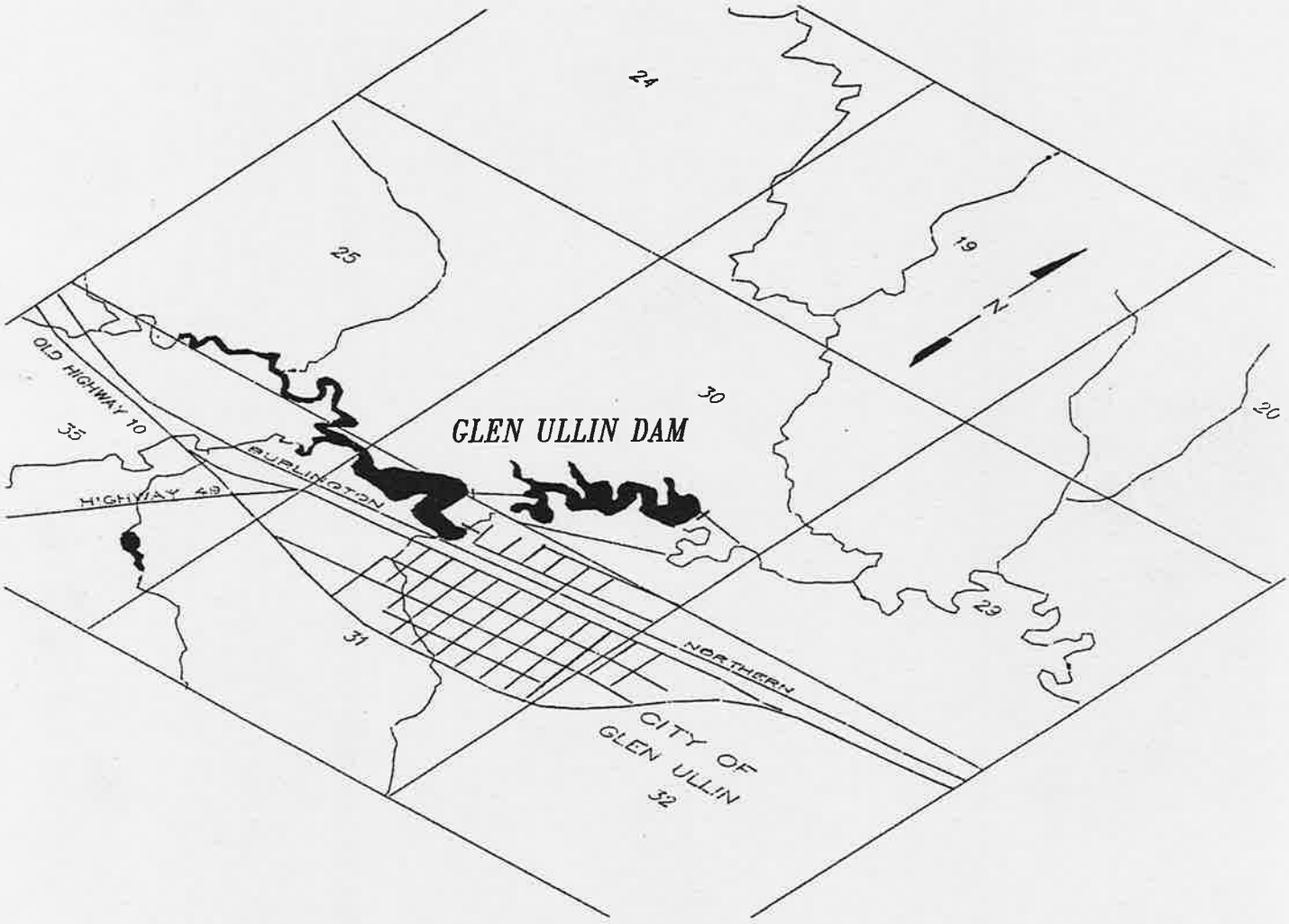
PRELIMINARY ENGINEERING REPORT
GLEN ULLIN DAM
SWC # 673
MORTON COUNTY



NORTH DAKOTA
STATE WATER COMMISSION
JULY 1990

PRELIMINARY ENGINEERING REPORT

GLEN ULLIN DAM

SWC PROJECT #673

North Dakota State Water Commission
900 East Boulevard
Bismarck ND 58505-0850

Prepared by:

James Lennington, P.E.
Water Resource Engineer

Submitted by:

Dale L. Frink, P.E.
Director of Engineering

Approved by:

David A. Sprynczynatyk, P.E.
State Engineer

TABLE OF CONTENTS

FIGURES

TABLES

I. INTRODUCTION

In October of 1989, the Morton County Water Resource District entered into an agreement with the North Dakota State Water Commission to investigate the possibility of refurbishing a diversion structure which is part of Glen Ullin Dam. The stated purpose of the refurbishment was to improve the supply of water to the north reservoir of Glen Ullin Dam. A copy of this agreement is included as Appendix B of this report.

As part of the agreement, the State Water Commission was to complete the following:

1. A topographic survey of the dam site.
2. A study of the hydrology of the upstream watershed.
3. A design of the outlet works necessary to safely and efficiently pass the design flood through the dam.

The dam and the adjoining land are owned by the North Dakota State Game and Fish Department. The dam is managed by the North Dakota State Parks and Recreation Department which in turn has leased it to the Glen Ullin Park Board.

II. BACKGROUND

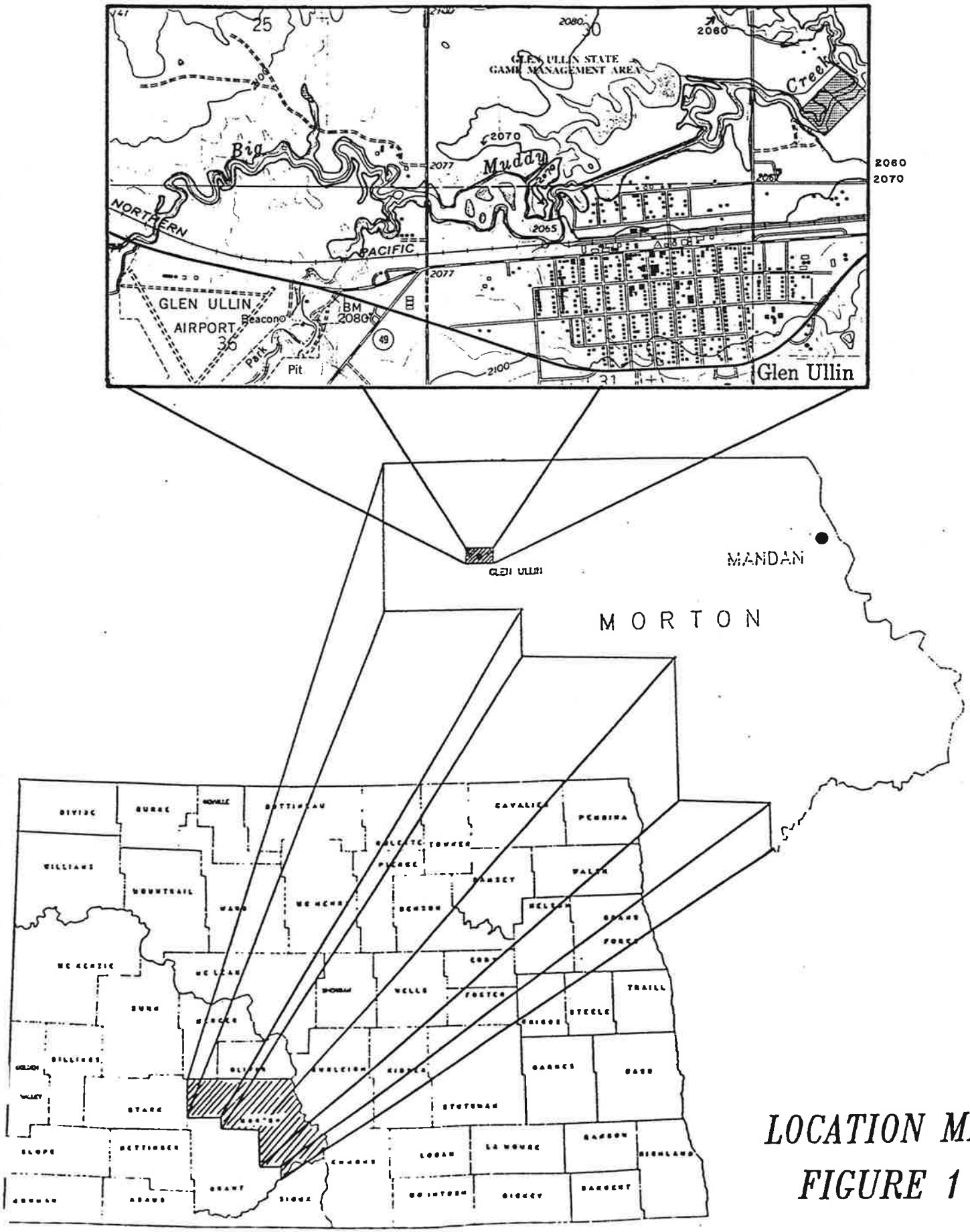
A. Project Description:

Glen Ullin Dam is located on Big Muddy Creek adjacent to the city of Glen Ullin in northwestern Morton County, North Dakota. The location of the dam is shown on Figure 1. The dam was originally constructed by the Northern Pacific Railway Company to provide water for steam locomotives on the nearby rail line.

The dam consists of one concrete weir structure, two earthen embankments connected by a low dike, and a rubble masonry spillway. The dam creates two reservoirs referred to in this report as the north and south reservoirs (See Figure 2). The first, or south reservoir was created in 1909, with construction of a rubble masonry weir in the creek channel. This structure washed out and was replaced in 1927 with a concrete weir structure approximately 206 feet in length, which exists to this date. This structure is referred to within this report as the south dam (See Figure 2).

In 1943, the railway company created an auxiliary reservoir in the creek channel downstream of the south dam by constructing two earthen dams in the creek channel, and a low dike in the area between. These structures are referred to in this report as the north dam (See Figure 2). Flows passing over the concrete weir making up the south dam were diverted around the north reservoir by means of a bypass channel some 2000 feet long. A 700-foot long channel, with slide gates, was constructed between the two

GLEN ULLIN DAM



LOCATION MAP
FIGURE 1

GLEN ULLIN DAM

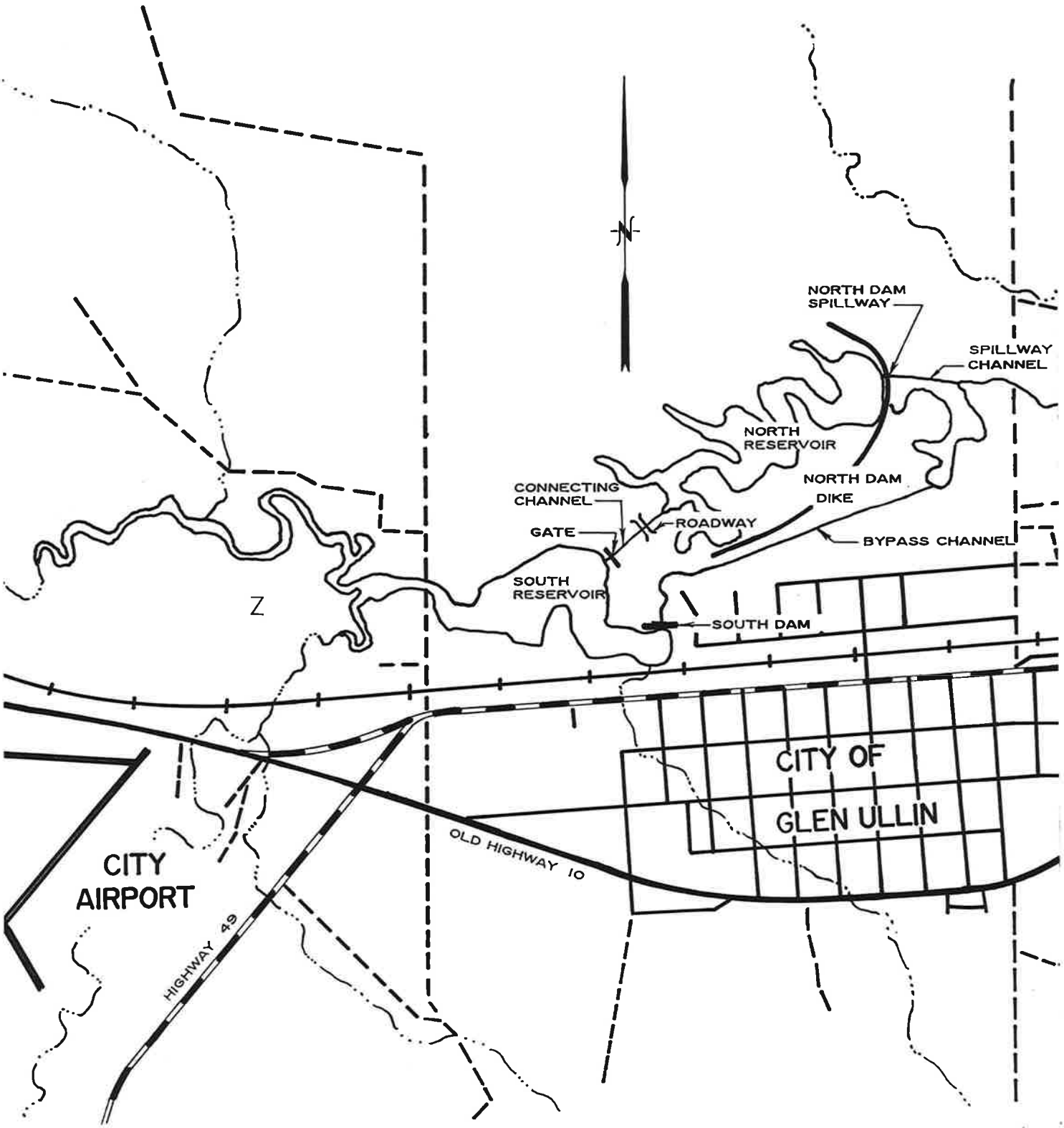


FIGURE 2

reservoirs to allow diversion of flows into the north reservoir. An outlet for the north reservoir was located several hundred feet to the north of the earth embankment in the downstream creek channel. This outlet consists of a rubble masonry spillway approximately 60 feet wide with concrete walls. This spillway discharges into the north dam spillway channel (See Figure 2), which discharges into Big Muddy Creek downstream. There is a roadway crossing the connecting channel with two corrugated metal pipe (CMP) culverts through it. This roadway is used by persons using the golf course and golf course maintenance vehicles. One of the culverts is 18 inches in diameter and the other is 24 inches in diameter. Both culverts have invert elevations of approximately 2064.1 msl.

The topography around the north dam and the structures are lower in elevation than those of the south dam. The spillway elevation of the south dam is approximately 2065 msl, while the elevation of the north dam spillway is 2063.7 msl. The sill elevation of the connecting channel slide gate is approximately 2064.4 msl. Water can therefore be retained at higher elevations in the south dam. The bypass channel allows flood flows to bypass the lower structures in the north dam. Because flood flows are diverted around the north dam, the north dam spillway and spillway channel were not designed to pass substantial flows. The north dam spillway channel was designed with a nearly flat slope, at an elevation only a few feet below the surrounding land. This channel has eroded back from its outfall into the

creek roughly 430 feet to a point approximately 300 feet downstream of the spillway. Erosion of this channel is likely to continue and would probably result in an eventual failure of the north dam spillway unless remedial measures are taken.

B. Basin Description:

Big Muddy Creek drains an area of about 80 square miles above Glen Ullin Dam. The dam is located 17.4 miles downstream of the most upstream point in the basin. The basin is characterized by uplands deeply cut by water erosion and the broad, gently sloping stream valley. The slope of Big Muddy Creek ranges from 100 feet per mile in the uplands to 5 feet per mile in the vicinity of the dam. The amount of time it takes for precipitation falling on the most upstream reaches of the basin to travel downstream to the dam (time of concentration) was calculated to be 16.7 hours. A map of the basin above Glen Ullin Dam is included as Figure 3.

WATERSHED OF GLEN ULLIN DAM

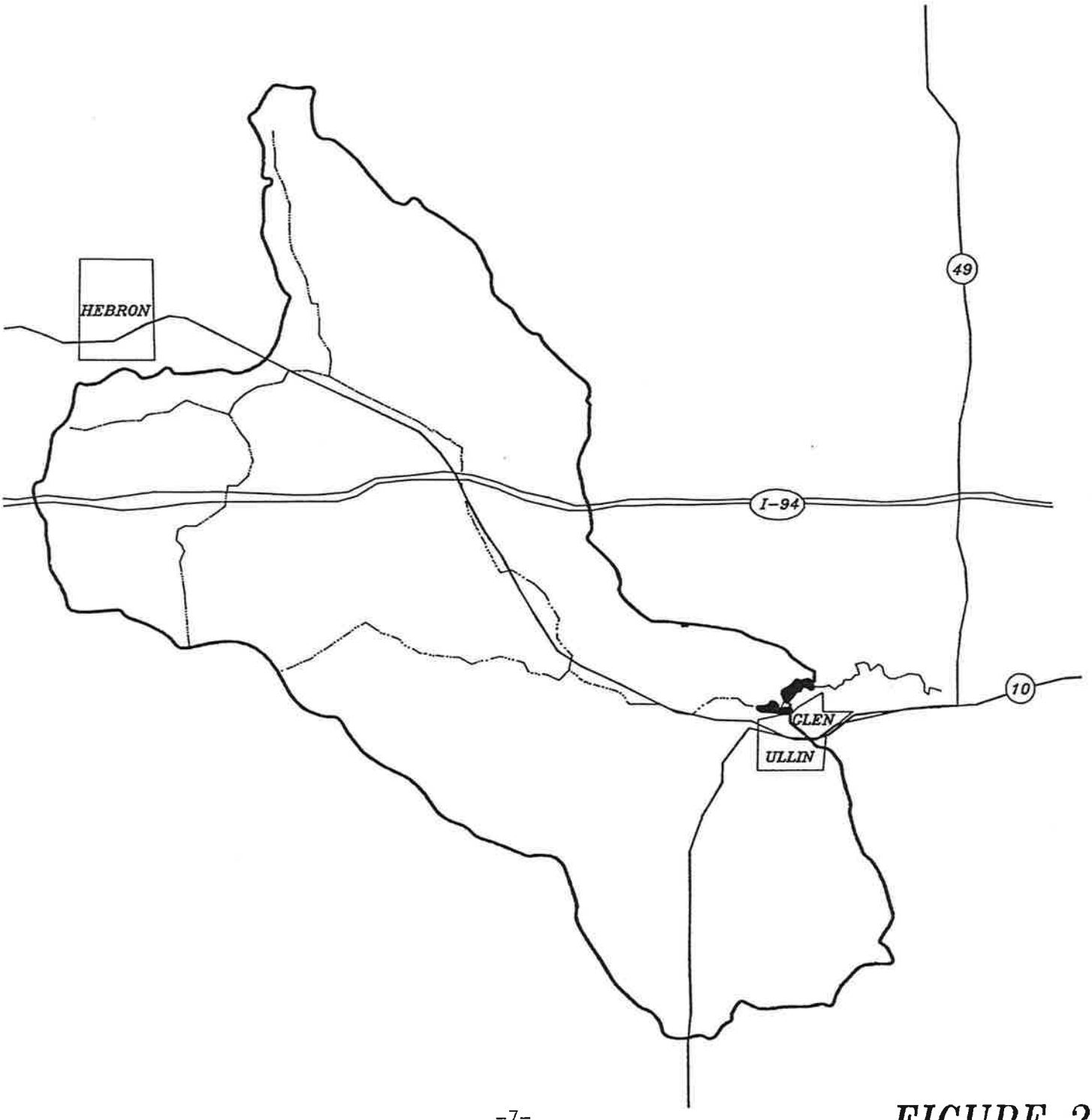


FIGURE 3

III. SCOPE

A. Objective:

The objective of this investigation is to establish what measures could be taken to improve the supply of water to the north reservoir of Glen Ullin Dam, while also ensuring or improving the integrity of the water conveyance structures.

The Glen Ullin Park Board has established the Crossroads Golf Course around the north reservoir. Improving the supply of water and conveyance structures of the north reservoir will increase the recreational benefits of the reservoir.

B. Alternatives:

Two alternatives for improving the supply of water to the north reservoir were developed. Alternative No. 1 is to improve the conveyance capability of the connecting channel and place a drop structure in the north dam spillway to control erosion. Alternative No. 2 consists of improving the conveyance capability of the connecting channel and blocking the north dam spillway. The relative advantages and disadvantages of the alternatives are discussed in Section VI Summary.

IV. PROCEDURE

This section consists of a discussion of the methods used to evaluate the performance of various design configurations in achieving the objective. The dam was evaluated following the guidelines of the North Dakota Dam Design Handbook (1). The dam was judged to be a class II dam, having low-hazard potential, and being less than 25 feet in height.

A. Hydrology:

The suggested precipitation criteria for a class II dam emergency spillway in the North Dakota Dam Design Handbook, are the 25- and 50-year events for velocity and freeboard, respectively. The 50-year event is that precipitation event which can be expected to be equalled or exceeded on an average once every 50 years. There are no criteria for the principal spillway of a class II dam. Because of the unusual layout of Glen Ullin Dam, channel designs were evaluated with 50-, 25-, 10-, 2-, and 1-year events. Precipitation quantities for each event were obtained from the SCS Hydrology Manual for North Dakota (2). Inflow flood hydrographs were developed using the HEC-1 Flood Hydrograph Package (3), with the calculated time of concentration and the precipitation values.

Table 1 shows the precipitation values and resulting peak inflows for the selected events.

Table 1

Recurrence Interval years	Precipitation inches	Peak Inflow cfs
1	1.55	830
2	1.95	1405
10	2.65	3443
25	3.65	4374
50	4.15	5370

B. Flood Routing:

Because of the inter-relationship between the two reservoirs and the connecting channel, a FORTRAN computer program was written by the author to route flood flows through Glen Ullin Dam. Acceptable peak reservoir water surface elevations were determined by examining survey information and 7.5-minute topographical maps. The acceptable peak water surface elevation for the south reservoir was determined to be 2070 msl. The acceptable peak water surface elevation for the north reservoir will depend on modifications to the north dam spillway. A portion of a 7.5-minute topographical map has been included with Figure 1.

Stage-discharge relationships or rating curves were developed for both dam spillways for use in the FORTRAN computer program. For the south dam spillway, the rating curve was determined with the broad-crested weir formula, and weir dimensions and elevations. This rating curve was checked for submergence effects after stage discharge relationships were developed for the creek channel downstream. The stage discharge relationships for Big Muddy Creek and the channel designs were developed using

the HEC-2 Water Surface Profiles (4). It was determined from these relationships that the weir formula was appropriate for the south dam spillway.

The stage discharge relationships for the north dam spillway and channel were dependent on the spillway channel design. Rating curves for the south dam and selected north dam spillway design for Alternative No. 1, are given in performance tables included in Section V. Results are presented later in this report.

The procedure used for evaluating each structure and channel design is described below. Stage discharge relationships were estimated for the north dam spillway using the stage discharge relationship for the creek channel downstream of the spillway channel, and the channel and spillway design being evaluated. This relationship was input into the routing program, along with the inflow hydrograph, and the connecting channel gate design being evaluated. The average net evaporation for the Glen Ullin area is 19 inches (2). The assumption was made that the north reservoir had filled the previous spring and then lost 19 inches of water to evaporation. With this assumption and a north dam spillway crest elevation of 2063.7, the starting water surface elevation for the north reservoir to be used in the model was 2062.1 msl. The starting water surface for the south reservoir was assumed to be 2064.5, which is 6 inches below the south dam spillway crest. The routing program was run and the results examined to evaluate the performance of the designs, relative to

the investigation objectives and acceptable water surface elevation criteria. The connecting channel and north dam spillway designs were then adjusted, along with the north spillway stage discharge relationship, and the routing program was rerun. The 50-year event was used for determining the necessary capacity of design structures. The performance of the design was then checked with the lower frequency events. The acceptable maximum channel velocity criteria used was 3.5 feet per second.

V. RESULTS

This section presents the results of the investigation. The investigation determined two alternatives which might feasibly achieve the objectives. The difference between the two alternatives centers on the treatment of the north dam spillway. In Alternative No. 1, the capacity of the north dam spillway to pass water is retained and measures are taken to control erosion in the north dam spillway channel. In Alternative No. 2, the north dam spillway is blocked and used as a fuse plug spillway for emergency use only. Both alternatives include refurbishing the connecting channel gate and excavation of the connecting channel.

A. Alternative No. 1:

Alternative No. 1 features the capability to pass flows over the north dam spillway. This is accomplished with excavation of the connecting channel, refurbishing the connecting channel gate, replacing the culverts under the connecting channel roadway crossing, placing a drop structure on the north dam spillway, and excavation in the north dam spillway.

The golf course clubhouse is located to the north of the north dam spillway channel. The elevation of the clubhouse foundation is 2064.4 msl. The north dam spillway crest elevation is 2063.7 msl. The banks along the north dam spillway channel are at an elevation of approximately 2065 msl. In order to minimize excavation in the north dam spillway channel, the drop structure should be located at the head of the gully formed by

erosion in the channel. This point is approximately 300 feet downstream from the spillway. With the banks of this channel at approximately 2065 msl, the acceptable peak north reservoir water surface elevation for Alternative No. 1 was determined to be 2065 msl. Water surface elevations higher than 2065 msl would require raising the banks along the spillway channel or locating the drop structure closer to the spillway. Either of these would be cost prohibitive.

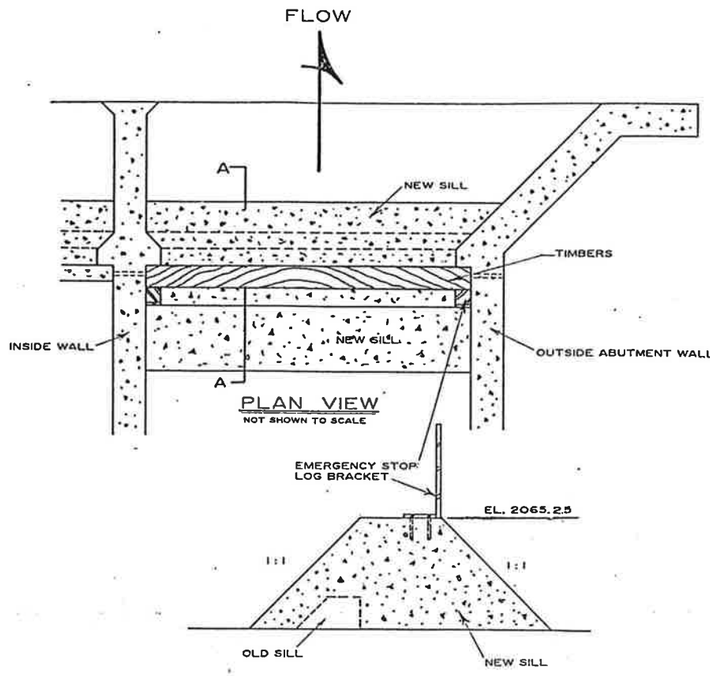
For this alternative, a connecting channel gate opening 12 inches high and 20 feet wide was selected, along with two 36-inch diameter culverts in the channel crossing, and a 48-inch diameter corrugated metal pipe drop inlet structure in the north dam spillway channel. This combination should adequately meet the objectives of the investigation while not exceeding the acceptable stage criteria.

For this investigation, it was assumed that it would be preferable to have the low flows pass over the south dam spillway, and therefore it was assumed that the connecting channel gate sill would be raised to an elevation of 2065.25 msl. With the crest of the south dam spillway at 2065 msl, this would mean that 3 inches of water would be going over the south dam spillway before water would enter the north reservoir through the connecting channel. The connecting channel gate has two bays, each 10 feet wide by 6 inches high, with a total cross-sectional area of 10 square feet. The gate could economically be constructed

on-site of treated lumber and concrete. The connecting channel and gate design are shown on Figure 4.

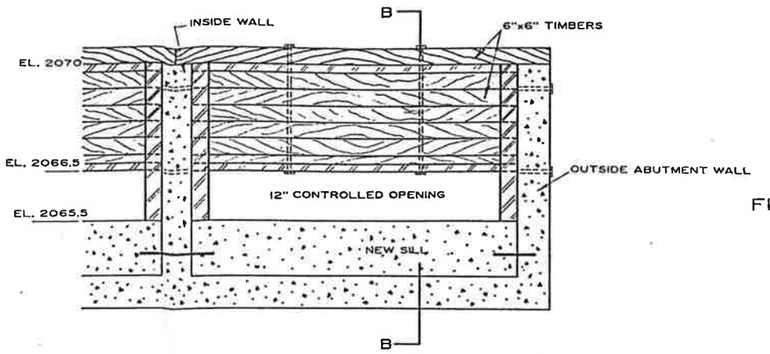
There is a roadway crossing the connecting channel approximately 450 feet downstream (northeast) of the gate. This crossing is used by persons using the golf course, and also by golf course maintenance vehicles. It was found that two 36-inch culverts would be necessary to pass the required flows through this crossing, while not overtopping the connecting channel banks. It was determined that the connecting channel should be excavated to an elevation of 2060 msl, with a 12.5-foot bottom width and 2:1 side slopes. This channel is presently at an elevation of around 2063 msl, and is choked by dense growths of emergent vegetation. Excavating this channel to an elevation of 2060 msl, should provide for about 3 feet of water in the channel which should be sufficient to inhibit emergent vegetation growth. The two culverts would be placed at an invert elevation of 2060 msl, with a flat slope. The improvements to this channel would involve 1800 cubic yards of excavation. The excavated material would be disposed in the vicinity of the gate structure and in areas along the north side of the south reservoir.

The north dam spillway channel drop structure would be located 300 feet downstream (east) of the rubble masonry spillway, at the head of the gully which has eroded in the channel. The drop structure would consist of a vertical drop inlet and an outlet pipe. It was determined that the most economical combi-

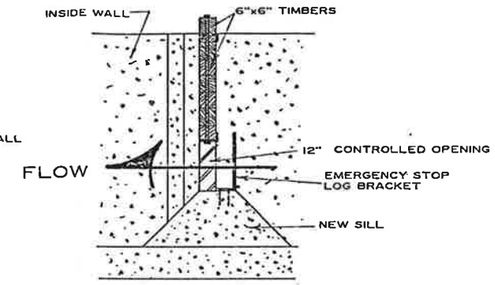


PLAN VIEW
NOT SHOWN TO SCALE

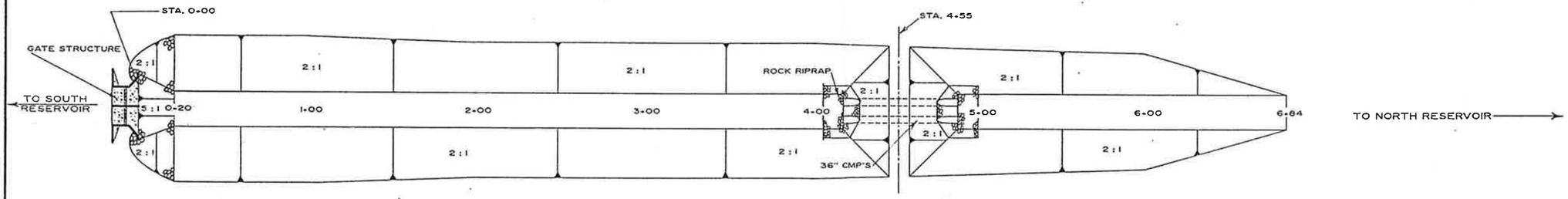
SECTION A-A
NOT SHOWN TO SCALE



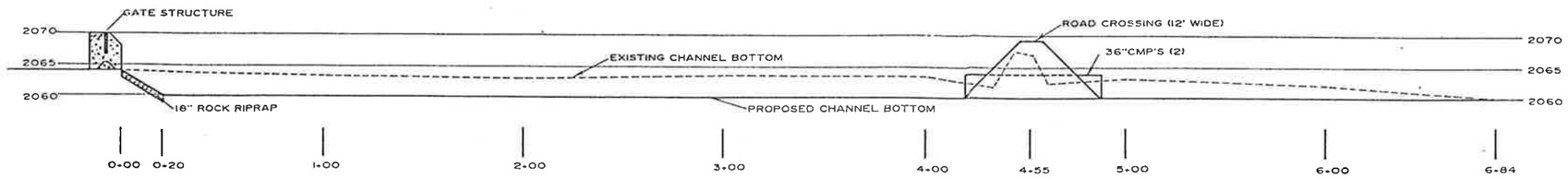
ELEVATION VIEW
NOT SHOWN TO SCALE



SECTION B-B
NOT SHOWN TO SCALE



PLAN VIEW
NOT SHOWN TO SCALE



ELEVATION VIEW
NOT SHOWN TO SCALE

SHEET OF

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 673

GLEN ULLIN DAM
CONNECTING CHANNEL

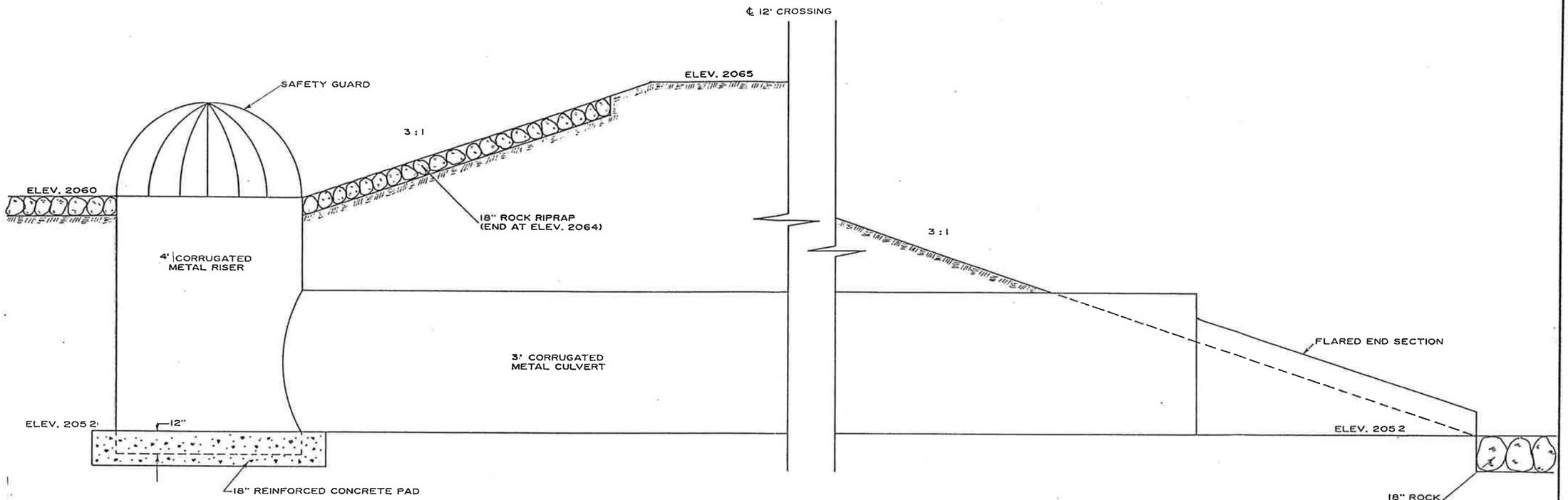
COUNTY MORTON DATE
SURVEYED: L.L.K. CHECKED BY: SUBMITTED:
DRAWN: J.L.W. DESIGNED BY: APPROVED:
DRAWING NO. 673-1 SCALE NO SCAL

FIGURE 4

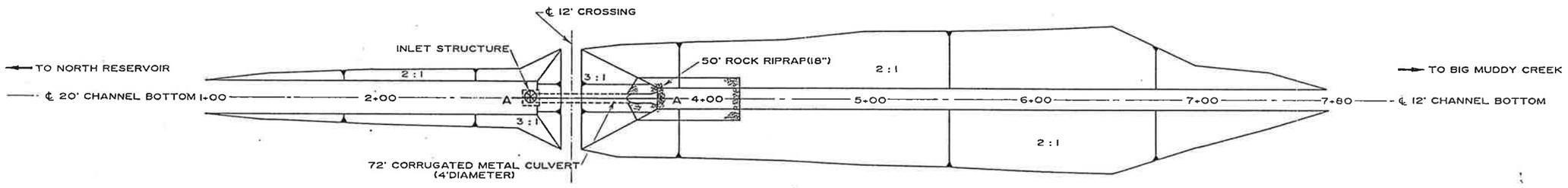
nation for the drop structure would be a 48-inch diameter CMP riser, with a 36-inch diameter CMP barrel. The crest of the drop structure inlet would be placed at an elevation of 2060.0 msl. The configuration of the structure is shown on Figure 5. There is some concern about the possibility of children playing on and in this drop structure, and steps should be taken to prevent access. The configuration shown on Figure 5 includes a trash rack on the inlet which would prevent access from the upper end of the structure. A heavy gage wire-mesh could also be placed over the barrel exit to prevent access. The barrel of the structure would be placed on a flat slope with an invert elevation of 2052 msl. This structure is not intended to retain water for extended periods and thus is not designed to. This structure will only be used when north reservoir water surface elevations exceed that of the north dam spillway crest (2063.7 msl).

If the structure was designed to retain water, provisions would have to be made for controlling seepage through the embankment. This was considered to be an unnecessary expense, and for this reason, the structure was designed for temporary use only. With this in mind, the connecting channel gate sill elevation was set at 3 inches higher than the south dam spillway crest elevation or 2065.25 feet msl.

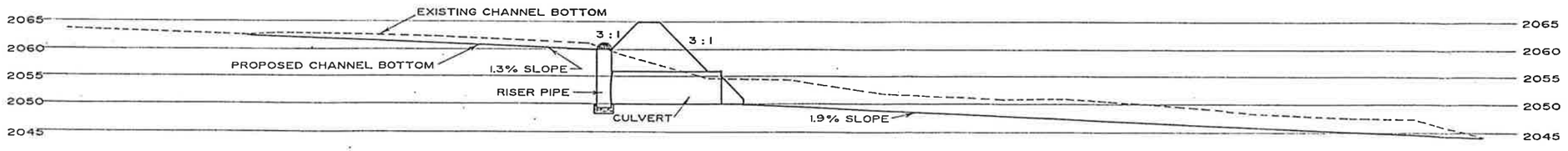
The channel immediately below the drop structure would be excavated to an elevation of 2052 msl, and would slope to an elevation of 2044 msl at the junction with Big Muddy Creek some

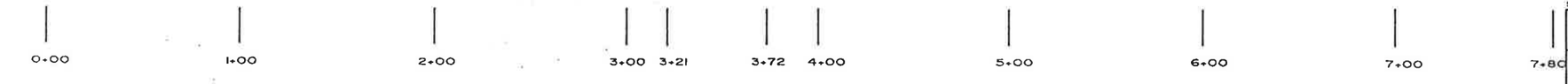


SECTION A-A
NOT SHOWN TO SCALE



PLAN VIEW
NOT SHOWN TO SCALE





ELEVATION VIEW
NOT SHOWN TO SCALE

SHEET OF

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 673

GLEN ULLIN DAM
(NORTH DAM SPILLWAY CHANNEL)

COUNTY MORTON DATE 5/90
SURVEYED: L.L.K CHECKED BY: SUBMITTED:
DRAWN: J.L.W DESIGNED BY: APPROVED:
DRAWING NO. 673-2 SCALE NO SCALE

FIGURE 5

430 feet downstream. The channel would have a bottom width of 12.5 feet, and 2:1 side slopes. Riprap would be placed around the outlet and in the channel, a distance of 50 feet downstream, to prevent erosion. The improvements to this channel would involve 4700 cubic yards of excavation. Some of the excavated material could be used to construct the drop structure embankment, the remainder to be disposed of on adjacent areas. During high flow periods, water from the creek would back up the spillway channel from Big Muddy Creek and submerge the drop structure outlet.

The channel between the north dam spillway and the drop structure inlet would be excavated to an elevation of 2060.0 msl at the structure, and would slope to an elevation of 2063 msl just downstream of the spillway, a distance of 300 feet upstream. This portion of the spillway channel would have a bottom width of 20 feet and 2:1 side slopes. With the crest of the north dam spillway at elevation 2063.7 msl, and the crest of the drop structure at 2060.0 msl, this channel will normally be dry. These improvements to the channel would involve 280 cubic yards of excavation. The excavated material would be disposed of along the north side of the spillway channel to provide additional freeboard.

There is presently a roadway across the bottom of the spillway channel just downstream of the north dam spillway. This

roadway would be rerouted to pass over the drop structure barrel embankment 300 feet downstream (See Figure 5).

Table 2 below shows the performance of the south dam spillway during each of the precipitation events, along with the corresponding peak water surface elevations in the creek below the south dam spillway.

Table 2

South Dam Spillway Performance
Alternative No. 1

Precip. Event Recurrence Interval	Peak South Dam W.S. Elevation	Peak Flow Rate Through South Dam Spillway	Peak W.S. Elevation In Creek
years	feet msl	cfs	feet msl
1	2066.7	731	2257.2
2	2067.3	1293	2059.3
10	2068.8	3307	2063.6
25	2069.4	4236	2065.1
50	2070.0	5218	2066.5

While the data listed in Table 2 is for peak elevations and flows with Alternative No. 1, the elevations and corresponding flows can also be used as a rating curve for the south dam spillway regardless of which alternative is used. This is possible because neither alternative involves changes to the south dam spillway.

Table 3 below shows the performance of the north dam spillway with Alternative No. 1 for each precipitation event. It can be seen from the table that even with the smallest event, enough

water will enter the north reservoir to exceed the north dam spillway's crest elevation and cause water to flow down the north dam spillway channel. For the 10- through 50-year events, the peak flow rate through the spillway is progressively less. This is because of the backwater effect caused by high water elevations on the creek downstream during the high flow period.

Table 3

North Dam Spillway Performance
Alternative No. 1

Precip. Event Recurrence Interval	Peak North Dam W.S. Elevation	Peak Flow Rate Through North Dam Spillway	Peak W.S. Elevation At Creek Junc
years	feet msl	cfs	feet msl
1	2064.0	59	2052.9
2	2064.1	66	2055.1
10	2064.7	75	2058.5
25	2064.7	70	2059.9
50	2065.0	63	2061.2

As an additional safety measure, provisions would be made for completely closing the connecting channel gate with stoplogs. These stoplogs would be made of 10-foot long treated 6-inch x 6-inch lumber. Because these stoplogs would only be used on an emergency basis, a mechanism for placing and removing them was not included in the cost estimate. The stoplogs could probably be placed by two persons, but would probably require some mechanized means of removal, such as a tractor with a front-end loader.

B. Alternative No. 2:

Alternative No. 2 features blocking off the north dam spillway. With this alternative, the spillway channel with its low banks (2065 msl) is not used and a somewhat higher water surface elevation in the north reservoir is acceptable. The dike along the southeast side of the north reservoir has a minimum elevation of 2066.1 msl. For this reason maximum water surface elevation for the north reservoir of approximately 2066 msl was selected. Higher elevations might endanger the dikes around the north reservoir and the spillway block.

For this alternative, a connecting channel gate opening of 6 inches high by 20 feet wide was selected with 24-inch diameter culverts in the channel crossing. As in Alternative No. 1, the connecting channel would be excavated to elevation of 2060 msl, with a 12.5-foot bottom width and 2:1 side slopes. This excavation will involve the removal of 1800 yards of material.

This alternative was evaluated only for the 50-year 24-hour precipitation event. During the 50-year event, the peak water surface elevation in the north and south reservoir would be 2066.1 msl and nearly 2070 msl, respectively. The peak discharge over the south dam spillway would be 5300 cfs.

The 6-inch opening in the connecting channel gate, coupled with the two 24-inch culverts in the roadway crossing, would serve to limit the rate at which water will flow through the

connecting channel and into the north reservoir. The gate opening and culverts were determined to be sufficiently small so as to prevent the dikes around the north reservoir from overtopping during the 50-year, 24-hour precipitation event. Because the gate opening and culverts control the rate at which water can enter the north reservoir and not the amount of water flowing into the reservoir, there is danger that the dikes can be overtopped during an event which lasts for a longer period. A typical spring runoff resulting from melting snow might last as long as several weeks. During a runoff event of this length, the water surface elevation in the north reservoir would be the same or nearly the same as in the south reservoir. With a top-of-dike elevation of 2066.1 msl and a south dam spillway elevation of 2065 msl, overtopping of the north reservoir dikes could easily occur with Alternative No. 2.

For this reason the block placed in the north dam spillway should be designed to overtop at a water surface elevation of 2065.5 msl. This should help to prevent overtopping and subsequent failure of the north reservoir dike or embankments.

With the north dam spillway blocked, the north reservoir can be managed higher than the present north dam spillway crest elevation of 2063.7 msl. The north reservoir could be managed at a water surface elevation the same as the south reservoir by maintaining the connecting channel gate sill elevation at the present 2064.4 msl. As surveying data for the investigation was

being collected, elevations of several of the golf course features were measured. The greens of hole numbers 6 and 7 at the west end of the north reservoir, were measured at elevation 2067.8 msl and 2066.3 msl, respectively. The green for hole number 2 to the north of the north reservoir was measured at 2069.3 msl. Hole number 8 is located to the south of the north reservoir and the north reservoir dike crosses the fairway. The elevation of the green for hole number 8 was measured at 2063.7 msl, which is the same elevation as the north dam spillway crest. This green is located on the other side of the north reservoir dike. Water surface elevations in the north reservoir higher than 2063.7 msl, might adversely affect these holes by raising the water table. Also, the high water surface elevations possibly would flood portions of some fairways.

Because of the danger of overtopping the north reservoir dike and the possible adverse effects of a higher water surface elevation, it would be necessary to operate the connecting channel gate with Alternative No. 2. This could be done with either of the following two operating options for Alternative No. 2.

The first and probably safest operating option would be to place stoplogs in the connecting channel gate. During the spring runoff or other high flow periods, the gate could be opened and water allowed to enter the north spillway until the desired elevation is reached. The gate would then be closed and the high flows would pass over the south dam spillway.

The second operating option would be to put the connecting channel gate sill at elevation 2065.25 msl. During high flow periods, the water surface elevation in the north dam would be monitored until the desired elevation is reached, and the gate would then be closed. After the high flows have subsided, the gate could be reopened.

Either of these two operating options would meet the objective of improving the supply of water to the north reservoir. The drawbacks of both options for Alternative No. 2 are as follows: 1) operation of the gate and monitoring of the north reservoir water surface elevation would be required, 2) mis-operating the gate could cause a failure of the dam or water surface elevations in the north reservoir which would adversely affect the golf course, 3) water will not flow through the north reservoir and over the north dam spillway which may not improve the quality of water in the north reservoir.

Although not included in the cost estimate for Alternative No. 2, a mechanism for placing and removing the stoplogs may be necessary.

C. Cost Estimate:

The preliminary cost estimate for Alternative No. 1 is $21,500 for construction. The itemized estimates for the two alternatives are shown in Tables 4 and 5. The preliminary cost estimate for Alternative No. 2 is $5,200.00 for construction.

Table 4
Alternative No. 1 Cost Estimate

Connecting Channel Gate Construction	$ 1,000.00
Connecting Channel Earthwork 1800 cu. yds @ $1.10	1,980.00
Connecting Channel Culverts	900.00
Installation	360.00
North Dam Spillway Upstream of Drop Structure, Earthwork 280 cu. yds @ $1.10	308.00
North Dam Spillway Downstream of Drop Structure, Earthwork 4700 cu. yds @ $1.10	5,170.00
Drop Spillway	4,200.00
Installation	1,720.00
North Dam Spillway, Bank Protection Downstream of Drop Structure, Riprap 90 cu yds @ $25.00	2,250.00
North Dam Spillway, Filter Fabric 175 sq. yds @ $4.00	700.00
Subtotal	$18,700.00
Engineering, Contract Administration and Contingencies @ 15%	2,800.00
TOTAL	$21,500.00

Table 5
Alternative No. 2 Cost Estimate

Connecting Channel Gate Construction	$ 1,000.00
Connecting Channel Earthwork 1800 cu. yds @ $1.10	1,980.00
Connecting Channel Culverts	900.00
Installation	360.00
North Dam Spillway Block 220 cu. yds @ $1.10	242.00
Subtotal	$ 4,500.00
Engineering, Contract Administration and Contingencies @ 15%	700.00
TOTAL	$ 5,200.00

D. Project Impacts:

The present condition of the connecting channel and gate severely restrict flows into the north reservoir. The project, as proposed, improves the flow of water into the north reservoir which would result in slightly lower water surface elevations in the south reservoir and higher water surface elevations in the north reservoir during high flow periods than with present conditions. The effect on the south reservoir elevations would be greater for Alternative No. 1 than for Alternative No. 2 because of the added spillway capacity. With Alternative No. 1, the potential for overtopping would be reduced and the dam would be safer than present. The same can be said for the second alternative, if the connecting channel gate is properly operated. The converse could also be true however, if the gate is not properly operated.

VI. SUMMARY

Two alternatives have been presented in this report which will accomplish the objective of the investigation to improve the supply of water to the north reservoir of Glen Ullin Dam. Alternative No. 1 features the capability of passing flood flows down the north dam spillway. This is accomplished by constructing a fixed opening 6 inches high in the connecting channel gate, and constructing a drop structure in the north dam spillway. This alternative includes 1800 cu. yds of excavation in the connecting channel and 4980 cu. yds of excavation in the north dam spillway. It also includes placement of two 36-inch culverts under the connecting channel roadway crossing. The estimated project cost for this alternative is $21,500.00.

Alternative No. 2 differs from Alternative No. 1 in that the north dam spillway is blocked to prevent flow from entering the north dam spillway channel. This would be accomplished by placing 220 cu. yds of fill in the north dam spillway. This alternative does include the same improvements to the connecting channel and gate as the first alternative. This alternative does not require the drop structure and the improvements to the north dam spillway channel. The estimated project cost for Alternative No. 2 is $5,200.00.

With Alternative No. 1, the water in the north reservoir would be freshened by water coming into the reservoir through the gate and connecting channel, causing water levels in the north

reservoir to rise until the north dam spillway elevation is exceeded. When this elevation is exceeded, water will pass over the spillway and down the spillway channel into Big Muddy Creek downstream. This flow-through of water should occur nearly every year and should improve the quality of the water in the north reservoir substantially. With Alternative No. 2, water would enter the north reservoir as the water surface elevation in the south reservoir rises during a precipitation event. Flow would pass through the connecting channel and gate into the north reservoir. This would continue until the north and south reservoir water surface elevations equalize. Since the outlet for the two reservoirs would be the south dam spillway, water would then flow back through the connecting channel into the south reservoir as the high flow subsides. While this back and forth flow of water between the two reservoirs will freshen the water in the north reservoir somewhat, Alternative No. 2 operated in this manner would not freshen the water as well as Alternative No. 1.

With Alternative No. 2, there is more potential for the north reservoir dikes to be overtopped. During a large precipitation event which lasts for a longer period of time than the events modeled in this report, there will be a tendency for the water surface elevations of the two reservoirs to equalize. The dike along the southeast side of the north reservoir has a minimum elevation of 2066.1 msl in the vicinity of the downstream channel embankment. The flood-routing results for a 50-year precipitation event indicated a peak water surface elevation in

the north reservoir of 2066.1 msl for the second alternative. For this reason, the block placed in the spillway for Alternative No. 2, should be designed to overtop at an elevation no higher than 2065.5 msl. This elevation is only 6 inches higher than the crest elevation of the south dam. Overtopping of the north dam spillway could potentially occur with a precipitation event which causes 6 inches or more of water to pass over the south dam spillway for a period longer than 24 hours. This could happen during spring runoff periods. Clearly, Alternative No. 2 will require operation of the connecting channel gate and monitoring of the north reservoir water surface elevations.

The elevation of the crest of the north dam spillway is presently 2063.7 msl, while the crest of the south dam spillway is at 2065.0 msl. Several of the golf course fairways are located at elevations which might be impacted by water surface elevations in the north reservoir much higher than 2063.7 msl. The green for hole number 7 is at an elevation of 2066.3 msl. Operation of the connecting channel gate would be necessary to maintain a water surface elevation lower than the south reservoir with Alternative No. 2. As the water was rising in both reservoirs, stoplogs could be placed in the gate once the north reservoir reached the desired elevation. The water surface elevation in the north reservoir would be lower than in the south reservoir. This would preclude having water flow back out to the south reservoir as the high flows subside and would probably result in poorer water quality in the north reservoir than other-

wise. Operation of this stoplog gate would require close monitoring of the water surface elevations in the north reservoir. Alternative No. 1 would maintain the existing north dam spillway crest elevation of 2063.7, which would be the normal operating elevation of the reservoir. This alternative would not require gate operation or monitoring except during extreme floods.

VII. CONCLUSION AND RECOMMENDATION

The general conclusion of this investigation is that Alternative No. 1 is preferable to Alternative No. 2, from the standpoint of achieving the objective of improving the supply of water to the north reservoir of Glen Ullin Dam. Alternative No. 1 will improve the quantity and quality of the water available to the north reservoir more than Alternative No. 2. Alternative No. 1 is also preferable from the standpoint of operation and monitoring. Although Alternative No. 2 is less costly, it is recommended that the Board proceed with Alternative No. 1.

The Board's decision of which alternative to proceed with will have to be made by comparing the advantages of Alternative No. 1 to the lower cost of Alternative No. 2.

Appendix A
Water Rights

Section 61-01-01 of the North Dakota Century Code states that all waters within the limits of the state belong to the public and are subject to appropriation for beneficial use, and the right to use the waters must be acquired pursuant to the laws of the state. Beneficial use includes the recreational use of water, such as that at Glen Ullin Dam. There is no state water use permit in existence for Glen Ullin Dam, however; there are nine state water use permits on Big Muddy Creek downstream of the dam, and five state water use permits on the Heart River downstream of its confluence with Big Muddy Creek. The total amount of water appropriated by the permits on Big Muddy Creek below Glen Ullin Dam is 3930 acre-feet. The U.S. Geological Survey (USGS) operated a stream gage on Big Muddy Creek from 1945 to 1969, near Almont, North Dakota, about 12 miles upstream of the confluence of Big Muddy Creek and the Heart River. The median yearly discharge passing this gage, totaled 16,700 acre-feet for the period of record.

Section 61-04-06.3 of the Century Code deals with priority of use, and states that "Priority in time shall give the superior water right." This means that water use permits obtained earliest in time have the highest right. One of the steps in obtaining a water permit is quantifying to amount of water used. Tables 6 and 7 show the relationship between water surface elevation and capacity for the two reservoirs at Glen Ullin Dam.

Table 6

Glen Ullin Dam
Elevation - Capacity Data For South Reservoir

Elevation feet msl	Area acres	Capacity acre-feet
2058.4	0.0	0.0
2060.0	6.1	3.3
2062.0	15.2	23.9
2063.5	18.2	48.9
2065.0	19.7	77.3
2066.0	24.6	99.4
2068.0	34.4	158.3
2070.0	44.2	236.9

Table 7

Glen Ullin Dam
Elevation - Capacity Data For North Reservoir

Elevation feet msl	Area acres	Capacity acre-feet
2054.0	0.0	0.0
2055.5	4.4	2.2
2062.5	16.7	71.4
2063.7	28.4	98.2
2065.0	41.0	143.1
2066.5	74.0	228.1
2068.0	97.1	356.1

The annual use of water at Glen Ullin Dam can be estimated by calculating the net amount of water which can be expected to evaporate from the two reservoirs in a year. The average annual evaporation for the Glen Ullin area is estimated as 35 inches (1). The average annual precipitation for the Glen Ullin area is estimated as 16 inches (2). Subtracting the average annual precipitation from the average annual gross evaporation gives an average annual net evaporation of 19 inches. The north reservoir

has a water surface area of approximately 28.4 acres at its spillway elevation of 2063.7 msl. With 19 inches of net evaporation loss, the annual use for the north reservoir can be estimated as 45 acre-feet. The south reservoir has a water surface area of 19.7 acres at its spillway elevation of 2065 msl. With 19 inches of net evaporation, the annual water use in the south reservoir can be estimated at 31 acre-feet. The annual water use for Glen Ullin Dam can then be estimated at 76 acre-feet.

APPENDIX B

SWC Project #673
October 2, 1989

A G R E E M E N T

Investigation of Diversion Structure Refurbishment at Glen Ullin Dam Glen Ullin, North Dakota

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter Commission, through its Secretary, David Sprynczynatyk, hereinafter Secretary; and the Morton County Water Resource District, hereinafter District, through its Chairman, Andy Mork.

II. PROJECT, LOCATION, AND PURPOSE

The District wishes to investigate the possibility of refurbishing a diversion structure which is a part of the Glen Ullin Railroad Dam in Glen Ullin, North Dakota. The dam is located on Big Muddy Creek within the city limits of Glen Ullin. The dam, which was originally constructed by the Burlington Northern Railroad Company in 1909, is currently used by the city for recreation purposes and the repairs will allow its continued satisfactory use.

III. PRELIMINARY INVESTIGATION

The parties agree that further information is necessary concerning the proposed project. Therefore, the Commission shall conduct the following:

1. Conduct a topographic survey of the dam site,

2. Conduct a study of the hydrology of the watershed upstream of the dam, and

3. Design the outlet works necessary to safely and efficiently pass the design flood through the dam.

IV. DEPOSIT - REFUND

The District shall deposit a total of $500.00 with the Commission to partially defray the costs of the field work necessary to conduct the investigation. Upon receipt of a request from the District to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the District with a statement of all expenses incurred in the investigation and shall refund to the District any remaining funds.

V. RIGHTS-OF-WAY

The District agrees to obtain written permission from any affected landowners for field investigations by the Commission, which are required for the preliminary investigation.

VI. INDEMNIFICATION

The District hereby accepts responsibility for and holds the Commission, the State Engineer, and their employees and agents, free from all claims and damages to public or private property, rights, or persons arising out of this agreement. In the event a suit is initiated or judgment rendered against the Commission, the State Engineer, or their employees or agents, the District

agrees to indemnify them for any settlement arrived at or judgment satisfied.

VII. CHANGES TO THE AGREEMENT

Changes to any contractual provisions herein will not be effective or binding unless such changes are made in writing, signed by both parties and attached hereto.

NORTH DAKOTA STATE WATER COMMISSION	MORTON COUNTY WATER RESOURCE DISTRICT
BY: [signature]	BY: [signature]
DAVID A. SPRYNCZYNATYK Secretary	ANDY MORK Chairman
DATE:	DATE: October 26/1989
WITNESS:	WITNESS: [signature]

APPROVED as to form this 17th day of Oct., 1989
ATTORNEY GENERAL
By Steven Novak
ASST. ATTORNEY GENERAL

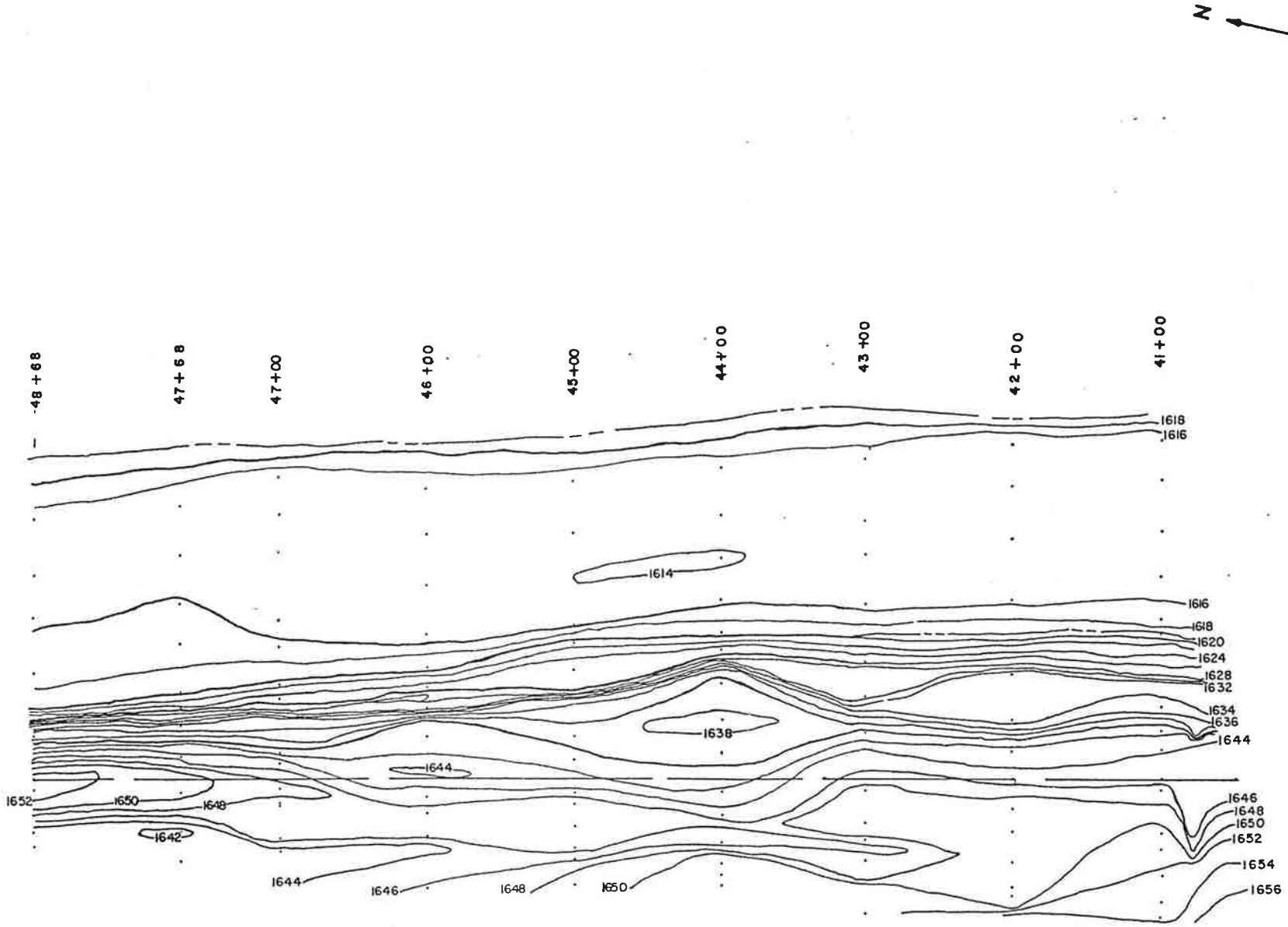
BIBLIOGRAPHY

1. Moum, R. A., Frink, D. L., and Pope, E. J., North Dakota Dam Design Handbook, Office of the North Dakota State Engineer, Second Printing, June, 1985.

2. Soil Conservation Service, U.S.D.A., Bismarck, North Dakota, Hydrology Manual for North Dakota

3. U.S. Army Corps of Engineers, HEC-1 Flood Hydrograph Package, September, 1981.

4. U.S. Army Corps of Engineers, HEC-2 Water Surface Profiles September, 1982.



HEART RIVER BANK STABILIZATION
SWC PROJECT #576-28
FORT LINCOLN
Topography Map
Stations 48+68 to 41+00
Sec. 13, T. 138 N., R. 81 W.
Contour Interval - 2 feet
Scale 1"=100'

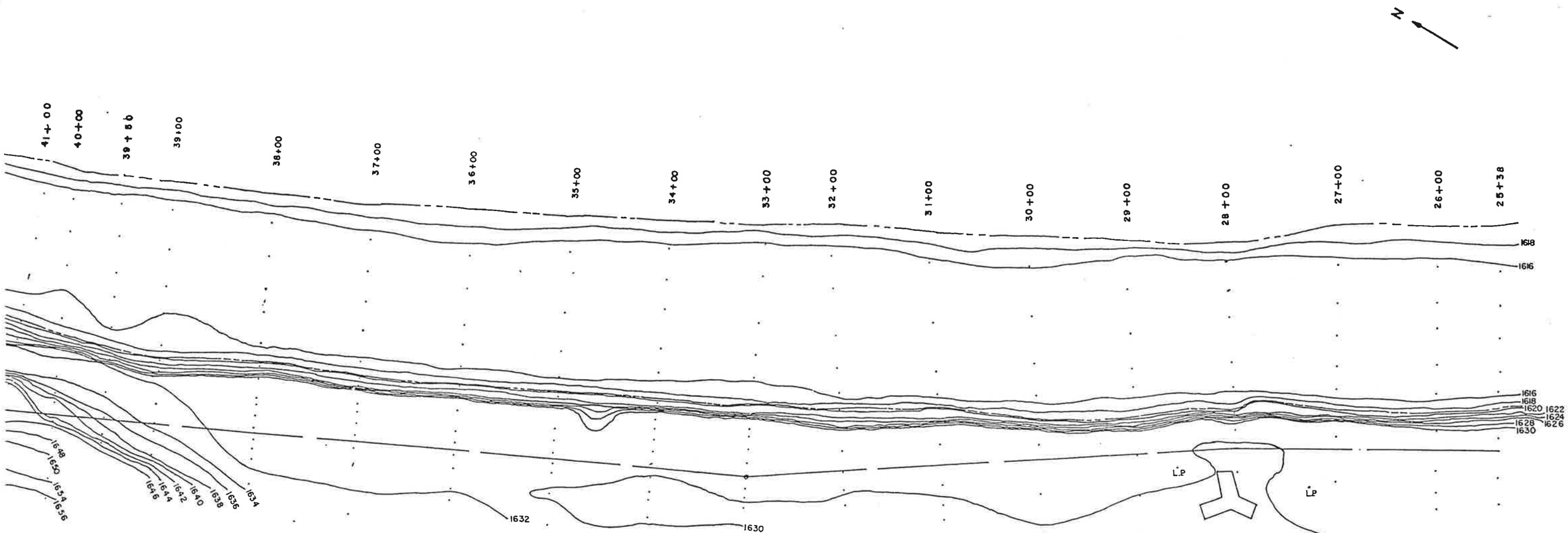
Project Drawings
Sheet 1 of 3

SURVEYED - 4-13-87

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 576-28
FORT LINCOLN BANK STABALIZATION
(HEART RIVER)

COUNTY MORTON DATE 9-4-87
SURVEYED: L.L.K. CHECKED BY: SUBMITTED:
DRAWN: ADP DESIGNED BY: APPROVED:
DRAWING NO. SCALE 1" = 5



HEART RIVER BANK STABILIZATION
SWC PROJECT #576-28
FORT LINCOLN
Topography Map
Stations 41+00 to 25+38
Sec. 13, T. 138 N., R. 81 W.
Contour Interval - 2 feet
Scale 1"=100'

Project Drawings
Sheet 2 of 3

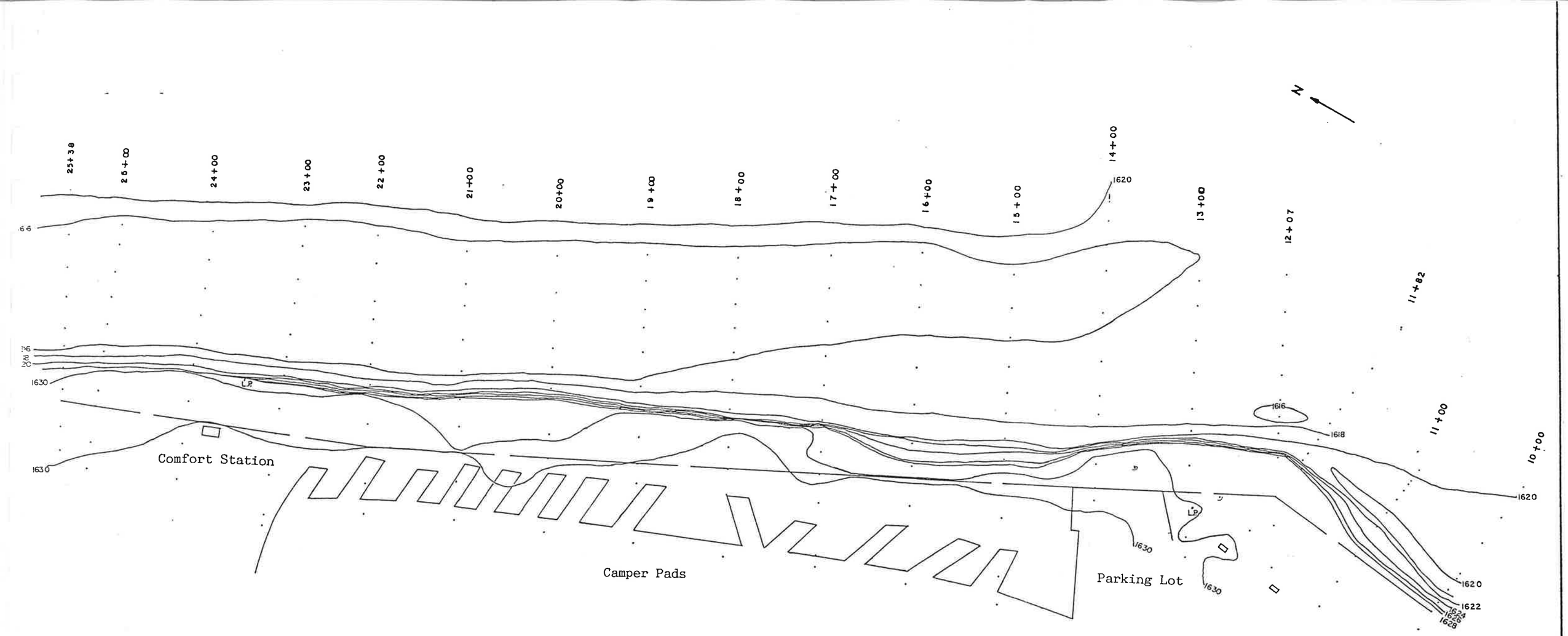
SURVEYED - 4-13-87

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 576-28
FORT LINCOLN BANK STABALIZATION

(HEART RIVER)

COUNTY MORTON DATE 9-4-87
SURVEYED L.L.K. CHECKED BY: SUBMITTED:
DRAWN: A.D.P. DESIGNED BY: APPROVED:
DRAWING NO. SCALE 1"=50'



HEART RIVER BANK STABILIZATION
SWC PROJECT #576-28
FORT LINCOLN
Topography Map
Stations 25+38 to 10+00
Sec. 13, T. 138 N., R. 81 W.
Contour Interval - 2 feet
Scale 1"=100'

Project Drawings
Sheet 3 of 3

SURVEYED - 4-13- 87

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 576-28
FORT LINCOLN BANK STABALIZATION
(HEART RIVER)

COUNTY MORTON DATE 9-4-87
SURVEYED: L.L.K. CHECKED BY: SUBMITTED:
DRAWN: A.O.P DESIGNED BY: APPROVED:
DRAWING NO. SCALE: 1" = 50'