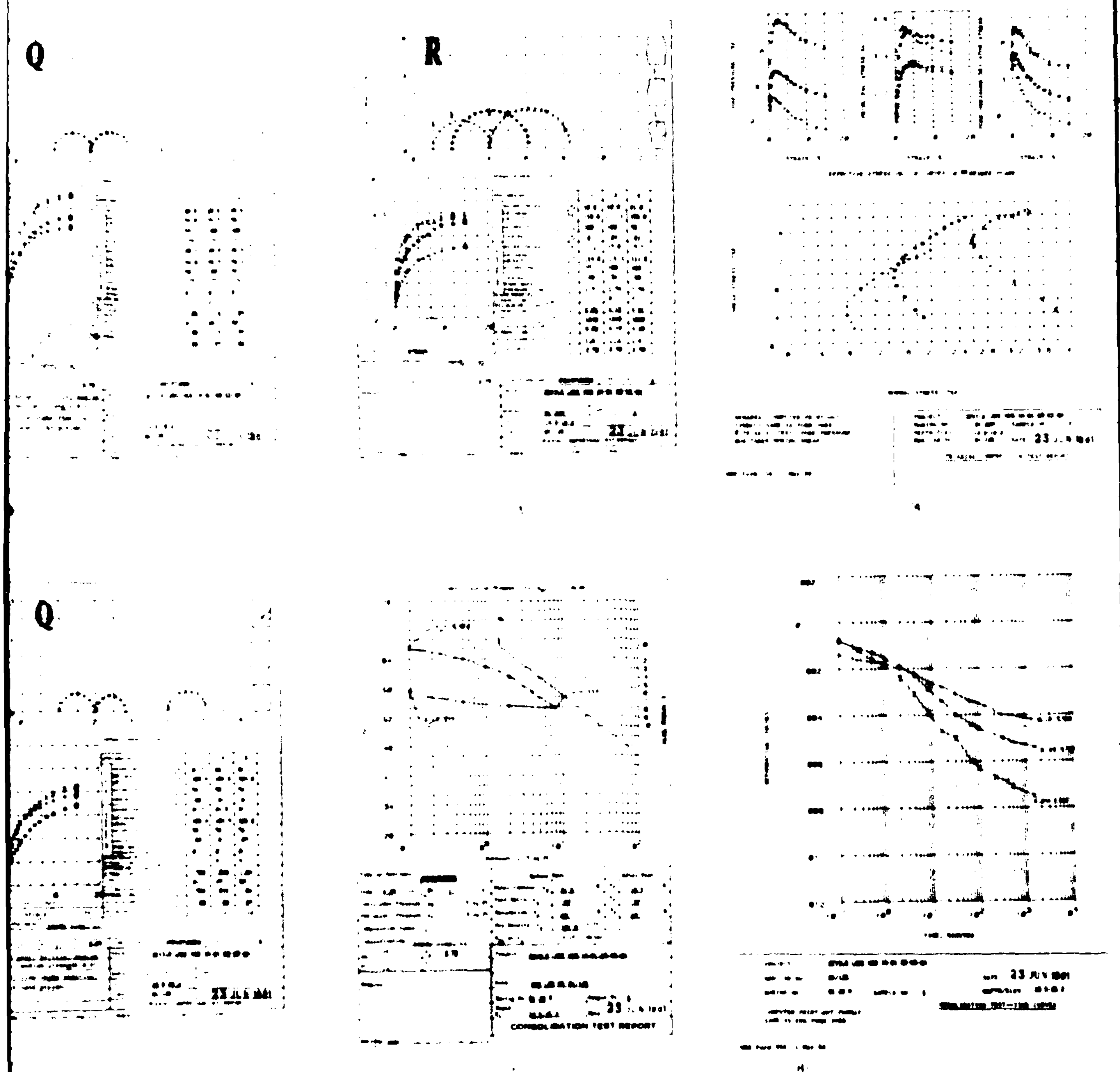


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

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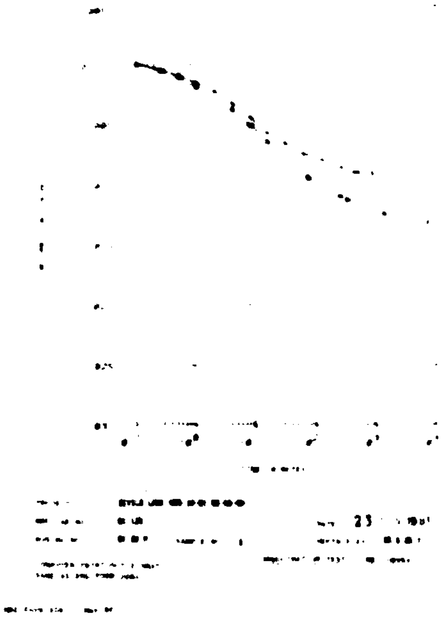
ST PAUL DISTRICT

DRAWING NO DATE

PLATE I-29



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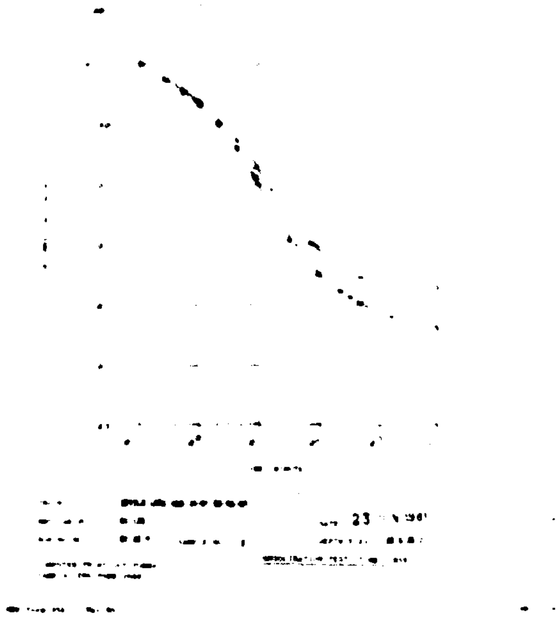

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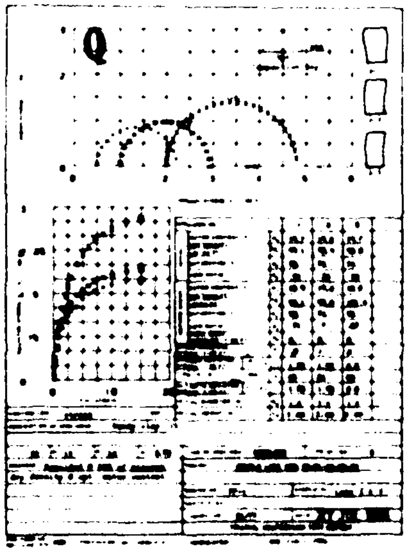


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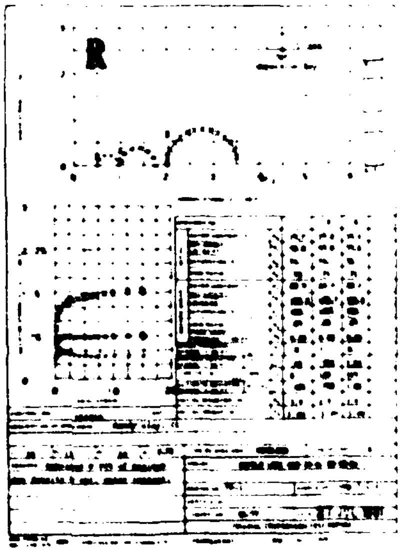


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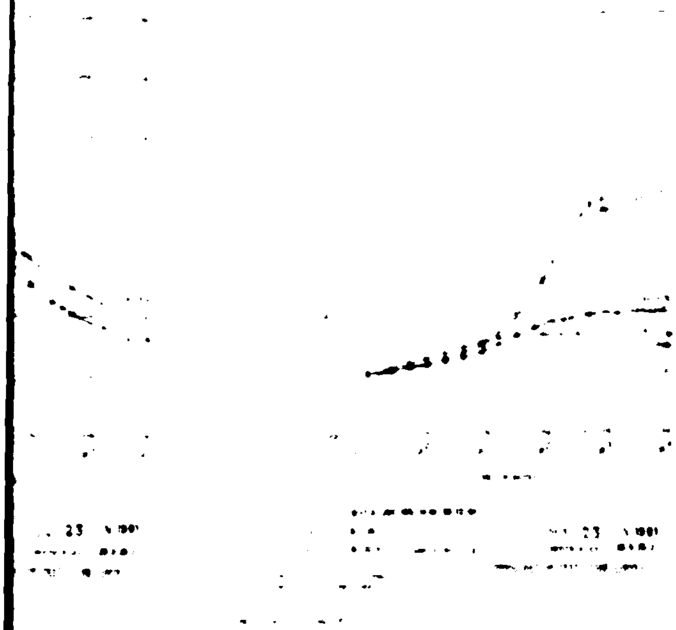

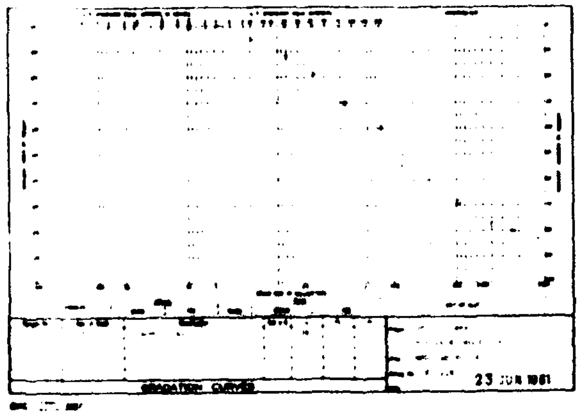


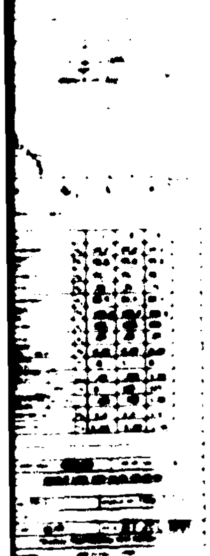

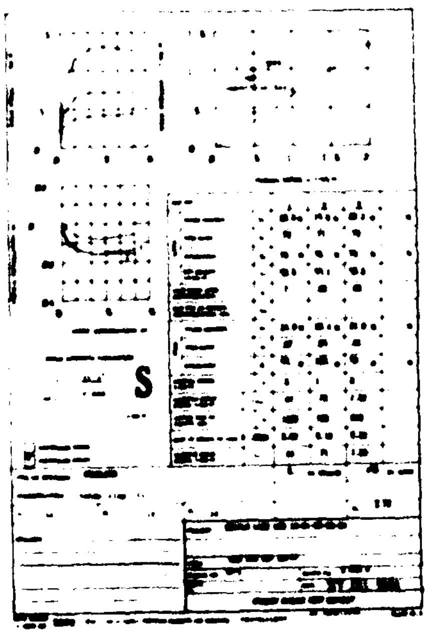

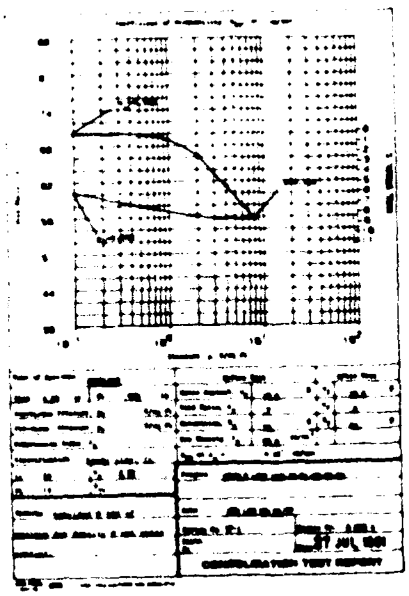


SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

**SOILS TEST DATA**

BORING B 22M

ST PAUL DISTRICT

DRAWING NO DATE


(1)


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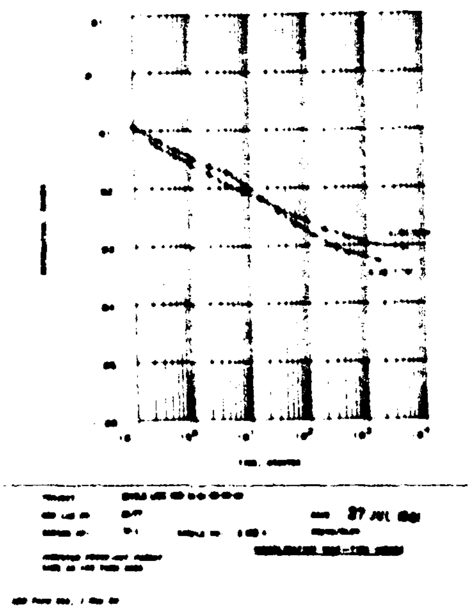


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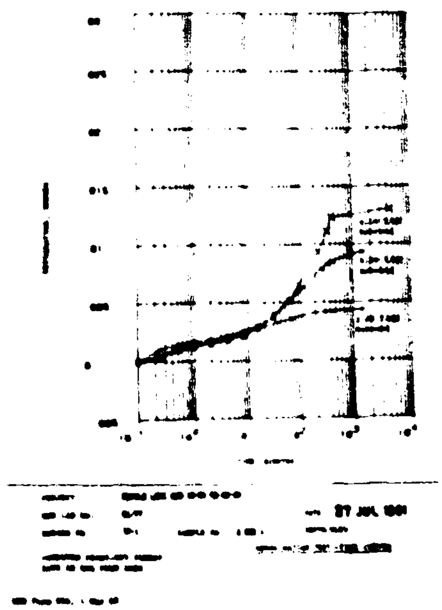


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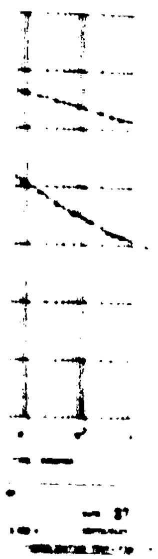


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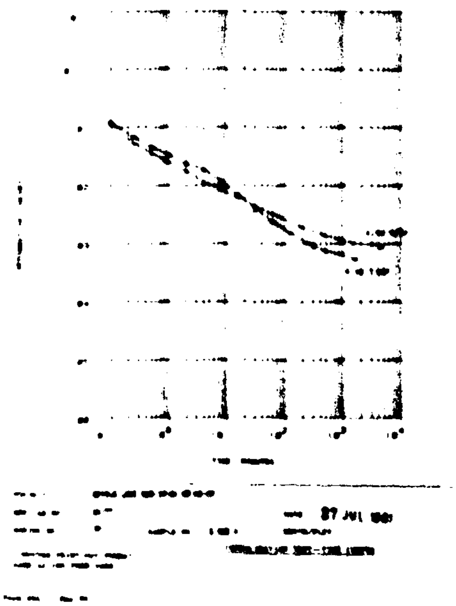


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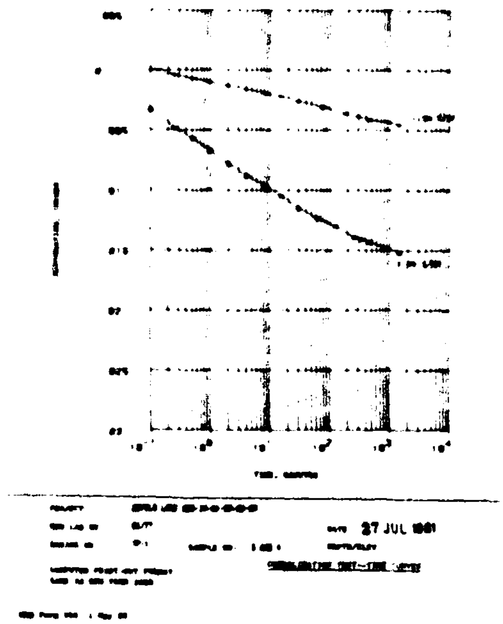


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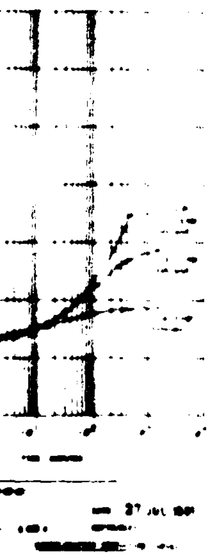


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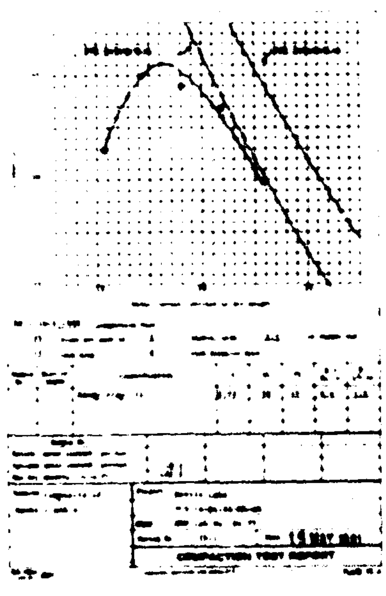


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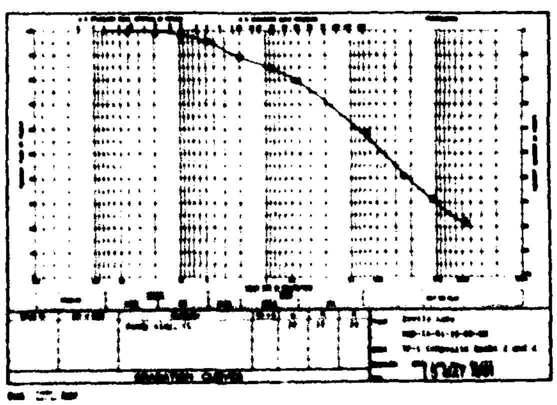

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SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

SOILS TEST DATA

BORING TP-1

ST PAUL DISTRICT

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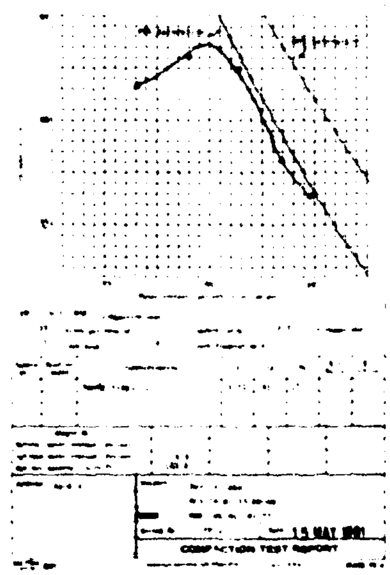
PLATE E 2[illegible]


15 MAY 1981
COMPACTION TEST REPORT

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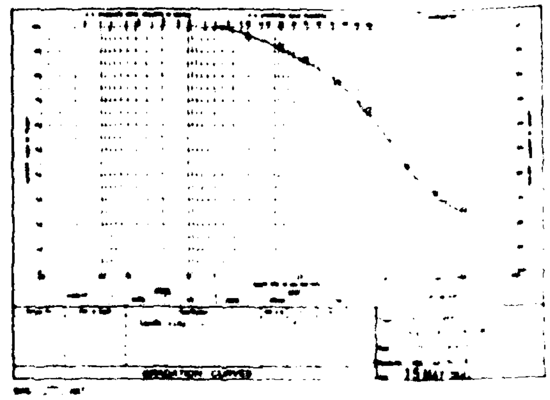
GRADATION CURVES
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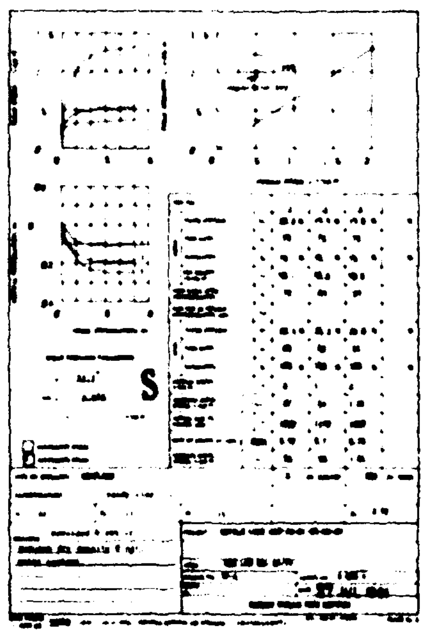
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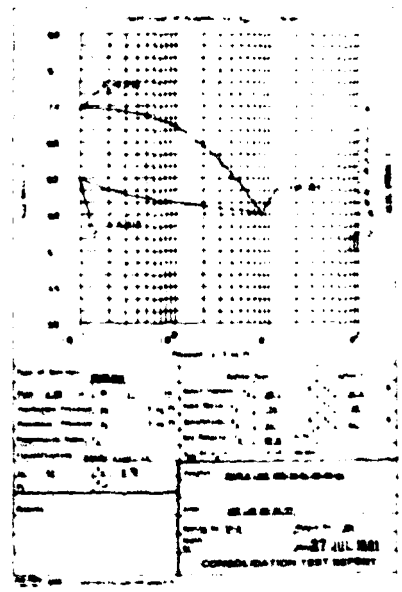
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CONSOLIDATION TEST REPORT

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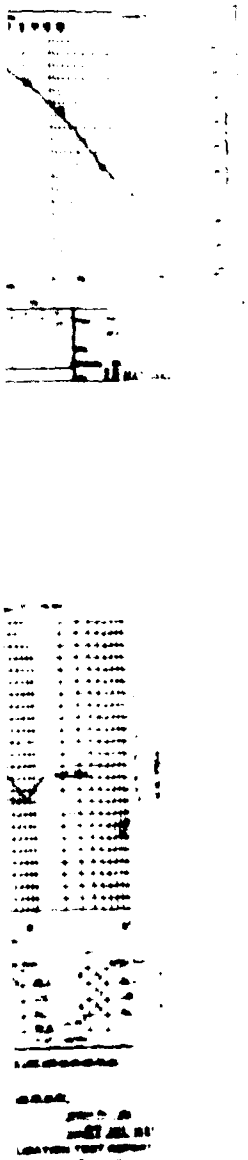
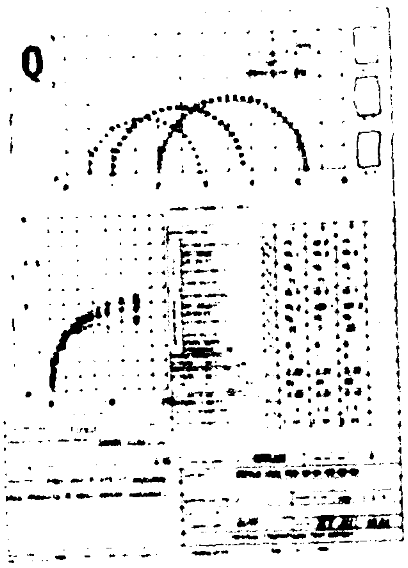
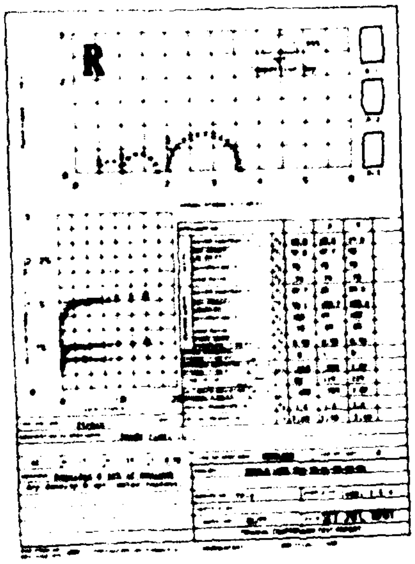
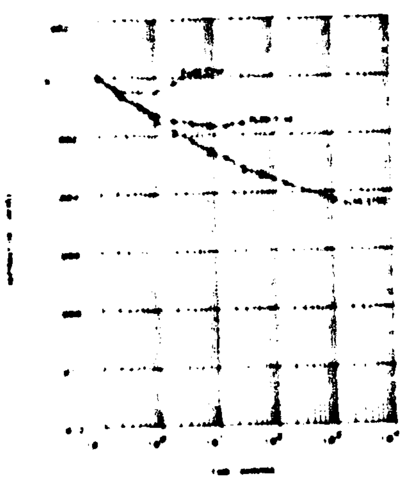
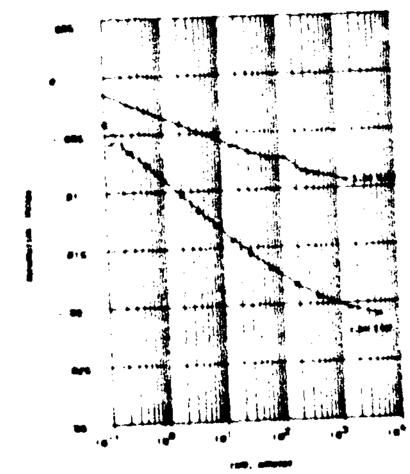






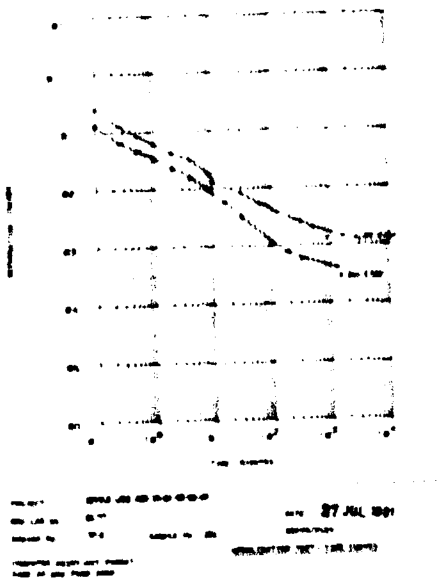
SECTION 205 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

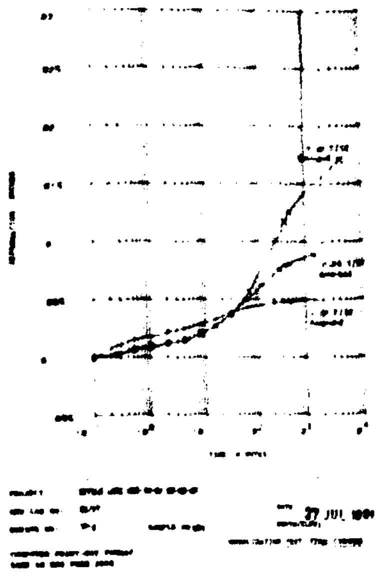
SOILS TEST DATA

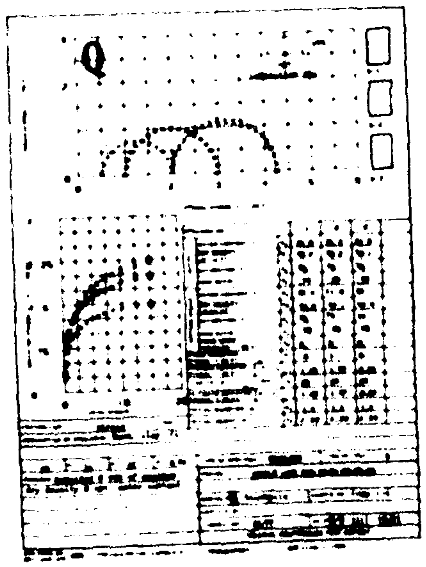
BORING TP-2

ST PAUL DISTRICT

DRAWING NO                DATE

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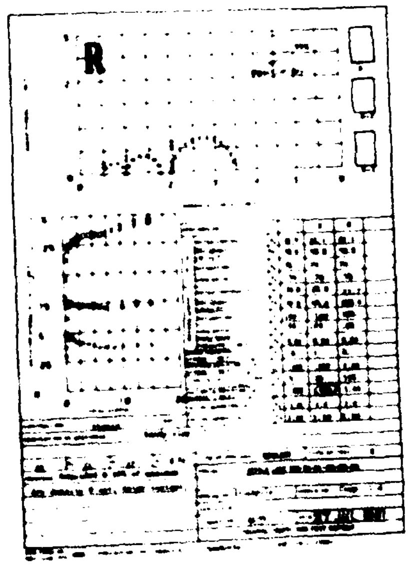


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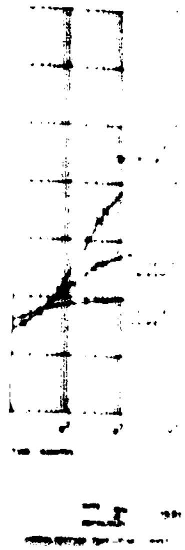

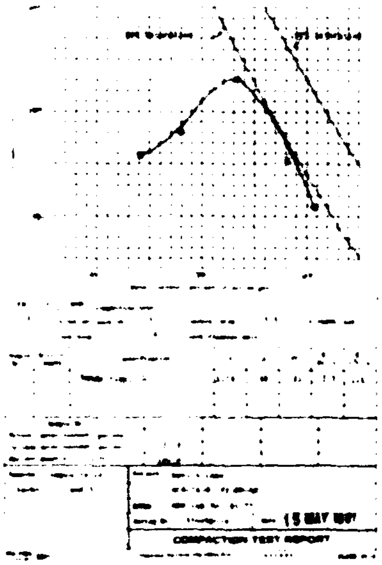


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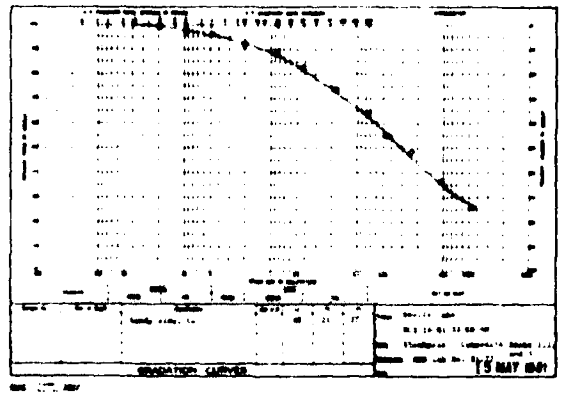


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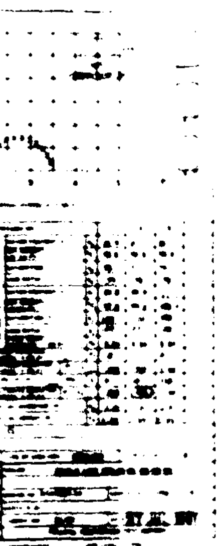
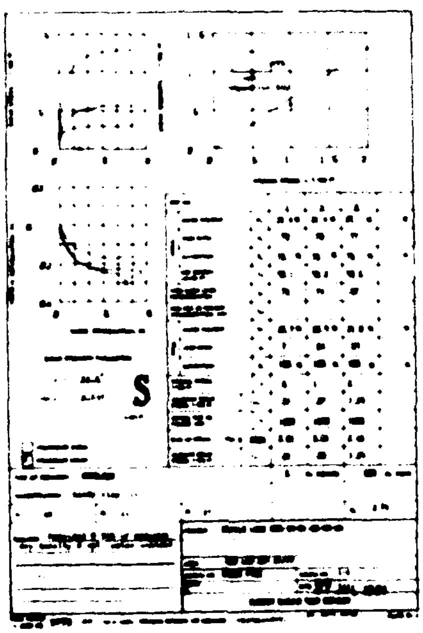
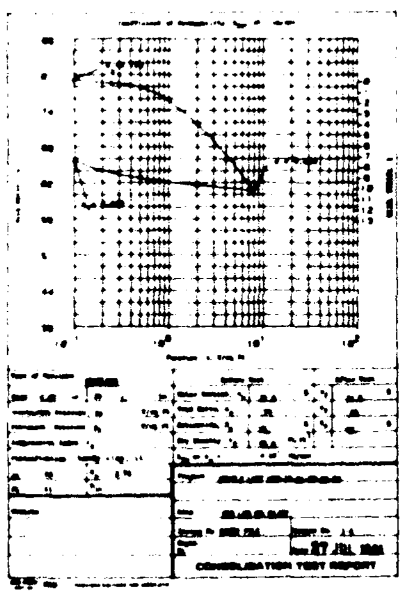


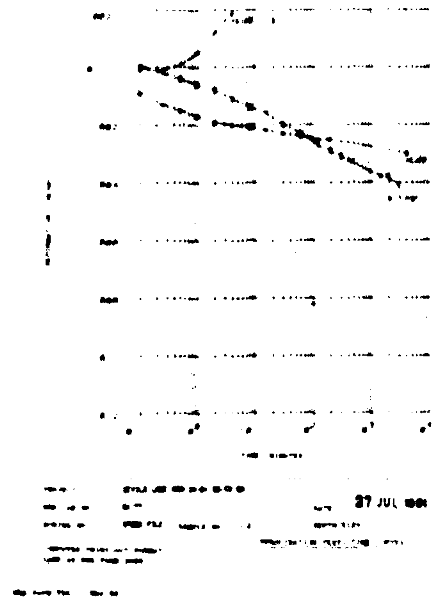

SECTION 205 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

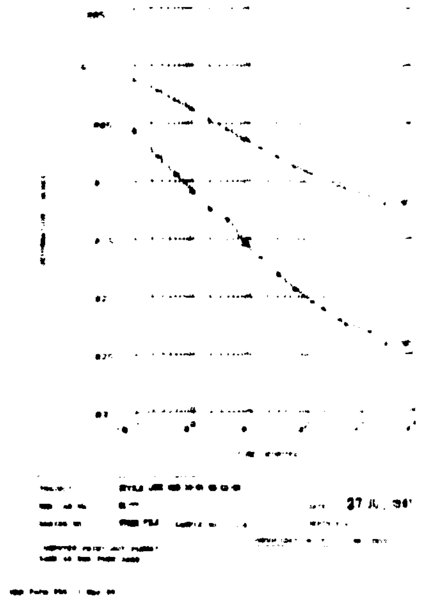
SOILS TEST DATA

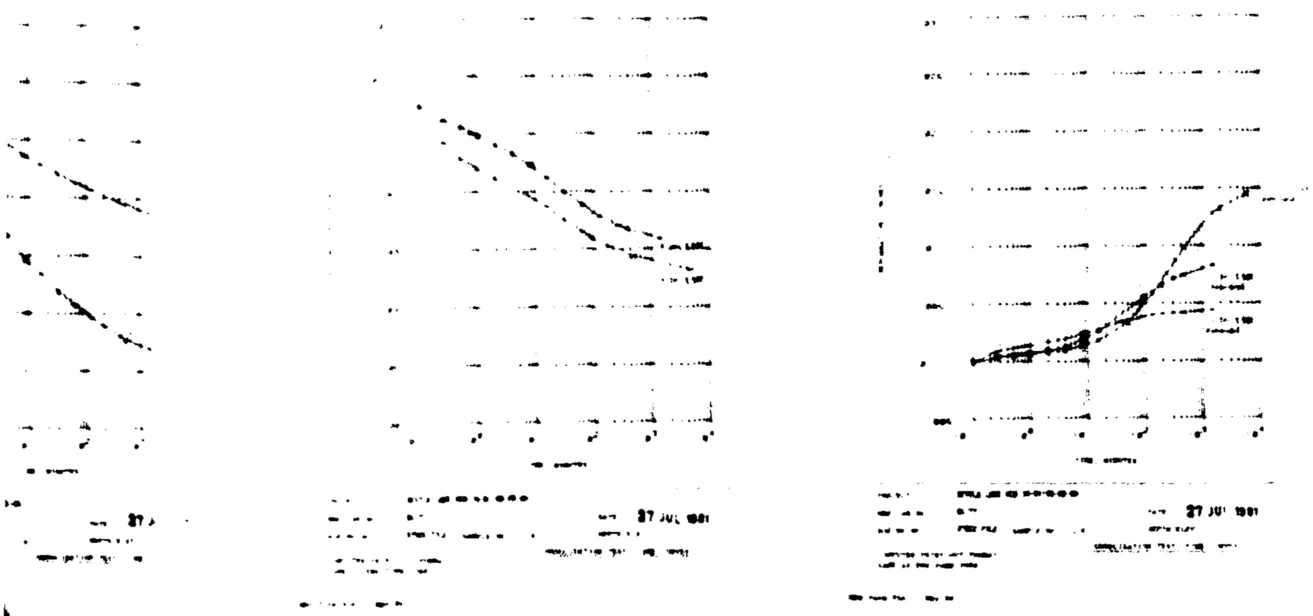
BORING STOCKPILE

ST PAUL DISTRICT

DRAWING NO    DATE





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SECTION 206 - DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

SOILS TEST DATA

BORING STOCKPILE

ST PAUL DISTRICT

DRAWING NO | DATE JAN 1983

PLATE E 20

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX F

DESIGN ENGINEERING

## APPENDIX F

## DESIGN ENGINEERING

### TABLE OF CONTENTS

PLATES

## APPENDIX F
## DESIGN ENGINEERING

### PURPOSE

1. This appendix describes the structures to be built and methods to be used to design the structures and equipment for the Devils Lake Flood Control Project. For features that were not designed for this report past designs for similar structures and equipment with similar loading and operating conditions were used to arrive at approximate designs. Supporting information is included, such as design criteria, structural materials, soil parameters, loads and loading conditions, and typical design computations for structures that were designed.

I. STRUCTURAL AND ARCHITECTURAL DESIGN ANALYSIS

### DESIGN CRITERIA

1. WORKING STRESSES

Working stresses to be used in the design will conform to those specified in Engineering Manual 1110-1-2101, "Working Stresses for Structural Design", including Change 2, dated January 1972. Loading conditions, design assumptions, and other criteria will be based on the applicable parts of the following references:

a. EM 1110-2-2000, "Standard Practice for Concrete", dated September 1982.

b. EM 1110-2-2103, "Details of Steel Reinforcement for Cast-in-Place Concrete", dated May 1971.

c. EM 1110-2-3102, "General Principles of Pumping Station Design and Layout", dated December 1962.

d. EM 1110-2-3103, "Architectual Design of Pumping Stations", dated February 1960.

e. EM 1110-2-3104, "Structural Design of Pumping Stations," dated June 1958.

f. EM 1110-2-2501, "Wall Design, Floodwalls", including Changes 1 through 3, dated June 1962.

g. EM 1110-2-2502, "Retaining Walls", including Changes 1 through 3, dated January 1965.

h. ETL 1110-2-256, "Sliding Stability for Concrete Structures", dated 24 June 1981.

i. EM 1110-2-2902, "Conduit, Culverts and Pipes", including Changes 1 and 2, dated April 1971.

j. ETL 1110-2-192, "Design Criteria for Seep Rings on Conduits and Pipes Through and Beneath Levees", dated August 1974.

k. Building Code Requirements for Reinforced Concrete, (ACI 318-63 and 77).

l. Technical Report SL-80-4, "Strength Design of Reinforced Concrete Hydraulic Structures", by Waterways Experiment Station, dated July 1980.

m. ETL 1110-2-265, "Strength Design Criteria for Reinforced Concrete Hydraulic Structures", dated 15 September 1981.

n. Bureau of Reclamations, "Moments and Reactions for Rectangular Plates", Monograph No. 27, dated 1963.

2. REINFORCED CONCRETE STRUCTURES

Reinforced concrete structures will be designed in accordance with Working Stress Design (WSD), and/or by Ultimate Strength Design (USD). A concrete compressive strength of 3,000 pounds per squre inch (psi) will be used in the design of the structures. For USD, a steel ratio of 25 percent of the balanced steel ratio and load factors of 1.5 and 1.9 for dead and live loads, respectively, will be used for the design of hydraulic structures. Reinforcing steel will be deformed billet-steel bars with yield strength of 40,000 psi and 48,000 psi for grade 40 and 60 respectively. Reinforcing will conform to ASTM A615.

3. ALUMINUM

Aluminum will be 6061-T6. Working stresses to be used in the design will be in accordance with EM 1110-1-2101.

4. STEEL SHEET PILING

Steel sheet piling will conform to the requirements of ASTM A328.

. MISCELLANEOUS STRUCTURAL STEEL

Miscellaneous structural steel will conform to the requirements of ASTM-A36. Working stresses for the design of structural steel will be in accordance with EM 1110-1-2101.

6. SOIL CONSTANTS

The soil to be used for backfilling all structures will be the native glacial till. It is estimated to have a dry density of 105 pounds per cubic foot (pcf), a saturated density of 125 pcf, a cohesive strength of zero pounds per square foot (psf) and an angle of internal friction of 30 degrees. Pressures exerted by soil backfill on structures will be determined based on active, passive, and at-rest coefficients. The allowable bearing capacity is estimated to be greater than 3,000 psf.

7. SETTLEMENT

Settlement of structures is not anticipated.

8. DEPTH OF COVER

The minimum depth of cover required for protection against frost action is 6.25 feet. Either this minimum depth will be provided at all structures or a nonfrost susceptible material will be provided under structures.

## DESIGN OF STRUCTURES

9. GENERAL

The design of the pumping station gate well, outlets, and pipes, is described in the following paragraphs.

10. PUMPING STATION (Plate 15)

The Creel Bay pumping station was designed using one-way or two-way bending, as appropriate. Moments and reactions for two-way bending were determined using Monograph No. 27. The pumping station will be partially earth-sheltered, with the remaining exposed surfaces insulated to prevent freezing during winter operation of the station. During these months the sump will be kept dry, when not in use, by closing the gate on the 72" RCP at the headwall and pumping the sump dry. Insulation will also be used over the inlet pipe to minimize frost penetration and freezing in the pipe. For maintenance or repair, pumps will be removed from the station by hoisting them onto dollies and rolling them through the doors. The floor slab will be designed for a live load of 150 psf and a point load of 8000 lb. Forty psf will be used for snow load on the roof of the superstructure. Design wind loading will be in accordance with ANSI A58.1. Hatches over trashracks, stop logs, and ladders, will be designed for point loading from the pumps.

The Creel Bay pumping station is envisioned to be cast-in-place concrete. Because of its location and environment, there is no need for a complex exterior treatment. The station will show good detail, but every attempt will be made to keep the details and image as simple and clear cut as possible. Skylights will be used to provide natural light to the interior of the station.

Site development adjacent to the pumping station will include the construction of hard surfacing on which to park and walk. These surfaces will tie into an access road. The site also has some unique features because of the land forms formed by the construction. Landscaping will serve to enhance the appearence of the pumping station and will be used to shade and define the parking lot. Species, primarily of deciduous trees, will be selected on the basis of their visual appearance, hardiness, disease resistance, and compatability with the area.

11. GATE WELL (Plate 16)

The Creel Bay outlet gatewell will be designed using one-way or two-way bending, as appropriate. Moments and reactions for two-way bending will be determined using Monograph No. 27. The gate lift will be hand-operated, with provisions for gas or electric-powered operators. Stop logs will be placed or removed from the top of the gatewell. The top hatch will be insulated to prevent ice from forming in the outlet pipe and gatewell during winter operation. Sheetpile retaining walls will tie the gatewell to the top of the embankment to retain fill over the pump discharge pipes.

12. PIPES AND OUTLETS (Plate 14)

Reinforced concrete pipe (RCP) will be designed using a safety factor of 2.0 when in the embankment and 1.0 elsewhere. RCP that is in or adjacent to the embankment will have bell and spigot joints. In other areas, tongue and groove joints may be used. RCP placed in the embankment will not have collars around the joints because settlement is not anticipated in this area. Additional soil investigation is necessary to design protection for the 16-inch cast iron pipe watermain through the south embankment, shown on plate 2.

13. HEADWALL (Plate 16)

A T-type retaining wall will be used to retain the parking area fill for frost protection over the inlet pipes for the Creel Bay outlet. A 1.5 safety factor for sliding stability, with base resultant in the middle one-third for overturning will be used. Allowable bearing pressures will not be exceeded. 72" RCP inlets for the gravity flow and pumping station will be cast in the wall. Both inlets will have safety guards, and the pumping station inlet will be gated at the wall.

II. MECHANICAL AND ELECTRICAL DESIGN ANALYSIS

MECHANICAL

1. FLOOD CONTROL PUMPS

a. The size of pumps in the Creel Bay pumping station have been determined in accordance with EM 1110-2-1410, EM 1110-2-3102 and EM 1110-2-3105. The types and speeds of the pumps will not be in accordance with EM 1110-2-3105. A 20-inch discharge size submersible sewage pump will be used and match the given head and capacity requirements already developed. The pumps have been sized to provide two-thirds of the required station capacity in the event one pump should fail. Two submersible pumps, each having a capacity of 8000 g.p.m., will be provided. The pumps will be of the submersible motor, direct coupled, centrifugal, sewage-type pump with a rail-type lift-out feature mating to a permanently anchored discharge shoe connection. No external lubrication system is required for this type of pump. A cantilever jib crane and hoist-trolley system will be provided for routine service and inspection of the pumps. The pumps may be removed through the double doors for off-site major service or repair. The submersible sewage pumps have been proven in municipal service over the last 15 to 20 years. A 20-inch submersible pump is currently available from at least three manufacturers and its cost is comparable to a conventional pump. A detailed cost analysis of alternate pumps and pump maintenance/removal systems is developed on Plate F-1. These pumps could not be specified using CE-2303.01; however, a specification has been prepared based on current manufacturer's equipment and previously developed specifications by other Corps Districts. This type of pump should provide better maintenance capability to the user, and the concept of its use in the instant case has been indorsed by the city of Devils Lake.

b. The two 8000 g.p.m. pumps will be pumping against a priming static head at gate closure of 20.0 feet. The static head during the design lake stage, elevation 1440.0 will be 20.5 feet and at gate closure will be 3.0 feet with a 2.0 feet pumping range. The equivalent length of the discharge pipe is about 227 feet. The use of a manifolded discharge was investigated and rejected on economics in favor of the integrity of separate discharge systems. A justification for siphonic discharge is developed on Plate F-3. Specifications will require satisfactory low head operation and testing will require such a demonstration.

2. SLUICE GATE LIFTS

The lift for the gate at the headwall will be an electrically-operated unit. The inlets at the pumping station will be provided with stoplog slots. The gate at the headwall will be provided with heating capabilities and a stringent allowance for leakage will be called for in the specification. The gravity closure gate will be manually operated with a provision for portable electric or hydraulic operator.

3. CRANE

A 5-ton jib crane will be located on a concrete column on the inside face of the west wall with the capability of swinging the 5-ton wire rope hoist unit over either of the two pumps. The pumps may be raised to the operating floor and placed on cribbing or bridging over the pump hatch cover. If off-site servicing is needed, either pump may be removed through the double entry door.

4. VENTILATION

a. Creel Bay pumping station will be provided with two separate and independent ventilating systems. Mechanical ventilation will be provided for the sump space below the operating floor. Mechanical ventilation will be provided for the operating room.

b. The sump ventilation system consists of an inline fan, mounted in the pump room, that removes air from the sump at the rate of 12 air changes per hour. The air is supplied to the sump through two supply openings in the wall equipped with back-draft dampers which will decrease the gravity flow of cold outside air into the sump during the winter. The sump ventilation system will be started manually. The operating room ventilation will be started manually.

5. HEATING AND HUMIDITY CONTROL

The heat loss of the Pump Room will be calculated at 40°F. room temperature and -14°F. outside temperature. Insulation will be used to meet North Dakota Energy Codes. Heating will be provided by electric unit heater(s) that will be manually activated. No strip heaters will be provided in the submersible motors. The entire sump area will be insulated and the building earth-bermed to minimize icing problems.

6. SUMP SIZE

The size of sump bays were increased by 65 inches in width and 10 feet in length from the forebay gate to the backwall, then for a sump proportioned to Hydraulic Institute (H.I.) standards. The result is the submersible pump suction is approximately 7 feet closer to the forebay openings. There is every reason to expect satisfactory performance for the submersible-type pump in the modified standard sump. Minimum submergence will be one foot over the pump volute, at normal heads.

7. SUPERSTRUCTURE

The size of the building was considered for reduction to minimum size for the submersible type pump. After design considerations based on structural and architectural aspects as well as operational benefits, the building was retained at the normal size for conventional pumps. Floor loading is based on the submersible pump being placed anywhere on the floor except the pump hatch covers. Special signs and warning will caution the operator only to place the pump on cribbing or bridging over the hatch cover.

8. SIPHONIC DISCHARGE

The station will make use of a siphonic discharge. The large number of operating hours and the small percentage of gravity flow available make siphonic discharge attractive. The station will be sized for pumping as a vented system and the pumping capacity increased by use of siphonic discharge with reduced operating time. An electrically-controlled valve actuated by an auxilary contact on the pump motor will "make" and "break" the siphon. The siphon will be "made" after an on-delay time allows the trapped air to escape. A manual valve or manual facility on the electrically operated valve will be provided.

9. OPERATION

The station will have certain intrinsic and operational advantages and disadvantages when either a conventional or submersible pump is considered. Based on the physical comparison chart developed on Plate F-2 and the cost comparison developed on Plate F-1, it is recommended that submersible pumps be used for the Creel Bay pump station. The submersible pumps are recommended for ease of maintenance and accessibility, although the projected operating costs over the project life will be higher.

ELECTRICAL

10. ELECTRIC POWER SOURCE

a. Electrical power for the pumping station will be supplied by No Dak Rural Electric Company, which serves the Devils Lake area. Three different types of services were considered.

(1) Three-phase secondary service from power company owned equipment.

(2) Three-phase primary service from city-owned equipment.

(3) Three-phase primary service for pumps and single-phase service for lighting and heating loads. City to own primary three-phase equipment, power company to own single-phase equipment.

b. It is recommended that alternative (1) be selected. The secondary service will be a 480Y/277, volts, three-phase, 4-wire, grounded system. The two stormwater pumps, jib crane, and unit heaters will utilize 480 volt three-phase power. A dry type step-down transformer will be used to provide a 120/240 volt, 1 phase, 3 wire system for lighting and convenience outlets and valve actuator.

c. 480 volt secondary service is recommended for these reasons:

(1) The city does not have personnel trained in the maintenance of high voltage equipment.

(2) The power company will provide better maintenance to the high voltage equipment than the city could provide.

(3) The reliability of the station will be increased.

11. SERVICE

The power company will install transformers and metering equipment near the pumping station.

12. SERVICE CAPACITY

Service capacity will be furnished in accordance with Plate F-4. Shortcircuit capacity required shall be in accordance with Plate F-5.

13. PUMP MOTORS

a. The stormwater submersible pump motors will be housed in an airfilled watertight casing and will have Class F insulated moisture resistant wingings. Each motor will be supplied with bearing and stator thermistors for thermal protection, and a leakage sensor for protection against seal failure.

b. The motor will be designed to operate on a three-phase, 460-volt electrical system. The pump motors will have cooling characteristics suitable to permit continuous operation in a totally, partially, or nonsubmerged condition.

14. CONTROL CENTER EQUIPMENT

a. Enclosure. The described equipment will be housed in a NEMA 12, freestanding Motor Control Center. The Control Center will be NEMA Class II, Type B construction. The design will be in accordance with the latest applicable NEMA standards for industrial controls and systems. (Pub. No. ICS 2-78)

b. Wiring. All wiring will have 600-volt insulation and all power wiring and bus work will be in complete conformity with the National Electrical Code and applicable NEMA Electrical Standards. Control wiring will be color coded.

c. Power Supply and Metering. The power supply will be 480 volts, three-phase, four wire, 60 cycle. The metering will be done ahead of the main disconnect switch and will be installed accordance with power company requirements.

d. Main Circuit Breaker. A three-pole, molded-case circuit breaker will be provided as the main disconnecting device. This breaker will have a NEMA interrupting rating of 22,000 amps at 600 volts, A.C. and a trip rating of 600 amperes.

e. Lighting Transformer Circuit Breaker. A two-pole molded-case circuit breaker with 40 ampere trip rating, will be provided ahead of the lighting transformer.

f. Lighting Transformer. A 10 KVA two-winding, dry-type, lighting transformer with 480-volt primary and 110/220 volt secondary will be furnished in the assembly ahead of the lighting panel.

g. Lighting Panel. A 12 circuit, circuit-breaker type lighting panel with 50A main circuit breaker will be furnished in the control center.

h. Combination Starters. The Control Center will include combination starters with circuit breakers or Motor Circuit Protectors (MCP) depending on motor size. The starters will protect the motors against overload and undervoltage conditions. They will have overload relays in the three lines of each unit. Overload relay resets will be operable through the door of the enclosure. Individual control power transformers will be provided for 120 VAC motor starter operation.

i. Hand Off Auto Selector Switches. A heavy-duty, three position, selector switch will be flush-mounted on the front door of the control center for the operation of each motor starter with automatic control. This selector switch will operate the starter when it is placed in the "manual" or "automatic" position. The automatic control system will operate the equipment in the manner described in Paragraph 6.

j. Pilot Lights. Door-mounted pilot lights will be provided to indicate pump motor status. These lights will provide the following indications; control power on, pump running, pump moisture detected, pump bearing overtemp and Pump stator overtemp.

k. Running Time Meters. A running time meter measuring hours and tenths-of-hours up to 9999.9 hours will be furnished for each pump motor.

l. Valve Actuators. Pump discharge line siphon breakers will be equipped with Valve Actuators. The Actuators will be controlled by an auxiliary contact on the pump motor starter through an "ON" time delay relay. Operation of the siphon breaker is described in Paragraph 8.

15. AUTOMATIC CONTROL SYSTEM.

a. A complete level-responsive automatic pump controller and alarm system will be supplied. It will utilize four direct-acting float switches, mounting hardware and a Duplex Pump Controller/Alternator.

b. The float switches will be of Type 316 stainless steel construction with mercury switches embedded inside. The floats will be flexibly-mounted with stainless steel clamps on a vertical 1" pipe mounted in the pump chamber. They will be connected to provide independent ON, common OFF pump operation and high level monitor/alarm.

c. Pilot control of the pump motor starters will be provided by a Controller having the following features; 120 VAC Input Power "both pumps ON" operation at the 3rd float level, automatic alternation of the two pumps on successive starts, common off float switch, and high-level monitor/alarm operated by the top float.

d. A bracket type door module shall be furnished with Float Circuit Test Switches to simulate level sensor operation. LED Indicators will be used to indicate operation of the sensor circuits. The door module will also be equipped with an Alternator Override Control allowing manual or automatic sequence determination.

16. ANNUNCIATION

A local alarm system will be mounted on the outside of the pump station. It will provide a visually brilliant red strobe alarm and audible bell which will be activated in response to the occurance of any of four malfunctions. The alarm system will normally operate on 120 volts A.C. It will automatically transfer to a 12 VDC-gelled electrolyte battery on a float charger in the event of failure of the normal power source. The four-alarm functions used will be control power failure, phase failure/unbalance, hige level in the station well, and pump motor sensors or overload relay tripped.

17. LIGHTING

Fluorescent lighting fixtures U.L. labeled for damp locations will be used in the pump operating room. The lighting level in the pump operating room will be 30 foot-candles. Incandescent lighting fixtures U.L. labeled for wet locations will be used in the sump locations. The lighting level in the sump will be 5 foot-candles. Fluorescent lighting fixtures shall be equipped with ambient compensated "cold weather" ballasts. The exterior of the pumping station will be illuminated by low pressure sodium security lighting.

18. WIRE AND CABLE

a. The wire and cable used will be in accordance with guide specifications CE-1404.04 Insulated Wire and Cable (for Hydraulic Structures). Conductor material for all control and power cable smaller than No. 1/0AWG will be of copper. Aluminum conductors will be permitted in dry locations and for sizes 1/0-AWG and larger only. Conductors will not be smaller than No. 12 AWG.

b. Conductors will be installed in conduit. Power cables will be sized for current-carrying capacity and voltage drop.

19. RECEPTACLES

Interior receptacles will be of the grounded-duplex type. Exterior receptacles will be of the weatherproof, tamperproof, grounded type. All receptacles will be protected with ground-fault circuit interrupters.

20. GROUNDING

All equipment will be grounded in accordance with the current edition of the National Electrical Code, ANSI CI including connections to the steel discharge pipes. A No. 4/0 AWG stranded, bare-copper, station grid will be connected to foundation rebar.

| ST PAUL DISTRICT COMPUTATION SHEET | DATE 22 April 1983 | PAGE 1 OF 3 | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE Design Engineering Section | COMPUTATION cost comparison | | |
| SUBJECT Creel Bay | SOURCE DATA | | |
| COMPUTED BY | CHECKED BY | APPROVED BY | |

| | | |
|---|---|---|
| Equipment Costs Pump and Motor | Based on 18" SAFV @ 875 rpm by Patterson Pump and 18LM @ 880 rpm by Aurora Pump $42,500 (Range $40,000-42,500) | Based on 20" CP3500 @ 504 rpm by Flygt Pump and AF16-S @ 705 rpm by A.B.S. Pump Co. $38,000 (Range $37,000 - $39,000) |
| Horsepower (nominal) | 75 hp. (Range 55-60 bhp) | 100 h.p. (Range 60-75 bhp) |
| Lubricator | Yes - $3500.00 | No |
| Motor Condensation Control Heater Cost | Yes - $500.00 | No |
| Heater Frequency of use 60% of year/every year over 50 year life. | $78 year - $968.00* | 75 |
| Pump Operating Costs Assume 278 days & 12 hrs/day every year for 50 yrs | 60 kw X 1654 hrs 99240 kwh @ $.05/kwh $4962.00 - $61586.20* | 75 kw X 1654 hrs 124050 kwh @ $.05/kwh $6202.50 - $76983.00* |
| 1 Interior Crane or Outside Truck Crane and Sky Lights | Yes - 2 ton jib crane $12,000.00 2 skylights @ $3000/2 pumps | Yes - 5 ton jib crane and wire rope hoist $16,000.00 |
| Truck Crane (35 ton) Mob & Demob Daily Rate | $2,000 $1,000 | $2,000 $1,000 |
| Frequency of Use (50 yr. useful pump life) | 7 days/10 years (2 mob & demob) when activated | 2 days/10 years (2 mob & demob) when activated |
| Cost of Crane Service (over useful pump life) | $9232.30* | $5035.80* |
| Ventilation Operating Room | Yes, per EM 1110-2-3105 powered - $1800 for a 2300 cfm unit | Optional - Gravity or comfort forced air |
| Feeder Capacity Size | -- | -- |
| | | |
| (1) First Cost (2) Operational Cost Ave. Annual Cost of (2) | $61,300.00 $71,786.50 $2,949.00 | $59,833.00 $82,018.80 $3,517.00 |
| *Cost on basis of constant | 1983 dollars. | |

1 Truck cranes are not readily obtainable on short notice in this area.

Creel Bay Pumping Station

| SUBJECT | CHECKED BY | DATE |
|---|---|---|
| Intrinsic and Operational Feature Comparison of Pumps | | 22 Apr 83 |

| FEATURE | | CONVENTIONAL | SUBMERSIBLE |
|---|---|---|---|
| Field Service | Pump | Enter sump when dewatered and perform repair, disassembly may or may not be accomplished. | Raise pump |
| | Motor | Motor repair and service/inspection is easy on operating floor. | Must raise pump to inspect service the motor. |
| Lubrication System | | Required | Not required |
| Motor Space Heater | | Required | Not required |
| # of starts of motor/hr | | 8 starts per hour | 10-12 starts/hr. |
| Failure or partial failure of bearings and/or seals. | | Pump could be operated with reduced performance expected. | Safeties provided in pump cavity for warning and shutdown-pump in inoperab[illegible] |
| Normal type of repair procedure | | Disassemble pump bowl assembly and repair/replace-offsite pump shaft, bearings and seals. | Repairs could take place in field. |
| Type of repair facility | | Any well-equipped machine shop with or without factory approved parts. | A specialized factory repair service with only factory approved parts. |
| Susceptibility to Siltation and Ice Damage | | Susceptible to silt damage and ice pressure. | Pump can be raised up and silt or debris removed. Raise up if ice expected form. |
| Operating skill required by city personnel | | Must become familiar with pump and lubrication system and inherent problem areas. | Familar with this type of pump used extensively in municipal sewage systems. |
| Susceptability to poor entrance conditions & hydraulic abnormalities | | H.I. sump data and results of numerous model tests are available. | Performance data not avai[illegible] able sewage applications usually not as critical. |
| Skill required by Contractor in installation | | Care in setting pump baseplace, & flexible coupling to prevent misalignment. | Discharge shoe is large rigid casting with little chance for improper insta[illegible] lation. |
| Operating room space availability | | Normal clearance space around motors and MCC. | Additional space availabl[illegible] in operating mode or poten[illegible] tial reduction superstructure. |
| Operating room environment | | Motor noise and heat make an undesirable prolonged shift (8 hr or greater) | No motor noise or heat in operating room. |
| | | | |

LMV FORM 1 AUG 60 107e

NCS 14
1 JUNE 78 (REPLACES NCO 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE | PAGE 3 OF 3 | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE Design Branch | COMPUTATION Siphonic Discharge | | |
| SUBJECT Energy Savings for Operation | SOURCE DATA Primary calc. | | |
| COMPUTED BY | CHECKED BY | APPROVED BY | |

(a) Hydraulic Data
Average annual block flow rainfall runoff = 3804 ac-ft.
Average station operating time = 8 months
With $16.57 \times 10^7$ c.f. and a 36 cfs station pumping rate,
then pump will be operating = 1277 hrs/yr

(b) Average sewage effluent flow = $4.88 \times 10^7$ c.f.
Sewage effluent pumping hours = 377

(c) Total operating hours = 1654 hrs.

(d) Pump capacity
Without siphonic discharge - 8000 gpm
With siphonic discharge - 14000 gpm (estimated)

(e) Savings in operating costs of electricity
18 cfs and 1654 hrs 124050*.05¢ = $6,202.50
31 cfs and 960 hrs 72029*.05¢ = $3,601.00
$2,601.50

Assume 0% gravity flow or 100% siphonic utilization recovering $2,665.00 savings annually

SERVICE ELECTRICAL CAPACITY

DEVILS LAKE

CREEL BAY PUMPING STATION

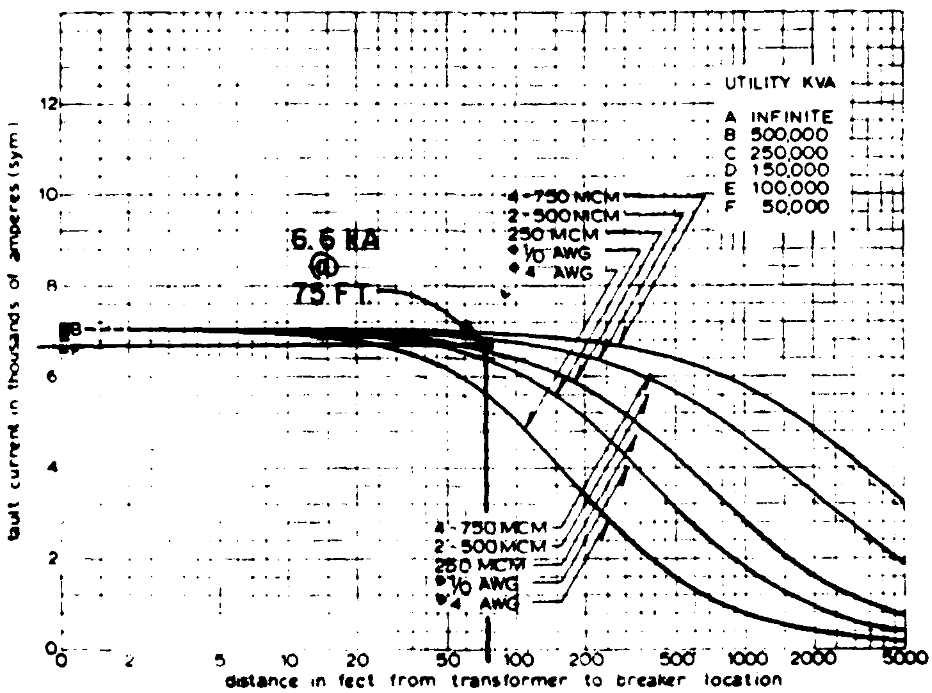
| | | | |
|---|---|---|---|
| 1. Pump Motors | | | |
| 2 motors at 100 HP | | | |
| 2 at 124 Amps at 460 volts | | | 248.0 Amps |
| 2. Unit Heaters | | | |
| 2 heaters at 5 KW | | | |
| 2 at 7.9 Amps at 460 volts | | | 15.7 Amps |
| 3. Gate Hoist, Jib Crane, Sump Pump | | | |
| 3 motors at 3 HP | | | |
| 3 at 4.8 Amps at 460 volts | | | 14.4 Amps |
| 4. Miscellaneous Loads | | 115 Volt | |
| Inside and outside lights - approx 5 KW and siphon breakers. | | 43.5 Amps | |
| Receptacles | | 9.0 Amps | |
| Fan | | 17.3 Amps | |
| | Sum | 69.8 Amps | |
| | Balanced | 34.9 | 17.5 Amps |
| | Subtotal | | 295.6 Amps |
| 5. 25% of Largest Motor (.25 x 124) | | | 31.0 Amps |
| 6. Service Size | | Total | 326.6 Amps |
| | | use | 400.0 Amps |
| 7. Main Circuit Breaker Size | | | |
| Amps subtotal + 250% x F.L.A. largest motor | | | |
| 295.6 + 2.5 (124) | | | 605.6 Amps |
| | | use | 600.0 Amps |

NCS 14
1 JUNE 79 (REPLACES NCD 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE APRIL, 83 | PAGE OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE | | COMPUTATION | |
| SUBJECT CREEL BAY PUMPING STATION | | SOURCE DATA | |
| COMPUTED BY J. KLIETHERMES | CHECKED BY B. NELSON | APPROVED BY | |

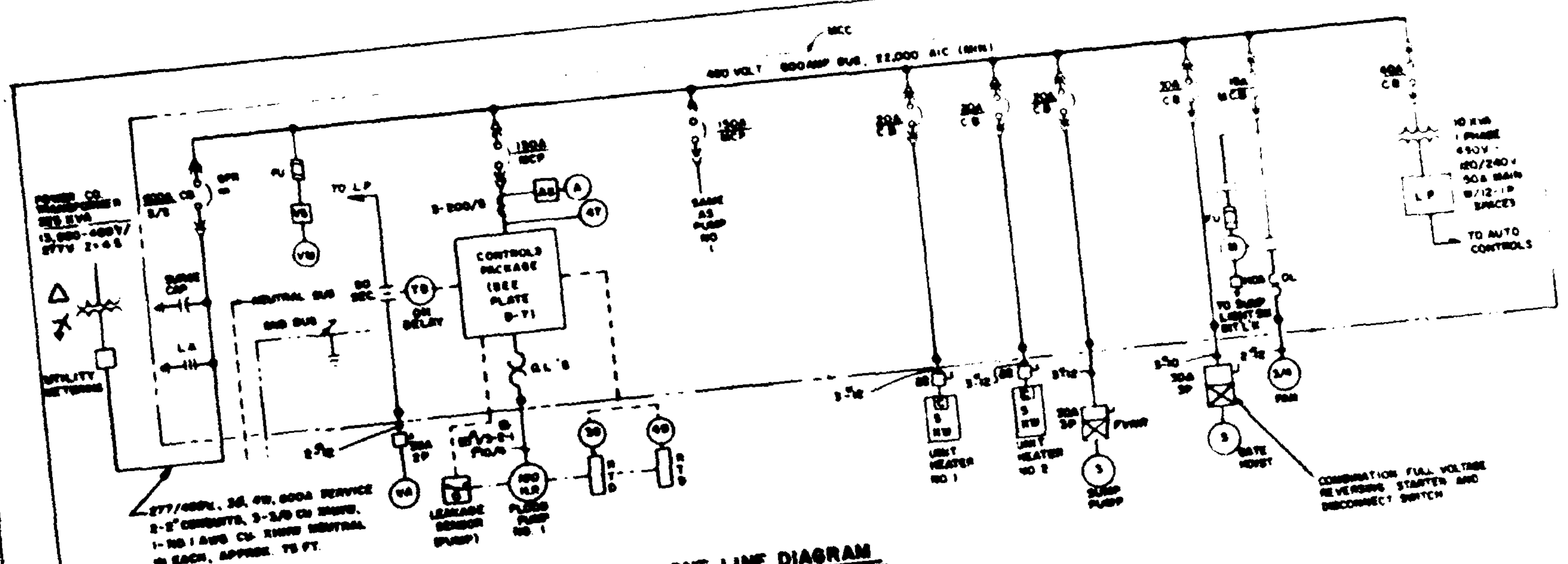
FAULT CALCULATIONS:

1. ASSUME 13.8KV - 277/480 VOLT, 3 PHASE, 225 KVA TRANSFORMER, 4.5 IMPEDANCE.
2. ASSUME INFINITE PRIMARY SOURCE FAULT ENERGY AVAILABLE.
3. ASSUME 75 FT. OF PRIMARY CONDUCTORS FROM TRANSFORMER TO MAIN DISCONNECT.
4. ASSUME TWO RUNS OF 3-3/0 THW. WITH 1-#1 NEUTRAL.
5. SEE GRAPH.



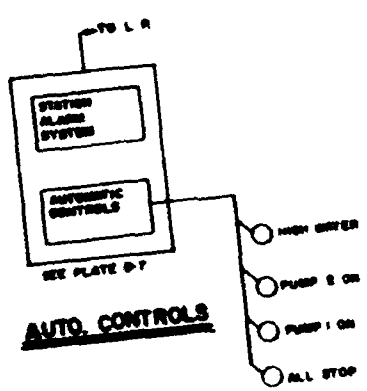
225 KVA TRANSFORMER • 4.5% IMPEDANCE • 480 VOLTS

6. TOTAL SHORT CIRCUIT CURRENT (100% MOTOR CONTRIBUTION INCLUDED) ________ 6,600 AMPS




## ONE LINE DIAGRAM

● SPECIAL CABLE ASSEMBLY




## AUTO. CONTROLS

## ABBREVIATIONS

A AMMETER
AS AMMETER SWITCH
C CONTACTOR
CB CIRCUIT BREAKER
CC CONDENSATION CONTROLLER
CAP CAPACITOR

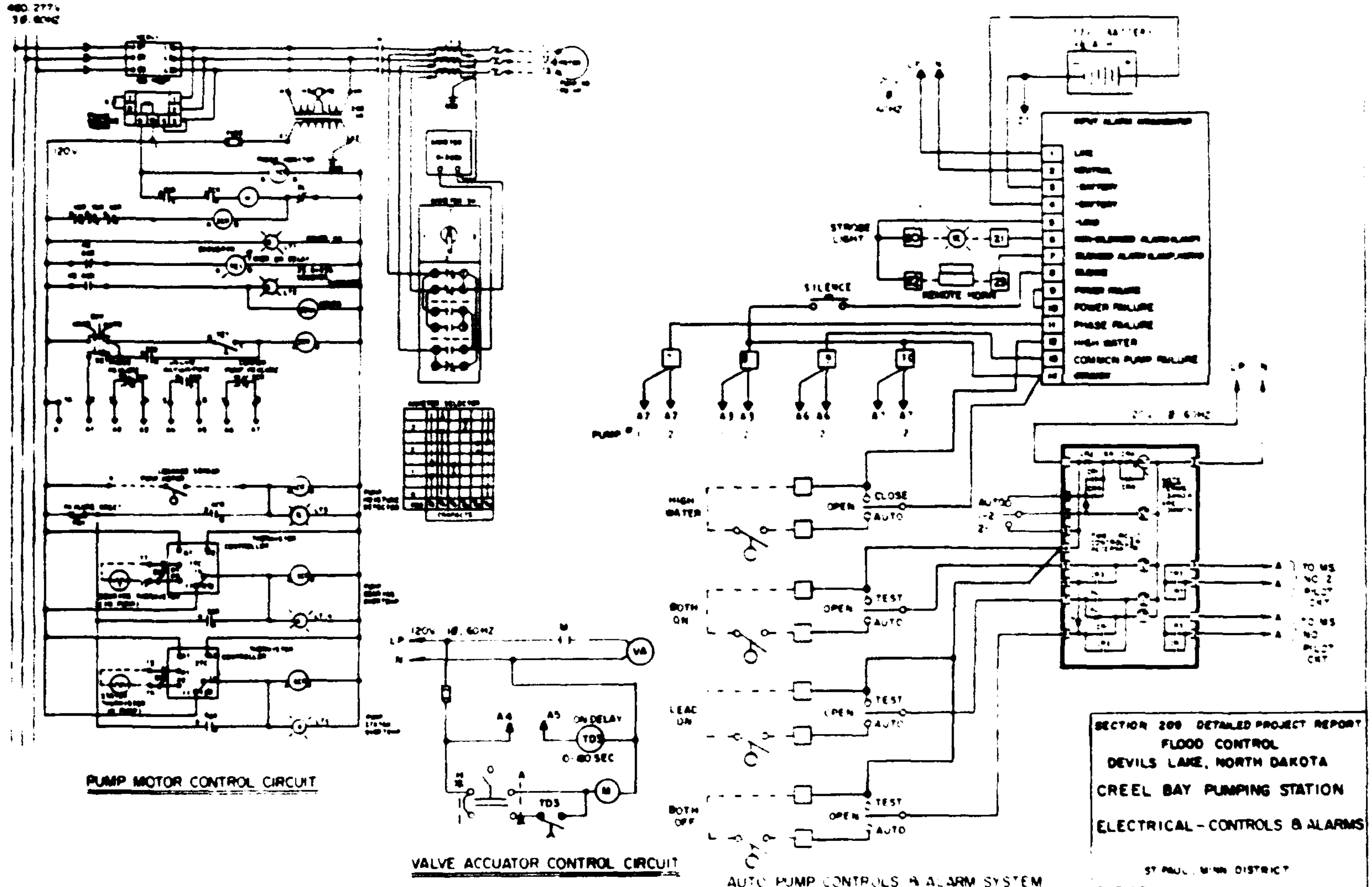
CS CONTROL SWITCH, HOA
CT CURRENT TRANSFORMER
DS DISCONNECT SWITCH
EF EXHAUST FAN
FS FLOAT SWITCH
FU FUSE
G GREEN LIGHT
GC GATE CONTROL
GFR GROUND FAULT RELAY
HOA HAND OFF AUTO SWITCH
LA LIGHTNING ARRESTER
LP LIGHTING PANEL
M STARTER CONTACT/COIL
MCC MOTOR CONTROL CENTER
MCP MOTOR CIRCUIT PROTECTOR

OL OVERLOAD RELAY
PL PUMP LUBRICATOR
R RED LIGHT OR RELAY
RTM RUNNING TIME METER
S SENSOR
AS SS AUTOMATIC SEQUENCER SOLID STATE

T THERMOSTAT
VM VOLT METER
VS VOLT METER SWITCH
DM DAMPER MOTOR
TD TIME DELAY RELAY (ON DELAY)
VA VALVE ACCUATOR (SYPHON BREAKER)
● BEARING TEMP DETECTION
● LOW V & S SEQ PROTECTION
● STATOR TEMP PROTECTION

SECTION 206 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA
CREEL BAY PUMPING STATION
ELECTRICAL ONELINE DIAGRAM
ST PAUL, MINN DISTRICT
FILE NO

PLATE F-6




SECTION 209 DETAILED PROJECT REPORT
FLOOD CONTROL
DEVILS LAKE, NORTH DAKOTA

CREEL BAY PUMPING STATION

ELECTRICAL - CONTROLS & ALARMS

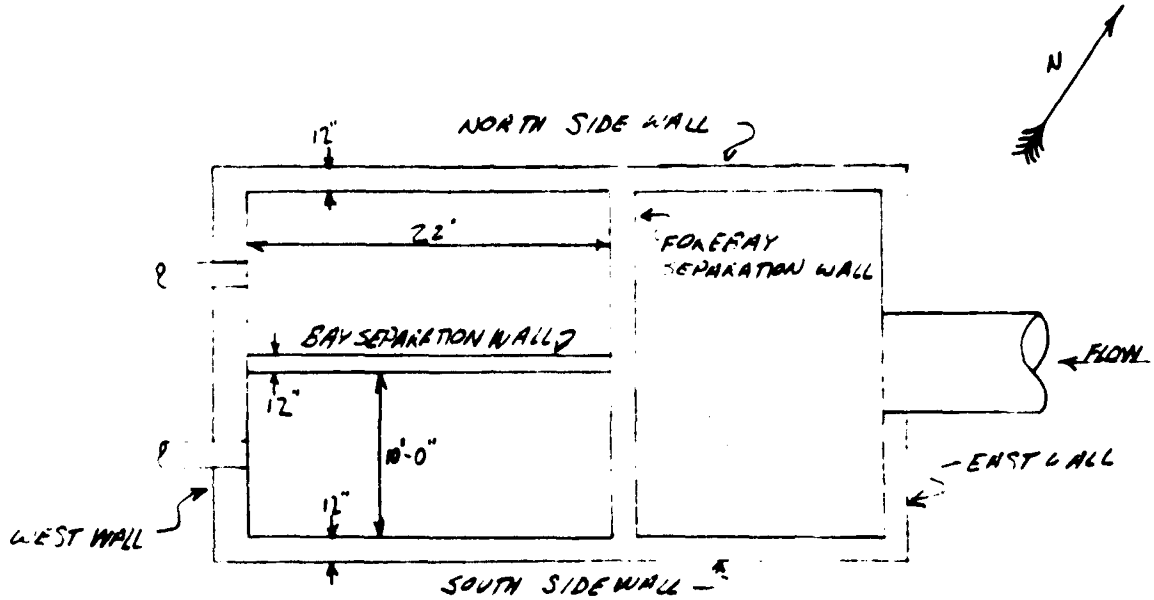
ST. PAUL, MINN. DISTRICT

FILE NO.

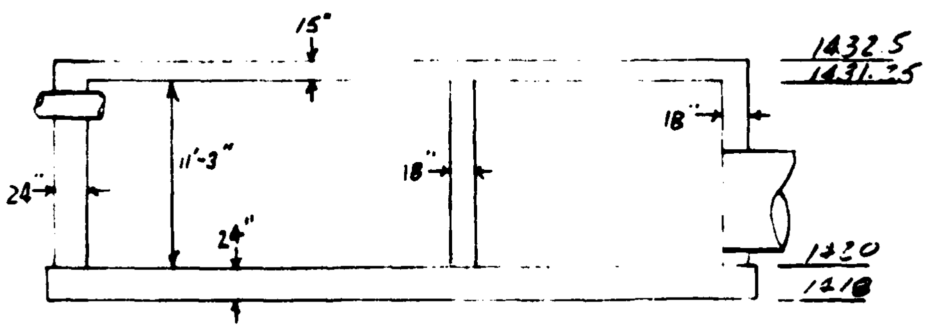
PLATE F-7

NCS 14
1 JUNE 79 (REPLACES NCD 14, 1 APR 63)

| | | | |
|---|---|---|---|
| ST. PAUL DISTRICT COMPUTATION SHEET | DATE May 83 | PAGE 1 OF | FILE NUMBER |
| NAME OF OFFICE STRUCTURAL | | COMPUTATION CREEL BAY PUMPING STATION | |
| SUBJECT DEVILS LAKE N.D | | SOURCE DATA | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |




PLAN




PROFILE

PLATE F-8
SAMPLE CALCULATIONS

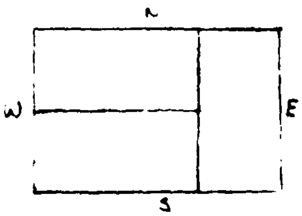
NCS 14
1 JUNE 79 (REPLACES NCS 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE MAY 83 | PAGE 2 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE STRUCTURAL | COMPUTATION CREEL BAY PUMPING STATION | | |
| SUBJECT DESIGN LOAD | SOURCE DATA | | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |

PLATE SIZES / THICKNESS

ASSUME $f_y = 40000$ psi
$f'_c = 3000$ psi
$\gamma_s = 125$ lb/ft³
$\phi = 30°$
$c = 0$ psf

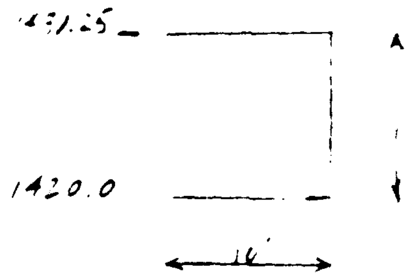
SAY INTAKE WALL FACES EAST



PLAN

USE MONOGRAPH #27 FOR PLATES

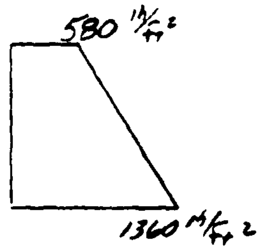
WEST WALL SUBSTRUCTURE

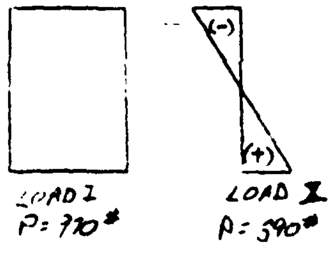



ASSUME 2' SURCHARGE
TOP OF FILL 1437.8

$K_o$ AT REST COEF = 1 - SIN 30°
= 0.50

Choose $\rho = 0.25\,\rho_b = 0.0093$




MONOGRAPH #27 CASE 5 FIXED FOUR SIDES
LOAD I p.40 LOAD II p.41

LOAD I $a = 10$ $b = 11.25$ $a/b = 0.89$ use $a/b = 7/8$
LOAD II SAME

SHEAR MAX $770(10)(0.4576) + 390(10)(0.2250) = 5287\#$

PLATE F-8
SAMPLE CALCULATIONS
(CONT.)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE May 85 | PAGE 3 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE STRUCTURAL | COMPUTATION CREEL BAY PUMPING STATION | | |
| SUBJECT DEVILS LAKE N.D | SOURCE DATA | | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |

(CONT.)

SHEAR MAX WEST WALL 5300 lb @ center of bottom edge

$V_c = 2\sqrt{f_c'}\, b\, d$

$d = \frac{[5300(1.9)]}{2\sqrt{3000}\,(12)} = \frac{5300(1.9)}{109.5\,(12)} = 7.7''$ required d for shear

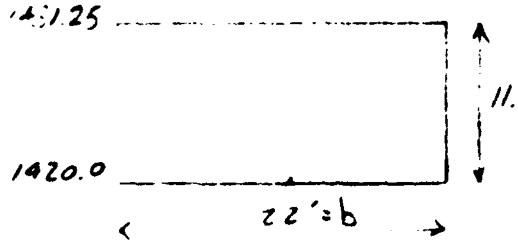
MOMENT MAX

$979(10)^2(.053) + 390(10)^2(.0181) = 5847$ k-ft
@ center of bottom edge

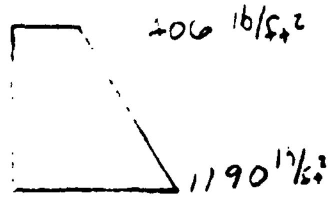
FACTOR 1.9(5850) = 11115 ft.k find min. d

$d^2 = \frac{11115\,(12)}{0.9(12)(0.0093)(40)(1-\frac{1}{2}(.0093)(15.69))} = 35.8\,in^2$ $\therefore$ d min = 6" for bending

SIDE WALL SUBSTRUCTURE




TOP OF FILL SLOPES FROM 1437 TO 1435
USE 1437 AS TOP OF FILL
USE 2' SURCHARGE




MONOGRAPH 27
CASE 5 FIXED FOR SIDES

LOAD I p.40 $a/b = \frac{11.25}{22} = 0.51$ P = 798# LOAD II p.42 $a/b = 0.51$ P = 392#

SHEAR MAX 798(11.25)(0.5142) + 392(11.25)(0.1991) = 5495 [illegible]/ft
@ center of bottom edge

$d = \frac{5495\,(1.9)}{109.5\,(12)} = 7.95''$ required d for shear

**PLATE F-8**

**SAMPLE CALCULATIONS**

**(CONT.)**

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE JULY 83 | PAGE 4 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE | | COMPUTATION | |
| SUBJECT | | SOURCE DATA | |
| COMPUTED BY | CHECKED BY GME | APPROVED BY | |

MOMENT MAX SIDE WALL

$$798(11.25)^2(-0.0195)+392(11.25)^2(-0.0160) = 9025 \text{ ft-k}$$

@ CENTER OF BOTTOM EDGE

FACTORED MOMENT 1.9(9025) = 17150 ft-k

$$d^2 = \frac{17150(12)}{0.9(12)(0.0093)(40000)(1-\frac{1}{2}(0.0093)(15.69))} = 55.26 \text{ in}^2$$

$d = 7.4''$ required for bending

SIDEWALLS ARE MOST CRITICAL SECTIONS FOR BENDING AND SHEAR.

SINCE WALLS WILL PROBABLY BE DESIGNED FOR CONSTRUCTABILITY AND SERVICABILITY CHECK SIDEWALLS FOR <u>VERY UNLIKELY</u> HYDROSTATIC LOADING. (SITE CONDITIONS VIRTUALLY ELIMINATE ANY HYDROSTATIC LOADS)

PLATE F-8

SAMPLE CALCULATIONS

(CONT.)

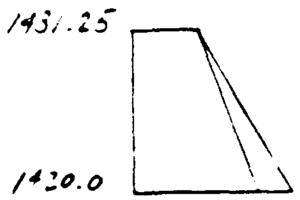
NCS 14
1 JUNE 70 (REPLACES NCS 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE JULY 83 | PAGE 4.1 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE | COMPUTATION | | |
| SUBJECT | SOURCE DATA | | |
| COMPUTED BY | CHECKED BY GME | APPROVED BY | |

CHECK WALL SIZE FOR HYDROSTATIC LOAD TO TOP OF STATION SLAB. i.e WATER ABOUT TO FLOOD EMPTY SUMP.

CHECK FOR CRITICAL CASE

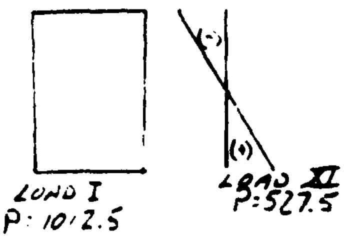
SIDEWALL




$6.5(K_o)(125) + 1.25(62.5) = 295^{\#}$

$11.25[(125-62.5)(K_o)] + 11.25(62.5) + 295 = 1540^{\#}$

CASE 5




SHEAR MAX $1012.5(11.25)(0.5142) + 527.5(11.25)(0.1991) = 7038^{\#}/ft$
@ CENTER OF BOTTOM EDGE

$d = \dfrac{7038(1.9)}{1095(12)} = 12.2$ in required for shear

MOMENT MAX $1012.5(11.25)^2(0.0815) + 527.5(11.25)^2(0.0160) = 11512$ ft-k

$1.9(11512) = 21873$ ft-k @ CENTER OF BOTTOM EDGE

$d^2 = \dfrac{21873(12)}{0.9(12)(0.0093)(40000)(1-\frac{1}{2}(0.0093)(15.6))} = 70.5\text{ in}^2 \therefore d = 9.4''$ required for bending

ONLY SMALL INCREASE IN SECTION DEPTH

PLATE F-8

SAMPLE CALCULATIONS

(CONT.)

NCS 14
1 JUNE 79 (REPLACES NCO 14, 1 APR 68)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE JULY 83 | PAGE 4.2 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE | COMPUTATION | | |
| SUBJECT | SOURCE DATA | | |
| COMPUTED BY | CHECKED BY GME | APPROVED BY | |

BENDING AND SHEAR REQUIRE RELATIVELY SMALL SECTION DEPTHS. THESE WALLS WILL BE DESIGNED FOR CONSTRUCTABILITY AND SERVICABILITY.

WALL SIZES

WEST WALL

SUPERSTRUCTURE SUPPORTS WALL MOUNTED JIB CRANE

USE 24" WALL THICKNESS

∴ SUBSTRUCTURE ALSO HAS 24" SECTION

ALL OTHER SUBSTRUCTURE EXTERIOR WALLS SHALL BE 18"

BAY SEPARATION WALL 12"

FOREBAY SEPARATION WALL 18"

NCS 14
1 JUNE 78 (REPLACES NCD 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE MAY 83 | PAGE 5 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE STRUCTURAL | COMPUTATION CREEL BAY PUMPING STATION | | |
| SUBJECT DEVILS LAKE N.D | SOURCE DATA | | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |

ESTIMATE WEIGHT OF PUMPING STATION

CONCRETE

SUBSTRUCTURE

BASE SLAB

$150(43)(25)(2) =$ 322500

TOP SLAB

$150(43)(25)(1.25)(0.90) =$ 177190

(ASSUME 10% HATCH OPENINGS

WEST WALL

$150(24)(11.25)(2) =$ 81000

SIDE WALLS (2)

$150(37.5)(11.25)(1.5)(2)$ 194475

BAY SEPARATION WALL

$150(22)(11.25)(1) =$ 37125

FOREBAY SEPARATION WALL

$150[(21)(11.25)(1.5) - 2(4)(5)(1.5)] =$ 44156

EAST WALL

$150[(21)(11.25)(1.5) - \pi(3.57)^2] =$ 47150

SUBSTRUCTURE TOTAL WEIGHT 903600

PLATE F-8

SAMPLE CALCULATIONS

(CONT.)

NCD 14
1 JUNE 79 (REPLACES NCD 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE MAY 83 | PAGE 6 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE STRUCTURAL | COMPUTATION CREEL BAY PUMPING STATION | | |
| SUBJECT DEVILS LAKE N.D | SOURCE DATA | | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |

EARTH WEIGHT

$.125[(2)(43)+2(25)]\frac{1}{2}(12.5) =$ 106250

SUPERSTRUCTURE ESTIMATE 200000

PUMP & EQUIPMENT ESTIMATE 21000

TOTAL DEAD WEIGHT 1,230850

CHECK BEARING CAPACITY

ASSUME WATER TO EL 1432.5

ASSUME TOP SLAB LIVE LOAD 150 psf

WATER WEIGHT

$62.5(27)(21)(11.25) =$ 474610

TOP SLAB LOAD

$150(27)(21) =$ 85050

DEAD WEIGHT 1230850

TOTAL STRUCTURE BEARING 1790510

AVERAGE BEARING PRESSURE $\frac{1790510}{25(43)} = 1665$ psf

1665 < 3000 OK

PLATE F-8

SAMPLE CALCULATIONS

(CONT.)

NCS 14
1 JUNE 79 (REPLACES NCD 14, 1 APR 63)

| ST. PAUL DISTRICT COMPUTATION SHEET | DATE MAY 83 | PAGE 7 OF | FILE NUMBER |
|---|---|---|---|
| NAME OF OFFICE STRUCTURAL | COMPUTATION CREEL BAY PUMPING STATION | | |
| SUBJECT DEVILS LAKE N.D | SOURCE DATA | | |
| COMPUTED BY MRF | CHECKED BY GME | APPROVED BY | |

FLOATING CHECK

ASSUME STATION IS DRY

UPLIFT FORCE

1432.5 - 1418 (24)(42)(62.5) = 913500

FACTOR OF SAFETY AGAINST FLOATING

$$\frac{1790510}{913500} = 1.96 > 1.10 \text{ OK}$$

PLATE F-8
SAMPLE CALCULATIONS
(CONT.)

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX G

RECREATIONAL AND CULTURAL RESOURCES INFORMATION

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX G

RECREATIONAL AND CULTURAL RESOURCES INFORMATION

TABLE OF CONTENTS



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DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX G

RECREATIONAL AND CULTURAL RESOURCE INFORMATION

# RECREATION CONCEPTS

## REGIONAL RECREATION ANALYSIS

The project area is within North Dakota Planning Region III, which includes Ramsey, Rolette, Benson, Cavalier, Eddy, and Towner Counties. Devils Lake is the largest city in this region and is the major trade center. The 1980 North Dakota State Comprehensive Outdoor Recreation Plan (SCORP) recognized Devils Lake as the major recreation attraction/resource in Region III. The area immediately surrounding Devils Lake and a group of five small lakes 10 to 15 miles north of Devils Lake have been identified by the North Dakota Parks and Recreation Department[1] as a significant recreation resource area that is being considered for future acquisition and development. The major recreation development constraint associated with the area is the fluctuation of Devils Lake water levels. This problem is most significant during periods of low water when access to and views towards Devils Lake are seriously impaired by exposed mud flats. Additionally, lake water quality deteriorates during low-water periods and could significantly inhibit water recreational use.

Devils Lake is currently a regional all-season recreation attraction. Waterfowl hunting at Devils Lake is a tremendously popular activity and is famous nationwide for its goose-hunting potential. However, a number of recreational activities are more frequently participated in regionally. Table G-1 ranks outdoor recreation activities in Region III for the years 1978, 1980, 1985, 1990, and 1995.[1]

[1]Source: 1980 North Dakota State Comprehensive Outdoor Recreation Plan.

Table G-1 - Ranking of Outdoor Recreation Activities and Mean-Days by Population

| Activity | 1978 | 1980 | 1985 | 1990 | 1995 |
|---|---|---|---|---|---|
| Bicycling | 1 (4.172)[a] | 1 (4.843) | 1 (5.946) | 1 (6.628) | 1 (7.337) |
| Snowmobiling | 2 (3.261) | 2 (3.319) | 3 (3.366) | 3 (3.476) | 3 (3.539) |
| Outdoor Pool Swimming | 3 (2.386) | 3 (2.759) | 2 (3.445) | 2 (3.844) | 2 (4.252) |
| Powerboating/Waterskiing | 4 (1.703) | 4 (1.836) | 4 (2.029) | 4 (2.265) | 4 (2.453) |
| Waterfowl Hunting | 5 (1.493) | 5 (1.447) | 6 (1.580) | 6 (1.629) | 5 (1.688) |
| Fishing | 6 (1.396) | 7 (1.401) | 8 (1.414) | 9 (1.395) | 9 (1.395) |
| Golf | 7 (1.312) | 6 (1.420) | 5 (1.519) | 5 (1.712) | 6 (1.644) |
| Ice Skating | 8 (1.134) | 8 (1.236) | 7 (1.417) | 7 (1.509) | 7 (1.604) |
| Camping | 9 (1.124) | 10 (1.122) | 10 (1.138) | 10 (1.143) | 10 (1.163) |
| Beach Swimming | 10 (1.088) | 9 (1.177) | 9 (1.324) | 8 (1.434) | 1 (1.531) |
| Sledding | 11 (1.008) | 11 (0.982) | 11 (0.985) | 13 (0.923) | 12 (1.041) |
| Picnicking | 12 (0.918) | 12 (0.931) | 12 (0.946) | 11 (0.960) | 11 (1.046) |
| Ice Fishing | 13 (0.786) | 13 (0.799) | 14 (0.797) | 14 (0.755) | 14 (0.720) |
| Baseball/Softball | 14 (0.643) | 14 (0.738) | 13 (0.873) | 12 (0.934) | 13 (0.834) |
| Nongame Hunting | 15 (0.617) | 15 (0.628) | 15 (0.636) | 15 (0.628) | 15 (0.632) |
| Upland Game Hunting | 16 (0.431) | 16 (0.441) | 17 (0.444) | 18 (0.452) | 20 (0.453) |
| Downhill Skiing | 17 (0.367) | 19 (0.379) | 19 (0.397) | 20 (0.441) | 19 (0.463) |
| Hockey | 18 (0.353) | 18 (0.384) | 18 (0.426) | 17 (0.496) | 17 (0.540) |
| Jogging | 19 (0.325) | 17 (0.386) | 16 (0.464) | 16 (0.544) | 16 (0.608) |
| Big Game Hunting | 20 (0.324) | 21 (0.327) | 21 (0.327) | 21 (0.315) | 21 (0.310) |
| Tennis | 21 (0.308) | 20 (0.342) | 20 (0.386) | 19 (0.451) | 18 (0.494) |
| Cross-Country Skiing | 22 (0.225) | 22 (0.242) | 22 (0.262) | 22 (0.284) | 22 (0.301) |
| Visiting Historical Places | 23 (0.222) | 23 (0.223) | 23 (0.215) | 23 (0.211) | 23 (0.210) |
| Horseback Riding | 24 (0.109) | 24 (0.104) | 24 (0.100) | 24 (0.096) | 24 (0.094) |
| Sailing | 25 (0.080) | 25 (0.081) | 25 (0.081) | 25 (0.082) | 25 (0.083) |
| Horseshoes | 26 (0.037) | 27 (0.041) | 27 (0.044) | 27 (0.048) | 27 (0.027) |
| Canoeing | 27 (0.035) | 26 (0.042) | 26 (0.054) | 26 (0.058) | 26 (0.065) |
| Hiking | 28 (0.019) | 28 (0.020) | 28 (0.020) | 28 (0.020) | 28 (0.021) |
| Trapshooting | 29 (0.013) | 29 (0.013) | 29 (0.013) | 29 (0.013) | 29 (0.013) |
| Archery | b b | b b | b b | b b | b b |
| Soccer | b b | b b | b b | b b | b b |

a Numbers in parentheses indicate popularity of activity.

b No participation occurred in the base year; therefore, no projections could be made.

## LOCAL RECREATION ANALYSIS

As previously noted, Devils Lake is the major recreation resource in Region III, and the city of Devils Lake is the largest community in Region III. Obviously, the presence of a major recreational resource immediately adjacent to the major regional population center creates tremendous local and regional recreational demand and need for recreational facilities. There are a number of local public existing and proposed facilities in the area of the city of Devils Lake. Table G-2 identifies these parklands and the facilities and services they offer.

With the population base in and around Devils Lake increasing, and participation increasing for key activities such as trail use, power-boating, fishing, ice skating, baseball/softball, tennis, picnicking, there is a need for additional recreation facilities.

## POTENTIAL RECREATION DEVELOPMENT ASSOCIATED WITH THE PROJECT

The project's proximity to the existing Lakewood and Roosevelt Parks creates potentials for connecting public lands into a regional park and/or linear trail/corridor. Recreational facilities which might be incorporated into the basic project include:

1. Nature interpretive facilities
2. Bicycle trails/paths
3. Picnicking facilities
4. Fitness trails
5. Field sports
6. Support facilities for above items (e.g., toilets)

## RECREATION COST-SHARING REQUIREMENTS

For projects such as this small local flood control project (Section 205) Corps policy (based upon Public Law 89-72) authorizes the implementation of recreation development if the following general conditions are met:

Table G-2 - Parklands and Facilities

I. DEVELOPED PARK BOARD PROPERTY

A. LAKEWOOD PARK

1. Facilities and Services

a. Camping

(1) 25 beach sites - no electrical hookups

(2) 75 park sites - no electrical hookups

(3) Water - two wells

b. Swimming

(1) Sandy beach area

c. Boating and Fishing

(1) Three wooden boat docks

(2) Three boat ramps

(3) Fish cleaning house

(4) Boatyard - leased from Park Board ar operated by private party

(a) Fishing supplies

(b) Rentals

(c) Lift space

(d) Concession

B. ROOSEVELT PARK

1. Facilities and Services

a. Outdoor pool

(1) Olympic, intermediate and wading sized pools

(2) Dressing rooms

b. Winter sports building

(1) Artificial ice during winter months

(2) Available for rent

(3) Concession

c. Two comfort stations

d. Picnic area - daytime only

(1) Playground equipment

(2) Picnic shelter

(3) Five softball diamonds

(4) Two tennis courts

(5) One volleyball/basketball court

C. ODD FELLOWS PARK

1. Facilities and Services

a. Pond - used for ice skating during the winter months. The area is lighted.

II. UNDEVELOPED PARK BOARD PROPERTY

A. SWEETWATER PARK

1. Exists as a slough

B. RUGER PARK - see section III

III. PROPOSED PARKS OWNED BY THE PARK BOARD

A. RUGER PARK

1. Facilities and Services Proposed

a. Nine hole golf course w/driving range

b. Picnic and playground area

c. Amphitheater

d. Softball complex

e. Ball courts

2. Drainage ditch w/two dams severs this property

B. SCHROEDER LAND

1. Facilities and Services Proposed

a. Overnight and daytime camping

b. Boating facilities

c. Fishing facilities

d. Swimming

e. Picnic/playground area

IV. OTHER RECREATION AREAS

A. ZIEBACH'S RECREATION AREA - under the direction of Tri-County Park Board (Ramsey, Nelson & Benson)

1. Facilities and Services

a. Overnight and daytime camping w/electrical hookups, water and showers

b. Boating facilities

c. Fishing facilities

d. Picnic grounds/playground equipment

B. EAST BAY RECREATION AREA

1. Facilities and Services

a. Picnic area

b. Overnight and daytime camping w/electric hookups and water

c. Information/concession office

d. The shoreline is too shallow for boating but may be used for swimming

C. SIX MILE BAY

1. Services

a. Boat launching

1. A non-Federal sponsor pays 1/2 the cost of recreation development.
2. A non-Federal sponsor operates, maintains and replaces the recreation development/area.
3. The developed facilities remain open to the public for the life of the project.

The project-related recreational opportunities were discussed with local public officials. Although local officials confirmed the need for these facilities, they did not indicate a firm willingness to participate in these potential recreation features.

## PROJECT BEAUTIFICATION MEASURES

Earthworks and landscape plantings will be incorporated into the basic project to visually buffer project structures as appropriate. Native plant materials will be used, and earthwork will be sensitively implemented to blend the project into the natural environment.

## CULTURAL RESOURCES

Periods of lake level fluctuations or stabilization and the subsequent environmental conditions associated with each change affected the human, faunal, and floral populations that occupied the Devils Lake area prehistorically and historically.

Our understanding of the human occupation of the Devils Lake area from prehistoric to historic times is very limited. The Devils Lake area has probably been occupied by people since Pleistocene or early Holocene times, although most occupational evidence comes from the Middle Woodland period (Steven J. Fox, 1982, Excavations at the Irvin Nelson Site, 32BE208, draft report submitted to the U.S. Fish and Wildlife Service, Denver, Colorado). The excavations at the Irvin Nelson site (32BE208) have yielded data from these later periods.

Two prehistoric occupations are represented at 32BE208. S. Fox (1982) states:

The earliest cultural materials from this site are of Middle Woodland cultural ascription and suggest a seasonal big game, bison, hunting focus. The Late Woodland cultural level also contained evidence of a seasonal food procurement pattern; however, these data indicate that a wider range of seasonally available resources were exploited. Especially noteworthy is the fact that the Late Woodland inhabitants of the site made but minimal use of the bison. Both Woodland components exhibit technologies containing lithic, ceramic, and bone artifacts. Local materials were widely used in stone tool manufacture.

Knowledge of the adaptations and settlement patterns of prehistoric human groups in the Devils Lake area is just beginning to be acquired. It is evident that future research into the prehistoric occupations and seasonal use patterns of the Devils Lake area will further knowledge of changes in lake levels and environmental conditions over time, and increase our understanding of peoples' adaptations to a unique set of environmental conditions.

The history of the Devils Lake area was also affected by the fluctuations in lake levels. Kurt Schweigert (1977, Historic Sites Cultural Resources Inventory in the Devils Lake Region, Central North Dakota Section, Garrison Diversion Unit, North Dakota, submitted to the Bureau of Reclamation, Billings, Montana) briefly summed up the effects with the following statement:

> The fluctuations of Devils Lake in historic times has had a large effect on the economy and settlement of the region. When the area to the north of the lake was surveyed prior to being officially opened for homesteading in 1883, Devils Lake was a series of four connected bays twenty-four miles long and up to seven miles wide. Water up to 35 feet deep covered an estimated 60,000 acres, and was surrounded by 180 miles of shoreline (Simpson 1912:140). The lake was extensive and deep enough to support a thriving steamboat operation, and several townsites were specifically located to front on the lakeshore. Between 1880 and 1910 the lake level declined about 12 feet, and commercial navigation of the lake was no

longer possible. By 1940 the lake consisted of two or three isolated pools no more than three feet deep, surrounded by sterile alkaline flats. The salinity and brackishness of the lake increased as the lake receded, and by 1932 the bathing beaches were closed at the major resort on the lake (Babcock 1952:21, 96, 104, 142). Dessication of the lake also led to the decline of the area as a waterfowl hunting resort, an industry which plays a considerable part in the local economy.

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX E

PUBLIC VIEWS

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX E

PUBLIC VIEWS

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DEVILS LAKE BASIN JOINT WATER MANAGEMENT BOARD

BOX 651

Devils Lake, ND 58301

October 3, 1979

Col. William W. Badger, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Dear Colonel:

A poll of the directors of the Devils Lake Basin Joint Water Management Board approved the procedures recommended at the basin task force meeting September 25 to proceed with a study to alleviate the high water problems caused by record runoffs into Devils Lake.

The board realizes that we must call on the combined expertise of the Corps of Engineers and Water Commission, plus possible other agencies, to solve the problem.

The board asked me to request your cooperation in the study and please consider this our formal request.

The Water Commission also is being asked to assist in the study. We propose calling your engineers, Water Commission representatives and possibly others to an early meeting to map a course of action.

As suggested by you, we may be asking help both to meet any emergency that may arise next spring and to proceed for assistance under your small projects program.

Please advise me if this is acceptable. We are anxious to attack the problem soon to be prepared for any situation that might arise from next spring's runoff.

The board also asked me to extend our thanks for your participation in the task force meeting and the valuable advice you offered.

Sincerely,

Charon Johnson, Chairman
Devils Lake Basin Joint
Water Management Board

[illegible]

Section 205 Flood Control Study, Devils Lake, North Dakota - Devils Lake Basin Joint Water Management Board and Task Force Meeting

Memo for Record

Planning Branch
Engineering Division

6 May 1980
Mr. Forsberg/tb-[illegible]

1. Subject meeting was held in Devils Lake on 29 April 1980. The meeting agenda, attendance list, and the minutes recorded by the Board secretary are inclosed.

2. After a review of the minutes from the previous meeting and a presentation on the water quality of Devils Lake, Mr. Russ Dushinske introduced me. Mr. Dushinske requested that I give a brief review of the conclusions of the reconnaissance report and discuss the status and schedule for the Section 205 detailed project report.

3. I stated that the Corps had conducted the reconnaissance study in response to a 3 October 1979 letter from the Devils Lake Basin Joint Water Management Board. The report addresses the problems stemming from the continuing rise in the water level of Devils Lake. The study examined seven alternative plans for stabilizing the water level of the lake and one plan for providing flood protection for the city of Devils Lake if the water level continues to rise. The study concluded that it is potentially feasible to meet the short-term need for protecting the city by raising about 2.5 miles of road near the head of Creel Bay (Landfill Road) and providing interior drainage facilities. It also concluded that development of a long-term plan to prevent major damages if the lake continues to rise was desirable.

4. The study recommended preparation of a detailed study of measures for meeting the short-term need of protecting the city from rising lake levels. We have received funds for this study, and it is being initiated. Measures to be studied include raising Landfill Road and providing interior drainage facilities at the head of Creel Bay. I stated that the study will not include development of a long-term plan for stabilizing the level of the lake (such as an outlet plan).

5. I reviewed the main tasks to be done for the DPR (detailed project report) (design, foundations, hydraulics, planning, economics, and environmental resources). I described the main stages of the study (problem identification, plan formulation, draft DPR, final DPR) and presented an approximate schedule for performing the work. I stressed that the schedule was approximate and that actual progress would depend on the availability of funds and manpower and the effects of problems which might develop during the course of the study. The schedule calls for completion of problem identification in December 1980, plan formulation in March 1981, the draft DPR in May 1981, the final DPR in August 1981, and construction during the 1982 construction season. Mr. John Olson, consulting engineer for the city, and Mr. David Sprynczynatyk, North Dakota State Water Commission, expressed concern about this schedule. They said that the structural integrity of the dikes for the city sewage lagoons is being threatened by the backwater from Creel Bay, and they believe an expedited schedule is necessary.

AD A147 505 DEVILS LAKE FLOOD CONTROL PROJECT SECTION 205 DETAILED PROJECT REPORT(U) CORPS OF ENGINEERS ST PAUL MN ST PAUL DISTRICT OCT 83 5/5

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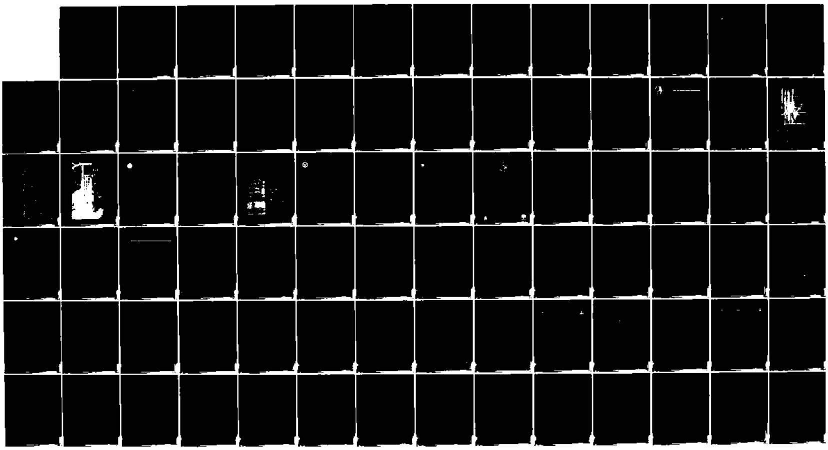

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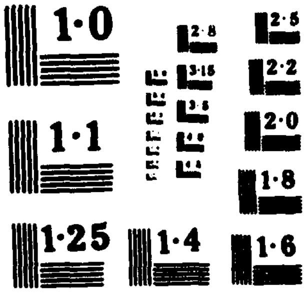
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8 May 1980

6. I stated we would be seeking the following kinds of information from the local community:

a. Maps, topographic information, soil boring data, aerial photos, and other technical data which may be available.

b. Social, environmental, and economic information.

c. Comments and concerns about alternative alignments, dam/dike top elevations, and other items.

Mr. Gordon Berg, North Dakota State Legislator, stated that the study could probably be expedited if this information were provided promptly.

7. I stated that the road raise might have to be designed like a low head dam. If the road were raised to elevation 1445 and the water level rose to 1440, as discussed in the reconnaissance report, failure of the structure could flood considerable residential and commercial property. In addition, if the water rose to this elevation, it could stay there for an extended period. Design criteria for a low head dam are more stringent than those for a dike. This could increase the amount of study effort required.

8. We reviewed the local cooperation requirements as given on page 15 of the reconnaissance report. Mr. Earl DeGroot, Water Quality Planner, North Central Planning, Box 651, Devils Lake, North Dakota (662-8131), stated that he was developing a history of the water quality in Devils Lake and would send us information about historical lake elevations he has collected. One person stated that Dr. Form, physics professor, North Dakota State University, Fargo, has developed a hydrologic model for Devils Lake that might be of use for the study. Mr. Spryncznatyk stated after the meeting that, for planning purposes, the North Dakota Water Commission and Highway Department were assuming that the lake could rise to elevation 1433 - 1437. This elevation defines the lake meander line, and land below this elevation is publicly owned. One person stated the lake was about 6,000 acres in 1940 and is now approaching 60,000 acres. Another person stated the water table was about 100 to 110 feet below the ground surface. I stated that we intend to work closely with State and local interests throughout the study and solicited any concerns and comments they may have as the study progresses.

9. After discussing the Section 205 study, the Board discussed the need for development of a long-term plan for stabilizing the water level of Devils Lake. After a brief discussion, the board passed a resolution requesting the Corps to develop such a plan. Mr. Ruchinske requested that I provide him information about how to request such a study. The meeting proceeded with reports on Channel Coulee, Hurricane Lake, and Ken's Creek and comments on the possible new water management districts.

NCSED-PB 5 May 1980

SUBJECT: Section 205 Flood Control Study, Devils Lake, North Dakota - Devils Lake Basin Joint Water Management Board and Task Force Meeting

10. I had met with Mr. Sharon Johnson and Mr. Russell Dushinske at 2:00 p.m. before the evening meeting. We discussed the reconnaissance report conclusions and toured the Creel Bay area. At 4:00 p.m. the same day I met with Mr. Clay Sorenson, District Engineer for the North Dakota Highway Department, Devils Lake District. Mr. Sorenson stated that Highways 20 and 57 at the "narrows" south of Devils Lake were programmed to be raised in 1981. About 6,000 feet of Highway 20 and 12,000 feet of Highway 57 would be raised to elevation 1440 (1435 plus 5 feet of freeboard).

11. We discussed the section of Highway 20 about 2,000 feet long located about 6,500 feet south of Highway 2. This section of road has a low elevation of 1440.3. If Landfill Road were raised to elevation 1445, water could pass around it by flowing over this section of Highway 20. Mr. Sorenson stated that the department does not have plans for raising this section of Highway 20. He also stated this section of road was not designed to maintain a difference in water elevation across it. The section has a 24-inch reinforced concrete pipe with an invert elevation of 1433.6. Mr. Sorenson expressed a desire to cooperate in the Section 205 study. However, he stated that Highway Department construction funds are probably not available for any road raises except those presently programmed and that planning and design funds are also limited. He requested a copy of the reconnaissance report and suggested two references giving historical lake levels:

a. "On the Postglacial History of the Devils Lake Region, North Dakota," S. Aronow, The Journal of Geology, Volume 65, No. 4, July 1957.

b. "A Study of Physical and Biological Conditions With a View to the Acclimatization of Fish," Department of Commerce, Bureau of Fisheries, Document No. 634, 1908.

12. Photographs of the Landfill Road, Creel Bay, narrows, and Highway 20 areas are retained in Planning Branch.

3 Incl
as

ALAN TORSBERG
Civil Engineer
Planning Branch
Engineering Division

CF:
ED-HP/Stan Kumpula
ED-HP/Maurice Bowers
ED-HP/Bud Johnson
ED-HA/Robbin Blackman
ED-D/Mike Meachen

3

PUBLIC

Date April 25, 1984

Time 7:00 p.m.

ATTENDANCE SHEET

| Name | Representing | Address | Phone |
|---|---|---|---|
| Mike Sauer | State Health Dept | Bismarck | 224-2154 |
| [illegible] | [illegible] Service | Devils Lake | 662-[illegible] |
| [illegible] | State Water Com | Bismarck | 662-4[illegible] |
| Art LANZ | State Water Bd | Devils Lake | |
| Mike Dwyer | State Water Comm | Bismarck | 224-49[illegible] |
| Leonard Deplazes, Jr. | | York | 583-224[illegible] |
| Leonard Deplazes | | York | 583-2272 |
| Charles Mertens | St. Rep. Dist 15 | Devils Lake, N. Dak | 662-2556 |
| [illegible] | Farmer East Devils Lake | R.3 Devils Lake, Rocheste N.D. | 396-2056 / 395-4452 |
| Paul Deplazes | Farmer | | |
| Dale Frink | State Water Comm. | BISMARCK | 224-2750 |
| [illegible] | [illegible] | Devils Lake | [illegible] |
| Eland Marchus | Water right Pierce | Wolford | 583-2337 |
| Edna Skaar | Hurricane Lake | Rugby No Dak | 776-[illegible] |
| John S Altman | | Rugby | |
| Gordon Brown | Hurricane Lake | York, N. D. | |
| [illegible] | Hurricane Lake | York | 5/1/8[illegible] |
| [illegible] M. Mittal | Hurricane Lake | Leeds | 466-24-9 |
| [illegible] L. Stine | Churchs Ferry | N.C. | 466-285[illegible] |
| Welton Webster | Dist 15 State Rep | Rt. 3 Devils Lake | 662-[illegible] |
| [illegible] Berg | | | |
| Earl De Groot | Noxious Control Planning | " | 662-813[illegible] |
| Alan Forsberg | Corps of Engineers | St. Paul, MN | |

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BOARD MEMBERS

Date April 28, 1980

Purpose

Time 7:00 p.m.

ATTENDANCE SHEET

| NAME | ADDRESS | PHONE |
|---|---|---|
| Bob Garske | Ramsey County | Webster |
| Ross Schroeder | Carrier Co. | Langdon |
| Charles Schroeder | Walsh Co. | Lawton, N. Dak. |
| Marvin | Pierce W.M.B | N. Dak. |
| Ross Rushinski | | |

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H-6

Page 1 of 1 pages.

CENCS-PB

Memo for Record

Section 205 Flood Control Study, Devils Lake, North Dakota - Field Review and Local Coordination Meeting

Planning Branch
Engineering Division

5 August 1980
Mr. Forsberg/th-5991

1. On 30 July 1980, Ms. Suzanne Gaines, Mr. Bob Aufang and I traveled to Devils Lake, North Dakota. The purpose of the trip was to inspect the project area and attend a coordination meeting.

2. During the afternoon of 30 July 1980, Ms. Gaines, Mr. Anfang, and I met briefly with Mr. John Olson, consulting engineer for the city. After this meeting, we visited the city sewage lagoon, dump road and Creel Bay areas and the part of the city that is developed on former lake bed.

3. In the evening, we attended a project coordination meeting with the city administrator; consulting engineer for the city; city commissioners; and representatives from the Devils Lake Basin Joint Water Management Board, Devils Lake Task Force, North Dakota State Game and Fish Department, and the U.S. Fish and Wildlife Service. The attendance list is attached. The purpose of the meeting was to review the status of subject study and discuss the preliminary information that has been developed.

4. Mr. John Olson, consulting engineer for the city, introduced me, and I gave a brief review of the problem. I stated that the Corps had completed a reconnaissance report in response to a 3 October 1979 letter from the Devils Lake Basin Joint Water Management Board. The report addresses the flooding problems associated with the rising water level of Devils Lake. Based on the results of the reconnaissance report, a detailed project report (DPR) is being prepared under the authority of Section 205 of the 1948 Flood Control Act. The DPR is analyzing measures for protecting the city from rising lake levels. The DPR does not include any measures for stabilizing the level of the lake (such as on outlet plan). I then briefly reviewed the study schedule and local cooperation requirements. The study schedule is attached.

5. We discussed the design lake elevation, alternative levee/dam alignments, interior drainage, and other items. I stated that we are attempting to predict future lake levels using hydrologic principles, but that this is a difficult problem. The State is using elevation 1435 as a design elevation for planning purposes, although the North Dakota Highway Department is raising some of the highways affected by the rise in lake levels to elevation 1440. No one in the group had any firm opinions on how high the lake would rise or what the design water elevation should be. However, several people thought that a water surface elevation of 1435 was reasonable because it would be consistent with State planning and would provide for about 10 feet of raise in lake elevation. Some people also expressed the belief that higher lake elevations would result in substantial damages, and that an outlet for the lake should be constructed in order to control this flooding. I stated that an outlet plan might create considerable controversy and is very uncertain.

NCSED-PB 5 August 1980
SUBJECT: Section 205 Flood Control Study, Devils Lake, North Dakota - Field Review and Local Coordination Meeting

6. Since the design water elevation has not yet been determined, we are analyzing protection to both elevations 1435 and 1440. We reviewed alternative alignments for water surface elevations of 1435 (three alternatives) and 1440 (four alternatives). An aerial photo showing the alignments is retained in Planning Branch. Preliminary cost estimates for the earth work, interior drainage, land, engineering, supervision, and inspection have been prepared. I stressed that these estimates were based on the limited amount of available information and are very preliminary. However, they indicate that alternative A-2 is significantly more economical than the other alternatives for elevation 1435. Alternative A-2 is a levee/dam about 1,100 feet long located about 1,200 feet west of Dump Road and running approximately parallel to the road. The preliminary estimates also indicate that the four alternatives for a water surface elevation of 1440 are about $0.6 to $1.5 million more expensive than the alternatives for elevation 1435. They are also about $1 million greater than the Federal cost limitation of $3 million. The alternatives for elevation 1440 are more costly because they require a levee/dam at three locations instead of one.

7. In response to a question, I stated that alternative A-2 could be designed with a 50-foot wide top so it could be efficiently raised 5 feet if needed in the future. (Preliminary cross sections are retained in the Planning Branch.) However, the Corps probably could not raise it in the future because the Section 205 authority states the project must "...be complete in itself and must not obligate the Federal Government to future work..." I stated that a levee/dam constructed to an elevation of 1435 and a top width of 50 feet might be considered "complete in itself" if the local or State interests committed themselves to raising the structure in the future if this proves necessary. It was the consensus of the group that a design water surface elevation of 1435 would be adequate because it would be consistent with State planning, would probably be within the Federal cost limitation, and could be raised if necessary. They did not express concern about the possible need for the local or State interests to commit themselves to raising the structure in the future if necessary.

8. We then discussed the interior drainage problems associated with the project. Because a relatively large area north of the lagoons (including Davis Flats and the airport), part of the storm sewer system for the city, and an area south of the lagoons would drain into the area on the city side of the levee/dam, a large interior drainage system would be required. The least costly system would have some combination of water holding areas and pumps to move the water from the interior drainage over the levee/dam and into the lake. The system would be designed for a 50-year frequency rain and would empty the holding areas in 3 days. Preliminary analysis indicates that a holding area about 5 feet deep with an area of about 150 acres would be required in the Davis Flats area; a holding area about 5 feet deep with an area of about 145 acres would be needed south of the lagoons;

[illegible] 5 [illegible] 1980

SUBJECT: Section 205 Flood Control Study, Devils Lake, [illegible] – Field Review and Local Coordination [illegible]

[illegible] capacity of about [illegible],000 gallons per minute would be needed [illegible] to the city side of the levee/dam. The city would be responsible for [illegible] lands, easements, and rights-of-way necessary for the holding [illegible] structures. I requested that the city [illegible] the availability of [illegible] land for the holding areas so that [illegible] boring and survey information for the holding area dikes could be collected.

9. I stated that, since Alternative [illegible] was the city's preferred alignment and appeared to be the most economical, we would collect boring and survey information on this alternative. [illegible] will also include collection of economic benefit, sociological, and environmental data. The next coordination meeting will be held when additional information has been developed.

10. On 31 July 1980, Messrs. Rob Collins, North Dakota Game and Fish; Steve Brock, U.S. Fish and Wildlife Service; Bob Anfang, Environmental Resources Branch; and I inspected the watershed and structure areas for the project. Ms. Gaines collected social information on 31 July and 1 August 1980. Messrs. Collins, Brock, and Anfang [illegible] no concern about potential direct negative environmental effects from the project. However, Messrs. Collins and Brock stated that landowners in the watershed [illegible] of the project might be induced to drain some wetlands in this area if the city were protected by the project from the effects of this drainage. We reviewed [illegible] area north of Trunk Highway 2 and the Burlington Northern railroad line, and it appears that a passage for water under the railroad tracks and the highway would have to be provided to drain this area. There are no culverts under the tracks and only small 12- to 16-inch culverts under Trunk Highway 2. Messrs. Collins and Brock did not think this area would be drained with or without the project because of the large expense of providing the necessary culverts.

2 Incl
as

ALAN FORSBERG
Civil Engineer
Planning Branch
Engineering Division

CF:
[illegible]/Suzanne Gaines, Bob Anfang
[illegible]/[illegible] Dempsey, [illegible] Pederson,
[illegible] Stachowiak
[illegible]

3

Devils Lake Flood Control Study
Section 205

| Name | Representing |
| --- | --- |
| Kent Cisen | City Administrator, Devils Lake |
| [illegible] | Olson-Kaufman Inc. |
| [illegible] | Devils Basin Joint Bd |
| Robert Haug | Devils Lake CONM |
| J. Olsen | Olson-Kaufman |
| Michael Connor | Devils Lake City Comm |
| Russ Dushinske | D.L. Basin WMB Task Force |
| Suzanne Garcia | Corps of Engrs / Sociologist |
| Robert Anfang | " " / Environmental |
| J K Lyinck | D L Basin Task Force |
| Steven Block | U.S. Fish and Wildlife Service |
| Bob Rollings | N.D. Game & Fish Dept |
| Alan Forsberg | US Corps of Engineers |
| Joe Belford | D.L. City Comm. |

United States Department of the Interior
FISH AND WILDLIFE SERVICE
AREA OFFICE—NORTH DAKOTA
1500 CAPITOL AVENUE
P.O. BOX 1897
BISMARCK, NORTH DAKOTA 58501

MAR 1 0 1981

Mr. Peter A. Fischer
Chief, Engineering Division
Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Fischer:

This responds to your letter of February 23, 1981, related to endangered species in the Devils Lake flood control study area.

I concur with your biological assessment that bald eagles and peregrine falcons will not be adversely affected by the proposed project.

Thank you for your cooperation.

Sincerely yours,

Gilbert E. Key

Gilbert E. Key
Area Manager

# TELEPHONE OR VERBAL CONVERSATION RECORD

For use of this form, see AR 340-15; the proponent agency is The Adjutant General's Office.

DATE: 30 April 1981

SUBJECT OF CONVERSATION: Devils Lake Section 205 Study - North Dakota Highway Raises

**INCOMING CALL**

| PERSON CALLING | ADDRESS | PHONE NUMBER AND EXTENSION |
|---|---|---|
| | | |

| PERSON CALLED | OFFICE | PHONE NUMBER AND EXTENSION |
|---|---|---|
| | | |

**OUTGOING CALL**

| PERSON CALLING | OFFICE | PHONE NUMBER AND EXTENSION |
|---|---|---|
| Alan Forsberg | St. Paul District | 725-5901 |

| PERSON CALLED | ADDRESS | PHONE NUMBER AND EXTENSION |
|---|---|---|
| Clay Someson | North Dakota State Hwy. Dept.<br>P.O. Box 817<br>Devils Lake, N.D. 58301 | 701-662-4082 |

SUMMARY OF CONVERSATION

The State Highway Department is raising several highways in the Devils Lake area because of the rising level of Devils Lake. I inquired about the design elevation they are using, their rationale for choosing it, and the schedule for the road raises. Mr. Someson said the roads are being raised to elevation 1435 plus 5 feet of freeboard. This elevation was based on historical lake elevations (el. 1435 in 1880), the elevation of the meander line (el. 1435), and cost effectiveness considerations. He gave this construction schedule:

| Road | Contract date | Cost |
|---|---|---|
| TH 19 | Completed | \$0.8 M |
| TH 57 (Narrows & Fort Totten) | May 1981 | 4.0 M(1) |
| TH 20 | Sep 1981 | 2.2 M(2) |
| | | \$7.0 M total |

(1) Includes bridge raise at the narrows.
(2) Includes bridge raise at the narrows. Bridge will have a control structure.

CF:
ED-GH/Dempsey
ED-GH/Johnson
✓ED-PB/Workman
ED-D/De LaForest

DA FORM 751, 1 APR 65 — REPLACES EDITION OF 1 FEB 58 WHICH WILL BE USED.

State Historical Society
of north dakota (STATE HISTORICAL BOARD)
NORTH DAKOTA HERITAGE CENTER, BISMARCK, N.D. 58505
TELEPHONE 701-224-2666

April 13, 1982

Ms. Sandy Blaylock
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, MN 55101

Re: Draft Cultural Resources Inventory Report: Devils La F od Control, Ramsey County, North Dakota. (Please refer any futur rrespondence to SHPO File: 82-1(4)1.2).

Dear Ms. Blaylock:

Thank you for providing a copy of the document referenced above to this office for review and comment.

In general, it is the opinion of this office that the report is adequate to document sufficient research and investigation to establish a valid inventory of cultural resources in the proposed construction zone(s). In this respect it appears the report fulfills the requirements of the scope of work. As is commonly the case with draft reports, this one obviously warrants a thorough editing to correct typos, spelling, work usage, etc. There are a few substantive matters that may warrant corrections to text. These are identified in the following section entitled, "Substantive Comments:".

Substantive Comments:

Page 3; paragraph 3; line 5: Suggests that the overviews were completed after the field survey. This is not a particularly serious fault, especially in a survey/inventory of this magnitude (relatively small scale) and in which no physical resources were identified. We make the notation only to point out the discrepancy with the excellent explanation of the purpose and intent of inventory "overview" sections as described on pages 60 and 61.

Page 6-8: Apparently construction of the proposed facilities will not directly, physically damage the cultural resources mentioned. Consideration must also be accorded, however, to potential effects to resources outside of the construction boundaries if construction of the facilities may add to or accelerate endangerment of the resources. For example, consideration should be given to potential effects resulting from water impoundments, inundation, wave wash, erosion, etc. on cultural resources lying between the current lake shore and the proposed facilities.

Page 27, paragraph 3: Relating to examples of McKlean Complex sites in North Dakota. The authors should be aware of recent work in, and findings from North Dakota's "Badlands" areas in order to assure current accuracy of earlier assumptions.

Page 54; paragraph 2: The railroad grade is a cultural resource and should have been recorded as such with site form, map, drawing, photograph(s), etc. Based on the information provided, it is likely that the grade does not bear sufficient integrity to warrant physical preservation. However, the segment discussed may be the only means still available to provide details about the grade's location, design, construction, etc.

Page 60; paragraph 1; lines 14-16: HAS, Inc. has succeeded in its goal to provide a document with value to future research.

Page 60; paragraph 2; lines 4-5: This doesn't seem to agree with information provided at Page 3; paragraph 3; line 5 and Page iii; paragraph 3. (See comment above at Page 3; paragraph 3; line 5.

Page 60; paragraph 2; lines 5-9 and Page 61; paragraph 1; lines 1-3: Excellent statements!

Page 67; paragraph 2; lines 3-4: See comment above at Page 6-8 concerning indirect effects.

Page 69: Agree with investigation results for inventory (right of way) area(s).

Page 70 (Recommendations): Disagree. The St. Paul District needs to be aware of (and consider potential effects to) cultural resources lying outside of the actual construction zone(s).

Please find a representative list of editorial suggestions/questions attached. Please be advised that these comments constitute a technical review of the referenced inventory report only and are not intended to be a definitive SHPO comment on the project. If you have questions about these comments or want to discuss any of the matters identified above, please contact Mr. Walter L. Bailey (701-224-2672) at your convenience.

Sincerely,

James E. Sperry for
State Historic Preservation Officer
(North Dakota)

WLB/je
Attachment

Representative Editorial Suggestions/Questions:

Page iii; paragraph 3: Suggests that the research of the overviews followed the fieldwork. Or should the word, "report" have been inserted after the words, ". . . historical study. . ." on line 3?

Page 4; paragraph 1; line 8: Is the term, ". . . river boat. . . " correct? If so, there should be additional explanation and documentation provided.

Page 4; paragraph 2; line 9: Is the hypothesis that humans didn't occupy the area during all of prehistoric time or only during periods of low water during prehistoric time?

Page 11-12 (continued paragraph): This is very interesting information about the historic land use - vs - water levels in the study area. Thank you for including both the data and the references.

Page 25; paragraph 3; line 2: Should, ". . . lancelot. . ." be lancelate?

Page 26; paragraph 2; line 4: Lake Sakakawea is west (not east) of Devils Lake.

Page 44; paragraph 2; line 3: ". . .Dakota Sioux. . ." is confusing, redundant or mispelled. Choose one name or the other, please.

Page 47; paragraph 4; line 3: What is a, ". . . good. . . " percentage? To the extent possible numerical indicators are preferable to comparative terms such as "good percentage, small groups, large bands" etc.,even if the figures are inexact or include a range (i.e., 150-300).

Page 50; paragraph 3; line 2: The date cited (". . .1897. . .") must be incorrect.

Page 56; paragraph 2; line 2: An, ". . . open. . ." what?

Page 58; paragraph 3; line 4: Should, ". . . team-powered. . . " be steam-powered?

Page 62, paragraph 1; line 10: Insert the words "information on" between, ". . . no" and "potential . . . "

**DISPOSITION FORM**

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| NCSPD-FS | Section 205 Flood Control Study, Devils Lake North Dakota - Coordination Meeting with City Council |

| TO | FROM | DATE | CMT 1 |
|---|---|---|---|
| Memo for Record | NCSPD-FS | 3 Aug 1982<br>Mr. Forsberg/wb/5901 | |

1. On 15 July 1982 a meeting was held in Devils Lake, North Dakota, to review the alternative plans and schedule for subject study. The rising lake level and the potential need for emergency protection measures were also discussed. An outline of my presentation, a copy of the minutes prepared by the city auditor, and the attendance list are attached.

2. After a discussion of the alternative plans, the city commission unanimously supported selection of plan B. The commission is very concerned about the potential for flooding because of the rising lake levels. They strongly support the project and request that we proceed in the most expeditious manner possible. We discussed the local cooperation requirements under the present policy and the possibility that they may be changed. We also discussed the need for a land management plan for the former lakebed area. This plan would be developed by the city with the participation of the State of North Dakota and the Federal Emergency Management Agency. The Corps could provide technical assistance if requested. The purpose of the plan would be to reduce the risk of additional damages if the proposed levee/dam were overtopped. Because of the unusual nature of the problem, we have not been able to develop a stage/probability relationship or estimate the level of protection the project would provide.

3. Colonel Rapp discussed the threat of flooding due to the present high water levels and the 13 July 1982 letter from the the State requesting technical assistance under the authority of P.L. 84-99. He advised that P.L. 84-99 funds would be available only in the event that imminent flooding was substantiated by the National Weather Service or the Corps Water Control Section and it was determined that local and State resources were inadequate to meet the need. He stated there was no imminent threat of flooding sufficient to trigger the P.L. 84-99 operations.

4. Colonel Rapp stated that measures developed after careful consideration of the water resources in the subbasin would be of much greater benefit to the area than measures implemented under emergency conditions.

3 Incl
as

ALAN FORSBERG
Civil Engineer
Flood Plain Management and Small
Projects Branch
Planning Division

DA FORM 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE. *U.S.GPO 1979-0-310-081

SWC North Dakota State Water Commission

GOVERNOR ALLEN I. OLSON
CHAIRMAN

VERNON FAHY
SECRETARY & STATE ENGINEER

December 9, 1982

Mr. Al Forsberg
U.S. Army Engineer District
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

RE: SWC Project #1721

Dear Mr. Forsberg

This letter is to inform you of the status of the floodplain management efforts in Devils Lake, North Dakota.

Late last summer, the City asked the State Water Commission to assist them in developing a floodplain management program. They are interested in doing so in order to protect future development from flood damages and to meet their requirements that are a condition of the Section 205 project. The State Water Commission agreed to provide this assistance.

On November 2, 1982, I met with several Devils Lake city officials to begin discussion on establishing a floodplain management program. The meeting was intended to be a preliminary one - to set out a plan of action and outline what needs to be done. We came to several conclusions:

1. Devils Lake needs to amend its zoning ordinance to meet the minimum standards of the National Flood Insurance Program.

2. In order to be an effective program, Creel Township as well as Devils Lake needs to be involved in floodplain management.

3. We need a good map of the area where elevations below 1440 can be easily identified.

4. A general meeting of governing officials should be held to outline the proposed floodplain management ordinance.

5. A general meeting for the public is needed to inform and to gain input before the final drafting of the ordinance.

As you know, I met again with the City on November 23rd and provided them a draft amendment to their ordinance. This draft has been sent to City Council members. Once we receive the enlarged quad maps from you, I will plan to meet with the City again to formally review the ordinance and incorporate any changes before public meetings are held.

... Boulevard Bismarck North Dakota 58505 ...

That summarizes our activities to date. I will keep you informed on future developments as we progress. Please feel free to call if you have any questions.

Sincerely yours,

Mary Fran Myers
Program Specialist

MFM:dm
cc: Michael Conner
City Administrator
Devils Lake, ND

# DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| NCSPD-FS | Section 205 Flood Control Study, Devils Lake, North Dakota - Coordination Meeting with City Council |

TO Memo for Record FROM NCSPD-FS DATE 13 December 1982 CMT 1

FORSBERG/bq/5901

1. On 23 November 1982 Messrs. Ralph Berger, ED-D; Mike Lesher, ED-GH; Bob Anfang, PD-ER; and I traveled to Devils Lake, North Dakota. The purpose of the trip was to review the study area and meet with the local interests.

2. In the morning we met with two representatives of the U.S. Fish and Wildlife Service, Messrs. Al Ludden, Bismarck office, and David James, Devils Lake Wetland office. We walked along the alignment of the south levee/dam and identified features such as culverts, cattle crossings, and wetlands that will affect the design of the project. The abandoned Burlington Northern railroad embankment has a culvert and cattle crossing which regulate a 65-acre wetland. This wetland lies between the embankment and Trunk Highway (TH) 20, and the U.S. Fish and Wildlife representatives believe it provides very important wildlife habitat. There is also some wetland located on the south side of the embankment in a ditch. It may be difficult to drain an area located south of the railroad embankment and north of the levee/dam. Options identified include:

a. Reverse the flow in the railroad embankment ditch. However, the impact of this action on the wetland north of the embankment would have to be determined.

b. Divert flow to the T.H. 20 ditch.

c. Drain into an existing sewer system. However, the city engineer said there are no sewers in the area.

d. Fill the low area.

e. Allow the water to pond and create additional wetland.

Mr. Berger will review the levee alignment where it crosses T.H. 20 to simplify the design and reduce costs. The south levee could be a road raise or constructed adjacent to the road.

3. Messrs. Ludden and James requested that we consider planting prairie grass species on the structures and borrow area. They said these grasses should be burned once every 3 years to provide the best wildlife habitat. Dave James stated the Fish and Wildlife Service would be willing to do the burning. I said I would request our engineering staff and the local sponsor to consider this plan. Any maintenance agreement would have to be with the local sponsor, but consistent with the operating and maintenance plan the Corps would provide for the project.

4. In the afternoon, we walked most of the alignment for the Creel Bay structure and borrow area. These features would be constructed across open meadow or cultivated land, except for the reach of levee/dam which would cross Creel Bay. No relocation of structures or removal of trees should be required.

5. It did not appear that the levee south of the airport would block the view the residents adjacent to T.H. 19 have of Creel Bay. The landward slope of this levee could be flattened somewhat if these homeowners object to the appearance of the levee. However, this reach of levee is low (about 5 feet high) and should not be too obtrusive. It appears that access roads to the borrow area could be constructed from T.H. 19 on Landfill Road. The present access road immediately south of Creel Bay could probably be upgraded to provide access to the pumping station.

6. Ralph Berger and Bob Anfang have photos taken during the field review.

7. In the evening a meeting was held to discuss the Section 205 project. A copy of the attendance list and the minutes prepared by the city administrator is attached. Some additional items not discussed in these minutes are:

a. I stressed that construction of a project was contingent on approval of the report, availability of funds, and execution of the local cooperation agreement.

b. We would prepare a brief emergency plan in case emergency action was needed next spring. We would also review the economic feasibility of incorporating some recreational features into the plan. When this work was done we would schedule a meeting with local representatives to review it. Messrs. Gordon Berg and Russ Dushinske requested that the study manager for the Devils Lake basin justification study be at one of the next meetings to discuss the basin study.

c. The local representatives did not anticipate any negative aesthetic impacts from the project. They believe the prairie grass and the periodic burning of these grasses would be acceptable.

d. The city has hired a staff city engineer. However, according to the city administrator we are to continue coordinating the project with Mr. John Olson of Olson and Kaufman, Consulting Engineers. Mr. Olson stated about 200,000 $yd^3$ of borrow was available near the south stormwater holding ponds.

e. Mr. T.K. Lydeck requested that we carefully reconsider the proposed wetland between the Creel Bay structure and Landfill Road. He stated this wetland would provide mosquito habitat and that the backwater from the wetland could affect the stability of the sewage lagoon dikes and reduce the flow velocities in the ditches. Based on conversations with John Olson and ED-GH, the backwater probably would not affect the stability of the lagoon dikes. Mike Lesher will review the effects of the backwater on the hydraulic characteristics of the ditches.

f. The pumping station will be designed so the city could install a land-spreading pump for the sewage effluent. The incremental cost of this feature would be a local cost. Mike Lesher has preliminary data on this pump.

g. I stated the pumping station would have sufficient capacity to restore the water storage capacity of the holding ponds within 7 days after a 100-year storm. They thought this was reasonable.

h. I stated that a preliminary review of groundwater effects associated with high lake levels was being prepared. Information collected to date indicates the groundwater problems they are now having would continue and perhaps increase somewhat. The biggest groundwater problem they have now is infiltration into sewerlines. However, these problems should not become substantially greater with higher lake levels because of the type of soils and geology in the area. Mr. Bob Whartman, ED-GH, is preparing a discussion of this effect which will be included in the DPR.

1 Incl
as

ALAN FORSBERG
Civil Engineer
Flood Plain Management and
Small Projects Branch
Planning Division

CF: (w/o incl)
ED-D/R. Berger
ED-GH/M. Bowers
ED-GH/M. Lesher
PD-ER/Bob Anfang

| Name | Representing |
| --- | --- |
| Dennis Riggin | Devils Lake City (mayor) |
| Mary Fran Myers | State Water Comm - Bis |
| Michael Connor | City of Devils Lake |
| [illegible] | Devils Lake - |
| Glenn J. Olson | City of Devils Lake, city office 662-4098; 6602418 home, Engineer |
| Jeff Hauge | NDSDH |
| John Olson | Olson-Kautzman |
| Robert Anfang | Corps of Engineers |
| Michael D. [illegible] | " " " |
| Ralph Berger | " " " |
| Al Forsberg | " " " |
| David A. Sprynczynatyk | North Dakota State Water Commission |
| Gordon Berg | C.D.V. |
| Russ [illegible] | DL Basin Jt. Water Board |
| Dale Frink | North Dakota State Water Commission |

# DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| NCSPD-FS | Section 205 Flood Control Study, Devils Lake, North Dakota - Coordination Meeting |

| TO | FROM | DATE | CMT 1 |
|---|---|---|---|
| Memo for Record | NCSPD-FS | 22 March 1983<br>FORSBERG/bq/5901 | |

1. On 15 March 1983, Messrs. Ed Fick and I traveled to Devils Lake, North Dakota, to meet with local interests.

2. We met with Messrs. John Olson, engineering consultant to the city and Gordon Berg upon arrival in the city. I collected some survey and mapping information from Mr. Olson and briefly discussed the status of both the Section 205 and basin justification studies. We then met with Messrs. Patrie and DeGroot, North Central Planning Council and discussed a coordination contract, the status of two Devils Lake studies and solicited their views on these studies.

3. That evening we met with a group of local people the mayor of Devils Lake has established for coordination of both the Section 205 and basin justification studies. A list of persons attending the meeting and an outline of my presentation to the committee is attached. We discussed the four alternative alignments for the south levee. The group concurred with the selection of "D" because it is about $400,000 less costly and would provide similar protection to the next best alignment. However, one group of houses at elevation 1440 to 1445 would not have freeboard protection with "D," but would with alignments A through C.

4. The committee asked if there would be emergency power for the pumping station. I stated it probably would not be necessary because of the large amount of ponding available, but I would review this question with our Design Branch. I stated the pumping station being designed for the draft report would not have provisions for pumping sanitary water to a landspreading system. The necessary information from the city is not available and to wait for it would delay the report. However, we could incorporate sanitary pumping provisions between the draft and final reports or for plans and specifications. Additional costs due to sanitary pumping facilities would be a local cost.

5. We discussed recreation and beautification features of the project. The committee will consider the desirability of a trail on the main structures from Lakewood Road to the borrow area. I stated that we would design the project without these recreation features but they could be added between the draft and final reports at their request. We discussed cost sharing for recreation features, the uncertain availability of funds, the need to connect to a trail "system," and the need for recreation features to be directly related to the permanent



DA FORM 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.

flood control project. They requested that the borrow area be graded to a uniform well-drained condition (no landscape mounds) and grass and trees be planted.

6. We discussed the emergency cofferdam plan which could be constructed if the lake rises to damaging levels before the Section 205 project could be constructed. The lake is approximately elevation 1427. The watershed storage appears full and the soil saturated. If the lake rises 1 or 2 feet, I believe the emergency cofferdam should be constructed. I recommend that water levels be monitored weekly.

7. John Olson provided me with plans for the watermain which parallels the BNRR tracks and survey data for TH 20 and a culvert near the BNRR tracks and TH 19. I observed water flowing through this culvert and east in a ditch towards Devils lake. The culvert passes through the gravel road about 50 feet east of its intersection with the tracks.

8. In general, the committees appeared to be pleased with the layout of the levee and interior flood control features.

9. Mr. Ed Fick discussed the basin justification study. The committees appeared to be very interested and supportive of the study. There was considerable discussion about water levels, outlets, water quality and study schedules.

2 Incl
as

ALAN T. FORSBERG
Acting Chief, Flood Plain Management and Small Projects Branch
Planning Division

CF: (w/incl)
ED-GH/M. Munter, L. Dempsey
ED-D/C. Spitzack, T. Heyerman
PD-ER/R. Blackman
PD-ES/E. McNally
PD-PF/E. Fick
EM/D. Christenson

March 15, 1983 - City A D.L.

| | |
|---|---|
| Glenn Olson | City of Devils Lake |
| E. W. Hagen | County D.E.S. coord. |
| [illegible] | Devils Lake city |
| [illegible] | City of D. Lake |
| David Regan | Mayors Committee. |
| Parnell J. Thorson | City of D. Lake. |
| Russ Dualeiresche | Mayors comm. |
| Michael Connor | City A D.L. |
| L. Jorgenson | City of D.L. |
| John Olson | Olson-Kaufman |
| Edward Fick | Corps of Engineers |
| AJ Forsberg | " " " |
| Gordon Berg | Mayors comm. |
| JK Lybeck | " " |



Inclosure 1

north dakota
state highway department

ALLEN I. OLSON, GOVERNOR
DUANE R. LIFFRIG, COMMISSIONER
RAY ZINK, CHIEF ENGINEER
Devils Lake, North Dakota 58301

Mr. Alan Forsberg
Department of the Army
St. Paul District Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minn. 55101

Dear Mr. Forsberg:

Enclosed you will find some plan and profile sheets with the grades, vertical curves (in red) and typical ditch sections you requested. The pavement in place is also shown on these profile sheets. The State Highway Department would want the same type surface sections after completion. I have also enclosed a recent bid price listing of materials that will be involved in this project.

On the ND Hwy. 19 crossing you will only have a .75 grade raise and for such a small increase we would hate to have you break up our present surfacing. We would rather have you raise this with a hot bituminous pavement material.

On the Hwy. 20 crossings we are not too happy with alternate #1 due to the design problems you would encounter with our service roads and the adjacent properties. If you do decide on this alternate plan, these problems must be worked out prior to construction. I do not foresee any problems with the other two alternates. We only showed one profile for alternate #2. Alternate #3 can be adjusted to fit by sliding our profile 60' south. You will need 18" C.M.P.'s and flapgates or some other positive shutoffs in our ditch section to maintain drainage.

I hope this answers all your questions, but if you do have any further questions please feel free to call 701-662-4082.

Yours truly,

Harvey L. Nordin, P.E.
Asst. District Engineer

jk

DISPOSITION FORM

For use of this form, see AR 340-15, the proponent agency is TAGCEN.

| REFERENCE OR OFFICE SYMBOL | SUBJECT |
|---|---|
| NCSPD-FS | Devils Lake Section 205 Flood Control Project Coordination Meetings |

TO Memo for Record FROM NCSPD-FS DATE 11 April 1983 CMT 1

FORSBERG/bq/5901

1. During the morning of 5 April 1983, a meeting to coordinate the fish and wildlife aspects of the recommended plan for subject project was held in Bismarck, N.D. The meeting was attended by Messrs. Al Ludden, U.S. Fish & Wildlife Service, Ms. Mary Fran Meyers, NDSWC; and Bob Anfang and Alan Forsberg, Corps of Engineers. This meeting is documented in a 7 April 1983 MFR prepared by Mr. Anfang.

2. During the afternoon of 5 April 1983, a meeting to coordinate the floodplain management plan for subject project was held in Bismarck, N.D. The meeting was attended by Gary Backstad, Dale Frink, NDSWC; A l Ludden, USFWS; Virginia Motoyama, FEMA; and Bob Anfang and Alan Forsberg, Corps. The agenda for the meeting and an outline of my brief presentation are attached.

3. I believe the NDSWC and the city of Devils Lake are making good progress towards developing a floodplain management plan consistent with our 28 February 1983 letter to the NDSWC. The conceptual plan is progressing well. Detailed language defining boundaries and "substantial improvement" of existing properties is still being developed and will be critical to an effective plan. This work is being coordinated with FEMA. Ms. Motoyama believes elevation 1440 could be administratively adopted as equivalent to the 100-year flood. I stressed the importance of no development below the meander line, not "moving" the meander line and regulating Creel and Grand Harbor Townships as well as the city of Devils Lake.

4. Mary Fran Meyer said they would be meeting soon with the city, and requested a copy of the general plan of the Section 205 project.

2 Incl
as

ALAN T. FORSBERG
Acting Chief, Flood Plain Management
and Small Projects Branch
Planning Division

CF:
PD-ER/Bob Anfang
PD-ES/Suzanne Gaines
PD-PF/Bill Spychalla

DA FORM 2496 REPLACES DD FORM 96, WHICH IS OBSOLETE.



U.S. GPO 1979-0-310-981/8129

# City asks for help with lake

By JACK ZALESKI
Journal Managing Editor

The Lake Level Study Committee on Monday night will recommend the Devils Lake City Commission seek a disaster declaration from the state because of the rising water level of Devils Lake.

The committee met Tuesday with North Dakota Director of Emergency Services Ron Anfodt, Bismarck, who outlined criteria required before the U.S. Army Corps of Engineers could come into the area to protect property against the rising water. Anfodt said the Corps presently does not feel the lake is a problem. "It's not a serious threat in the eyes of the Corps," Anfodt said.

Under present rules, the Corps apparently believes level 1428 feet is not high enough to warrant action. The lake level on Tuesday morning was 1427.84 feet and rising. Anfodt said the Corps would not come in until the water level was between the 1428 to 1429-foot elevation.

Because of the Corps reluctance to act on the rising lake, Anfodt said the city has an alternative: seeking a disaster emergency declaration through the state which, if approved, could then bring state help and trigger federal help.

Informed Tuesday night of the city's intention to seek a disaster declaration because of the lake, North Dakota Governor Allen Olson said the State Water Commission has been studying the lake situation for about a year. "We are developing a contingency plan," he said, "and we will be able to react immediately to the request."

Olson said the decision whether or not to grant disaster declaration will be considered giving "great weight to local concerns." He said it is his responsibility to make an initial assessment of the situation, and then possibly bring in federal help, if necessary.

"The state has the National Guard and contingency funds to deal with emergency situations," Olson said. "We are aware of the problems up here and we are concerned and ready to act."

The city commission is expected to approve the disaster declaration request at Monday's regular meeting.

Fence at the UND biological station and Game and Fish Dept. offices on Creel Bay is being covered slowly by the rising waters of Devils Lake. Shoreline property all around the big lake is being inundated by the growing lake. (Journal Photo by Joy Day)

Devils Lake, N.D. Journal Wednesday, April 27, 1983

Devil's Lake, N.D. Journal Wednesday, May 4, 1983

# Lake nears 100-year high

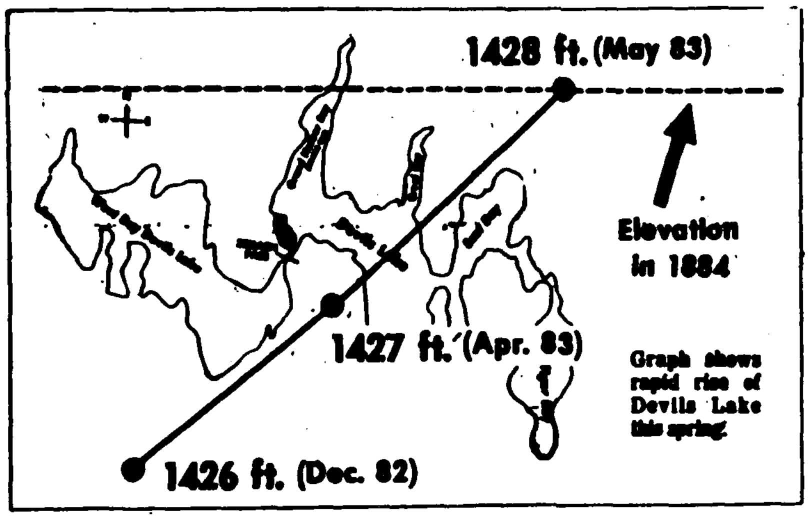
By JACK ZALESKI
Journal Managing Editor

There are people in the region who swear they remember when the water level in Devils Lake was as high as it is today.

They don't, unless they're about 100 years old.

The lake, approaching 1428 feet, was last at that level between 1884 and 1885, according to records from the United States Geological Survey. At that time the water elevation was on its way down from a measured high in 1867 of 1438.4 feet.

Unlike the situation 100 years ago, the lake today is on its way up. Since December of 1982 the lake has climbed more than two feet, rising all through the winter for the first time in decades. The lake today was 1427.92 feet and rising slowly.




Graph shows rapid rise of Devils Lake this spring.

The lake reached an historic low in 1940 when it bottomed out at 1400.9 feet. Since that year, however, the lake has risen in fits and starts — some years up and some years down. But the overall trend for the last 43 years has been upward. The net gain in elevation during that period was about 27 feet. In 1974-75 and 1979-80 the lake registered two of its more spectacular gains, rising four and three feet, respectively. The lake reached a 70-year high elevation of 1425 feet (the projected elevation under the Garrison Project restoration and stabilization plan) in July 1975.

But today's level is unique in the experience of nearly all living area residents, and the consequences of the spreading and rising lake are causing consternation among city officials, property owners, road maintenance agencies, park districts and water managers.

At Lakewood Park on the east shore of Creel Bay, picnic, playground, bathroom and boat-launching facilities are being inundated. During Tuesday's strong westerly winds waves heaped the lake up onto the beach, lapping at the foundations of the main bathhouse on the beach.

At the Ziebach Pass and East Bay recreation areas, which are managed by the Tri-County Park Board, docking areas and beaches have disappeared under the rising water. A spokesman for the parks said it will take "lots of work" to make the areas as usable as they have been in the past.

Private home and cottage owners on the lake shore were beginning this week to talk informally about the danger to their properties from the rising lake. Foundations and sewer systems are threatened. A group of landowners was planning tentatively to meet this week to determine a way to express their concern to appropriate local and state water management agencies.

Meanwhile the city of Devils Lake was moving ahead to secure a disaster emergency declaration from the state because the rising lake directly threatens the city's sewer lagoon system.

The city hopes to secure funding to construct a cofferdam to hold back the lake while a larger, permanent dike is contructed near the old dumpground road south of Highway 19 and the Municipal Airport. The dike would serve to hold the rising lake back from the lagoons.

The bottom of the lagoons, according to Devils Lake Mayor Dennis Riggin, is at the 1427-foot elevation, about a foot lower than the present level of the lake.

Devils Lake, N.D. Journal Wednesday, May 4, 1983

Wind-whipped waters of Creel Bay push against the east shore Tuesday, inundating trees, playground and picnic sites. At extreme left is foundation of the bathhouse at Lakewood Beach. A few more inches of rise and the lake will flood the building. (Journal Photo by Joy Day)

ALLEN I. OLSON
GOVERNOR

# State of North Dakota

EXECUTIVE OFFICE
BISMARCK

May 6, 1983

Colonel Edward C. Rapp
District Engineer
St. Paul Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

Since my letter of March 24, we have been extremely fortunate in that our statewide flooding problems have been reduced to the Devils Lake Basin. The current lake level is about 1428.0 and rising to an anticipated elevation of 1429.0.

As you well know, these levels have already and will continue to present major problems for this area of our state.

State and local governments have initiated several actions to protect property, facilities and resources in the Devils Lake Basin.

Because flooding is already taking place, I have ordered several state agencies to provide me with a plan of action to deal with present and future problems. The extent of these problems, throughout the entire Devils Lake Basin, will severely impact on existing state and local resources.

At this time I believe it is necessary to request specific assistance from the Corps of Engineers to deal with a problem of immediate concern. I ask for you to use authorities under Public Law 99 to begin actions planned under the Corps 205 Project for Devils Lake, which deal with the construction of a cofferdam. In my opinion, this project's completion is critical prior to this fall. Construction of the dam would eliminate undue pressure on the existing temporary dike which now protects the City of Devils Lake sewage lagoon system.

Because of the high water levels, the existing dike is already receiving damage. If this dike should fail, the sewage lagoon system, which is being taxed to capacity, is in serious danger of being severely damaged. Any damage to the existing lagoon system would present a serious public health problem to the people of Devils Lake. I believe the cofferdam is important to protect the sewage lagoon system, the existing dike, and to complement the existing 205 Project as planned. Since the cofferdam construction is part of the Corps project already being developed, funds spent would simply be expended earlier than originally planned.

Colonel Edward C. Rapp
Page 2
May 6, 1983

It would be most helpful if you can speed up the present project and also provide technical and equipment assistance as the situation requires.

As in the past, I ask you to coordinate this assistance through Mr. Ronald D. Affeldt, Director, Division of Disaster Emergency Services.

Thank you for your prompt consideration and assistance in this extremely critical matter.

Sincerely,

Allen I. Olson

ALLEN I. OLSON
Governor

AIO:mh

# Pumping started at 'dike'

By JACK ZALESKI
Journal Managing Editor

Three [illegible] pumps which have a combined capacity [illegible] move nearly [illegible],000 gallons of water per minute [illegible] expected to be in operation today at the old dumpground road west of Devils Lake.

The road has been serving as a dike against the [illegible] waters of Devils Lake. The lake level is nearing the [illegible] foot elevation.

Devils Lake city engineer Glenn Olson said two of the big pumps were started last Friday afternoon and a third was to be put on line later today.

"The purpose of this operation," Olson said, "is to lower the level of the drainage ditch that drains the city's storm [illegible] the Davis flats, the [illegible] lagoons and the drain from the city's [illegible]

[illegible] has flooded [illegible] cells, and the rising lake [illegible] dumpground road is [illegible] the [illegible] from flowing [illegible] into Creel [illegible] the pumps are moving the water over the road into the bay. The road was closed to traffic Friday.

Olson said that since Friday the level in the [illegible] drainage ditch has dropped about two inches. He said he [illegible] the pumps, working 24 hours a day, will be pumping for at least two weeks.

Friday work crews expanded the pad near the pumping site to accommodate three tractors (the pumps are [illegible] operated). Previously the area could hold only one machine.

Two of the pumps are on loan from the U.S Army Corps of Engineers at Baldhill Dam near Valley City and the third is the city's. Olson said the Corps has more pumps at Baldhill should the city have to increase pumping capacity.

The dikes of the lagoon also are eroded in places, Olson said, but not seriously as yet. He said regular dike maintenance is scheduled for this summer. "It's a normal procedure," he said, "and has been planned for some time. Some areas are eroded from wave action and must be repaired."

Olson said that because of the high level of the lagoon cells, they are not operating efficiently. "The level in the cells is substantially above design capacity," he said, "so they are not functioning as well as they would if levels were lower."

The city received permission about a week ago to discharge cell 2 into a holding pond to the west of the lagoon, and currently is waiting for permission to discharge cell 1.

"Once we have permission to discharge No. 1," Olson said, "we can get down to a good operational level and that will decrease the smell problem substantially."

DEPARTMENT OF THE ARMY
ST PAUL DISTRICT, CORPS OF ENGINEERS
1135 U S POST OFFICE & CUSTOM HOUSE
ST PAUL, MINNESOTA 55101

May 11, 1983

REPLY TO
ATTENTION OF:
Emergency Management Division

Honorable Allen I. Olson
Governor of North Dakota
State Capitol
Bismarck, North Dakota 58505

Dear Governor Olson:

I am responding to your May 6, 1983 letter concerning the high water levels in the Devils Lake basin.

We agree with the State and National Weather Service predictions that water levels will rise through June but probably will not exceed 1428.5 feet. The long range forecast for the next month is for below normal rainfall. Given this appraisal, we believe that flood protection for this summer can best be achieved by defending at Landfill Road for lake levels less than 1429. We have provided pumps at Landfill Road and are prepared to provide additional pumps and technical assistance to the city.

Should the lake level exceed 1428.6 because of basin-wide storms with heavy rainfall or a very wet summer, we would reevaluate the situation. If conditions unexpectedly become worse, we could provide additional advance measures under Public Law 84-99. Attached are excerpts from the Federal regulations governing such operations. Additional flood threat and specific evidence of State and local commitment would be required before we could emplace an emergency cofferdam in advance of the Devils Lake 205 project.

A better approach is to accelerate the planning, design, and construction of the Devils Lake 205 project at Creel Bay. We are moving forward to June 83, the publication of the draft report. With approval from the Office, Chief of Engineers and the appropriation of funds, it would be possible to complete the final plans and specifications in time for a fall 1983 award and construction of a cofferdam at the head of Creel Bay. This measure would provide temporary protection to elevation 1433 while the permanent 205 project is under construction. We believe this approach would minimize risk in the most cost effective way.

The cofferdam should be built this fall under less hazardous wave conditions. Putting the cofferdam in now to last two full seasons would cost two to three times more than if we waited until October-November 1983. The lake level prediction does not justify this added cost.

Gcvernor Allen I. Olson

We will be meeting with members of your staff at Bismarck on May 19, 1983. In the meantime, we will continue to coordinate closely with the State and Devils Lake officials on plans to minimize damages in the basin.

Sincerely,

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer

Copy Furnished:
Mr. Ronald D. Affeldt, Disaster Emergency Svcs
Mr. Vern Fahy, ND State Water Commission

United States Department of the Interior
BUREAU OF MINES
P. O. BOX 25086
BUILDING 20, DENVER FEDERAL CENTER
DENVER, COLORADO 80225
Intermountain Field Operations Center

July 19, 1983

Colonel Edward G. Rapp, District Engineer
St. Paul District, Corps of Engineers
ATTN: Planning Division,
Flood Plain Management and Small Projects
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

Bureau of Mines personnel have reviewed the Draft Devils Lake, North Dakota, Flood Control Project Section 205 Detailed Project Report and Environmental Assessment for its treatment of mineral resources in or near the project area.

Our records indicate one sand and gravel operation, in section 34 of T 153 N, R 64 W, within the project area. We suggest that future versions of the report include an inventory of known and potential mineral resources, and a brief discussion of the effects the project may have on them.

Sincerely yours,

Jim Jinks

Jimmie E. Jinks, Acting Chief
Intermountain Field Operations Center

423 Sixth Street P O Box 1048
DEVILS LAKE, NORTH DAKOTA 58301
PHONE 701 662-4098

CITY OF DEVILS LAKE
THE FRIENDLY CITY
NORTH DAKOTA



July 19, 1983

Colonel Edward G. Rapp
District Engineer
U.S. Army Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This is a letter of intent for the Section 205 flood control project at Devils Lake, North Dakota.

We have been involved in planning for the project and have reviewed the draft detailed project report. The city of Devils Lake supports construction of the recommended flood control plan. The city is legally constituted and has the capabilities to satisfy the requirements of local cooperation.

In accordance with Section 221 of Public Law 91-611, approved on December 31, 1970, as amended, the city as local sponsor would agree to:

1. To provide without cost to the United States all lands, easements, and rights-of-way, including ponding and borrow areas, necessary for the construction, operation, and maintenance of the project;

2. To accomplish all alternations and relocations of buildings, streets, and utilities, except for those utilities that are an integral part of project structures;

3. To hold and save the United States free from damages caused by the construction and the subsequent operation and maintenance of the project, except damages due to the fault or negligence of the United States or its contractors;

4. To provide all costs in excess of the $4,000,000 Federal cost limitation;

5. To maintain and operate the project after completion without cost to the United States in accordance with regulations prescribed by the Secretary of the Army;

6. To prevent any encroachment on constructed works and ponding areas that would interfere with the proper functioning of the project; and, if ponding is impaired, to provide promptly and without cost to the United States substitute storage or equivalent pumping capacity;

7. To comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved January 2, 1971, in the acquisition of lands, easements, and rights-of-way necessary for the construction and subsequent maintenance of the project; and to advise affected persons of pertinent procedures, policies, and benefits in connection with this act;

8. To comply with Section 601 of Title VI of the Civil Rights Act of 1964 (Public Law 88-352) and with Department of Defense Directive 5500.11 issued in response to this act and published in Part 300 of Title 32, Code of Federal Regulations, in connection with the construction operation, and maintenance of the projett;

9. Establish and enforce a floodplain management program for the city of Devils Lake and for the portions of Creel and Grand Harbor Townships subject to the zoning authority of the city. It would include the following provisions:

   a. All new development or substantial improvements to existing development within the protected area of this project below elevation 1440 feet msl would be raised or floodproofed to an elevation of 1440 feet.

   b. Annual warnings would be published that all land below the elevation of the natural lake outlet has been inundated in the past and could be again.

   c. All persons proposing new development on or purchasing property lying below the elevation of the natural outlet would also receive this warning.

d. The program would be coordinated with the State and Federal Emergency Management Agency. This coordination would ensure that the program is consistent with State and Federal Floodplain Management Programs.

e. If an outlet for the lake is constructed, the 1440 foot msl regulatory elevation within the protected area of this project would be replaced by a new elevation consistent with Federal Emergency Management Agency and State floodplain management policies.

I understand that these requirements will be included in the final detailed project report and the local cooperation agreement (Section 221 agreement). I also understand the Section 221 agreement would be the written contract between the city and the Corps. Execution of the Section 221 agreement would follow approval of the final detailed project report and precede issuance of construction funds, contingent on the availability of funds. The final project costs would be determined after final payment to the construction contractor is made. The local share of the project costs would then be adjusted to reflect actual rather than estimated costs.

Sincerely,

Dennis L. Riggin, President
Devils Lake City Commission

MJC/pr

United States Department of State

*Washington, D.C. 20520*

July 21, 1983

Colonel Edward G. Rapp
St. Paul District
Corps of Engineers, Department of the Army
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55701

Dear Colonel Rapp:

I refer to your letter of June 27, 1983 concerning the Draft Devils Lake Flood Control Project Section 205 Detailed Project Report and Draft Environmental Assessment.

I note the reference to the Garrison Diversion Unit (page 2-3) and the reported indefinite deferral of development of the Warwick-McVille irrigation area. I further note that Table 1 of the Draft Environmental Assessment (page EA-3) indicates that E.O. 12114 (Environmental Effects Abroad of Major Federal Actions) is "Not applicable."

The related "Finding of No Significant Impact" concludes that an environmental impact statement will not be prepared in connection with this project.

Sincerely,

Tom Wilson
Deputy Director
Office of Environment and Health

cc: DOI - Mr. Sturgill

**DEPARTMENT OF HEALTH & HUMAN SERVICES**

Office of the
Regional Director

Region VIII
Federal Office Building
1961 Stout Street
Denver CO 80294

ROFEC

July 22, 1983

Edward G. Rapp
Colonel, Corps of Engineers
District Engineer
Dept. of the Army
St. Paul District
1135 U. S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

We have reviewed the Draft Devils Lake Flood Control Project, Section 205 Detailed Project Report located at Devils Lake, North Dakota.

We have concluded that the present availability of social services in the impacted area may be adequate. However, should population growth rise drastically in the affected community, additional social services would be required.

We suggest that the North Dakota Department of Human Services be added to the list of agencies from which comments are to be solicited.

Sincerely yours,

E. W. McIntire
Contracting Officer

United States Department of Agriculture
Soil Conservation Service
P. O. Box 1458
Bismarck, ND
58502

July 26, 1983

Colonel Edward G. Rapp
District Engineer
Corps of Engineers/St. Paul District
Department of the Army
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

File Code 190-[illegible]

Dear Colonel Rapp:

The Soil Conservation Service has reviewed the Draft Devils Lake Flood Control Project Section 205 Detailed Project Report and Environmental Assessment. We have the following comments:

1 1. The draft report and assessment briefly address prime farmland. Find attached soil survey sheets and a prime farmland legend for the project area. These attachments can be utilized by plotting the proposed structural measures on them in order to determine approximate acreages of prime farmland that would be affected by the considered alternatives.

2 2. It appears that the selected plan could have numerous changes to existing agricultural systems, land use, land treatment, drainage patterns and private land unit severance. It is suggested that these items be specifically addressed to minimize the adverse impacts of the proposed action.

We appreciate the opportunity to comment.

Sincerely,

J. Michael Nethery
State Conservationist

Attachments

The Soil Conservation Service is an agency of the Department of Agriculture

Corps of Engineers Responses to Soil Conservation Service Comments

1. The impacts on prime farmland were considered in the planning process. The proposed project would affect a maximum of 15 acres of land designated as prime farmland. As stated on page EA-24, the use of prime farmlands for flood control features is considered an acceptable tradeoff and is compatible with the Executive Memorandum on Prime and Unique Farmlands.

2. Impacts on land use, drainage patterns, and other existing resources were evaluated and considered in the planning process. These impacts are described in the detailed project report in the sections on "Alternative Plans" and "Description of the Recommended Plan" and in the environmental assessment in the "Environmental Effects" section.

Department of Energy
Western Area Power Administration
Billings Area Office
P.O. Box EGY
Billings, Montana 59101

JUL 27 1983

In reply refer to B2200, B3000

6450.-

Alan Forsberg
Planning Division
Flood Plain Management and Small Projects
Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St Paul, MN 55101

Subject: Section 205 Detailed Project Report--Flood Control Project at Devils Lake, North Dakota

Dear Mr. Forsberg:

Reiterating your telecon of July 22, 1983, with Bob Jones of my staff, Western Area Power Administration (Western) has two (2) transmission lines crossing the north edge of Creel Bay for which we are investigating various alternatives for improving access for structure maintenance and increasing overwater clearances. Cost estimates are currently being developed for the various alternatives. The alterantives were previously presented in a July 21, 1983, letter to Colonel Edward G. Rapp, District Engineer, St. Paul District, St. Paul, Minnesota.

After recently receiving and reviewing your project report, it appears that if you could move the North Embankment to the southwest, Western could re-route its transmission lines around it on dry land. Enclosed is a machine copy of Figure 10 from your report, marked in red to show the possible relocation of the embankment in relation to Western's transmission lines.

We understand the Corps would consider locating the embankment to accommodate our needs. Would you please develop cost estimates reflecting the costs of constructing the North Embankment in our proposed location? If this plan, compared to our other plans, would reduce our cost, Western could contribute funding towards construction.

Please also furnish us the dates of any public meeting the Corps plans conducting for this project and your proposed construction schedule.

Sincerely,

JAMES D. DAVIES

James D. Davies
Area Manager

Enclosure

cc: Colonel Edward G. Rapp, District Engineer, U. S. Army Corps of Engineers, St. Paul, MN (w/cy of encl)

Corps of Engineers Note: After this letter, the Western Area Power Administration completed their analysis of alternative power line alignments and chose a plan that does not affect the design of the flood control project.

north dakota
state highway department

[illegible] OLSON, GOVERNOR | DUANE R. LIFFRIG, COMMISSIONER | RAY ZINK, CHIEF ENGINEER

Devils Lake, North Dakota 58301

July 29, 1983

District Engineer
St. Paul District, Corps of Engineers
ATTN: Planning Division
1135 US Post Office & Custom House
St. Paul, MN 55101

Re: Section 205 Detailed Project Report
Devils Lake Flood Control Project

I have reviewed the referenced report and concur in general with the proposed project details as they may affect area state highways. I offer the following comments on specific details that should be considered in your final design process.

The portion of the south embankment in the area between ND Highway 20 and the service road does not comply with current department safety standards. We presently require 6:1 slopes on all driveways and ditch blocks that abut on state highways. I would suggest that the north face of the embankment in the immediate area of the highway be flattened to 6:1 (H:V).

I am also concerned with the operational characteristics of the embankment in this same area. Since the top of the embankment will be nearly flush with the surface of ND Highway 20, there may be a tendancy for motorists to use the embankment as a driveway. If it is necessary for the embankment elevation to be nearly the same as the highway grade, I would suggest that the embankment be widened sufficiently to serve as a driveway and the driveways presently located near Sta. 35+00, your survey, be eliminated. If this action is taken, the existing driveway west of the highway at Sta. 35+00 should also be relocated to match conditions on the east side.

In regard to the proposed culvert removal and installation of new culverts on ND Highway 19 near the north ponding area, I believe that project details should allow for settlement of disturbed roadway embankment material and subsequent need for future pavement repairs. It is my experience that it is very difficult to compact disturbed soil adequately in such circumstances in order to avoid all future consolidation. Thus it is normal for some settlement to occur, creating a bump in the highway surface. In order to correct this, I would suggest that project documents assign responsibility for any necessary future maintenance of disturbed roadway areas.

Prior to beginning construction on this project, it will be necessary for my office to process permits authorizing any proposed work within the state highway rights of way. In order to accomplish this, I would appreciate having the opportunity to review the final plans at an early date.

If my office can be of any further assistance in this project, please let me know.

Sincerely,

STATE HIGHWAY DEPARTMENT

Clay F. Sorneson
District Engineer

jk

**Corps of Engineers Note: The St. Paul District will coordinate plans and specifications with the State Highway Department.**

united power association
elk river, minnesota 55330 • phone 612-441-3121

August 5, 1983

Colonel Edward G. Rapp
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

ATTN: Planning Division
Flood Plain Management and Small Projects

Dear Colonel Rapp:

We received the Draft Devils Lake Flood Control Project Section 205 Detailed Project Report and Environmental Assessment on July 11, 1983. As you requested, we have reviewed the document and have the following comments to offer.

The recommended plan (Plan B) involves, in part, the construction of a flood barrier and pumping station at the neck of Creel Bay southwest of Devils Lake. The flood barrier is known as the Creel Bay embankment. United Power Association (UPA) owns and operates a 230 kilovolt high voltage transmission line which presently crosses the area proposed for construction of the Creel Bay embankment. The UPA transmission line is the line depicted in Figure 10 of the subject document crossing the embankment in the area of the proposed pumping station. As best as we can determine from information in the document, the pumping station is proposed to be located in the immediate vicinity of our transmission line. Both the pumping station and the embankment will require modifications of our facilities. Preliminary review by our engineering personnel indicates that a transmission structure and support guys may be necessary on the embankment as well as relocating several other structures in the area. We would, of course, expect to be reimbursed for the costs of these changes, should they become necessary.

We look forward to working closely with your office to effect any changes to our facilities which may be necessary because of the flood control project at Devils Lake. We request that you keep us informed of the progress of the project. Please let us know if we can be of any further assistance.

Sincerely yours,

UNITED POWER ASSOCIATION

Dan McConnon, Manager
Environmental and Lands Division

DM:stp

**Corps of Engineers Note: The St. Paul District will conduct coordination during preparation of plans and specifications to ensure that there is no conflict between the UPA power lines and the main embankment.**

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
Atlanta GA 30333
(404) 452-4257
August 9, 1983

Colonel Edward G. Rapp
District Engineer
Department of the Army
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

Thank you for sending us the Draft Devil's Lake Flood Control Project Section 205 Detailed Project Report and Environmental Assessment (EA). We understand that this report is being processed under an accelerated schedule because of the imminent flood threat at Devil's Lake, North Dakota. We are responding on behalf of the U.S. Public Health Service and are offering the following comments on this EA and the proposed "Finding of No Significant Impact" for your consideration in minimizing any potential public health impacts from the proposed action.

1 We believe the Report and EA should address the potential impacts associated with vectorborne disease or nuisance problems in the area. The design and construction of this project must not *allow any increase in local* vector populations which could cause potential vectorborne disease or nuisance problems. We suggest that both the local and State health departments be contacted for a history of the vectorborne disease and nuisance problems in the area and the steps necessary to mitigate and prevent the occurrence of any potential problems. Special consideration should be given to the effect of the drainage scheme and down-drainage time for storm waters in holding ponds upon vector breeding cycles. We also understand that several wetlands will be *drained and/or modified in terms* of water levels and drainage. While the preservation or creation of wetlands are important national environmental objectives, these objectives need to be and can be compatible with vector control measures to protect public health.

General health guidelines have been developed for water resource projects in the United States to control and prevent vector problems. They were originally published by the Centers *for Disease Control* (CDC) in 1965 and were reprinted without revision by CDC, U.S. Public Health Service, in 1975 in Prevention and Control of Vector Problems Associated with Water Resources. In February 1971, the original CDC guidelines were revised by the U.S. Environmental Protection Agency; these guidelines were reprinted in October 1971 in Health Guidelines for Water and Related Land Resources Planning, Development and Management. Additional information about vectors is discussed in our Mosquitoes of Public Health Importance and Their Control, *Revised 1977*. The CDC documents are available upon written request.

Corps of Engineers Responses to the Public Health Service Comments

1. *The St. Paul District has coordinated with the State Health Department* throughout the development of this proposed project. The Health Department has no problems with implementation of the project. The proposed project should not worsen the vector problem in the project area. Some of the wetlands that would be affected by the project would be maintained at their existing levels and would not fluctuate differently than they do under existing conditions. The wetland areas behind the *Creel Bay embankment, which are created* by high lake levels, would be drained as a result of the project. The total number of wetland acres before and after project construction would remain essentially the same. The interior drainage ponding areas would be drained as rapidly as possible after a storm in order to maintain storage capacity for subsequent storm events.

Page 2 - [illegible]

e appreciate the opportunity to review the Report and EA. Should you have any uestions about our comments, please contact Mr. Robert L. [illegible], Jr., or me at FTS 236-[illegible], or [illegible], respectively.

Sincerely yours,

Frank S. Lisella, Ph.D.
Chief, Environmental Affairs Group
Environmental Health Services Division
Center for Environmental Health

August 12, 1983

Colonel Edward G. Rapp
U.S. Army Corps of Engineers
St. Paul District
1135 U.S. Post Office & Custom House
St. Paul, MN 55101

RE: SWC Project #1712

Dear Colonel Rapp:

I have reviewed the Section 205 Detailed Project Report for the flood control project at Devils Lake, North Dakota. I believe the report provides a good analysis of the flooding problem at Devils Lake and concur with your conclusions on methods to solve that problem. The North Dakota State Water Commission fully supports the report's recommended plan to alleviate the immediate threat of flooding to the City of Devils Lake.

1 In reviewing the report, I noted that on a number of pages reference is made to the impact of the standard project flood. There seems to be a discrepancy between references on some pages saying it would cause a 16 foot rise and on others saying it would cause a 19 foot rise. Also, the report should be consistent and show the low elevation in 1940 being 1401, and the increase in the lake level being about 27 feet in the last 40 years.

2 On page 12, the report states that Channel A carries water which frequently exceeds State standards. If this has actually been recorded, exact reference of the source of the data should be made.

3 On page 32, the report indicates that right-of-way must be purchased above elevation 1430 msl around Stump Lake, if Stump Lake is used for storage. This may not be the case since the State has consistently claimed ownership to the meandered line around the lake, which is above elevation 1430 in some areas.

4 Throughout the report reference is made to the involvement of the State Water Commission in floodplain management. This should be clarified, since it is in fact the North Dakota State Engineer that has regulatory authority for floodplain management. This authority was granted by the State Legislature in 1981.

Corps of Engineers Responses to the State Water Commission

1. As planning progressed, the level of the lake continued to rise, resulting in different impacts and water levels being documented in each planning stage. The final report was revised throughout to show consistent standard project flood impacts and water levels.

2. The source of this information is the Water Monitoring Projects (1977, 1978, and 1979), Special Report Number 3, North Central Planning Council, January 1980.

3. Noted.

4. Noted.

Colonel Rapp
August 12, 1985
Page 2

It is commonly recognized, that the levees proposed by the recommended
plan are a short term solution to the flooding problems. As such, I
strongly believe the floodplain management requirements of the local
government are a very important part of this project. Expenditure of
public tax dollars for flood protection projects cannot be justified
without assurances that future development will not require similar
5 protection. I believe the Corps' requirement for floodplain management
should be clearly stated, since there has been some confusion on this in
the past. I hope the Corps will closely monitor the City's compliance
with the floodplain management provisions of the cooperative agreement
until such time a long term, permanent solution to the problems can be
determined. In line with the seeking of a long term permanent solution,
I believe the Corps should diligently continue to work toward finding
such a solution.

Again, I and the State Water Commission support the Section 205 Flood Control project in Devils Lake. I am well aware of the additional work you and your staff have undertaken to ensure this project is completed in a timely manner.

Sincerely yours,

Vernon Fahy
State Engineer

VF:DAS:HFN:dm
cc: Dennis Riggin, Mayor
Devils Lake, ND

Corps of Engineers Responses to the State Water Commission (Cont.)

5. Concur.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
1860 LINCOLN STREET
DENVER COLORADO 80295 0699

Ref: 3PM-EA

AUG 16 1983

Allen Foresberg
U.S. Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Foresberg:

This letter is to confirm your discussion with Mike Hammer of my office.

The Region VIII office of the Environmental Protection Agency was unable to provide detailed comments on the U.S. Army Corps of Engineers, St. Paul District, Section 205 Flood Control Project, Devils Lake, North Dakota Draft Environmental Assessment during the prescribed comment period. This was due to non-receipt by my office of the document prior to the close of the comment period.

1 In response to your telephone request for comments in order to facilitate your issuance of a Finding of No Signficant Impact, we verbally expressed the following concerns:

1) continued draining of wetland areas in the upper Devils Lake Basin would aggravate the rising lake level, and

2) the implementation of a strong floodplain ordinance in the lake bed was necessary.

While we feel strongly about further wetland drainage, we feel the need to address the potential flooding threat as discussed in the Environmental Assessment takes precedence.

We understand that the St. Paul District will be conducting a Section 205 study of the Devils Lake Basin in the near future. The question of wetland drainage should be addressed in that study. The Region VIII office of the Environmental Protection Agency would appreciate receiving reports related to this study.

Sincerely yours,

Elmer Chenault, Acting Branch Chief
Environmental Assessment Branch

Corps of Engineers Responses to the U.S. Environmental Protection Agency Comments

1. The Devils Lake basin study (a study separate from this Section 205 study) will investigate the cause of the rising lake levels and possible solutions to the problem. Both floodplain zoning and wetland drainage will be among the concerns addressed in the basin study. The St. Paul District will continue coordination with the EPA as the Devils Lake basin study and the Section 205 study progress.

United States Department of the Interior
OFFICE OF THE SECRETARY
OFFICE OF ENVIRONMENTAL PROJECT REVIEW
Room 688, Building 67
Denver Federal Center
Denver CO 80225-0007

?? ?? ?78

AUG 3 0 1983

Colonel Edward G. Rapp
District Engineer
St. Paul District, Corps of
Engineers
1135 U.S. Post Office and
Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

We have reviewed the Draft Detailed Project Report and Environmental Assessment, Flood Control Project at Devils Lake, Ramsey County, North Dakota, and have the following comments.

Fish and Wildlife Resources

The combined report and assessment adequately describes existing fish and wildlife resources and adequately evaluates project construction impacts. Our concerns have been resolved through early coordination and the selection of Alternative "B with its mitigation features. We concur with the selected plan.

Cultural and Recreational Resources

In view of the acknowledged significance of the Devils Lake area as a recreation resource, we recommend that the Corps of Engineers continue to pursue discussions with local officials with regard to the inclusion of recreational facilities with this project.

We were pleased to see that the consultation with the North Dakota State Historic Preservation Officer has taken place and that cultural resource surveys have been completed for most of the project area. The Corps of Engineers is to be commended for its attention to recreational and cultural resources during the planning process for this project.

Mineral Resources

Sand and gravel is the sole mineral product produced in Ramsey County, North Dakota. Bedrock beneath the site is the Cretaceous Pierre Formation, predominantly shale with a maximum thickness of 600 feet. Above the shale is glacial drift, ranging from a few feet to over 350 feet in thickness. Other than the sand and gravel, there are no known mineral values in the project area.

Sincerely,

Robert F. Stewart

Robert F. Stewart
Regional Environmental Officer

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX I

U.S. FISH AND WILDLIFE SERVICE COORDINATION INFORMATION

DEVILS LAKE FLOOD CONTROL PROJECT

SECTION 205

DETAILED PROJECT REPORT

APPENDIX I

U.S. FISH AND WILDLIFE SERVICE COORDINATION INFORMATION

TABLE OF CONTENTS

NCSED-ER 6 November 1980

Mr. Gilbert Key
Area Director
U.S. Fish and Wildlife Service
1500 Capitol Avenue
Bismarck, North Dakota 58501

Dear Mr. Key:

The St. Paul District is currently investigating alternative solutions to protect the city of Devils Lake, North Dakota, from the rising water levels of Devils Lake in the vicinity of Creel Bay. The proposed project would be located within 4 miles of the city and would consist of various levee and interior drainage alternatives. Preliminary analysis has shown that construction of a levee across the head of Creel Bay just west of Landfill Road would be the most cost-effective alternative. Depending on the level of protection provided, additional alignments may also be necessary along Trunk Highway 19 south of the airport plus near the intersection of Trunk Highway 20/57 and the Burlington Northern Railroad tracks south of the city. The levee plan would also include construction of interior drainage facilities. On the inclosed map, proposed levee alignments are designated in red and temporary holding areas for interior drainage waters are shown within existing contours in blue. The study would not include long-term plans to prevent damages if the lake continues to rise, such as a plan to stabilize the lake level by constructing an outlet.

In accordance with the Endangered Species Act of 1973, as amended, we request information on the presence of threatened or endangered species in the project area.

If you have any questions concerning this request, please contact Mr. Robin Hinckman of the Environmental Resources Branch at FTS 725-7233. Thank you for your cooperation.

Sincerely,

1 Incl
As stated

WILLIAM W. BADGER
Colonel, Corps of Engineers
District Engineer

United States Department of the Interior
FISH AND WILDLIFE SERVICE
AREA OFFICE - NORTH DAKOTA
1500 CAPITOL AVENUE
P.O. BOX 1897
BISMARCK, NORTH DAKOTA 58501

NOV 28 1980

Colonel William [illegible] Badger
District Engineer, Corps of Engineers
St. Paul District
1135 U. S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Badger:

This responds to your letter of November 6, 1980, relating to threatened or endangered species and a proposed levee and drainage project near Devils Lake, North Dakota.

The following endangered species could be found in the project area:

bald eagle (Haliaeetus leucocephalus)
peregrine falcon (Falco peregrinus)

Both species would occur in a migratory or transient status.

If we can be of further assistance on this matter, please advise.

Sincerely yours,

Gilbert E. Key

Gilbert E. Key
Area Manager

ANFANG/db/7771
23 February 1981

r. Gilbert L. Key
Manager
Fish and Wildlife Service
Box 1897
rck, North Dakota 58501

Dear Mr. Key:

In November 19 , we received a letter from your office listing endangered species which could occur in the Devils Lake, North Dakota, flood control study area. In accordance with the Endangered Species Act of 1973, as amended, the endangered species assessment for the Devils Lake Section 205 flood control study is inclosed for your review.

If you have any questions or require additional information, please contact Mr. Blackman of the Environmental Resources Branch at FTS 725-7233. Thank you for your cooperation.

Sincerely,

PETER A. FISCHER
Chief, Engineering Division

1 Incl
as stated

ENDANGERED SPECIES ASSESSMENT
DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL

## 1.00 PROJECT DESCRIPTION

### Location

1.01 A closed basin, Devils Lake is located in northeastern North Dakota and receives the runoff from approximately 3,580 square miles located largely north of the lake. Devils Lake is divided into several bays and separate lakes which are interconnected when the lake reaches higher levels. The area included in this study is in Ramsey County and centers around the city of Devils Lake and, in particular, Creel Bay from the southwest and East Bay from the south.

### Project Authorization and Purpose

1.02 General authority for this study is contained in Section 205 of the Flood Control Act, approved 30 June 1948; as amended by Section 205 of the Flood Control Act, approved 23 October 1962; Section 61 of the Water Resources Development Act, approved 7 March 1974; and Section 133(b) of the Water Resources Development Act, approved 22 October 1976. The purpose of the study is to investigate measures to protect the city of Devils Lake, North Dakota, from flood damages that would occur if lake levels continues to rise. The floodplain area of immediate concern consists mainly of commercial and residential developments, the city sewage treatment lagoons, and vacant land.

### Description of Proposed Alternatives

1.03 The major alternatives would be located within 4 miles of the city and would consist of various levee and interior drainage alternatives. Preliminary analysis indicates that construction of a levee across the head of Creel Bay just west of Landfill Road would be the most cost-effective alternative. Depending on the level of protection provided, additional alignments may also be necessary along Trunk Highway 19 south of the airport and near the intersection of Trunk Highway 20/57 and the Burlington Northern Railroad tracks south of the city. The second major alternative being considered consists of raising about 1½ miles of Landfill Road. Interior drainage facilities would also be required and could be located north and south of the existing sewage lagoons (see attached map). Other alternatives would also be considered but would probably consist of various levee designs located in the same general area.

## 2.00 EXISTING ENVIRONMENTAL SETTING

2.01 All of the alternatives would be located in grassland-wetland complexes west and southwest of the city of Devils Lake. Waterfowl, primarily ducks, are abundant around the sewage lagoons, which also contain some aquatic vegetation. Creel Bay is highly eutrophic, and filamentous algae are abundant there in August due to high nutrient levels. Vegetation along the lakeshore includes cattail (Typha sp.), sedge (Carex sp.), foxtail barley (Hordeum jubatum), kochia (Kochia scoparia) and cordgrass (Spartina pectinata).

2.02 The upland areas around Creel Bay are vegetated by milkweed (Asclepias sp.), buffaloberry (Shepherdia argentea), Canada thistle (Cirsum arvense), curly dock (Rumex drispus), poison ivy (Rhus radicans), and various other shrubs, grasses, and sedges. The levees south of town would be located in pasture land paralleling either a county road or railroad.

2.03 All of the alternatives are located close to town, primarily in pasture land. Very few trees are present to provide any roost or nest sites.

3.00 IMPACTS OF ALTERNATIVES ON THREATENED AND ENDANGERED SPECIES

3.01 A letter from the U.S. Fish and Wildlife Service dated 28 November 1980 stated that the endangered bald eagle (Haliaeetus leucocephalus) and peregrine falcon (Falco peregrinus) may be in the project area in a migratory or transient status (see attached letter). The following is an assessment of potential impacts on these species in the project area.

Bald Eagle

3.02 In North Dakota breeding populations of the bald eagle occurred in the vicinity of the larger rivers and lakes that were bordered with mature stands of trees. According to Stewart (1975) the only recent breeding record for the bald eagle was in 1975, when a breeding pair and one young bird were seen in the western part of the State, near the Missouri River in McLean County. In the vicinity of Devils Lake, active nests were located in 1884, 1894, 1902, 1903, and the latest in 1923. The nests in 1902, 1903, and 1923 were situated in bur oaks at heights ranging from 20 to 40 feet. During the 1800's breeding populations were a regular occurrence along the Red River of the North, in the Devils Lake area and along the Missouri River. The last active nest was seen in the Devils Lake area in 1923.

3.03 The North Dakota Game and Fish Department has no recent records of bald eagle nesting in the Devils Lake area. Although the main migration routes are farther to the west, eagles may occasionally pass through the area during their annual spring and fall migration. No eagles are usually present in the area during lake freeze-up between 1 December and 1 April. The main migration periods are early April and October through mid-November (S. Kohn, personal communication, December 1980 and January 1981).

3.04 The U.S. Fish and Wildlife Service does not have any recent records of bald eagle nesting in the Devils Lake area (J. Nelson, personal communication, December 1980). However, a small group of migrating eagles usually seen in the spring and fall make temporary use of the lake and surrounding wetlands and woodlands (S. Brock, personal communication, December 1980).

3.05 In summary, the bald eagle has not nested in the Devils Lake area since 1923 but does migrate through the area during spring and fall migration. However, major migration routes are located farther to the west. The flood control alternatives considered for the city of Devils Lake would have little or no effect on the continued existence of the bald eagle in the area.

Peregrine Falcon

3.06 Since no breeding records have been reported since 1954, it would appear that breeding populations of the peregrine falcon have been completely extirpated from North Dakota. During the 1800's and early 1900's, a few scattered pairs were observed regularly, chiefly on the Little Missouri Slope in the western part of the State. There is no record of the presence of the peregrine falcon in the Devils Lake Basin (Stewart, 1975).

3.07 The State Game and Fish Department has not recorded any instances of nesting or wintering of the peregrine falcon in the Devils Lake area. It is even doubtful if the falcon migrates through the area (however, the State does not keep records of migration) (S. Kohn, personal communication, December 1980).

3.08 The U.S. Fish and Wildlife Service does not have any records of the falcon nesting in the Devils Lake Basin (J. Nelson, personal communication, December 1980). However, the falcon may migrate through the area, but this would be a rare occurrence (S. Brock, personal communication, December 1980).

3.09 In summary, breeding populations of the peregrine falcon have probably been extirpated from North Dakota, and only occasional migrants visit the Devils Lake Basin. Therefore, the flood control alternatives considered for the city of Devils Lake would have no effect on the continued existence of this species in the area.

## BIBLIOGRAPHY

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Kohn, S. December 1980. Personal communication. North Dakota Game and Fish Department. Bismarck, North Dakota.

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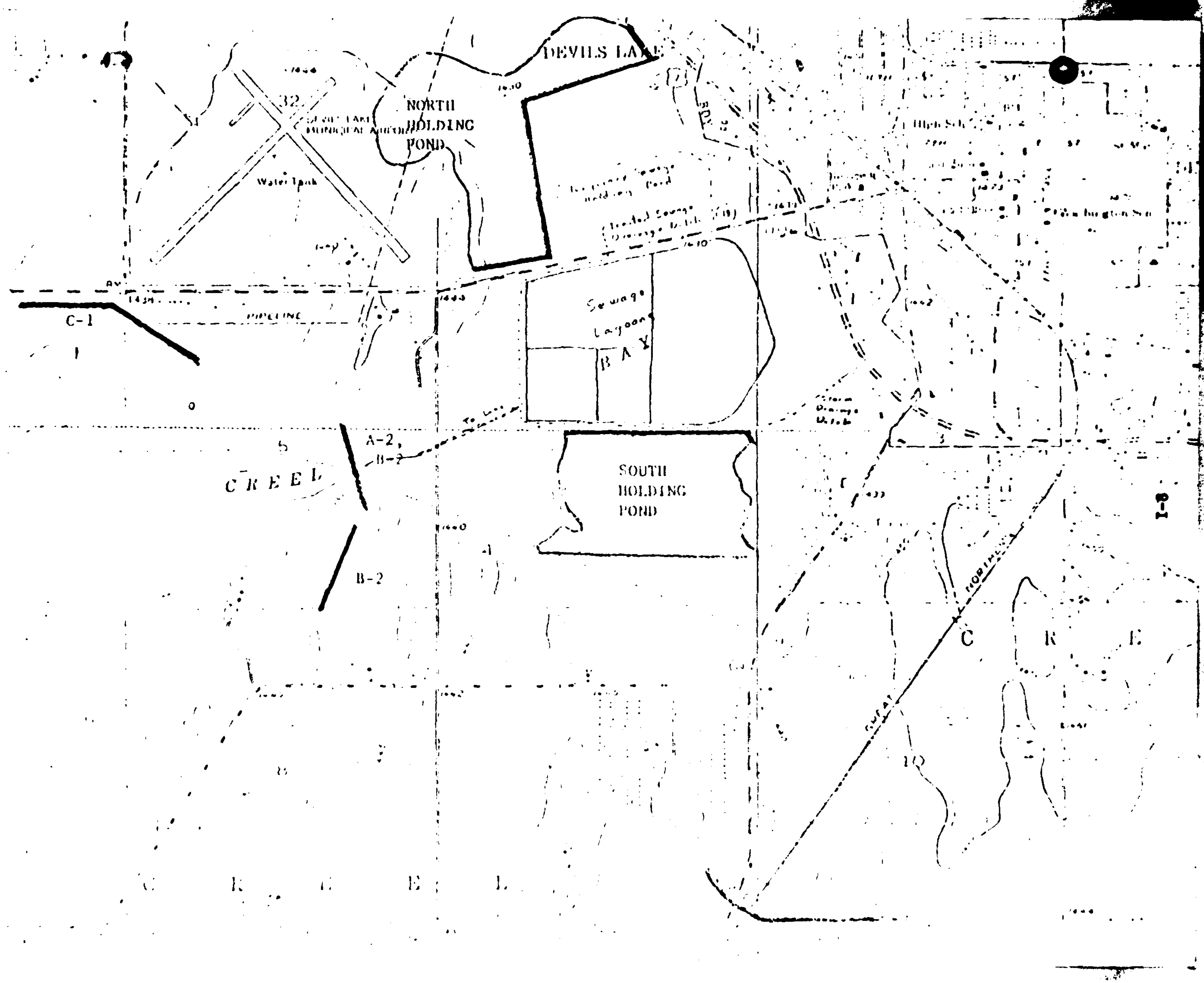
Stewart, R.E. 1975. Breeding Birds of North Dakota. Tri-College Center for Environmental Studies. Fargo, North Dakota. 295 pp.


DEVILS LAKE
NORTH HOLDING POND
Water Tank
PIPELINE
C-1
A-2,
B-2
B-2
C R E E L
B A Y
Sewage Lagoons
SOUTH HOLDING POND
GREAT NORTHERN
C R E E L
C R E E
High Sch.

United States Department of the Interior

FISH AND WILDLIFE SERVICE
AREA OFFICE—NORTH DAKOTA
1500 CAPITOL AVENUE
P.O BOX 1897
BISMARCK, NORTH DAKOTA 58501

MAR 1 0 1981

Mr. Peter A. Fischer
Chief, Engineering Division
Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Mr. Fischer:

This responds to your letter of February 23, 1981, related to endangered species in the Devils Lake flood control study area.

I concur with your biological assessment that bald eagles and peregrine falcons will not be adversely affected by the proposed project.

Thank you for your cooperation.

Sincerely yours,

Gilbert E. Key

Gilbert E. Key
Area Manager

# United States Department of the Interior

FISH AND WILDLIFE SERVICE
[redacted]—NORTH DAKOTA
1500 CAPITOL AVENUE
BISMARCK, NORTH DAKOTA 58501


JUL 1 9 1983

Colonel Edward G. Rapp, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office & Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

We have reviewed the Section 205 Draft Detailed Project Report Flood Control Project at Devils Lake, North Dakota. Our comments are to aid the Corps in the development of the Final Detailed Project Report. They do not satisfy the requirement of the Department of the Interior to review and comment on any forthcoming environmental statement.

The selected alternative, Plan "B", and accompanying mitigation features are compatible with previously raised Fish and Wildlife Service concerns and recommendations. We concur with the selected plan.

You will find attached our final report in comformance to Section 2(b) of the Fish and Wildlife Coordination Act. The North Dakota Game and Fish Department letter of July 15, 1983, which is attached to our report, comments on our conclusions and recommendations.

If you have any questions or comments, please contact Al Ludden of my staff at FTS: 783-4492.

Sincerely,

FOR M. S. Zschomler
Field Supervisor-Habitat Resources

Attachment

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

# FLOOD CONTROL AT DEVILS LAKE

# NORTH DAKOTA

A REPORT ON FISH AND WILDLIFE RESOURCES

UNITED STATES DEPARTMENT OF THE INTERIOR

FISH AND WILDLIFE SERVICE

# FISH AND WILDLIFE RESOURCES
# IN RELATION TO
# CREEL BAY AT DEVILS LAKE
# FLOOD CONTROL PROJECT
# NORTH DAKOTA

PREPARED BY:

NORTH DAKOTA FIELD OFFICE

U.S. FISH AND WILDLIFE SERVICE

BISMARCK, NORTH DAKOTA

United States Department of the Interior
FISH AND WILDLIFE SERVICE
[redacted]—NORTH DAKOTA
1500 CAPITOL AVENUE
BISMARCK, NORTH DAKOTA 58501

JUL 1 9 1983

Colonel Edward G. Rapp, District Engineer
St. Paul District, Corps of Engineers
1135 U.S. Post Office and Custom House
St. Paul, Minnesota 55101

Dear Colonel Rapp:

This is our report on the effects the local flood control project at the head of Creel Bay at Devils Lake, North Dakota, will have on fish and wildlife resources. This report is to accompany the Corps of Engineers Detailed Project Report through the final review process. It is prepared under the authority of and in accordance with the provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.). It is also consistent with the intent of the National Environmental Policy Act of 1969 (P.L. 91-190; 83 Stat. 852, 856). It addresses the effects of the various alternative plans on fish and wildlife resources, and conveys recommendations which are designed to prevent, mitigate or compensate adverse effects to these resources. This report supercedes all previous reports which apply to the local flood protection project for Devils Lake. Comments on the conclusions and recommendations of this report by the North Dakota Game and Fish Department (NDGFD) are contained in the attached letter dated July 15, 1983, by Commissioner Dale Henegar.

Our recommendations and associated costs for mitigating and/or compensating project-caused fish and wildlife losses are congruous with the Presidential directive (of June 1978) on environmental quality and water resources management. That directive states:

> In all project construction appropriation requests, agencies shall include designated funds for all environmental mitigation required for the project and shall require that mitigation funds be spent concurrently and proportionately with construction funds throughout the life of the project.

## DESCRIPTION OF STUDY AREA

Devils Lake, a city of 7,448 persons, is located in Ramsey County, North Dakota. It is situated at the northeast end of Creel Bay which is an arm of Devils Lake. The lake is located at the south end of the Devils Lake Basin and is the terminous for basin water.

Devils Lake Basin is a closed basin located in north-central North Dakota (Figure 1) which covers about 2.4 million acres. Landforms in the Basin are largely the result of glaciation. An extensive ground moraine formed an undulating plain interspersed with areas of lake plain, outwashes and moraine called the Drift Plain.

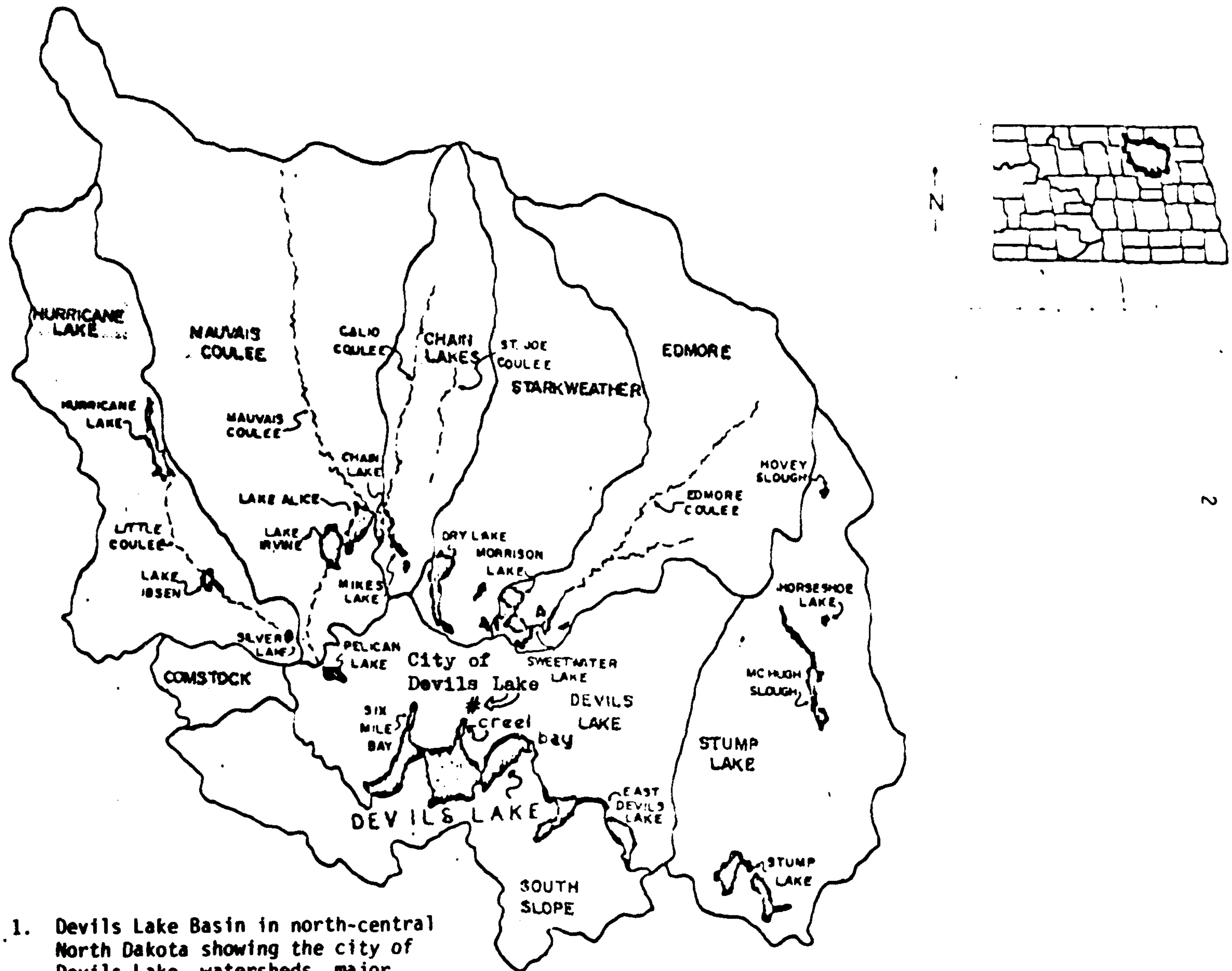



Figure 1. Devils Lake Basin in north-central North Dakota showing the city of Devils Lake, watersheds, major waterways and lakes.

Throughout the Basin are numerous shallow wetland depressions, sometimes termed prairie potholes. These shallow depressions make up a maximum water surface area of 412,000 acres of drained and undrained wetlands. Such an area attracts large concentrations of grebes, ducks, geese, coots, shorebirds and gulls.

An analysis of land use and cover by Landsat satellite imagery dated September 13, 1974, showed that approximately 70 percent of the Basin is cultivated land. Remaining areas include 8 percent grassland, 16 percent water areas, 3 percent woodland and 3 percent miscellaneous areas.

## DESCRIPTION OF THE PROJECT

The Corps has developed four alternative plans (Figure 2) for the protection of the city of Devils Lake and its sewage lagoon against flooding.

- Dikes in Plan "A" would protect from lake levels up to 1435 feet (msl) and have a top elevation of 1440 feet (msl). One dike would be constructed for a distance of 1,100 feet across Creel Bay. A much shorter dike would be constructed in the SE¼ of Section 9, T. 153 N., R. 64 W. Figure 2 shows the plan.

- Plan "B" is the Corps' preferred plan. Dikes would protect up to 1440 feet (msl) and have a top elevation of 1445 feet (msl). Several dikes would be constructed (Figure 2): (1) a 2,400-foot long dike immediately south of the airport; (2) a 2,900-foot long dike across the head of Creel Bay; and (3) a 3,100-foot long dike south of the sewage lagoon.

- Plan "C" would protect up to 1445 feet (msl) and have a top elevation of 1450 feet (msl). The plan would require two dikes (Figure 2): (1) a 16,000-foot long dike across the head of Creel Bay; and (2) a 7,200-foot long dike south of the sewage lagoon.

- Plan "D" would protect up to 1450 feet (msl) and have a top elevation 1455 feet (msl). The plan would require a nearly continuous ring levee around the south and west sides of the city.

The interior drainage system for the four alternative plans would consist of two holding ponds with gated outlets and a large pumping station. There would be a system of ditches and pipes linking the holding ponds to the pumping station. The north holding pond would be combined with the existing lagoon effluent holding pond. The combined storm and effluent water, meeting State water quality standards, would be discharged into the lake via the pumping station.

In addition to the basic drainage system, Plan "D" would require an additional holding pond, pumping station and ditch/pipe system. The added facilities would accommodate drainage from the eastern part of the city.

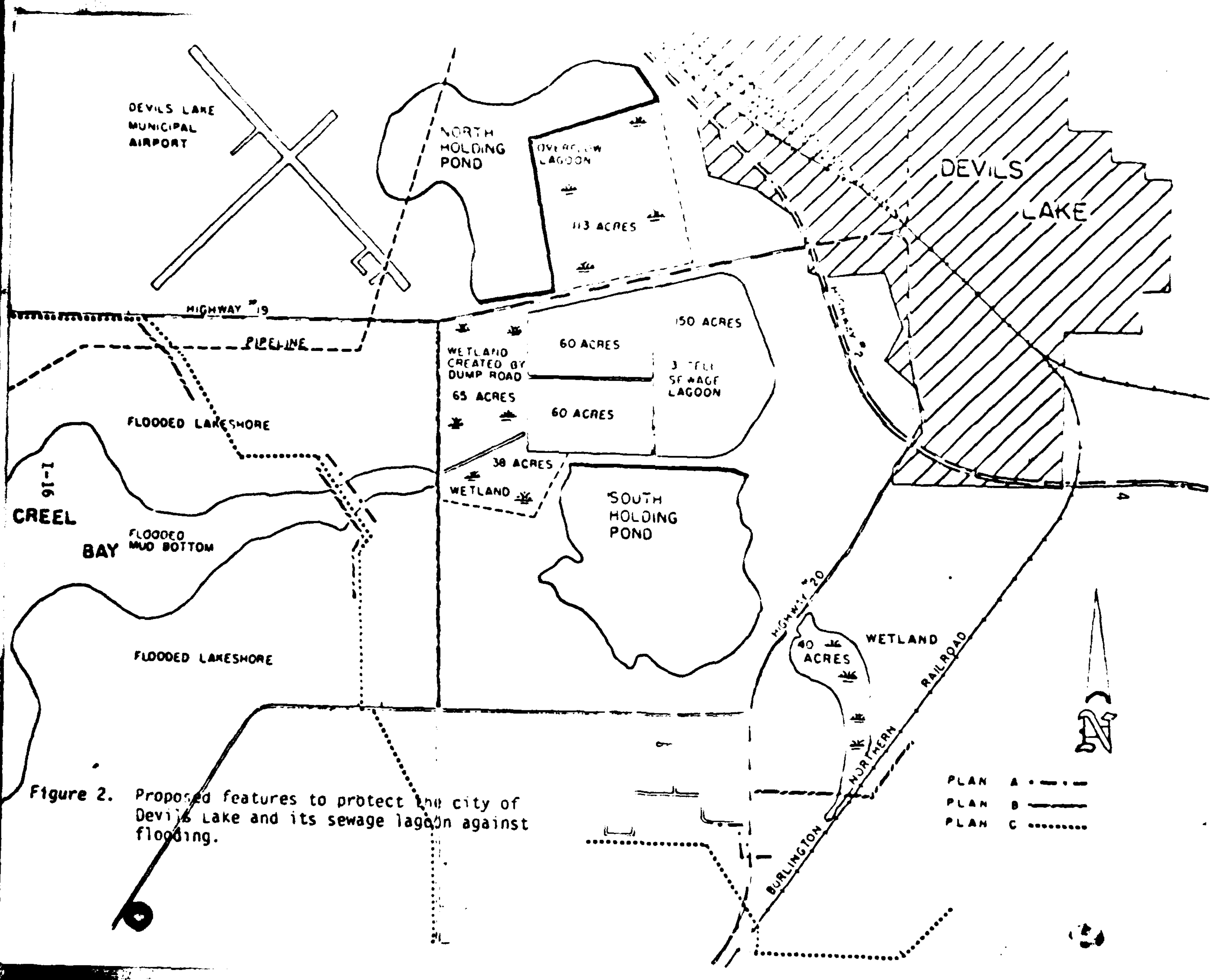



Figure 2. Proposed features to protect the city of Devils Lake and its sewage lagoon against flooding.

## EVALUATION METHODOLOGY

Habitat Evaluation Procedures were not used in our field investigations. They were not appropriate for this study which utilized primarily existing data during a short time period.

Onsite visits were made to the proposed project area to evaluate the impacts to fish and wildlife resources. Aerial imagery, maps and drawings of project features, and descriptions provided by the Corps of Engineers supplemented the evaluation.

## FISH AND WILDLIFE RESOURCES

### Fish Resources

Devils Lake provides the most important water based recreation area in eastern North Dakota. It primarily serves people in a 150-mile radius and supports about 240,000 angler days annually. Primary species of game fish include northern pike, walleye, white bass, crappie and yellow perch. The basic forage fish species is the fathead minnow. All these species are found in Creel Bay. Crappie, white bass and yellow perch occasionally spawn in the bay along its shallow areas. Yellow perch begin to spawn from April 15 and may extend into July, white crappie and white bass begin in late May and may extend into mid-July. Some invertebrate species important as fish food found in the bay include water boatmen, backswimmer, midge, caddisfly and amphipod (*Gammarus* spp.).

The water in Devils Lake does not meet North Dakota water quality standards. The North Central Planning Council reports fall fertilizer application, wetland drainage, summer fallow and intensive fall cultivation as some of the agricultural practices suspected of causing water quality deterioration. Nitrogen and phosphorus nutrients are products of these practices carried by runoff into coulees heading toward Devils Lake. These two nutrients stimulate the growth of aquatic plants, such as algae. When algal blooms die, the decomposition creates an added demand on the available free oxygen used by fish and invertebrates. This process, known as eutrophication, could eliminate the sport fishery of Devils Lake if not corrected.

Sewage lagoon effluent discharged by the city of Devils Lake is a major source of nutrient inputs into Creel Bay. The city is currently studying ways to reduce the input of phosphorus and nitrogen into the bay.

### Wildlife Resources

A 113-acre overflow sewage lagoon lies north of the city's sewage treatment facility and ND Highway 19. Vegetation in the artificially flooded wetland includes: cattail (*Typha* spp.), horsetail (*Equisetum* spp.), bulrush (*Scirpus* spp.) and sedge (*Carex* spp.). A 65-acre wetland lies immediately west of the sewage lagoon. The dump road impounds the wetland and the city pumps treated sewage effluent into the wetland, keeping it wet. Predominant vegetation is the same described in the aforementioned overflow lagoon, but with the addition of common reed (Phragmites communis). Southwest of the sewage lagoon is a 38-acre wetland that is intermittently flooded. Predominant vegetation includes Nuttall's alkaligrass (Puccinellia airoides), foxtail barley (Hordeum jubatum), curlycup gumweed (Grindelia squarrosa), curled dock (Rumex crispus) and kochia (Kochia scorparia). Southeast of the sewage lagoon is a 40-acre wetland vegetated by cattail (Typha spp.), bulrush (Scirpus spp.), sedge (Carex spp.) and common reed (Phragmites communis). The wetland is impounded by the embankment of an abandoned Great Northern rail track. All wetland locations are displayed in Figure 2.

When the water level of Devils Lake rises the upper end of Creel Bay is intermittently flooded; then, the lake eventually recedes leaving a mud bottom immediately west of the dump road. Temporarily flooded lakeshore occurs landward from the bay's intermittently flooded mud bottom. Predominant vegetation along the lakeshore include: cattail (Typha spp.), sedge (Carex spp.), foxtail barley (Hordeum jubatum) and kochia (Kochia scoparia).

The medium to low habitat value of the three cells in the sewage lagoon can sustain waterfowl production during drought years by providing food, nesting sites, loafing areas and permanent water to breeding dabblers. Potential breeders include mallards, gadwalls, shovelers and blue-winged teal. Lesser scaup is the most numerous of the divers that loaf or feed in the lagoon. Redheads and canvasbacks are commonly seen.

Wetlands adjacent to and near the sewage lagoon have a high wildlife habitat value. The habitat is productive for a diversity of animal life from the lower invertebrates to waterfowl and other birds that utilize wetlands for nesting, brooding, feeding and migratory stopover.

## Endangered Species

Four endangered species are officially listed for North Dakota: the whooping crane, bald eagle, peregrine falcon and black-footed ferret.

Based on our records and knowledge of the project study area, the bald eagle and peregrine falcon could be present, but only in a migratory or transient status. We have no records of these birds nesting or having permanent residence in the area of the proposed project.

# EFFECTS OF ALTERNATIVE PLANS ON FISH AND WILDLIFE RESOURCES

The four alternative plans are analyzed for changes they could cause to biological resources in the proposed project area.

## Fish Resources

Table 1 shows the number of upland and flood-plain acres that would be covered by each of the four plans. Construction of the dikes and associated cofferdams across Creel Bay could induce silt and turbidity temporarily reducing water quality in the upper end of the bay. Benthic organisms could be smothered and fishery resources forced to abandon feeding, breeding and nursery waters. Silt material could introduce substances toxic to aquatic life forms, if the borrow areas are not carefully chosen for clean materials. Additional construction could be required for access onto the flood plain to construct the dikes. This would decrease the diversity of fish habitat with the filling over of hydric soils and plants.

Table 1. Acreage estimates of each of the four plans.

| | Plan A (1440)* | Plan B (1445) | Plan C (1450) | Plan D (1455) |
|---|---|---|---|---|
| Upland | 2.75± | 15.00± | 47.40± | 69.00± |
| Creel Bay | 1.50± | 3.40± | 3.90± | 3.90± |
| Ponding Areas (110-year event) | 825.00± | 825.00± | 825.00± | 900.00± |
| Total Acreage | 829.25± | 843.40± | 876.30± | 972.90± |

*Number in parenthesis is the top elevation of each dike.

Plan "A" would require the smallest area (1.5 acres) of fill in the flood plain. Plans "B", "C" and "D" would require greater than 3 acres of fill in the flood plain to cross Creel Bay. These plans could cause the greatest degradation of water quality affecting aquatic life forms.

Plan "B", which would require less fill-area than Plans "C" and "D", has a higher level of lake stage protection than Plan "A". It would cover more area than Plan "A" at the head of Creel Bay, but it would reduce the chance of a flooded sewage lagoon. Conversely, not protecting the city's sewage treatment facility could result in contaminating Creel Bay from raw sewage.

Any plan selected for Creel Bay could increase the chance for agricultural, residential and industrial development on the flood plain. This would increase the chance for possible releases of nutrients, pesticides and other pollutants into the bay. Pesticides and other toxic substances would affect fish resources directly. High nutrient loads would affect these resources indirectly by an added demand on available free oxygen.

Wildlife Resources

Plans to protect the city and its sewage lagoon would require dikes to the west and southeast of the city. Plan "A" would require the smallest area (2.75 acres) of upland for the construction of project features. Plans "C" and "D", covering the greatest upland area, would require the clearing of about 2.5 acres of woodland. This habitat is of high value to resident game and nongame species.

Plans "B", "C" and "D" would require a dike south of the sewage lagoon blocking the outlet of a 40-acre wetland (Figure 2). A new outlet for the wetland would be constructed to prevent the inundation of adjacent land. This proposed action could drain the water from the wetland habitat that has a high wildlife value.

If water in the 65-acre wetland and the 38-acre wetland (Figure 2) would affect interior drainage or weaken the dump road or the dike across Creel Bay, they may need to be drained. This would destroy a high use area for many waterfowl species and other birds.

If one of the four plans were not selected, the rising level of Devils Lake would inundate the head of Creel Bay. Wetlands would be replaced by the deeper, permanent water of lake habitat.

Plan "B" would provide a higher level of protection than Plan "A" to the wetlands behind the dump road. As opposed to Plans "C" and "D", it would also require less construction activity and would not clear any woodland.

If not restricted, agricultural, residential and industrial developments would occur on the protected flood plain behind the proposed dikes. This would be incompatible with existing wildlife resources.

## Endangered Species

Our March 10, 1981, letter concurs with the Corps' biological assessment that eagles and peregrine falcons will not be adversely affected by the proposed project.

## PLAN OF DEVELOPMENT FOR FISH AND WILDLIFE RESOURCES

### Fish Resources

We urge the Corps of Engineers to use only clean fill material for the construction of the dikes and associated cofferdams. This would help to reduce excessive turbidity and prevent the entrance of potentially polluted materials into the waters of Creel Bay. The placement of fill material below the water surface of the bay should be avoided from May through June. This would avoid creating problems for fish spawning activities.

The Corps is urged not to allow the direct access of vehicles and heavy equipment onto hydric soil sites. If routes need to be constructed for access onto the flood plain, they should be constructed of nontoxic and nonerodable material. The routes should then be removed as soon as possible. Care should be taken to prevent any petroleum products, chemicals or other deleterious materials from entering the waterway.

A zero discharge system for the city's sewage lagoon would remove a major source of phosphorus and nitrogen input into Creel Bay. The city and the ND State Department of Health have discussed the possibility of spreading effluent on an upland area west of the lagoon. We support and encourage the Corps, efforts in their review of such a plan which would improve the water quality of the bay.

Executive Order 11988 on Flood Plain Management is adhered to when planning efforts protect, manage and enhance or restore the natural and beneficial values of a flood plain. Agricultural, residential and industrial development should be regulated in the flood plain of the former lakebed at the head of Creel Bay. Such a restriction would prevent the release of nutrients, pesticides and other pollutants into Creel Bay. We encourage the Corps to participate with the project sponsors, the ND State Water Commission and the Federal Emergency Management Agency in the development of flood plain regulations.

Wildlife Resources

If either Plan "C" or "D" were to be selected, the clearing of 2.5 acres of native woodland should be compensated by woody plantings. The Corps or the project sponsor should plant and maintain at project cost 2 acres of trees for every acre that is cut. This would be consistent with the policy of the ND Game and Fish Department. Plantings could be done on project lands, or other sites could be located near the project area. An estimated $1,230 would be required at project cost to plant 5 acres of trees. A total of $240 would be needed for cultivation during a 5-year period.

A new drainage outlet would be constructed for a 40-acre wetland. The Corps should design the new outlet to match the elevation of the natural one to prevent a loss of water and habitat. The Corps has advised the FWS that the 65-acre wetland would not be drained; instead, the Corps proposes a grassed inlet at elevation 1428.0 feet (msl) be constructed into the dike. This would then allow a 5-year frequency runoff at elevation 1428.26 feet (msl) to fill the wetland. We are pleased to note that both wetlands are being protected; however, should they be drained, additional mitigation would be required.

The 38-acre wetland would be drained. The Corps proposes to compensate for this loss with the construction of a weir to elevation 1426.75 feet (msl) in two new culverts under ND Highway 19. The new weir and runoff would increase the surface area of the north holding pond from 113 acres to 167 acres.

All disturbed sites for project purposes and all dike surfaces should be revegetated with native grasses. Planting rates, species and maintenance recommendations should be coordinated with the U.S. Soil Conservation Service in Bismarck, North Dakota. Estimated costs are $60 per acre for establishing the native grasses and $3 per acre for annual maintenance.

We encourage the Corps to participate with the project sponsors, the ND State Water Commission and the Federal Emergency Management Agency to help regulate development in the former lakebed at the head of Creel Bay. Such an effort would be consonant with Executive Order 11988 in regulating agricultural, residential and industrial encroachment into the flood plain.

Wetlands are essential breeding, rearing and feeding areas for many species of wildlife. In this case, the replacement of a project-caused loss to wetland habitat would be consonant with Executive Order 11990, Protection of Wetlands.

## RECOMMENDATIONS

To safeguard fish and wildlife resources from project-incurred losses, we recommend that:

Fish Resources

1. The following stipulations be included in the construction contracts:

   a. Only clean fill material be used for the construction of the dikes and associated cofferdams.

   b. No fill material is to be placed below the water surface of Creel Bay from May through June.

   c. All vehicles or heavy machinery be kept out of the hydric soil sites in or near the proposed work area.

   d. Access routes onto the flood plain are to be constructed of nontoxic and nonerodable material and removed as soon as possible.

   e. Care be taken to prevent any petroleum product, chemicals or other deleterious materials from entering the waterway.

2. The Corps of Engineers consult with the city of Devils Lake, the ND State Department of Health, and the U.S. Environmental Protection Agency (Denver) about the development of a zero discharge system for the city's sewage lagoon.

3. The Corps of Engineers participate with the project sponsors, the ND State Water Commission and the Federal Emergency Management Agency in formulating a plan to regulate flood-plain development.

Wildlife Resources

1. The selection of either Plan "C" or "D" would require compensating the loss of native woodland by planting and cultivating 5 acres of trees at an estimated project cost of $1,470.

2. The Corps of Engineers take the following precautions to prevent wetland drainage:

   a. Construct the new outlet for a 40-acre wetland to match the elevation of the natural one.

   b. Protect the 65-acre wetland as is being presently proposed.

3. All disturbed sites and dike surfaces should be revegetated with native grasses. The Corps of Engineers should coordinate with the U.S. Soil Conservation Service, Bismarck, North Dakota, about the planting rates, species and maintenance recommendations. The estimated cost per acre for establishing the native grasses is $60 and the annual maintenance cost is $3.

4. The FWS concurs with the Corps' proposal to allow the north holding pond to increase from 113 acres to 167 acres.

5. The Corps of Engineers participate with the project sponsors, the ND State Water Commission and the Federal Emergency Management Agency, in formulating the flood-plain management plan.

SUMMARY

The adverse impacts of all four alternative plans tend to be minor to fish and wildlife resources, even though there is some required prevention, mitigation and compensation of habitat losses. The FWS favors the Plan "B" alternative; however, we would have no objection to any plan if our foregoing recommendations are incorporated into the project plan.

Thank you for this opportunity to provide the evaluation and recommendations for fish and wildlife resources in the Creel Bay area. Please notify us of any changes in project plans, and do not hesitate to contact us. We also request that you inform us of actions taken on each of the recommendations.

Sincerely,

For M. S. Zschomler
Field Supervisor-Habitat Resources

NORTH DAKOTA
GAME & FISH
DEPARTMENT
"Variety in Hunting and Fishing"

2121 Lovett Avenue
Bismarck, North Dakota 58505
Phone 701/224-2180

July 15, 1983

Mr. M.S. Zschomler
Supervisor, Habitat Preservation
U.S. Fish and Wildlife Service
1500 Capitol Avenue
Bismarck, ND 58505

Re: Fish and Wildlife Resources
Flood Control Project
Devils Lake, ND

Dear Mr. Zschomler:

We have reviewed the above referenced report and concur with the conclusions contained therein.

Sincerely,

for Dale L. Henegar
Commissioner

M:DLH:lr

Summary of Fish and Wildlife Plan of Development, Fish and Wildlife Service Recommendations, and Method of Incorporation Into Selected Plan

| Recommendation | Method of Incorporation |
|---|---|
| **1. Plan of Development** | |
| a. Fill material. | Fill would be obtained from borrow areas that have no record of being used as dumps or disposal areas for contaminated material. Fill would be clay and similar materials but would be placed in a manner resistant to erosion. |
| b. Avoid fill placement in water during May and June. | It is not possible to guarantee that fill will not be placed in water during specific times because emergency actions may be required. However, the Corps will, to the extent possible, avoid fill placement in water in May and June. |
| c. Do not allow access onto hydric (wet) soils. | Fill must be placed in hydric sites at Creel Bay, but fill would be placed on access routes or areas would be dewatered for the majority of construction. Vehicles would not drive directly into water or wet soils. |
| d. Temporary fill should be removed. | All temporary fill would be removed as soon as possible. |
| e. Toxic materials and chemicals should be prevented from entering the waterway. | As part of the project plans and specifications, the contractor must prevent chemicals and debris from entering the waterway. |
| f. A land-spreading system for the city's treated sewage effluent should be implemented. | The city, State Department of Health, and U.S. Environmental Protection Agency have been investigating the feasibility of spreading treated sewage water on land. These studies are not completed, but the Corps embankment and interior drainage facilities would be compatible with such a system. |
| g. Floodplain regulations for the project area should be developed. | A land management plan, which would involve floodplain regulations, is part of the selected plan. The Corps does not have the authority to develop such a plan, but would provide technical assistance to the implementing agencies. |
| h. If either plan C or D is selected, woodland losses should be compensated. | Plan B is the selected plan. If other alternatives would be evaluated again, woodland compensation would be considered. |

Summary of Fish and Wildlife Plan of
Development, Fish and Wildlife Service
Recommendations, and Method of Incorporation
Into Selected Plan (Cont.)

| Recommendation | Method of Incorporation |
|---|---|
| i. The new outlet for the wetland near the south embankment should be constructed to an elevation similar to that of the existing one. | The new grassed waterway outlet would be constructed to the same elevation as the existing culvert under the railroad. The water level would be maintained. |
| j. Wetlands near the sewage lagoons should be maintained or replaced if possible. | The 65-acre wetland would be maintained. A notch would be cut at about elevation 1428 feet msl in the surrounding dike to allow water to overflow into the wetland. This 35-acre wetland would have to be drained. This 35-acre wetland depends on water levels and is dry when the lake is lower than 1,425 feet msl. With the project, this area would be converted to a drier upland grass area. The outlet of the north holding pond would be constructed to maintain a wetland with a maximum depth of 1.6 feet. |
| k. All disturbed sites should be revegetated with native grasses, and these plantings should be coordinated with the U.S. Soil Conservation Service. | All disturbed sites suitable for revegetating would be seeded or planted. The final planting plan has not yet been developed, but it would involve native grass species. Coordination with the SCS has been initiated and will continue. The final planting and maintenance plan will be coordinated with the SCS, State Water Commission, and Fish and Wildlife Service. |
| l. A plan to regulate development in the floodplain should be formulated. | The State of North Dakota is developing a floodplain regulation plan and is coordinating it with local sponsors. This plan would regulate future developments. The land management plan in the selected plan is considered consistent with Executive Order 11988 on floodplains. |
| m. The selected plan supports Executive Order 11990, Protection of Wetlands. | The Corps agrees. |
| 2. <u>FWS Recommendations</u> | |
| a. Fish Resources. | |
| (1) Use clean fill. | See 1.a. above. |
| (2) Do not place fill material below water surface from May through June. | See 1.b. above. |

Summary of Fish and Wildlife Plan of Development, Fish and Wildlife Service Recommendations, and Method of Incorporation Into Selected Plan (Cont.)

| Recommendation | Method of Incorporation |
|---|---|
| (3) Vehicles should be kept out of hydric (wet) soils. | See 1.c. above. |
| (4) Access routes should be of nontoxic and non-erodable material and should be removed as soon as possible. | As stated above, clean fill would be used. The fill will consist of clay and similar material but would be placed in a manner that would resist erosion. Temporary fill would be removed as soon as possible. See 1.a., 1.c., and 1.d. above. |
| (5) Care should be taken to prevent chemicals and other material from entering the waterway. | See 1.e. above. |
| (6) The Corps should consult with appropriate agencies in the development of a zero-discharge system for the city's sewage lagoon. | See 1.f. above. |
| (7) The Corps should participate with concerned agencies in the development of a plan to regulate floodplain development. | See 1.g. above. |
| b. Wildlife Resources. | |
| (1) Plan C or D would require woodland compensation. | See 1.b. above. |
| (2) Wetlands: | |
| (a) The new outlet for the wetland near the south embankment should be constructed to the elevation of the existing outlet. | See 1.i. above. |
| (b) Wetlands near the sewage lagoons should be maintained or compensated. | As stated in 1.j. and 1.m. above, wetlands would be preserved. The 65-acre wetland would be maintained. A permanent wetland would be maintained in the north holding pond. |
| (3) All disturbed sites should be revegetated with native grasses. Coordinate plan with the U.S. Soil Conservation Service. | See 1.k. above. |

Summary of Fish and Wildlife Plan of
Development, Fish and Wildlife Service
Recommendations, and Method of Incorporation
Into Selected Plan (Cont.)

| Recommendation | Method of Incorporation |
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| (4) Increase the size of the north holding pond from 113 to 167 acres. | Because excess storage is available in the north holding pond, a permanent wetland would be maintained in this area. The size of the wetland would depend on the size of the storm event. |
| (5) The Corps should participate in the development of a floodplain regulation plan. | The State and project sponsors are developing a plan to regulate floodplain development. The Corps will provide technical assistance as required. These regulations would be similar to other floodplain regulations that would apply to how existing developments are modified, which future uses are permitted, and how developments would be constructed The land management plan in the selected plan requires floodplain regulations. See 1.1. above. |



End