PRELIMINARY ENGINEERING REPORT

GOLDEN-RUSH LAKE

S.W.C. PROJECT NO. 475

STEELE COUNTY

NORTH DAKOTA

STATE WATER COMMISSION

DECEMBER 1988

PRELIMINARY ENGINEERING REPORT

GOLDEN-RUSH LAKE

SWC PROJECT #475

North Dakota State Water Commission
900 East Boulevard
Bismarck, ND 58505-0187

Prepared by:

Bradley T. Benson
Water Resource Engineer

Submitted by:

David A. Sprynczynatyk, P.E.
Director of Engineering

Approved by:

Vernon Fahy, P.E.
State Engineer

Prepared For The Steele County
Water Resource Board

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I. INTRODUCTION

In April of 1988, the North Dakota State Water Commission entered into an agreement with the Steele County Water Resource Board to improve the flow conditions at the outlet of Golden Rush Lake, hereinafter referred to as Rush Lake. A copy of the agreement can be found in Appendix I.

The project area is located approximately 15 miles east of Finley, in Steele County (Figure 1). The Golden Lake Complex consists of a diversion dam located on Beaver Creek in Section 28, Township 148 North, Range 55 West; Rush Lake located in Sections 3 and 10, Township 147 North, Range 55 West; Golden Lake located in Sections 2 and 11, Township 147 North, Range 55 West; North Golden Lake located in Section 2, Township 147 North, Range 55 West, and in Sections 35 and 26, Township 148 North, Range 55 West, and all of the inter-connecting diversion ditches and structures (Figure 2).

The area is dominantly one of low relief, with the drainage mainly towards the east. Rush Lake receives water out of Beaver Creek from the north and is fed by ephemeral streams on its west and south perimeters, and discharges into Golden Lake to the east via the canal connecting the two lakes. Golden Lake returns any excess water into North Golden Lake, where it is returned into Beaver Creek and allowed to follow the natural drainage to the east.

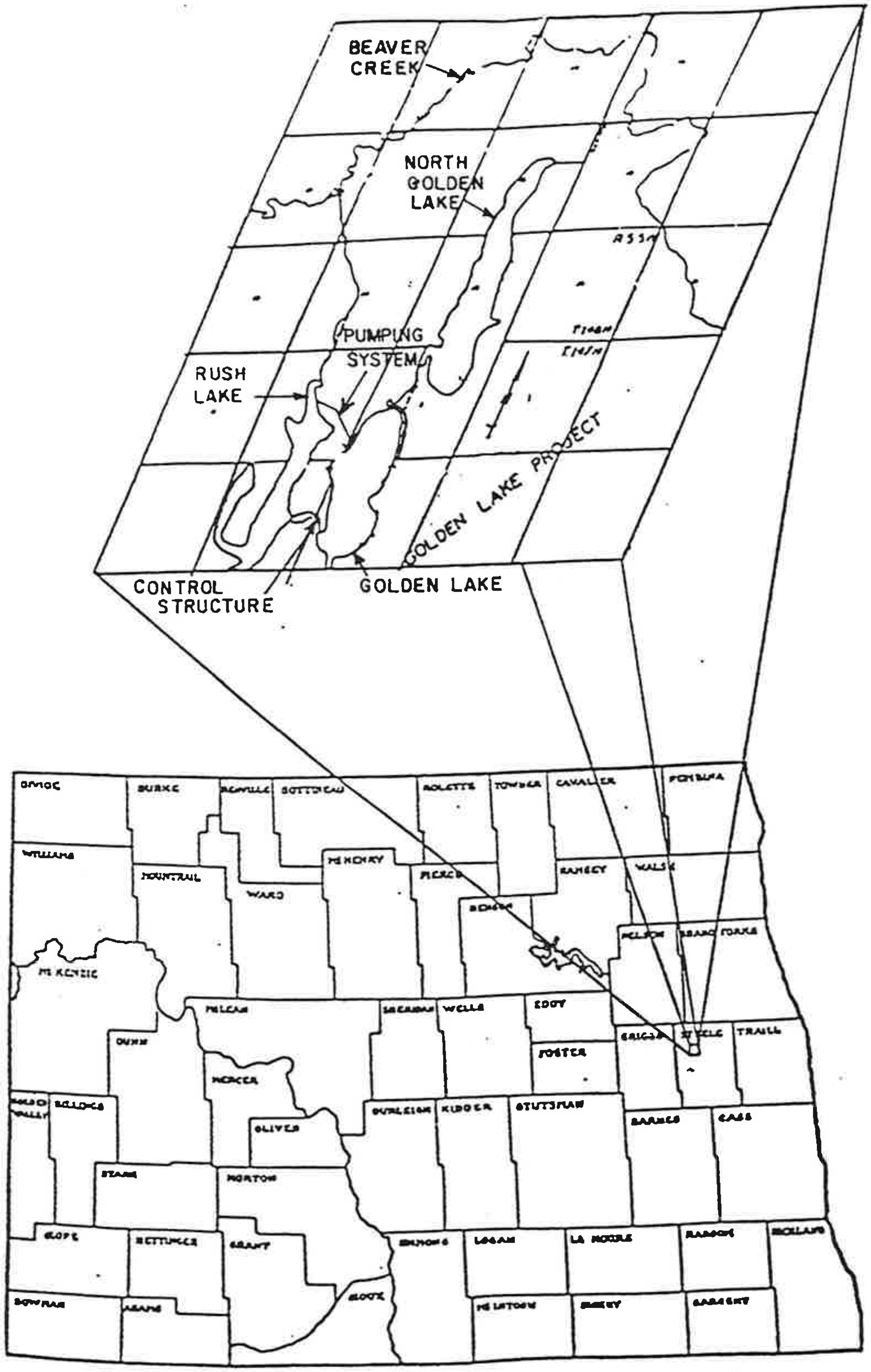


Figure 1 Location of project area

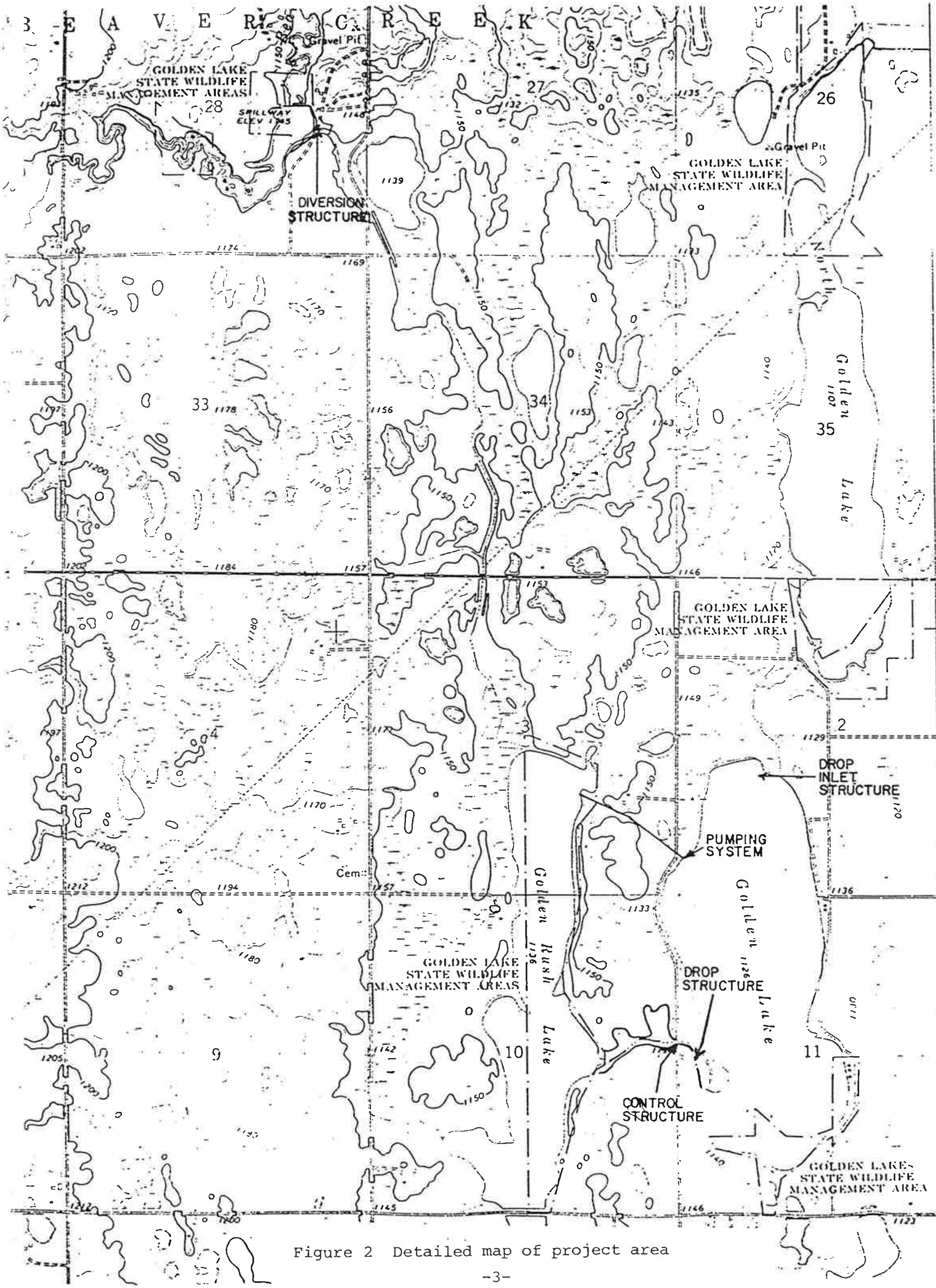


Figure 2 Detailed map of project area

II. BACKGROUND

The Golden Lake Restoration Project was originally conceived in 1949, with construction beginning in 1956. The objective was to raise the level of Golden Lake to make it useable for water-based recreation by the surrounding communities.

Raising the elevation of Golden Lake was accomplished by diverting water from Beaver Creek into Rush Lake and allowing gravity flow to move the water into Golden Lake. The water level is maintained in Golden Lake by the means of a drop inlet structure discharging into North Golden Lake. In 1966, modifications to the project allowed any excess water in North Golden Lake to be diverted into Beaver Creek. The principle reason was to improve water quality.

In the fall of 1985, the water quality in Golden Lake was becoming a concern, and alternatives were reviewed to try to alleviate any potential problems. The nitrogen and phosphorous levels in the lake are endangering the sport fishing in the lake, and having a negative impact on all water-based recreation. A two-phase approach was adopted to improve the water quality: 1) transfer the unmixed bottom water (hypolimnion layer), by the use of a pump into Rush Lake where nutrient assimilation takes place on the return path to Golden Lake, markedly improving the water quality; and 2) retaining the spring run-off in Rush Lake, allowing the water to warm and to be naturally aerated, thereby reducing the nutrient load, before releasing it into Golden Lake.

The pumping phase (Phase 1) of the project was implemented in the summer of 1987. The pump is designed to run during the summer months, as this is the time when the lake is stratified.

III. SCOPE

This investigation addresses Phase 2 of the approach. The Board desired to improve their ability to control the elevation of Rush Lake. The investigation looked at the following alternatives:

1. Leaving the control structure at its present location and:
   a. leave the channel in its existing condition.
   b. conduct a channel cleanout.
   c. improving the channel.
2. Moving the control structure to the outlet of Rush Lake.

This section includes a discussion of the objectives and, a brief description of the alternatives evaluated.

3.1 Objective:

The objectives of this investigation are to: 1) ensure better control of Rush Lake; and 2) improve the flow conditions of the channel connecting Rush and Golden Lakes, with the primary purpose to improve the water quality in Golden Lake.

The second phase of the project involves the transfer of water from Rush to Golden Lake in the fall, to allow for the storage of the following spring's runoff. Ideally, the larger the volume of water to be moved out of Rush Lake into Golden Lake in the fall the better, as this will mean that a larger volume of water will be able to be stored in Rush Lake in the spring. The importance in increasing the volume of the water moved from Rush Lake into Golden Lake in the spring, is that this will represent a larger volume of "naturally treated water," which will result in an increased benefit to the water quality in Golden Lake. The transfer of water from Rush Lake into Golden Lake is to be completed within a time-frame of 14-30 days.

At present, the control of Rush Lake is accomplished by a control structure, located at the roadway crossing downstream on the channel connecting Rush and Golden Lakes. The control structure consists of a series of flashboards that can be either removed or inserted to control the elevation of the lake. The effectiveness of the control structure is severely reduced by the present condition of the channel connecting Rush Lake and Golden Lake. The channel in its present condition, overgrown with cattails, constricts the flow and acts as a major control on the elevation of Rush Lake.

3.2 Alternatives:

1. **Leaving the Control Structure at the Present Location:**

   Option A.

   The existing condition option was developed to compare the effectiveness of all remaining options.

   Option B.

   The channel cleanout option would involve cleaning the vegetation out of the channel, without any modification to the channel.

   Option C.

   The channel improvement option would involve modifying the original channel along its present alignment, and include dredging into Rush Lake as well.

2. **Moving the Control Structure to the Outlet of Rush Lake:**

   This alternative involves moving the control of Rush Lake to the outlet of the lake, as well as modifying the original channel. This alternative would also call for dredging into Rush Lake.

IV. PROCEDURES

This section includes a discussion of the methods used to evaluate the alternatives. The methods include: 1) hydraulic analyses, using the HEC-2 computer program; and 2) storage routing, using the level-pool reservoir option of the HEC-1 computer model.

4.1 Hydraulics:

A hydraulic analysis was conducted on the channel connecting Rush and Golden Lakes, using the U.S. Army Corps of Engineer HEC-2 computer program. The program is used to develop water surface profiles for steady gradually varied flow in natural or man-made channels. The effects of various obstructions such as bridges, culverts and weirs may be considered in the computations, this feature was used to model the two culverts, located just downstream from the control structure.

Water surface profiles were generated for both alternatives, with the objective to obtain rating curves at the outlet of Rush Lake. A rating curve illustrates the stage at Rush Lake for a given discharge.

The computational procedure is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated using manning's equation. Computation of the water surface profiles are based on the following data: starting water surface elevations and starting discharges; channel geometry and length; and channel roughness, or manning's "n" value.

Starting Water Surface Elevation and Discharge:

The starting conditions were obtained by calculating the flow over the drop structure that is located downstream from the control structure. The discharges were calculated by assuming a certain depth of water flowing over the drop structure and using the following equation for finding the discharge over a sharp crested weir:

$$Q=CH^{1.5}L$$

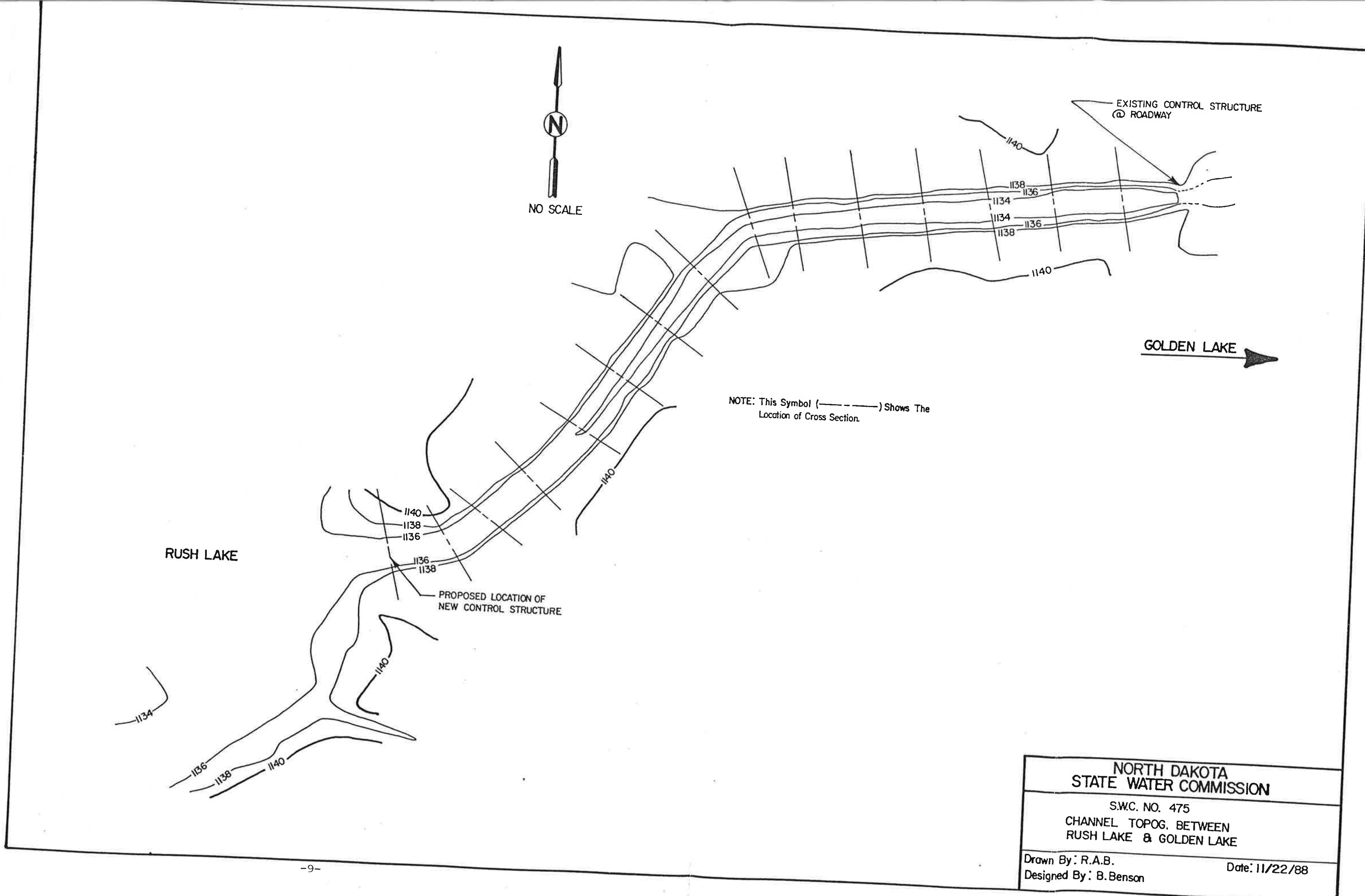
Where Q=discharge in cfs; C=3.0, the coefficient for a sharp crested weir; H=head, depth of flow in feet; and L=length of the weir, 18 feet for this structure. The starting water surface elevation, WSEL, was obtained by adding the assumed depth of flow to the known elevation of the top of the drop structure, 1132.2 MSL. The following table gives the assumed depths of flow and the associated discharges and starting water surface elevations used as starting conditions:

Table 1 - Starting Conditions

H (ft)	Q (cfs)	WSEL
.2	5	1132.4
.3	10	1132.5
.5	19.1	1132.7
1.0	54	1133.2
1.5	99.2	1133.7
2.0	152.7	1134.2
2.5	213.4	1134.7

Channel Geometry and Length:

The channel geometry and reach lengths, lengths between successive cross-sections, were obtained from survey data collected on the channel in June of 1988 (Figure 3). The original cross-sectional geometry was used as input into the HEC-2 computer program, for the existing condition and channel cleanout options of the 1st alternative.



EXISTING CONTROL STRUCTURE
@ ROADWAY
NO SCALE
N
1140
1138
1136
1134
GOLDEN LAKE
NOTE: This Symbol (————) Shows The Location of Cross Section.
RUSH LAKE
PROPOSED LOCATION OF NEW CONTROL STRUCTURE
NORTH DAKOTA
STATE WATER COMMISSION
S.W.C. NO. 475
CHANNEL TOPOG. BETWEEN
RUSH LAKE & GOLDEN LAKE
Drawn By: R.A.B.
Designed By: B. Benson
Date: 11/22/88

Figure 3

The HEC-2 computer program allows the repetition of a single cross-section, with the ability to compensate for an increase in elevation as you proceed upstream. This feature was employed for the channel improvement option of the 1st alternative, and for the 2nd alternative. The repeated cross-section had the original side slopes, 3 horizontal to 1 vertical, with a bottom width of 38 feet.

The slope for the channel improvement option of the 1st alternative was determined by interpolating between 1133.5 MSL, at the outlet of Rush Lake, to the floor of the control structure, 1132.7 MSL. This elevation change allows sufficient head to move the water down the channel, and will increase the volume of water able to be moved from Rush to Golden Lake. With the distance between the outlet of Rush Lake approximately 1500 feet, and the difference in elevation equal to .80 feet, the channel slope equals .05 percent. The cross-section was repeated, starting at the control structure and proceeding upstream to the outlet of Rush Lake, at 100 feet intervals, with an increment of .05 feet added at every repetition of the cross-section.

The slope for the 2nd alternative was determined by running a straight line from an elevation of 1133.5 MSL, at the outlet of Rush, to the top of the drop structure, which is at an elevation of 1132.2 MSL. The top of the drop structure was used as an ending elevation, because an elevation below this would result in modification to the channel downstream from the control structure, which would result in the modification of the drop structure, causing an increase in costs, with little or no added benefit to the overall objectives of this project. The distance between the outlet of Rush and the drop structure is approximately 1800 feet, with the change in elevation equal to 1.3 feet, resulting in a slope of .07 percent. Using this slope and the same cross-section with 3:1 side slopes and a 38 foot bottom width, the cross-section was repeated, starting at the control structure and proceeding upstream to the outlet of Rush Lake, at 100 feet intervals with .07 feet added to the elevation of the repeated cross-section.

Manning's "n" Value:

Manning's "n" value, or channel roughness, for the existing condition option, was determined by comparing water surface elevations computed, using the HEC-2 computer model with water surface elevations measured during the survey of the channel, in June of 1988. The starting discharge was calculated to be 4 cfs, with the starting water surface elevation equal to 1132.40. The "n" values were adjusted at each cross-section, until the elevations computed by the program came into close agreement with those collected at the time of the survey.

The channel cleanout option, and channel improvement options used an "n" value calculated using a formula that considers the following factors: irregularity of the surfaces of the channel sides and bottom; variations in shape and size of cross-sections; obstructions; vegetation; and meandering of the channel. The "n" value was calculated to be .060, using channels dredged in earth with minor variation in the cross-sectional shape, no obstructions, normally expected vegetation growth in the channel, and with a minor effect due to meandering of the channel.

4.2 Hydrology:

Storage Routing:

Since inflows into Rush Lake are not a concern in the scope of this project, a detailed hydrologic model was unnecessary. The level-pool reservoir routing component of the HEC-1 computer model was used to model the drawdown of Rush Lake. The drawdown is represented by the stage or elevation at Rush Lake versus time, and the storage in Rush Lake versus time. The storage versus time relationships were used to develop a storage moved - time relationships for the proposed alternatives. This relationship is of particular importance, realizing that one of the objectives is to maximize the volume of water moved from Rush Lake into Golden Lake, and to complete this transfer within a limited time-frame. This component assumes a level water surface. With no inflows into the reservoir, the storage-outflow characteristics were calculated at 24-hour time intervals, covering a time span of 62 days, and based on the following data: 1) the storage volume versus elevation for Rush Lake, and 2) the reservoir stage-discharge rating curves described above.

Reservoir Storage Data:

The storage data for Rush Lake, was computed by providing the surface area versus elevation data to the HEC-1 computer model, which calculates the storage volume versus elevation relationships. The HEC-1 computer model uses the conic method to compute reservoir volume from surface area versus elevation data, with the volume assumed to be zero at the lowest elevation given, even if the surface area is greater than zero at that point. A method that is used and gives similar results, is to multiply the surface area of a body of water times the mean depth, or simply, the depth of water at the deepest point divided by 2.

An area capacity curve for Rush Lake was developed in 1983. The method was to use the areas associated with elevations taken from a topographic map of the area. The limitation in this method is the fact that the depth of the lake was estimated, which could result in a large margin of error when calculating the storage of the lake. It was discovered that the storage capacity was overestimated as a result of this limitation.

In order to determine more accurately the storage in Rush Lake, profiles were surveyed across the lake in September of 1988. The results of the survey showed that the water surface elevation was at 1136.00 MSL, with the elevation of the lake bottom at 1132.50 MSL, giving a water depth of 3.5 feet. Using the survey data, a contour at an elevation of 1133.00 MSL was drawn (Figure 4). The area associated with this elevation, and the areas associated with elevations of 1136.00 MSL, and 1140.00 MSL, obtained by using the quadrangle map of the project area, were input into the computer model. The following table gives the storage versus elevation data for Rush Lake, computed by the HEC-1 computer model. Figure 5 is the area-capacity curve for Rush Lake.

Table 2 - Storage vs. Elevation for Rush Lake

Elevation (MSL feet)	Area (acres)	Storage (acre-feet)
1132.50	0.00	0.00
1133.00	83.00	13.83
1136.00	221.63	454.09
1140.00	378.10	1639.70

Reservoir Outflow Rating Curve:

The outflow rating curves for Rush Lake were obtained from the hydraulic analyses of the proposed alternatives. Table 3 gives the outflow rating curves for Rush Lake.

Table 3 - Outflow Rating Curves for Rush Lake

Flow (cfs)	Existing Conditions	Channel Cleanout	Channel Improvement	New Structure
5.0	1136.0	1135.3	1133.9	1133.9
10.0	1136.4	1135.5	1134.1	1134.1
19.1	1136.9	1135.8	1134.4	1134.4
54.0	1138.0	1136.5	1135.4	1135.3
99.2	1138.9	1137.5	1136.7	1136.8
152.7	1139.8	1139.7	1138.6	1139.4
213.5	1141.2	1141.0	1140.7	1141.0

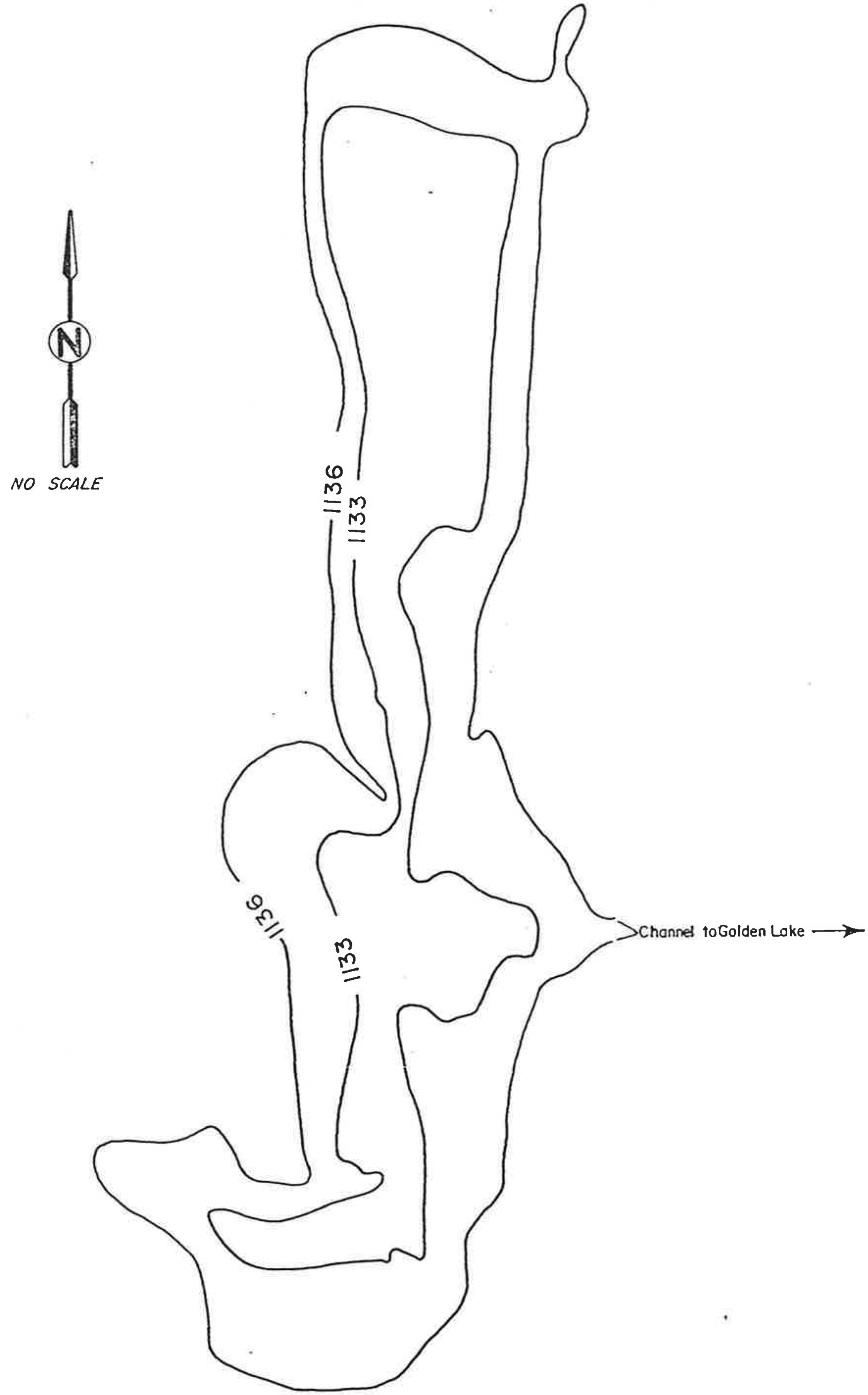


Figure 4 Topographic map of Rush Lake

GOLDEN RUSH LAKE PROJECT #475

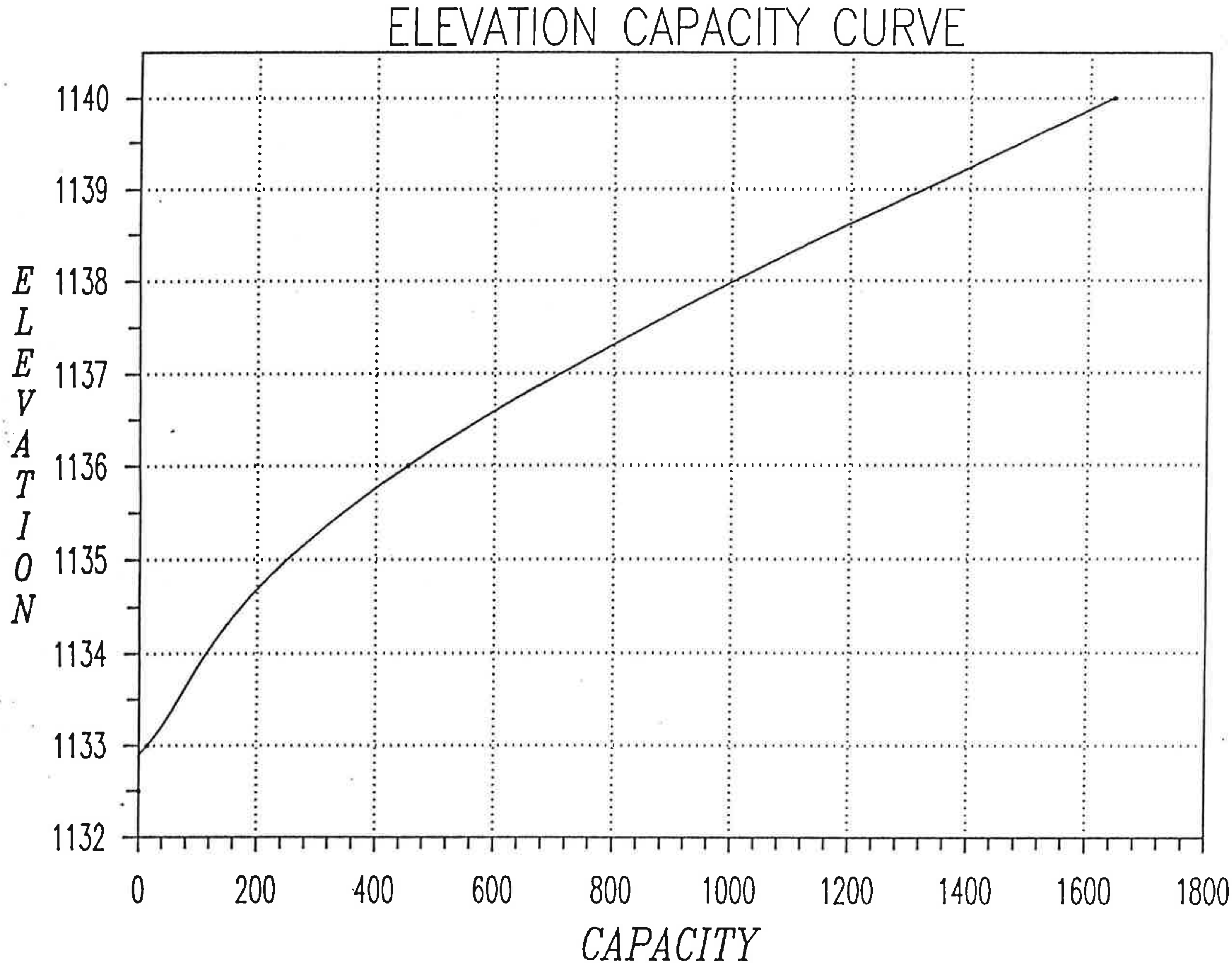


Figure 5

V. RESULTS

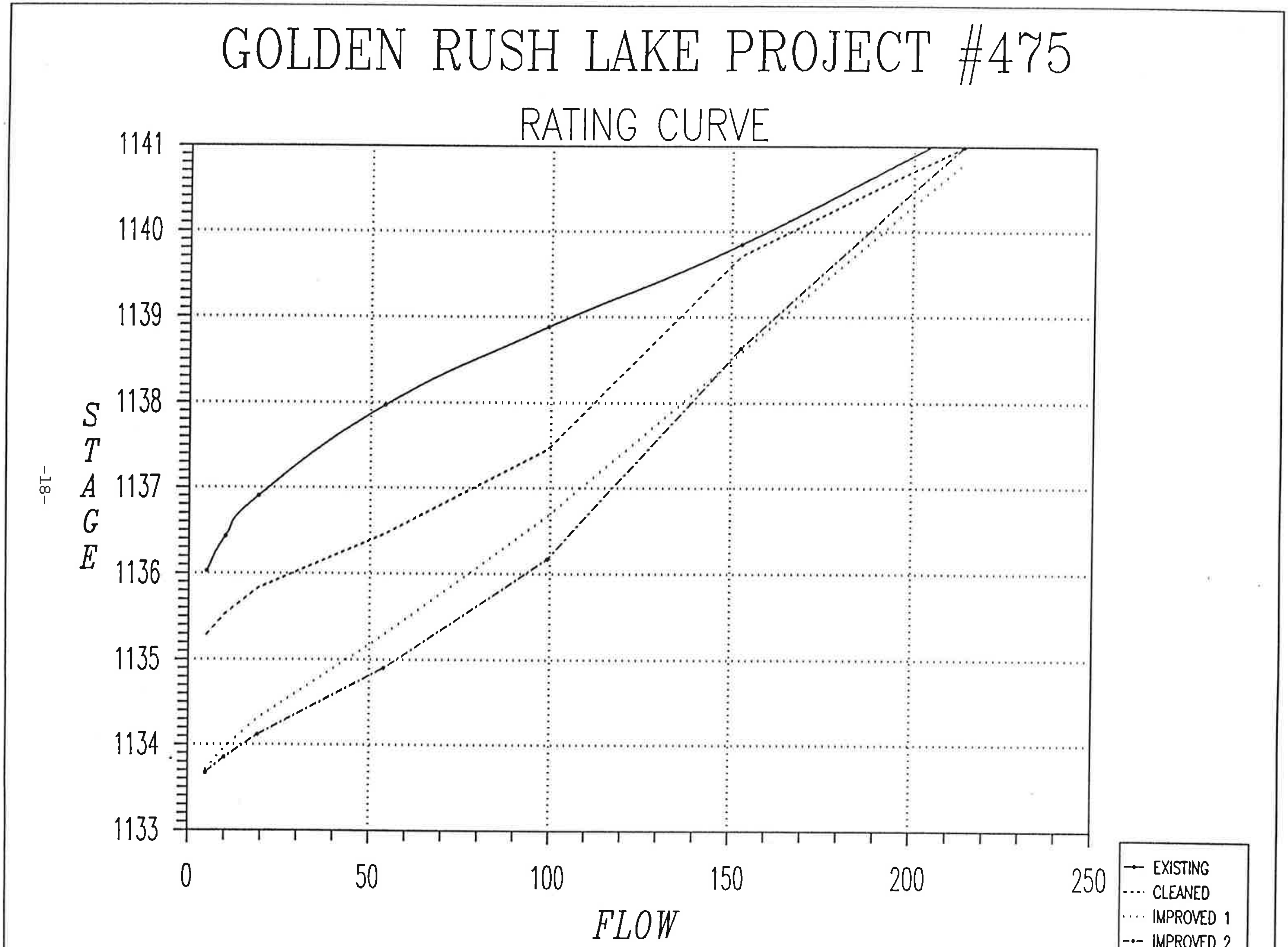
The following section covers the results of the hydraulic analyses and, the storage routing for the proposed alternatives. Included is a discussion of the preliminary design of the new control structure, detailed cost estimates for the proposed alternatives and, conclusions based on the findings of this investigation.

5.1 Hydraulics:

Figure 6 shows the rating curves for the proposed alternatives. The curves, especially for the channel cleanout and the moving of the control structure, show a distinct increase in slope at 100 cfs. This break in slope is a result of a shift in control of the backwater curve. Below 100 cfs, the drop structure is the control for the backwater curve. Above this flow, the carrying capacity of the culverts at the roadway crossing is exceeded, resulting in a shift of control of the backwater curve to the roadway crossing.

5.2 Storage Routing:

The results of the storage routing of Rush Lake are shown in Figure 7, which shows the stage-period relationships, and Figure 8 which illustrates the storage moved-period relationships for the proposed alternatives. Detailed information on the storage-outflow characteristics can be found in Appendix II. Table 4 - summarizes the volume of water moved and the time interval necessary for each of the proposed alternatives.


GOLDEN RUSH LAKE PROJECT #475
RATING CURVE
STAGE
1141
1140
1139
1138
1137
1136
1135
1134
1133
FLOW
0
50
100
150
200
250
EXISTING
CLEANED
IMPROVED 1
IMPROVED 2
Figure 6

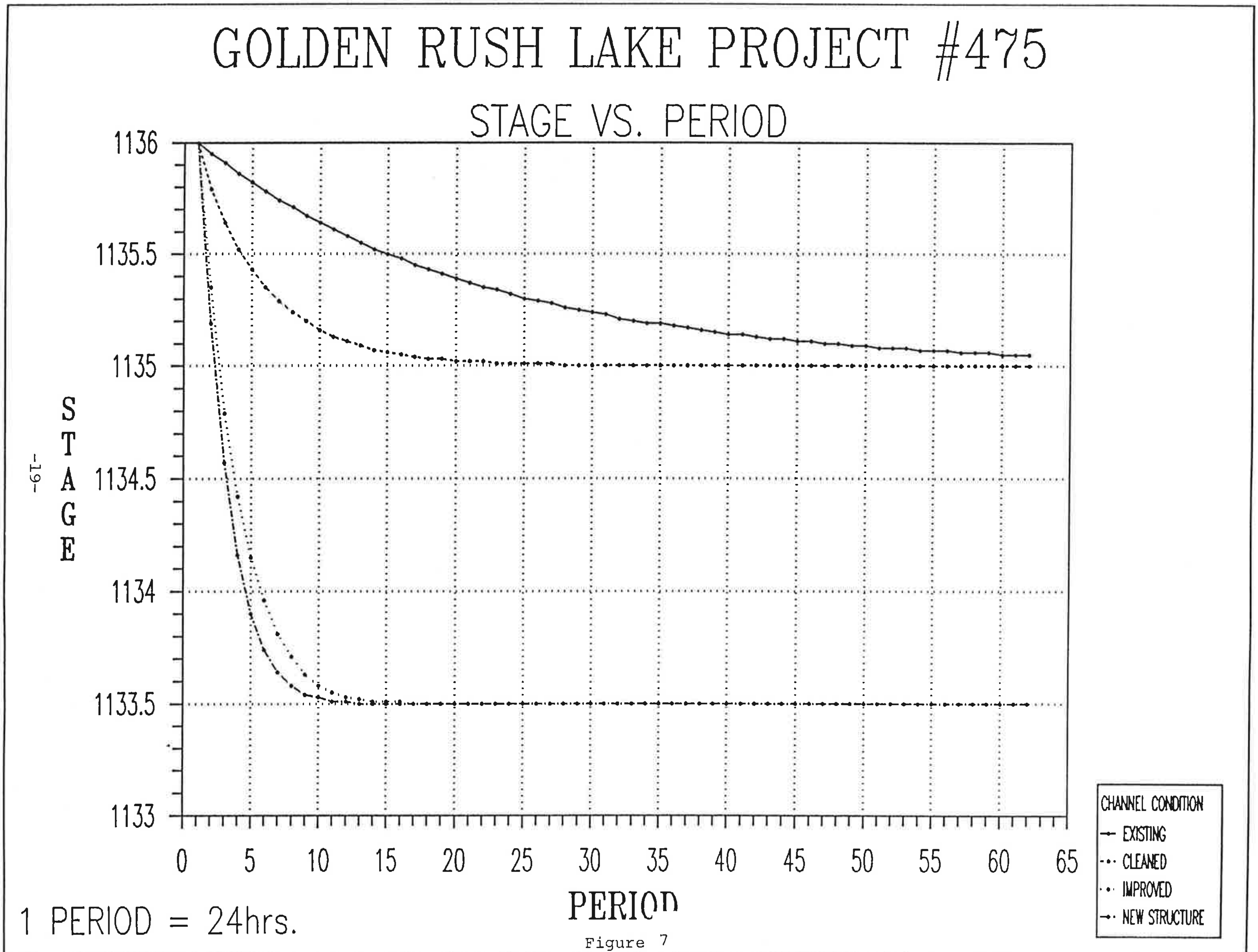

GOLDEN RUSH LAKE PROJECT #475
STAGE VS. PERIOD
STAGE
1136
1135.5
1135
1134.5
1134
1133.5
1133
0
5
10
15
20
25
30
35
40
45
50
55
60
65
PERIOD
1 PERIOD = 24hrs.
CHANNEL CONDITION
EXISTING
CLEANED
IMPROVED
NEW STRUCTURE

Figure 7

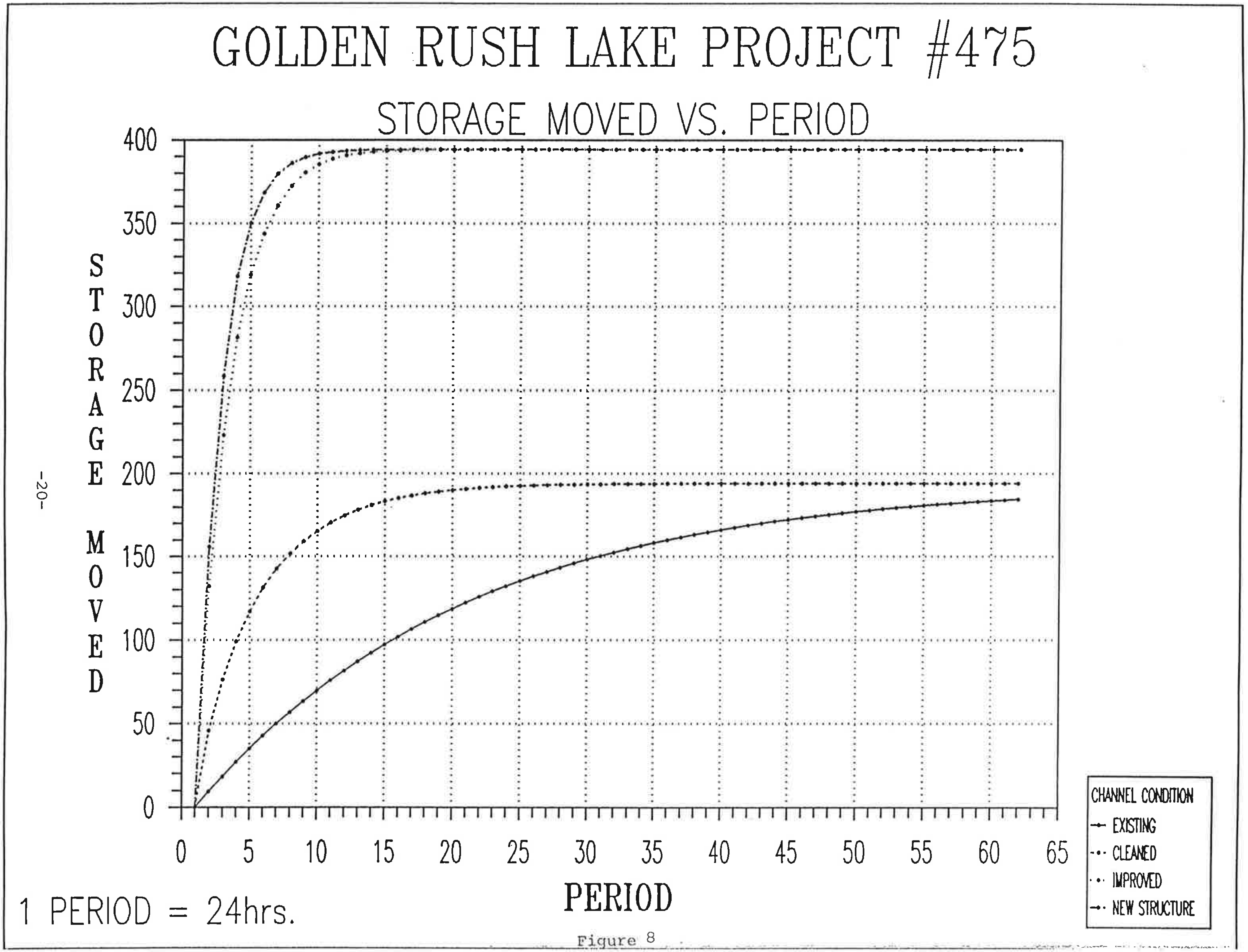

GOLDEN RUSH LAKE PROJECT #475
STORAGE MOVED VS. PERIOD
STORAGE MOVED
400
350
300
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
50
55
60
65
PERIOD
CHANNEL CONDITION
EXISTING
CLEANED
IMPROVED
NEW STRUCTURE
1 PERIOD = 24hrs.

Figure 8

Table 4 - Summary Of Storage Routing For Rush Lake

Alternative 1	Storage Moved (acre-ft)	Time Interval (days)
Existing Conditions	185	62
Channel Cleanout	194	43
Channel Improvement	394	24
Alternative 2	394	19

5.3 Preliminary Design and Cost Estimates:

Design Criteria:

The first step in the design of the control structure was to determine the span of the structure, or for all practical purposes, the weir length. This length is important because the channel at the outlet of Rush Lake, and not the control structure should control the flow. In order to determine the appropriate length, the weir length corresponding to the stage-discharge relationships for this alternative was calculated using the weir equation, this length turned out to be approximately 7.5 feet. The next step was to generate a rating curve using a weir length of 10 feet. This rating curve was plotted against the rating curve for this alternative (Figure 9). By comparison of the two curves, one can see that the channel is the primary control of flow at all stages, which simply means, at equal stages the channel's carrying capacity is less than the flow over the control structure.

Description:

Figure 3 gives the approximate location of the new control structure, with the design very similar to the control structure presently used. It was determined to use a stoplog structure to control the elevation of Rush Lake (Figure 10). A sheet piling structure would extend across the channel, with the control structure located at the channel centerline. The control structure

RUSH LAKE PROJECT #475

COMBINED RATING CURVE

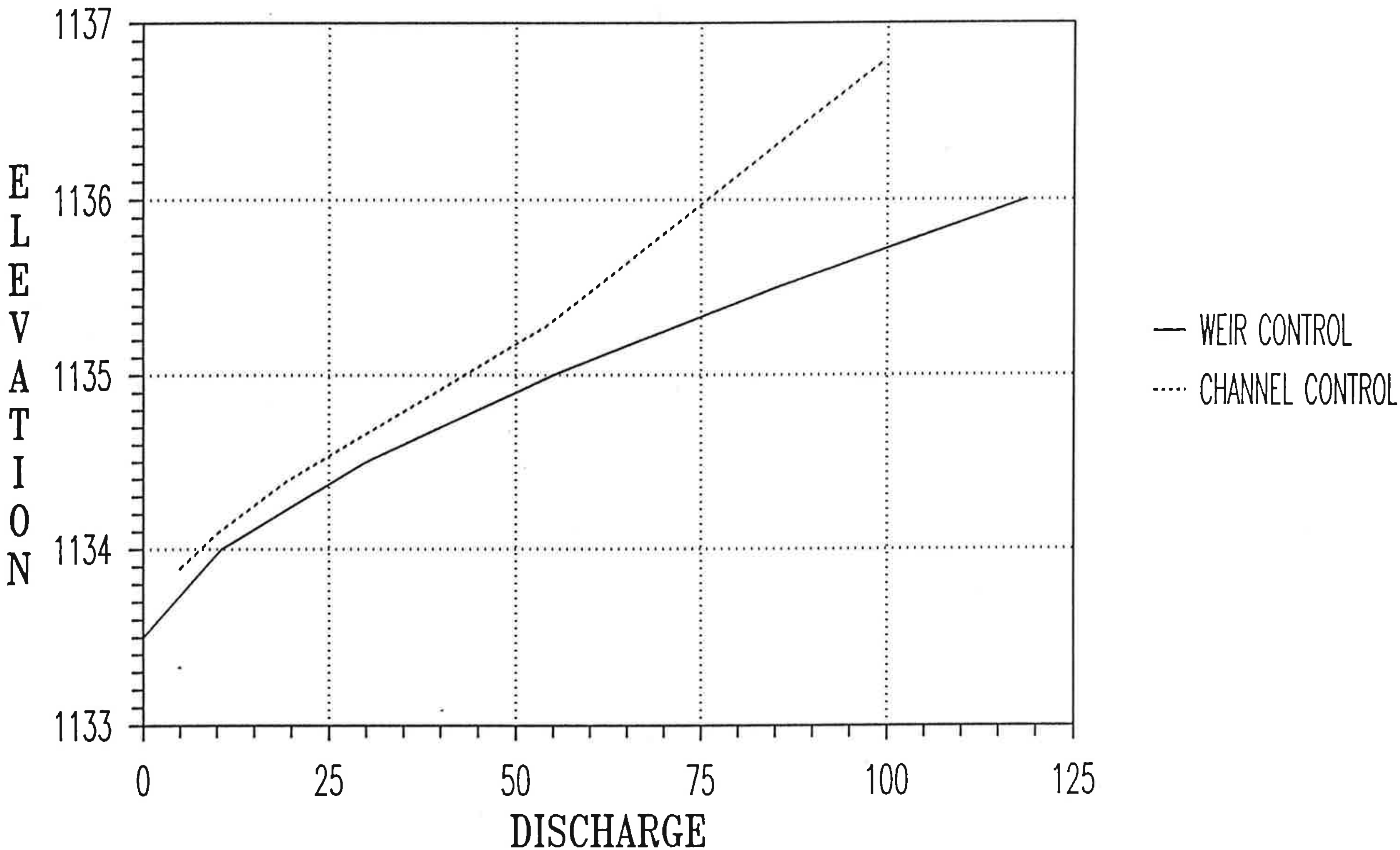
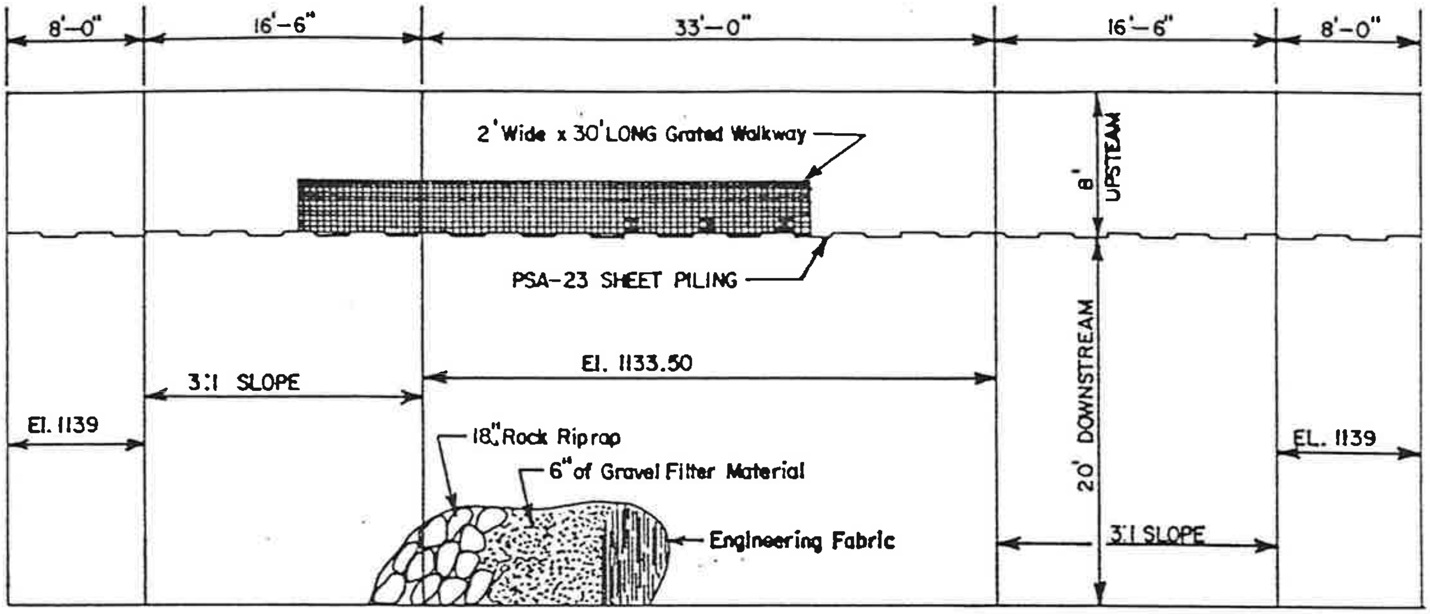
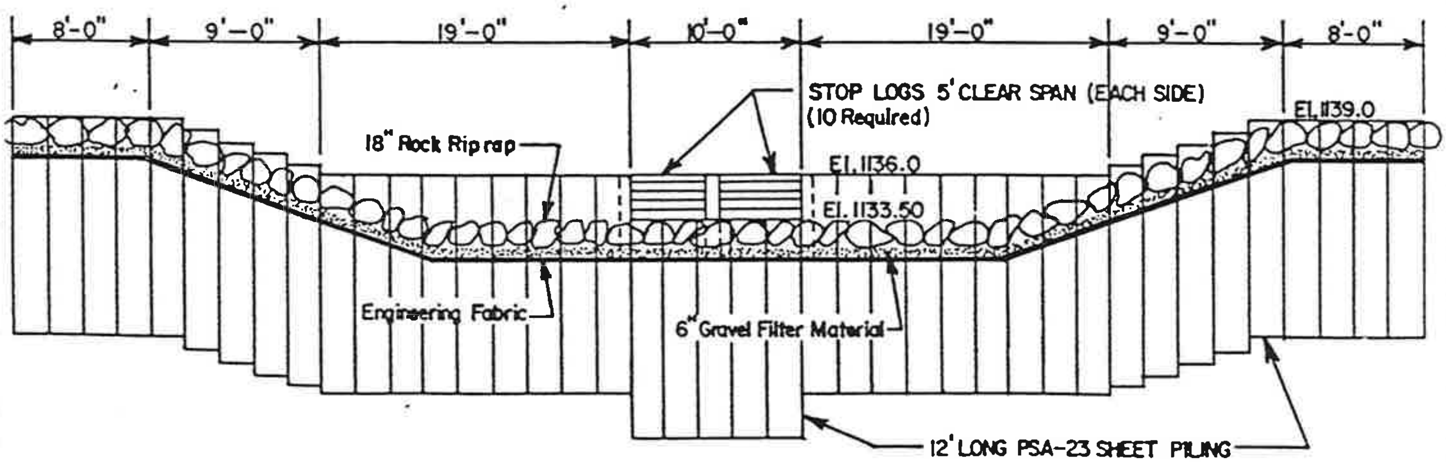


Figure 9



PLAN VIEW

NO SCALE



ELEVATION VIEW

NO SCALE

Figure 10 Preliminary design of the new control structure would consist of two 5-foot bays and a walkway along the upstream face to aid in the removal of the stoplogs. The base of the control structure would be at an elevation of 1133.50 MSL, with the elevation of the top stoplog at 1136.00 MSL, the present elevation of Rush Lake. The sheet piling extending across the channel would also be at an elevation of 1136.00, and slope up at a 3:1 ratio along both banks to an elevation of 1139.00, at which point it would extend laterally for approximately 8 feet. Erosion protection would consist of a 1-foot thick layer of rock riprap overlying a 6-inch filter blanket. The protection would run the entire length of the sheet piling, and extend 20 feet downstream and 8 feet upstream. Table 5 - gives the detailed cost estimate for the new control structure.

Table 5 - Control Structure Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	L.S.	$5,000.00	$ 5,000.00
2.	Water Control	1	L.S.	8,000.00	8,000.00
3.	Site Preparation and Restoration	1	L.S.	3,000.00	3,000.00
4.	Removal Control Structure		L.S.	1,000.00	1,000.00
5.	Stop Log Structure and Walkway	1	L.S.	8,000.00	8,000.00
6.	Excavation (Channel)	2800	C.Y.	2.25	6,300.00
7.	Excavation (Lake)	270	C.Y.	6.00	1,620.00
8.	Fill	30	C.Y.	2.50	70.00
9.	Sheet Piling	744	L.F.	6.50	4,850.00
10.	Rock Riprap	58	C.Y.	30.00	1,740.00
11.	Filter Material	25	C.Y.	20.00	500.00
12.	Geotextile Fabric	270	S.Y.	2.60	$ 700.00
	Subtotal				$40,780.00
	Contingencies, Engineering and Contract Administration				$13,600.00
	TOTAL				$54,380.00

Channel Cleanout Cost Estimate:

Table 6 shows the detailed cost estimate for the channel cleanout option of the 1st alternative, leaving the control structure at the present location.

Table 6 - Channel Cleanout Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	L.S.	$5,000.00	$ 5,000.00
2.	Water Control	1	L.S.	2,500.00	2,500.00
3.	Site Preparation and Restoration	1	L.S.	3,000.00	3,000.00
4.	Excavation	1700	C.Y.	4.00	6,800.00
5.	Earth Fill	60	C.Y.	2.50	150.00
6.	Rock Riprap	10	C.Y.	30.00	300.00
	Subtotal				$17,750.00
	Contingencies, Engineering and Contract Administration				$ 5,950.00
	TOTAL				$23,700.00

Channel Improvement Option:

A detailed cost analysis of the channel improvement option of the 1st alternative can be found in the following table:

Table 7 - Channel Improvement Cost Estimate

	Item	Quantity	Units	Unit Price	Total
1.	Mobilization	1	L.S.	$5,000.00	$ 5,000.00
2.	Water Control	1	L.S.	8,000.00	8,000.00
3.	Site Preparation and Restoration	1	L.S.	3,000.00	3,000.00
4.	Excavation (Channel)	2300	C.Y.	2.25	5,175.00
5.	Excavation (Lake)	270	C.Y.	6.00	1,620.00
6.	Earth Fill	85	C.Y.	2.50	212.50
	Subtotal				$23,007.50
	Contingencies, Engineering and Contract Administration				7,662.50
	Total				$30,670.00

5.4 Conclusions:

This investigation shows that by conducting a channel cleanout, 194 acre-feet of storage could be moved from Rush to Golden Lake in 43 days, at a cost of approximately $24,000.00. By improving the channel, the volume of water moved from Rush into Golden Lake, increases from 194 to 394 acre-feet, and the time interval is reduced from 43 to 24 days. The cost of this alternative is approximately $31,000.00. The alternative that relocates the control structure to the outlet of Rush Lake, allows 394 acre-feet of storage to be moved in 19 days at a cost of approximately $53,000.00.

VI. SUMMARY

In 1985, the water quality in Golden Lake was becoming a concern. The lake was found to have high levels of nitrogen and phosphorous which are endangering all water-based recreation.

In an attempt to improve the water quality a two-phase approach was adopted, using Rush Lake as a biological filter. Phase 1 involves pumping the unmixed bottom water of Golden Lake into Rush Lake, with nutrient assimilation occurring on the return path into Golden Lake via the channel connecting the two lakes. This phase was implemented in the summer of 1988. Phase 2 involves the retention of spring runoff in Rush Lake. The runoff would be held in the lake, allowing it to warm and be naturally aerated, thereby resulting in nutrient assimilation and an improvement in the water quality. Once these conditions are met, the water would be released into Golden Lake. The transfer of water from Rush to Golden must take place within a time-frame of 14-30 days.

This investigation focuses on the second phase of the project. The objectives are: 1) maximize the volume of water moved from Rush to Golden Lake, and 2) ensure the transfer of water takes place within the time-frame of 14-30 days. The alternatives studied are as follows:

1. Leaving the control structure at its present location, and:
    a. leave the channel in its existing condition.
    b. conduct a channel cleanout.
    c. improving the channel.
2. Moving the control structure to the outlet of Rush Lake.

Hydraulic analyses were performed on the proposed alternatives using the HEC-2 computer model. The HEC-2 computer model generated water surface profiles for each alternative. Using the water surface profiles, rating curves were developed for the outlet of Rush Lake for each alternative. A rating curve illustrates the relationship between a starting discharge and the resulting elevation of the water surface at Rush Lake.

The results of the hydraulic analysis and the elevation-area relationships for Rush Lake were input into the storage routing option of the HEC-1 computer program, to determine the drawdown characteristics of Rush Lake associated with each alternative. The results of this investigation, as well the cost estimates for the options considered are as follows:

Existing Conditions:

The channel in its existing condition can move 185 acre-feet, in a time period of 62 days.

Channel Cleanout:

By conducting a channel cleanout, 194 acre-feet can be moved covering 43 days. The cost of this option is approximately $24,000.00.

Channel Improvement:

The channel improvement option increases the volume of water moved to 394 acre-feet, with the transfer complete in 24 days. The cost associated with this option is approximately $31,000.00.

New Control Structure:

Moving the control structure to the outlet of Rush Lake, would allow 394 acre-feet to be transferred in a period of time covering 19 days.

VII. RECOMMENDATION

The following recommendation is based on the objectives of this investigation, which are: 1) maximize the volume of water moved from Rush into Golden Lake; and 2) complete the transfer of water within a time span of 14-30 days. The recommendation is to conduct channel improvements and leave the control structure at its present location. This option fulfills the requirements and is the most cost effective, totalling approximately $31,000.00.

APPENDIX I

Agreement Between
The North Dakota State Water Commission
And The
Steele County Water Resource District

April 19, 1988
SWC Project #~~155~~ 475

A G R E E M E N T

Design a Control Structure at the Outlet of Rush Lake

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the Interim State Engineer, David A. Sprynczynatyk; and the Steele County Water Resource Board, hereinafter referred to as the Board, acting through its Chairman, Bennett Rindy.

II. PROJECT, LOCATION, AND PURPOSE

The Board wishes to improve flow conditions at the outlet of Rush Lake, Section 10, Township 147 North, Range 55 West, Steele County. The existing control structure is located at the roadway crossing downstream on the channel connecting Rush Lake and Golden Lake. The channel upstream of the existing control structure constricts the flow and controls the lake elevation.

III. PRELIMINARY INVESTIGATION

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

1. A site topography of outlet area of Rush Lake.
2. A survey of the channel between Rush Lake and Golden Lake for possible channel improvements.
3. Survey a profile of the road on the south side of Rush Lake.
4. Develop a preliminary design for a control structure at the outlet of Rush Lake
5. Investigate improvements to channel connecting Rush and Golden Lake.

IV. DEPOSIT - REFUND

The Board will deposit a total of $900 with the Commission to partially defray the costs of the investigation. Upon receipt of a request from the Board to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by either of the parties, the Commission shall provide the Board with a statement of all expenses incurred in the investigation and shall refund to the Board any unexpended funds.

V. RIGHTS-OF-ENTRY

The Board 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 Board hereby accepts responsibility for, and holds the Commission, its employees, and the State Engineer, free from all claims and damages to public or private property, rights, or persons arising out of this investigation. In the event a suit is initiated or judgment entered against the Commission, its employees, or the Interim State Engineer, the Board shall indemnify it for any judgment 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	STEELE COUNTY WATER RESOURCE DISTRICT
By: [signature]	By: [signature]
David A. Sprynczynatyk, P.E. Interim State Engineer	Bennett Rindy Chairman
DATE: 4/21/88	DATE: 5/3/88
WITNESS: Todd Sando	WITNESS: [signature]

APPENDIX II

Detailed Information On The
Storage-Outflow Characteristics Of Rush Lake

GOLDEN RUSH LAKE PROJECT #475
RESERVOIR ROUTING USING HEC-1
CHANNEL;EXISTING CONDITIONS

PERIOD (24 hrs.)	VELOCITY (fps)	STORAGE (acre-ft)	STAGE (MSL ft)	STORAGE MOVED (acre-ft)
1.00	4.85	454.09	1136.00	0.00
2.00	4.62	444.70	1135.95	9.39
3.00	4.40	435.76	1135.91	18.33
4.00	4.18	427.25	1135.86	26.84
5.00	3.98	419.15	1135.82	34.94
6.00	3.79	411.45	1135.78	42.64
7.00	3.60	404.11	1135.74	49.98
8.00	3.43	397.14	1135.71	56.95
9.00	3.26	390.50	1135.67	63.59
10.00	3.11	384.18	1135.64	69.91
11.00	2.96	378.17	1135.61	75.92
12.00	2.81	372.44	1135.58	81.65
13.00	2.68	367.00	1135.55	87.09
14.00	2.55	361.82	1135.52	92.27
15.00	2.42	356.89	1135.50	97.20
16.00	2.31	352.19	1135.48	101.90
17.00	2.20	347.73	1135.45	106.36
18.00	2.09	343.48	1135.43	110.61
19.00	1.99	339.43	1135.41	114.66
20.00	1.89	335.59	1135.39	118.50
21.00	1.80	331.92	1135.37	122.17
22.00	1.71	328.44	1135.35	125.65
23.00	1.63	325.12	1135.34	128.97
24.00	1.55	321.97	1135.32	132.12
25.00	1.48	318.96	1135.30	135.13
26.00	1.41	316.11	1135.29	137.98
27.00	1.34	313.39	1135.28	140.70
28.00	1.27	310.80	1135.26	143.29
29.00	1.21	308.34	1135.25	145.75
30.00	1.15	305.99	1135.24	148.10
31.00	1.10	303.76	1135.23	150.33
32.00	1.04	301.64	1135.21	152.45
33.00	0.99	299.62	1135.20	154.47
34.00	0.94	297.70	1135.19	156.39
35.00	0.90	295.87	1135.19	158.22
36.00	0.86	294.13	1135.18	159.96
37.00	0.81	292.47	1135.17	161.62
38.00	0.77	290.90	1135.16	163.19
39.00	0.74	289.40	1135.15	164.69
40.00	0.70	287.97	1135.14	166.12
41.00	0.67	286.61	1135.14	167.48
42.00	0.64	285.32	1135.13	168.77
43.00	0.60	284.09	1135.12	170.00
44.00	0.58	282.92	1135.12	171.17
45.00	0.55	281.80	1135.11	172.29
46.00	0.52	280.74	1135.11	173.35
47.00	0.50	279.73	1135.10	174.36
48.00	0.47	278.77	1135.10	175.32
49.00	0.45	277.86	1135.09	176.23
50.00	0.43	276.99	1135.09	177.10
51.00	0.41	276.17	1135.08	177.92
52.00	0.39	275.38	1135.08	178.71

53.00	0.37	274.63	1135.08	179.46
54.00	0.35	273.92	1135.07	180.17
55.00	0.33	273.24	1135.07	180.85
56.00	0.32	272.59	1135.07	181.50
57.00	0.30	271.98	1135.06	182.11
58.00	0.29	271.39	1135.06	182.70
59.00	0.27	270.84	1135.06	183.25
60.00	0.26	270.31	1135.05	183.78
61.00	0.25	269.80	1135.05	184.29
62.00	0.24	269.32	1135.05	184.77

GOLDEN RUSH LAKE PROJECT #475
RESERVOIR ROUTING USING HEC-1
CHANNEL CLEANOUT

PERIOD (24 hrs.)	VELOCITY (fps)	STORAGE (acre-ft)	STAGE (MSL ft)	STORAGE MOVED (acre-ft)
1.00	28.51	454.09	1136.00	0.00
2.00	17.75	408.21	1135.79	45.88
3.00	13.18	377.52	1135.64	76.57
4.00	9.84	354.69	1135.52	99.40
5.00	7.90	337.09	1135.43	117.00
6.00	6.35	322.96	1135.35	131.13
7.00	5.10	311.62	1135.29	142.47
8.00	4.18	302.42	1135.24	151.67
9.00	3.44	294.86	1135.20	159.23
10.00	2.83	288.65	1135.16	165.44
11.00	2.32	283.54	1135.13	170.55
12.00	1.91	279.34	1135.11	174.75
13.00	1.57	275.88	1135.09	178.21
14.00	1.29	273.04	1135.07	181.05
15.00	1.06	270.71	1135.06	183.38
16.00	0.87	268.78	1135.05	185.31
17.00	0.72	267.21	1135.04	186.88
18.00	0.59	265.91	1135.03	188.18
19.00	0.49	264.84	1135.03	189.25
20.00	0.40	263.96	1135.02	190.13
21.00	0.33	263.24	1135.02	190.85
22.00	0.27	262.64	1135.02	191.45
23.00	0.22	262.15	1135.01	191.94
24.00	0.18	261.75	1135.01	192.34
25.00	0.15	261.42	1135.01	192.67
26.00	0.12	261.15	1135.01	192.94
27.00	0.10	260.93	1135.01	193.16
28.00	0.08	260.74	1135.00	193.35
29.00	0.07	260.59	1135.00	193.50
30.00	0.06	260.47	1135.00	193.62
31.00	0.05	260.37	1135.00	193.72
32.00	0.04	260.28	1135.00	193.81
33.00	0.03	260.21	1135.00	193.88
34.00	0.03	260.16	1135.00	193.93
35.00	0.02	260.11	1135.00	193.98
36.00	0.02	260.07	1135.00	194.02
37.00	0.01	260.04	1135.00	194.05
38.00	0.01	260.01	1135.00	194.08
39.00	0.01	259.99	1135.00	194.10
40.00	0.01	259.97	1135.00	194.12
41.00	0.01	259.96	1135.00	194.13
42.00	0.01	259.95	1135.00	194.14
43.00	0.00	259.94	1135.00	194.15
44.00	0.00	259.93	1135.00	194.16
45.00	0.00	259.92	1135.00	194.17
46.00	0.00	259.92	1135.00	194.17
47.00	0.00	259.91	1135.00	194.18
48.00	0.00	259.91	1135.00	194.18
49.00	0.00	259.91	1135.00	194.18
50.00	0.00	259.91	1135.00	194.18
51.00	0.00	259.90	1135.00	194.19

52.00	0.00	259.90	1135.00	194.19
53.00	0.00	259.90	1135.00	194.19
54.00	0.00	259.90	1135.00	194.19
55.00	0.00	259.90	1135.00	194.19
56.00	0.00	259.90	1135.00	194.19
57.00	0.00	259.90	1135.00	194.19
58.00	0.00	259.90	1135.00	194.19
59.00	0.00	259.90	1135.00	194.19
60.00	0.00	259.90	1135.00	194.19
61.00	0.00	259.90	1135.00	194.19
62.00	0.00	259.89	1135.00	194.20

GOLDEN RUSH LAKE PROJECT #475
RESERVOIR ROUTING USING HEC-1
CHANNEL IMPROVEMENT

PERIOD (24 hrs.)	VELOCITY (fps)	STORAGE (acre-ft)	STAGE (MSL ft)	STORAGE MOVED (acre-ft)
1.00	77.26	454.09	1136.00	0.00
2.00	55.84	322.10	1135.35	131.99
3.00	36.07	230.95	1134.79	223.14
4.00	22.92	172.45	1134.42	281.64
5.00	14.92	134.93	1134.15	319.16
6.00	9.92	110.29	1133.96	343.80
7.00	7.00	93.52	1133.81	360.57
8.00	4.92	81.70	1133.71	372.39
9.00	3.12	73.72	1133.63	380.37
10.00	1.98	68.66	1133.58	385.43
11.00	1.26	65.45	1133.55	388.64
12.00	0.80	63.41	1133.53	390.68
13.00	0.51	62.12	1133.52	391.97
14.00	0.32	61.30	1133.51	392.79
15.00	0.20	60.78	1133.51	393.31
16.00	0.13	60.45	1133.51	393.64
17.00	0.08	60.24	1133.50	393.85
18.00	0.05	60.10	1133.50	393.99
19.00	0.03	60.02	1133.50	394.07
20.00	0.02	59.97	1133.50	394.12
21.00	0.01	59.93	1133.50	394.16
22.00	0.01	59.91	1133.50	394.18
23.00	0.01	59.90	1133.50	394.19
24.00	0.00	59.89	1133.50	394.20
25.00	0.00	59.88	1133.50	394.21
26.00	0.00	59.88	1133.50	394.21
27.00	0.00	59.88	1133.50	394.21
28.00	0.00	59.88	1133.50	394.21
29.00	0.00	59.88	1133.50	394.21
30.00	0.00	59.87	1133.50	394.22
31.00	0.00	59.87	1133.50	394.22
32.00	0.00	59.87	1133.50	394.22
33.00	0.00	59.87	1133.50	394.22
34.00	0.00	59.87	1133.50	394.22
35.00	0.00	59.87	1133.50	394.22
36.00	0.00	59.87	1133.50	394.22
37.00	0.00	59.87	1133.50	394.22
38.00	0.00	59.87	1133.50	394.22
39.00	0.00	59.87	1133.50	394.22
40.00	0.00	59.87	1133.50	394.22
41.00	0.00	59.87	1133.50	394.22
42.00	0.00	59.87	1133.50	394.22
43.00	0.00	59.87	1133.50	394.22
44.00	0.00	59.87	1133.50	394.22
45.00	0.00	59.87	1133.50	394.22
46.00	0.00	59.87	1133.50	394.22
47.00	0.00	59.87	1133.50	394.22
48.00	0.00	59.87	1133.50	394.22
49.00	0.00	59.87	1133.50	394.22
50.00	0.00	59.87	1133.50	394.22
51.00	0.00	59.87	1133.50	394.22

52.00	0.00	59.87	1133.50	394.22
53.00	0.00	59.87	1133.50	394.22
54.00	0.00	59.87	1133.50	394.22
55.00	0.00	59.87	1133.50	394.22
56.00	0.00	59.87	1133.50	394.22
57.00	0.00	59.87	1133.50	394.22
58.00	0.00	59.87	1133.50	394.22
59.00	0.00	59.87	1133.50	394.22
60.00	0.00	59.87	1133.50	394.22
61.00	0.00	59.87	1133.50	394.22
62.00	0.00	59.87	1133.50	394.22

GOLDEN RUSH LAKE PROJECT #475
RESERVOIR ROUTING USING HEC-1
NEW CONTROL STRUCTURE

PERIOD (24 hrs.)	VELOCITY (fps)	STORAGE (acre-ft)	STAGE (MSL ft)	STORAGE MOVED (acre-ft)
1.00	93.15	454.09	1136.00	0.00
2.00	64.17	298.07	1135.19	156.02
3.00	39.21	195.54	1134.57	258.55
4.00	20.80	136.03	1134.16	318.06
5.00	11.67	103.83	1133.90	350.26
6.00	6.92	85.40	1133.74	368.69
7.00	4.10	74.48	1133.64	379.61
8.00	2.31	68.12	1133.58	385.97
9.00	1.31	64.53	1133.54	389.56
10.00	0.74	62.50	1133.53	391.59
11.00	0.42	61.36	1133.51	392.73
12.00	0.23	60.71	1133.51	393.38
13.00	0.13	60.35	1133.50	393.74
14.00	0.07	60.14	1133.50	393.95
15.00	0.04	60.02	1133.50	394.07
16.00	0.02	59.96	1133.50	394.13
17.00	0.01	59.92	1133.50	394.17
18.00	0.01	59.90	1133.50	394.19
19.00	0.00	59.89	1133.50	394.20
20.00	0.00	59.88	1133.50	394.21
21.00	0.00	59.88	1133.50	394.21
22.00	0.00	59.88	1133.50	394.21
23.00	0.00	59.88	1133.50	394.21
24.00	0.00	59.87	1133.50	394.22
25.00	0.00	59.87	1133.50	394.22
26.00	0.00	59.87	1133.50	394.22
27.00	0.00	59.87	1133.50	394.22
28.00	0.00	59.87	1133.50	394.22
29.00	0.00	59.87	1133.50	394.22
30.00	0.00	59.87	1133.50	394.22
31.00	0.00	59.87	1133.50	394.22
32.00	0.00	59.87	1133.50	394.22
33.00	0.00	59.87	1133.50	394.22
34.00	0.00	59.87	1133.50	394.22
35.00	0.00	59.87	1133.50	394.22
36.00	0.00	59.87	1133.50	394.22
37.00	0.00	59.87	1133.50	394.22
38.00	0.00	59.87	1133.50	394.22
39.00	0.00	59.87	1133.50	394.22
40.00	0.00	59.87	1133.50	394.22
41.00	0.00	59.87	1133.50	394.22
42.00	0.00	59.87	1133.50	394.22
43.00	0.00	59.87	1133.50	394.22
44.00	0.00	59.87	1133.50	394.22
45.00	0.00	59.87	1133.50	394.22
46.00	0.00	59.87	1133.50	394.22
47.00	0.00	59.87	1133.50	394.22
48.00	0.00	59.87	1133.50	394.22
49.00	0.00	59.87	1133.50	394.22
50.00	0.00	59.87	1133.50	394.22
51.00	0.00	59.87	1133.50	394.22

52.00	0.00	59.87	1133.50	394.22
53.00	0.00	59.87	1133.50	394.22
54.00	0.00	59.87	1133.50	394.22
55.00	0.00	59.87	1133.50	394.22
56.00	0.00	59.87	1133.50	394.22
57.00	0.00	59.87	1133.50	394.22
58.00	0.00	59.87	1133.50	394.22
59.00	0.00	59.87	1133.50	394.22
60.00	0.00	59.87	1133.50	394.22
61.00	0.00	59.87	1133.50	394.22
62.00	0.00	59.87	1133.50	394.22