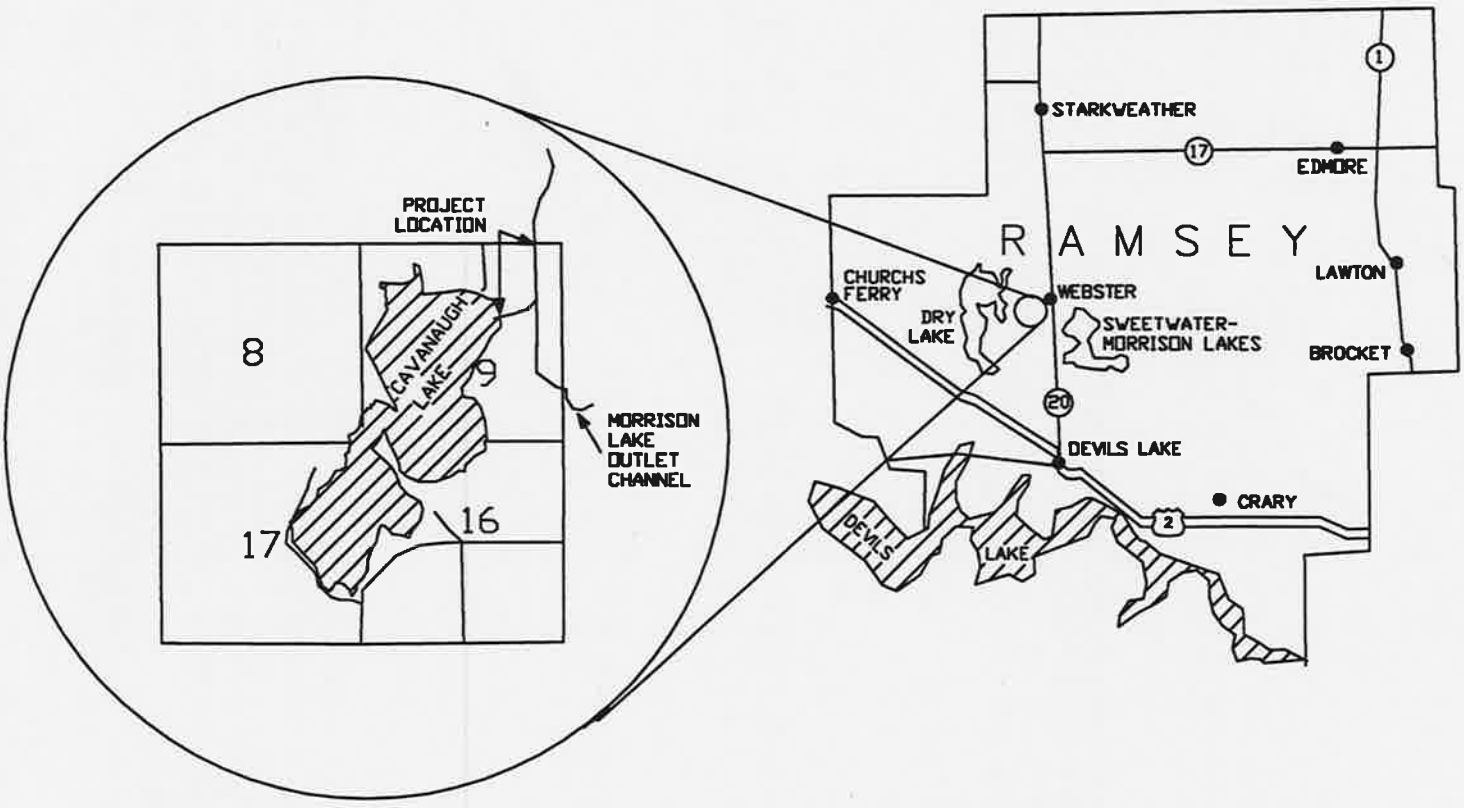
PRELIMINARY ENGINEERING REPORT

CAVANAUGH LAKE DIVERSION

SWC NO. 1298
RAMSEY COUNTY



NORTH DAKOTA
STATE WATER COMMISSION

May 1993

PRELIMINARY ENGINEERING REPORT

Cavanaugh Lake Diversion
SWC Project #1287

May 1993

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

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TABLE OF CONTENTS

Tables

TABLE OF CONTENTS (CONT.)

Page

Figures

APPENDICES

I. INTRODUCTION

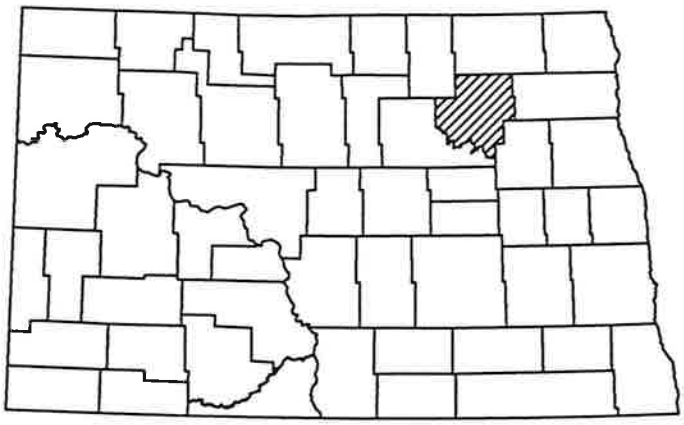
Study Objectives:

In September of 1992, the North Dakota State Water Commission, the North Dakota State Game and Fish Department, and the Ramsey County Water Resource District entered into an agreement to investigate the feasibility of diverting water from the Morrison Lake outlet channel (Webster Coulee) into Cavanaugh Lake. The agreement called for the State Water Commission to conduct a field survey of the project area, including a topographic survey of the proposed diversion site, a topographic survey of the lake shoreline, and soundings of the lake bottom to determine area-capacity information; perform a preliminary design of a structure to divert water into Cavanaugh Lake; prepare a preliminary cost estimate for the proposed diversion structure; and prepare a written report documenting the findings of the investigation. A copy of the agreement is contained in Appendix A.

Project Location and Purpose:

The project is located in Section 9, Township 155 North, Range 64 West (T 155 N, R 64 W), approximately 1.5 miles south of the city of Webster, North Dakota. Figure 1 shows the location of the project within the state of North Dakota.

The Morrison Lake outlet channel lies east of Cavanaugh Lake in Section 9, T 155 N, R 64 W. Currently, when the water level in the Morrison Lake outlet channel exceeds an elevation of 1453.5 msl in this reach, flow enters Cavanaugh Lake through a gated 36-inch



CAVANAUGH LAKE DIVERSION

SWC # 1298

LOCATION MAP

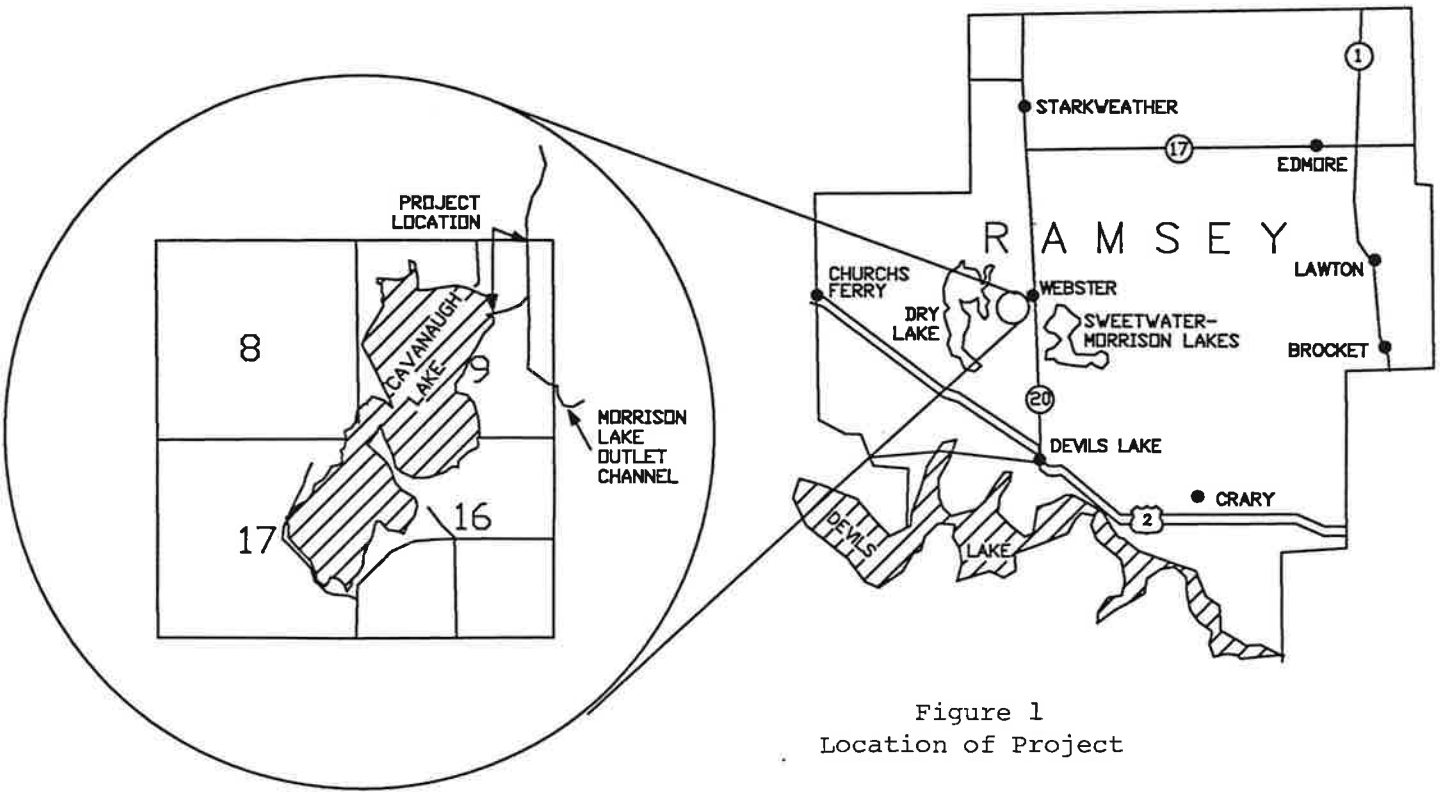


Figure 1
Location of Project

diameter Corrugated Metal Pipe (CMP) culvert located at the northeast corner of Cavanaugh Lake.

This investigation evaluates alternatives for constructing a diversion structure in the Morrison Lake outlet channel. The diversion structure will increase the water level in the channel during lower flows, enabling water to be diverted into Cavanaugh Lake more frequently. The investigation also evaluates possible inlet structures for Cavanaugh Lake. The improved ability to divert water into Cavanaugh Lake will provide a more stable water level which will be beneficial to the lake's fishery.

II. GEOLOGY AND CLIMATE

Cavanaugh Lake is part of an interconnected chain of lakes that are a tributary to Devils Lake in northeastern North Dakota. It lies adjacent to the outlet channel for Sweetwater and Morrison Lakes.

The Devils Lake Basin is a closed basin in the drainage of the Red River of the North. Physiographically, it lies within the Central Lowlands Province, an area of glacial drift and lacustrine plains that formed during the last ice age. The topography of the basin varies from steeply rolling glacial drift with a slope of over 15 percent, to the flat and featureless glacial outwash plain which has a slope of only three percent. The entire basin is dotted with numerous potholes and small shallow lakes which are natural reservoirs for surface runoff.

The climate for the Devils Lake Basin is characterized by warm summers and cold winters. Frequent spells of hot weather and occasional cool days characterize the summer. Temperatures are very cold in the winter, when arctic air frequently surges over the area. The average temperature for the basin is 38 degrees Fahrenheit. The annual precipitation for the basin is 16.5 inches, of which 75 percent falls in April through September, which is the growing season for most crops. The prevailing wind direction is from the northwest.

III. WATER LEVEL SELECTION

The first step in the design of a diversion structure for Cavanaugh Lake is to select a lake level. The current inlet to Cavanaugh Lake consists of a 36-inch diameter CMP culvert located at the northeast corner of the lake. Water will enter the lake through the culvert when the water level in the Morrison Lake outlet channel lying adjacent to Cavanaugh Lake exceeds an elevation of 1453.5 msl. A flap-gate on the downstream end of the culvert prevents water from leaving the lake through it. The lake does not have an outlet structure at this time, although a dike constructed at the northeast corner of the lake will overtop when the lake level exceeds an elevation of 1455.9 msl.

Two lake levels were evaluated during the investigation; 1453.7 msl and 1454.7 msl. The project design will allow a slight variation from these levels without significant modifications to the design.

The 1453.7 msl lake level will raise the lake slightly from its current level. The lake level was 1453.0 msl when it was surveyed in October 1992. A 1453.7 msl lake level will provide a maximum depth of 6.9 feet in the north portion of Cavanaugh Lake and a maximum depth of 12.5 feet in the south portion. Figure 2 shows a contour map of Cavanaugh Lake obtained from the October 1992 survey data. Figures 3, 4, and 5 show area-capacity curves for the north portion of the lake, the south portion of the lake, and a combined area-capacity curve for the entire lake,

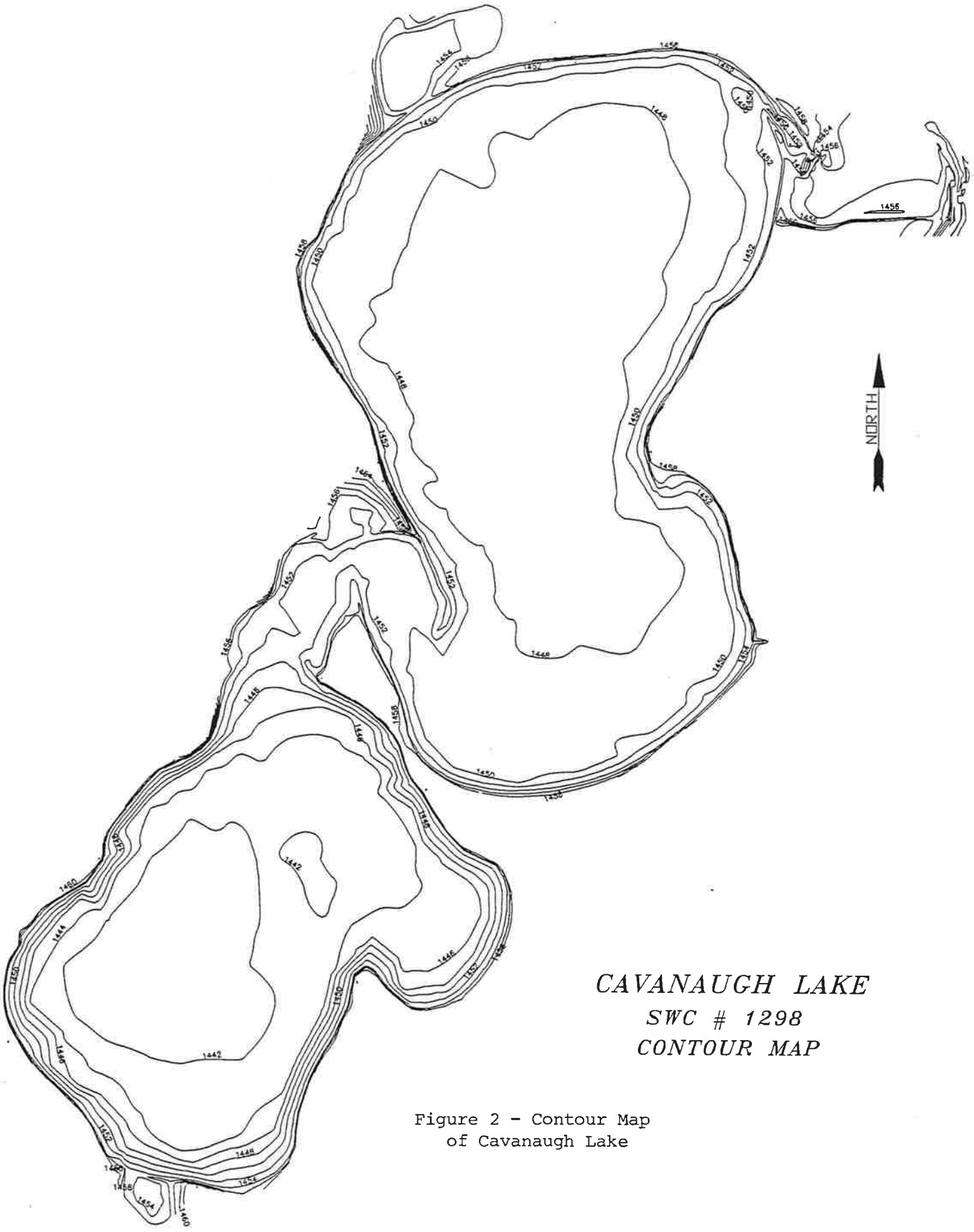


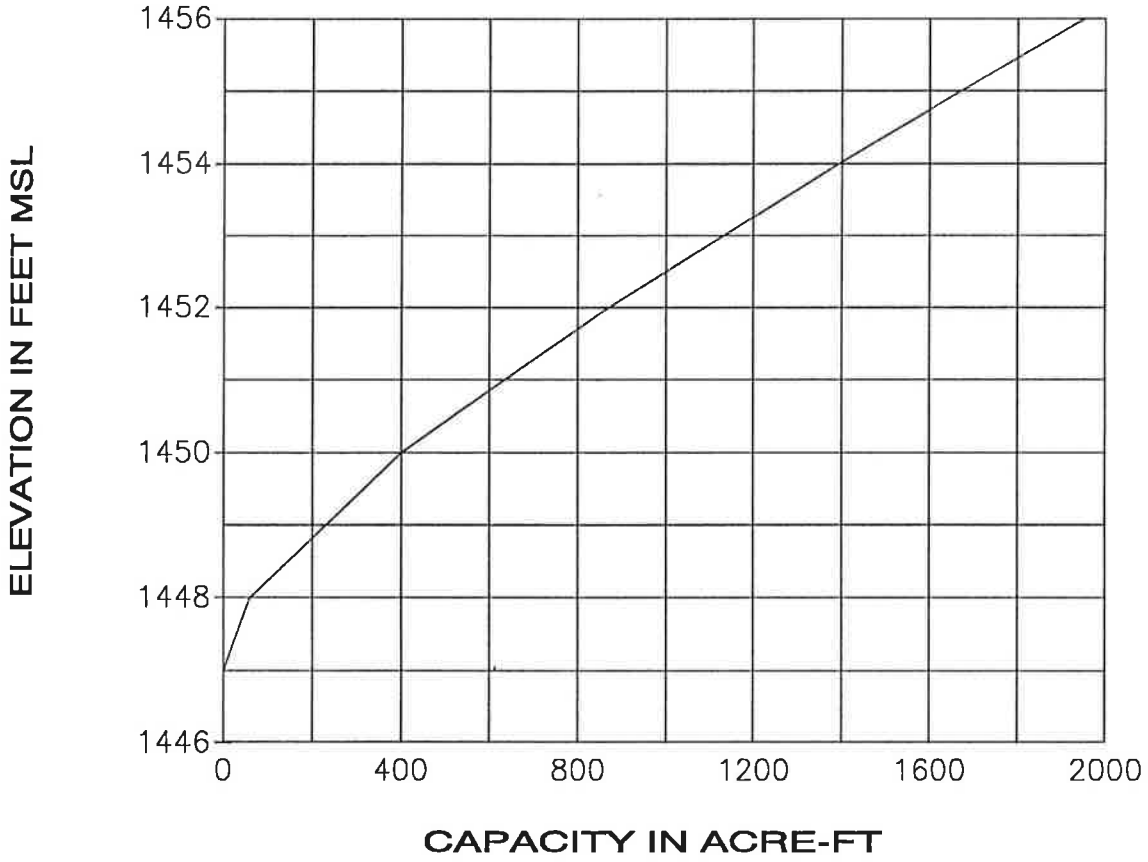
Figure 2 - Contour Map
of Cavanaugh Lake

CAVANAUGH LAKE DIVERSION

SWC #1298

ELEVATION/CAPACITY

FOR NORTH LAKE



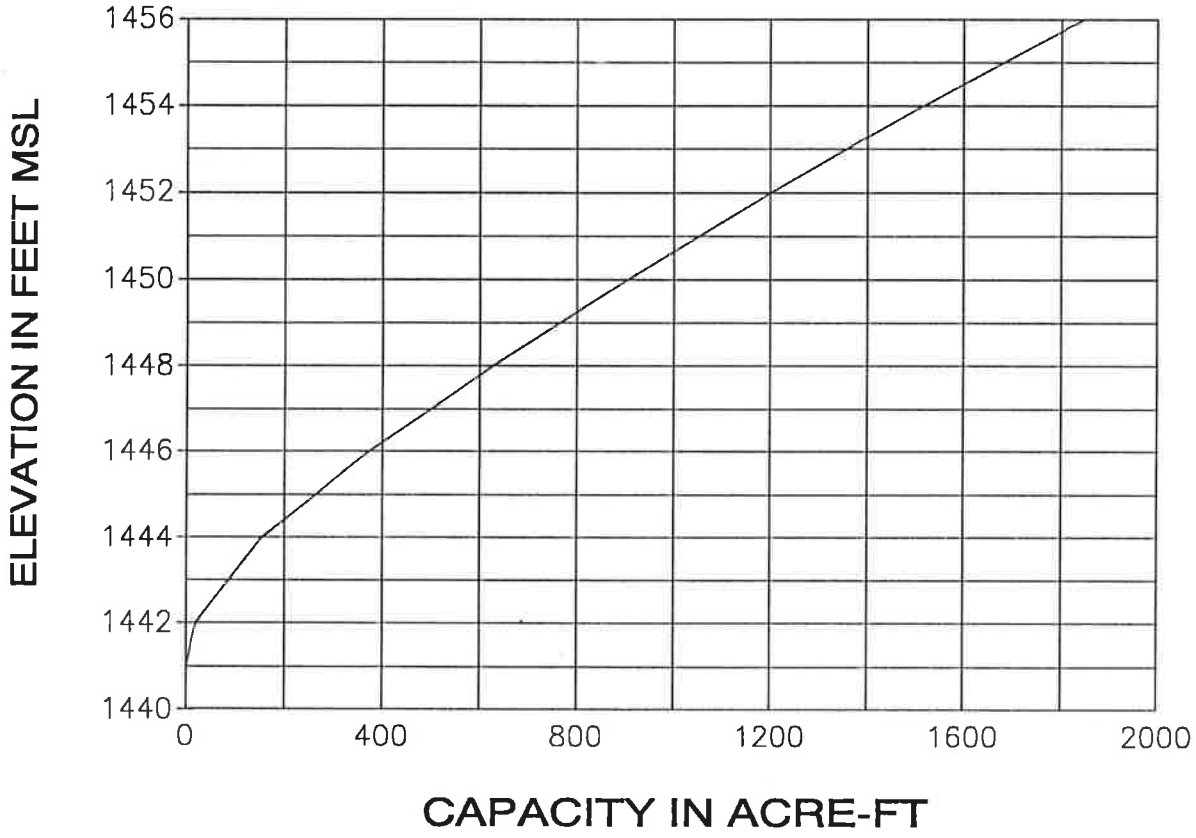
ELEVATION (msl)	AREA (acres)	CAPACITY (acre-ft)
1447.0	0.0	0.0
1448.0	121.0	61.0
1449.0	169.5	230.5
1450.0	218.0	400.0
1451.0	235.0	635.0
1452.0	252.0	870.0
1453.0	261.5	1131.5
1454.0	271.0	1393.0
1455.0	279.5	1672.5
1456.0	288.0	1952.0

Figure 3
Area-Capacity Curve For
North Portion of Cavanaugh Lake

CAVANAUGH LAKE DIVERSION

SWC #1298

ELEVATION/CAPACITY FOR SOUTH LAKE



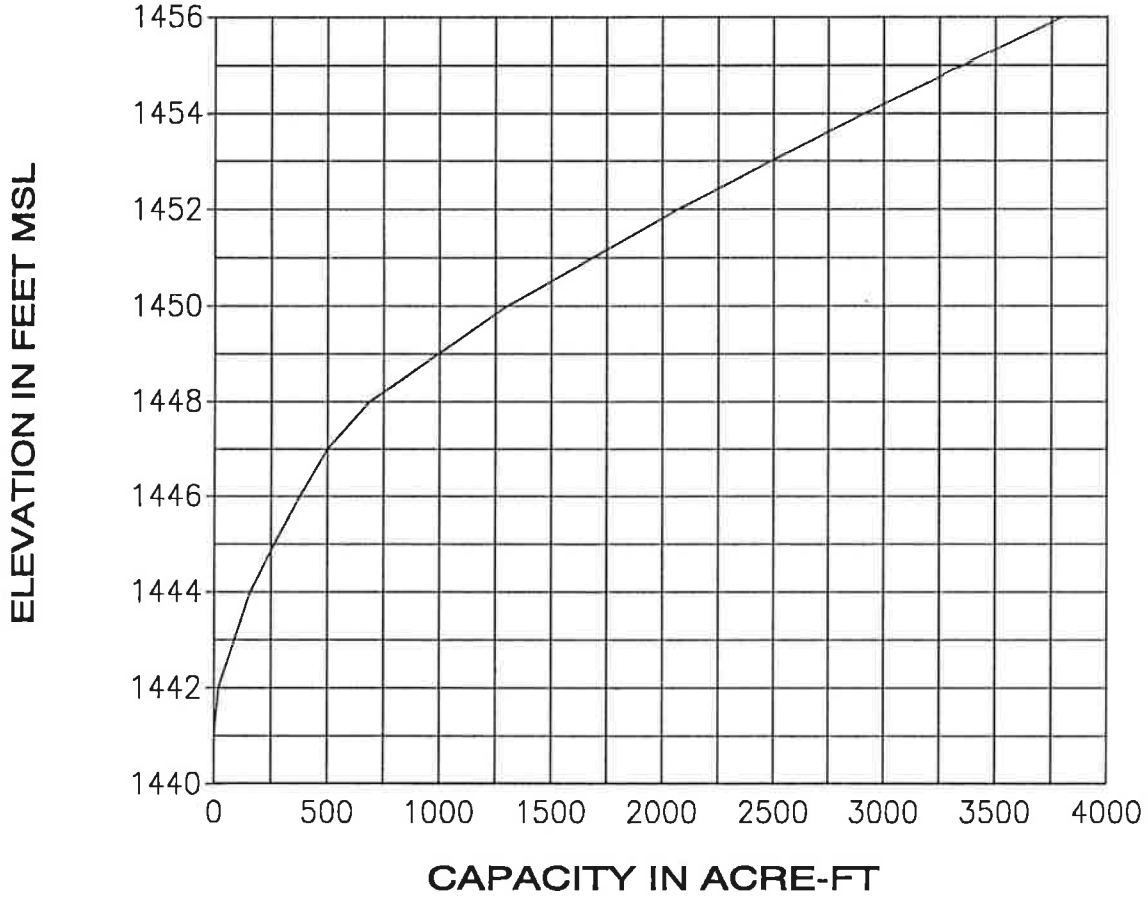
ELEVATION (msl)	AREA (acres)	CAPACITY (acre-ft)
1441.0	0.0	0.0
1442.0	39.0	20.0
1443.0	68.0	88.0
1444.0	97.0	156.0
1445.0	109.0	265.0
1446.0	121.0	374.0
1447.0	127.0	501.0
1448.0	133.0	628.0
1449.0	138.0	766.0
1450.0	143.0	904.0
1451.0	148.5	1052.3
1452.0	154.0	1200.5
1453.0	158.5	1359.0
1454.0	163.0	1517.5
1455.0	165.5	1683.0
1456.0	168.0	1848.5

Figure 4
Area-Capacity Curve For
South Portion of Cavanaugh Lake

CAVANAUGH LAKE DIVERSION

SWC #1298

ELEVATION/CAPACITY FOR ENTIRE LAKE



ELEVATION (msl)	AREA (acres)	CAPACITY (acre-ft)
1441.0	0.0	0.0
1442.0	39.0	20.0
1443.0	68.0	88.0
1444.0	97.0	156.0
1445.0	109.0	265.0
1446.0	121.0	374.0
1447.0	127.0	501.0
1448.0	254.0	689.0
1449.0	307.5	996.5
1450.0	361.0	1304.0
1451.0	383.5	1687.3
1452.0	406.0	2070.5
1453.0	420.0	2490.5
1454.0	434.0	2910.5
1455.0	445.0	3355.5
1456.0	456.0	3800.5

Figure 5
Area-Capacity Curve
For Entire Lake

respectively.

The 1454.7 msl lake level will raise the lake to its meandered level. This is the maximum level the lake can be maintained at without flooding deeded land. The meandered level was determined by comparing the original 1884 GLO plats with survey data that was obtained for the investigation. Flood easements will be necessary to maintain Cavanaugh Lake above its meandered level. A 1454.7 msl lake level will provide a maximum depth of 7.9 feet in the north portion of the lake and 13.5 feet in the south portion.

IV. HYDRAULICS

A hydraulic analysis of the Morrison Lake outlet channel near Cavanaugh Lake was performed using the HEC-2 computer model, developed by the U.S. Army Corps of Engineers. HEC-2 calculates water surface profiles for steady, gradually varied flow in natural or man-made channels for flows due to various precipitation events. The data needed to perform these computations includes: flow regime, cross section geometry, and reach lengths. The computational procedure used by the model is based on the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. This computation is generally known as the Standard Step Method.

The hydraulic analysis began downstream of the road between Section 4 and Section 9, T 155 N, R 64 W. The analysis proceeded upstream past a dike extending from the Morrison Lake outlet channel to Cavanaugh Lake in Section 9, T 155 N, R 64 W. The split flow capability of the HEC-2 program was used to divert flow into Cavanaugh Lake.

V. ALTERNATIVES

Three alternatives to divert water into Cavanaugh Lake were considered as part of this investigation. The first alternative involves installing gates on the culverts through the road between Section 4 and Section 9, T 155 N, R 64 W, and installing a control structure at the location of the existing inlet structure. The second alternative involves installing gates on the culverts through the road between Section 4 and Section 9, T 155 N, R 64 W, and constructing a channel and control structure along a property line in the NE¼, Section 9, T 155 N, R 64 W. The third alternative involves constructing a gated stop log structure in the Morrison Lake outlet channel downstream of the dike extending from the Morrison Lake outlet channel to Cavanaugh Lake in Section 9, T 155 N, R 64 W, and constructing a channel and control structure along the dike to Cavanaugh Lake. The following sections describe these alternatives in detail:

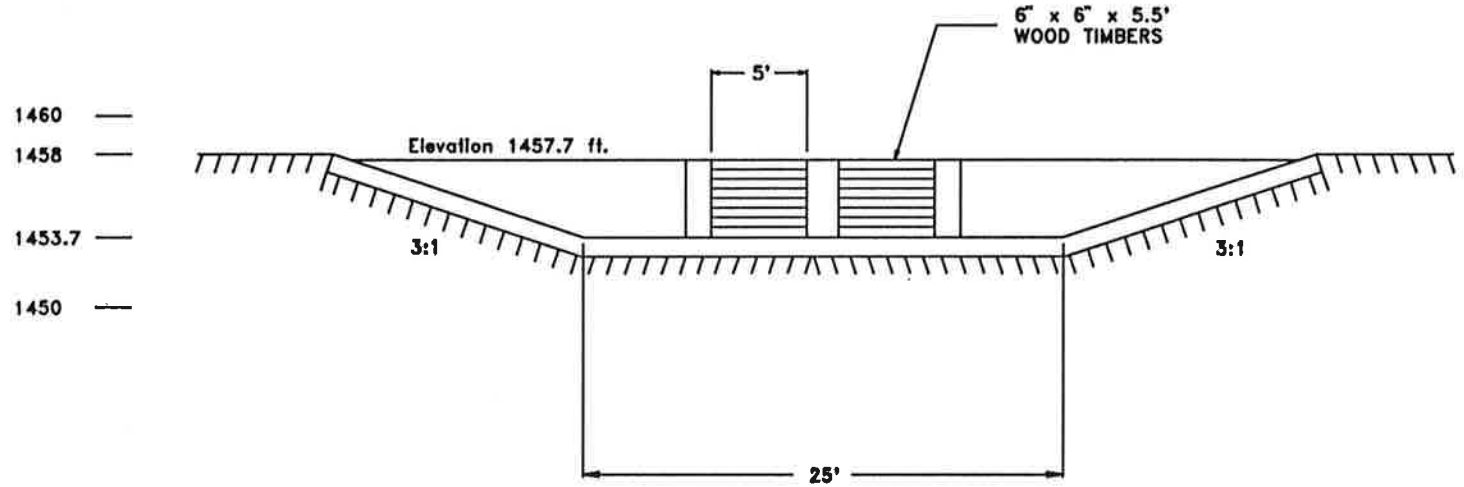
Alternative One:

This alternative involves constructing a concrete headwall on the six 57-inch by 38-inch arch culverts that pass beneath the roadway between Section 4 and Section 9, T 155 N, R 64 W, and installing slide gates on the upstream ends of the culverts. When the flow in the Morrison Lake outlet channel exceeds 400 cfs, which is the design flow for the channel, all of the slide gates will remain open. A flow of 400 cfs in the Morrison Lake outlet channel corresponds to a 10-year runoff event.

When the level of Cavanaugh Lake is low, and the flow in the Morrison Lake outlet channel is less than 400 cfs, some of the slide gates will be closed to maintain a higher water level upstream of the gates. The ability to control the water level upstream of the gates will allow water to be diverted into Cavanaugh Lake more frequently. An operating plan will need to be developed to regulate the closure of the gates for various outflows from Morrison Lake. The goal of the operating plan is to maintain a water level of 1456.6 msl upstream of the culverts. A portion of the dike along the northeast corner of Cavanaugh Lake will need to be raised slightly to facilitate this water level. An example of an operating plan is contained in Section VI of this report.

An inlet structure, consisting of two 5-foot wide stop log structures, will be installed near the location of the existing inlet structure to allow water to be diverted into Cavanaugh Lake and to control its level. The stop log structures will be located in a 25-foot wide channel with 3:1 (3 Horizontal to 1 Vertical) side slopes that will connect Cavanaugh Lake to the low-lying area adjacent to the Morrison Lake outlet channel in the NE¼, Section 9, T 155 N, R 64 W. The invert of the stop log structures will be set at elevation 1453.7 msl. Figure 6 shows a profile view of the proposed stop log structures. Figure 7 shows the proposed layout of Alternative One.

The stop log structures will be operated by adding or removing wood timbers. The wood timbers are 6 inches wide, 6 inches thick,



Cavanaugh Lake Diversion
SWC # 1298
Stop Log Control Structure for
Alternatives One, Two, and Three

Scale 1" = 10'

Figure 6
Profile View of
Stop Log Structures

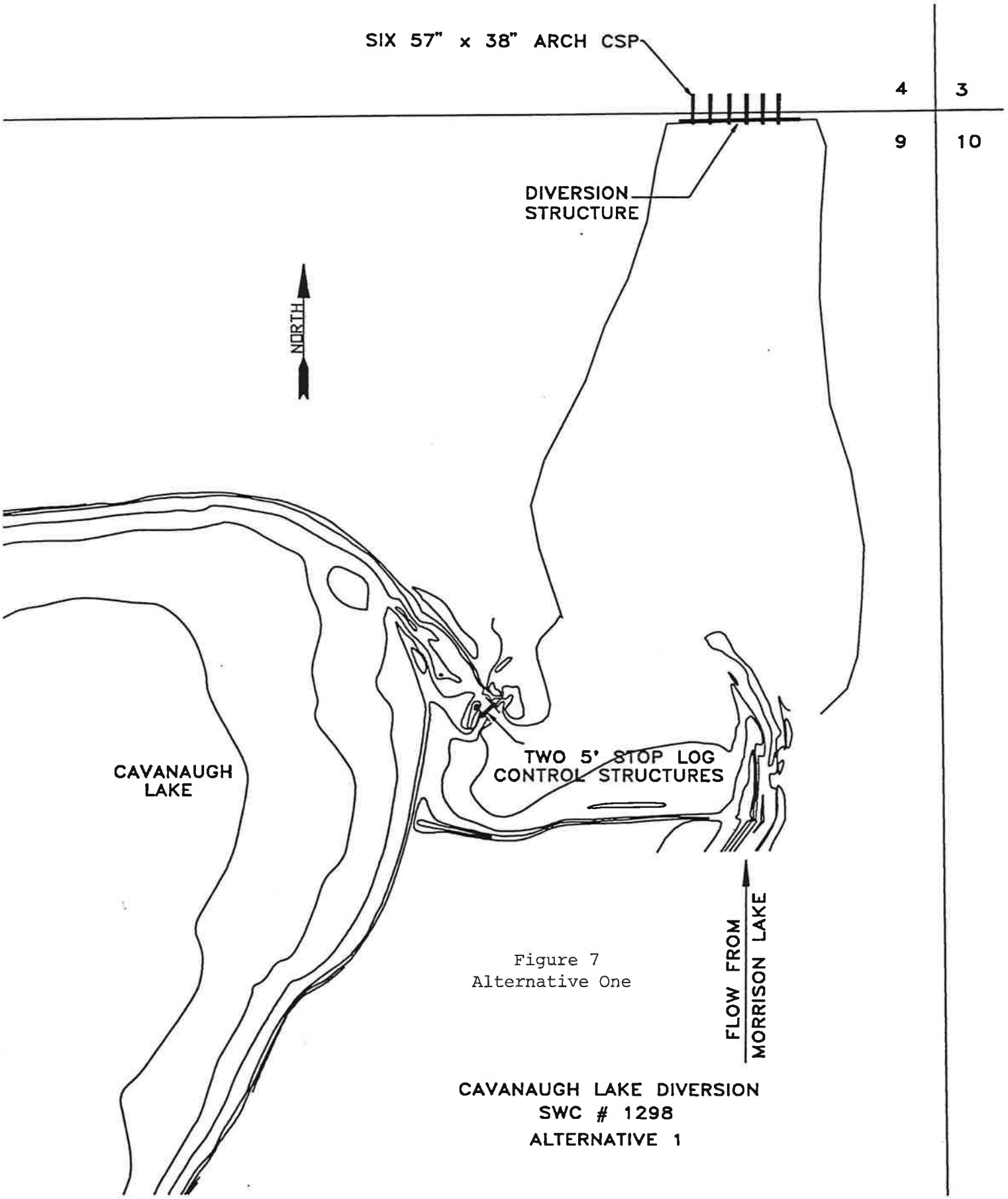


Figure 7
Alternative One

CAVANAUGH LAKE DIVERSION
SWC # 1298
ALTERNATIVE 1

and 5.5 feet long. The timbers will slide into notches in the stop log structures. A total of eight timbers will be needed for each structure. If Cavanaugh Lake is below its control elevation and flow is passing through the Morrison Lake outlet channel, the timbers should be removed from the stop log structures to allow water to enter Cavanaugh Lake. When the lake is full, the timbers should be placed in the stop log structures again to prevent additional water from entering the lake.

The time required to fill Cavanaugh Lake is dependent on the level of the lake. Table 1 lists the time that will be required for Cavanaugh Lake to fill for various starting lake levels. The times were calculated assuming a constant water level of 1456.6 msl in the Morrison Lake outlet channel.

Table 1 - Filling Time for Alternative One

Initial Lake Level (msl)	1453.7 msl Lake Level Water Volume Required (acre-ft)	1453.7 msl Lake Level Time Required (days)	1454.7 msl Lake Level Water Volume Required (acre-ft)	1454.7 msl Lake Level Time Required (days)
1450.0	1480.5	5.0	1918.0	6.4
1451.0	1097.2	3.7	1534.7	5.1
1452.0	714.0	2.4	1151.5	3.9
1453.0	294.0	1.0	731.5	2.4
1453.7	0.0	0.0	437.5	1.5
1454.7	-	-	0.0	0.0

Alternative One is estimated to cost $52,000. This cost estimate applies for both the 1453.7 msl and 1454.7 msl lake levels. Table 2 contains a cost estimate for Alternative One.

Table 2 - Preliminary Cost Estimate for Alternative One

Item	Quantity	Unit	Unit Price	Total
Mobilization	1	LS	$3,000.00	$ 3,000
Stripping and Spreading Topsoil	300	SY	0.25	75
Construct Diversion Structure				
(a) Sheet Pile	150	LF	25.00	3,750
(b) Concrete	20	CY	300.00	6,000
(c) Reinforcing Steel	2,800	Lbs	0.50	1,400
(d) 60"x42" Slide Gate	6	Ea.	2,200.00	13,200
(e) Relocate and Align Pipes	1	LS	1,000.00	1,000
(f) Miscellaneous Materials	1	LS	1,000.00	1,000
Construct Control Structure				
(a) Excavate Channel	200	CY	2.00	400
(b) Sheet Pile	130	LF	25.00	3,250
(c) Concrete	14	CY	300.00	4,200
(d) Reinforcing Steel	1,960	Lbs	0.50	980
(e) Rock Riprap	15	CY	25.00	375
(f) Miscellaneous Materials	1	LS	1,000.00	1,000
Seeding	0.5	Ac.	300.00	150
Subtotal				$39,780
Contingencies			(+/- 10%)	4,073
Contract Administration			(+/- 10%)	4,073
Engineering			(+/- 10%)	4,074
Total				$52,000

Alternative Two:

This alternative involves constructing a concrete headwall on the six 57-inch by 38-inch arch culverts that pass beneath the roadway between Section 4 and Section 9, T 155 N, R 64 W, and installing slide gates on the upstream ends of the culverts. When the flow in the Morrison Lake outlet channel exceeds 400 cfs, which is the design flow for the channel, all of the slide gates will

remain open. A flow of 400 cfs in the Morrison Lake outlet channel corresponds to a 10-year runoff event.

When the level of Cavanaugh Lake is low and the flow in the Morrison Lake outlet channel is less than 400 cfs, some of the slide gates will be closed to maintain a higher water level upstream of the gates. The ability to control the water level upstream of the gates will allow water to be diverted into Cavanaugh Lake more frequently. An operating plan will need to be developed to regulate the closure of the gates for various outflows from Morrison Lake. The goal of the operating plan is to maintain a water level of 1456.6 msl upstream of the culverts. A portion of the dike along the northeast corner of Cavanaugh Lake will need to be raised slightly to facilitate this water level. An example of an operating plan is contained in Section VI of this report.

A 25-foot wide channel with 3:1 side slopes will be constructed along the property line (fence line) between the NW¼NE¼, Section 9, T 155 N, R 64 W, and the SW¼NE¼, Section 9, T 155 N, R 64 W, to convey flow into Cavanaugh Lake. The channel will be approximately 1600 feet long. The east end of the channel will tie into the Morrison Lake outlet channel at an elevation of 1453.0 msl. An inlet structure, consisting of two 5-foot wide stop log structures, will be constructed at the west end of the channel to allow water to be diverted into Cavanaugh Lake and to control its level. The invert of the stop log structures will be set at elevation 1453.7 msl. Figure 6 shows a profile view of the

proposed stop log structures. Figure 8 shows the proposed layout of Alternative Two.

The stop log structures will be operated by adding or removing wood timbers. The wood timbers are 6 inches wide, 6 inches thick, and 5.5 feet long. The timbers will slide into notches in the stop log structures. A total of eight timbers will be needed for each structure. If Cavanaugh Lake is below its control elevation and flow is passing through the Morrison Lake outlet channel, the timbers should be removed from the stop log structures to allow water to enter Cavanaugh Lake. When the lake is full, the timbers should be placed in the stop log structures again to prevent additional water from entering the lake.

The time required to fill Cavanaugh Lake is dependent on the level of the lake. Table 3 lists the time that will be required for Cavanaugh Lake to fill for various starting lake levels. The times were calculated assuming a constant water level of 1456.6 msl in the Morrison Lake outlet channel. The filling times for Alternative Two are greater than the filling times for Alternative One because the diversion channel for Alternative Two is longer, which results in higher head losses.

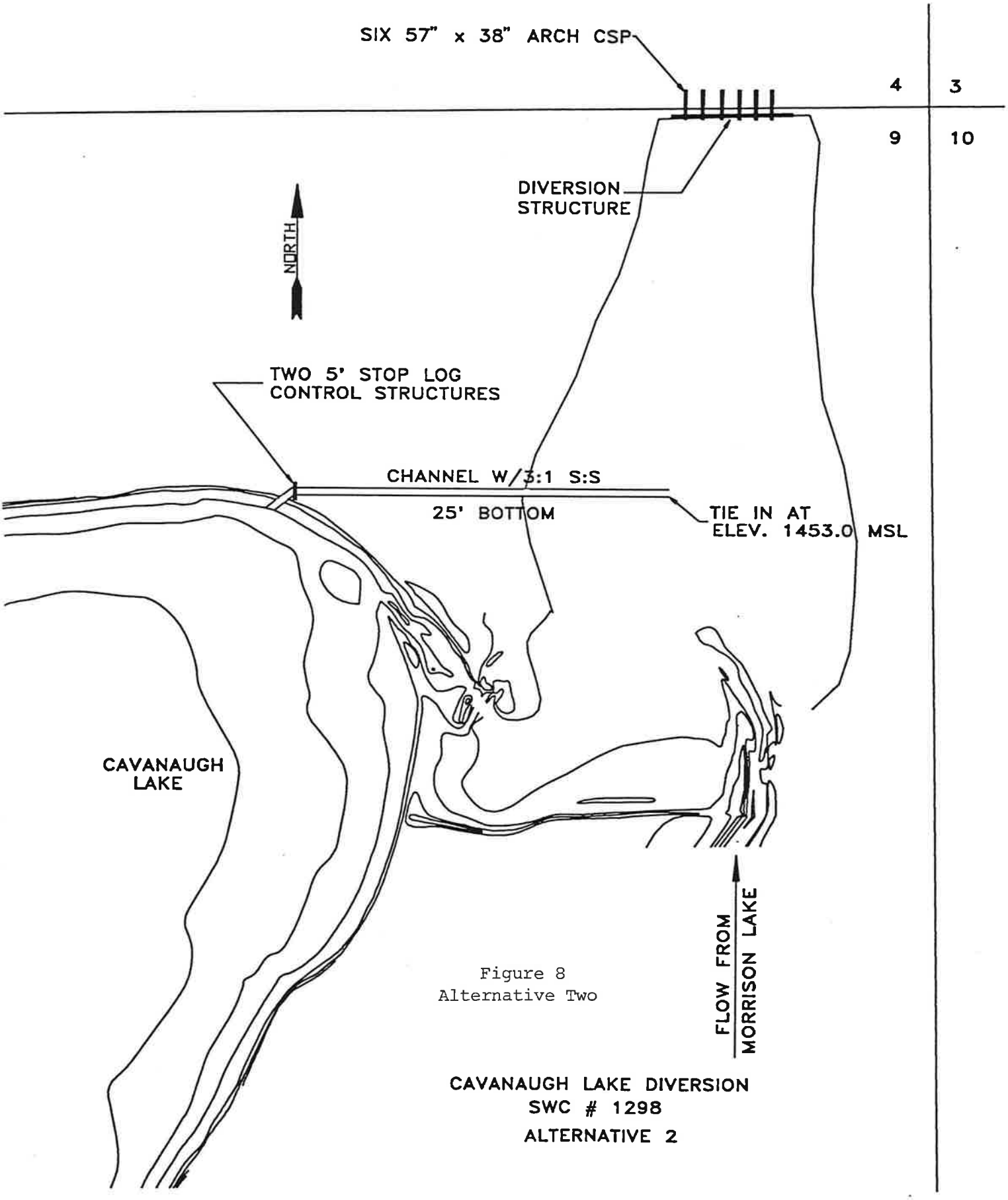


Figure 8
Alternative Two

Table 3 - Filling Time for Alternative Two

Initial Lake Level (msl)	1453.7 msl Lake Level: Water Volume Required (acre-ft)	1453.7 msl Lake Level: Time Required (days)	1454.7 msl Lake Level: Water Volume Required (acre-ft)	1454.7 msl Lake Level: Time Required (days)
1450.0	1480.5	6.9	1918.0	9.0
1451.0	1097.2	5.1	1534.7	7.2
1452.0	714.0	3.3	1151.5	5.4
1453.0	294.0	1.4	731.5	3.4
1453.7	0.0	0.0	437.5	2.1
1454.7	-	-	0.0	0.0

Alternative Two is estimated to cost $68,000. This cost estimate applies for both the 1453.7 msl and 1454.7 msl lake levels. Table 4 contains a cost estimate for Alternative Two.

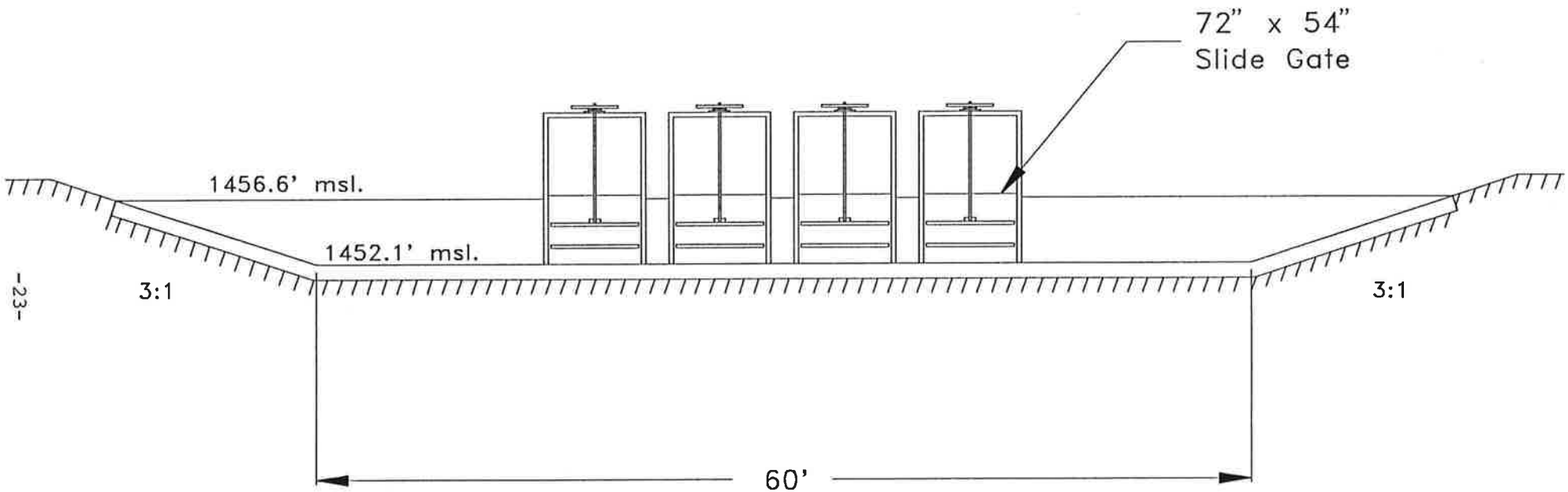
Table 4 - Preliminary Cost Estimate for Alternative Two

Item	Quantity	Unit	Unit Price	Total
Mobilization	1	LS	$5,000.00	$ 5,000
Stripping and Spreading Topsoil	7,500	SY	0.25	1,875
Construct Diversion Structure				
(a) Sheet Pile	150	LF	25.00	3,750
(b) Concrete	20	CY	300.00	6,000
(c) Reinforcing Steel	2,800	Lbs	0.50	1,400
(d) 60"x42" Slide Gate	6	Ea.	2,200.00	13,200
(e) Relocate and Align Pipes	1	LS	1,000.00	1,000
(f) Miscellaneous Materials	1	LS	1,000.00	1,000
Construct Control Structure				
(a) Excavate Channel	6,600	CY	1.30	8,580
(b) Sheet Pile	130	LF	25.00	3,250
(c) Concrete	14	CY	300.00	4,200
(d) Reinforcing Steel	1,960	Lbs	0.50	980
(e) Rock Riprap	15	CY	25.00	375
(f) Miscellaneous Materials	1	LS	1,000.00	1,000
Seeding	2	Ac.	300.00	600
Subtotal				$52,210
Contingencies			(+/- 10%)	5,263
Contract Administration			(+/- 10%)	5,264
Engineering			(+/- 10%)	5,264
Total				$68,000

Alternative Three:

This alternative involves constructing a gated stop log structure in the Morrison Lake outlet channel to act as a diversion structure. The structure will be located several feet downstream of a dike extending from the Morrison Lake outlet channel to Cavanaugh Lake in the NE¼, Section 9, T 155 N, R 64 W. The structure will contain four 72-inch by 54-inch slide gates. A walkway will be located on the downstream end of the diversion structure to allow access to the slide gates. When all four slide gates are open, the stop log structure is capable of passing the flow due to a 10-year runoff event (400 cfs) without causing a significant increase in the water surface elevation in the Morrison Lake outlet channel. The Morrison Lake outlet channel is designed to pass the flow due to a 10-year runoff event within the banks of the channel. Figure 9 shows a profile view of the diversion structure for Alternative Three.

When the level of Cavanaugh Lake is low and the flow in the Morrison Lake outlet channel is less than 400 cfs, some of the slide gates will be closed to maintain a higher water level upstream of the gates. The ability to control the water level upstream of the gates will allow water to be diverted into Cavanaugh Lake more frequently. An operating plan will need to be developed to regulate the closure of the gates for various outflows from Morrison Lake. The goal of the operating plan is to maintain a water level of 1456.6 msl upstream of the culverts. A portion of the dike along the northeast corner of Cavanaugh Lake will need to



Cavanaugh Lake Diversion
SWC # 1298
Diversion Structure for
Alternative Three

Figure 9
Profile View of
Diversion Structure

SCALE: 1" = 10'

be raised slightly to facilitate this water level. An example of an operating plan is contained in Section VI of this report.

A 25-foot wide channel with 3:1 side slopes will be constructed along the dike extending from the Morrison Lake outlet channel to Cavanaugh Lake in the NE¼, Section 9, Township 155 North, Range 64 West, to convey flow into Cavanaugh Lake. The channel will be approximately 1,100 feet long. The east end of the channel will tie into the Morrison Lake outlet channel at an elevation of 1453.0 msl. An inlet structure, consisting of two 5-foot wide stop log structures, will be constructed at the west end of the channel to allow water to be diverted into Cavanaugh Lake and to control its level. The invert of the stop log structures will be set at elevation 1453.7 msl. Figure 6 shows a profile view of the proposed stop log structures. Figure 10 shows the proposed layout of Alternative Three.

The stop log structures will be operated by adding or removing wood timbers. The wood timbers are 6 inches wide, 6 inches thick, and 5.5 feet long. The timbers will slide into notches in the stop log structures. A total of eight timbers will be needed for each structure. If Cavanaugh Lake is below its control elevation and flow is passing through the Morrison Lake outlet channel, the timbers should be removed from the stop log structures to allow water to enter Cavanaugh Lake. When the lake is full, the timbers should be placed in the stop log structures again to prevent additional water from entering the lake.

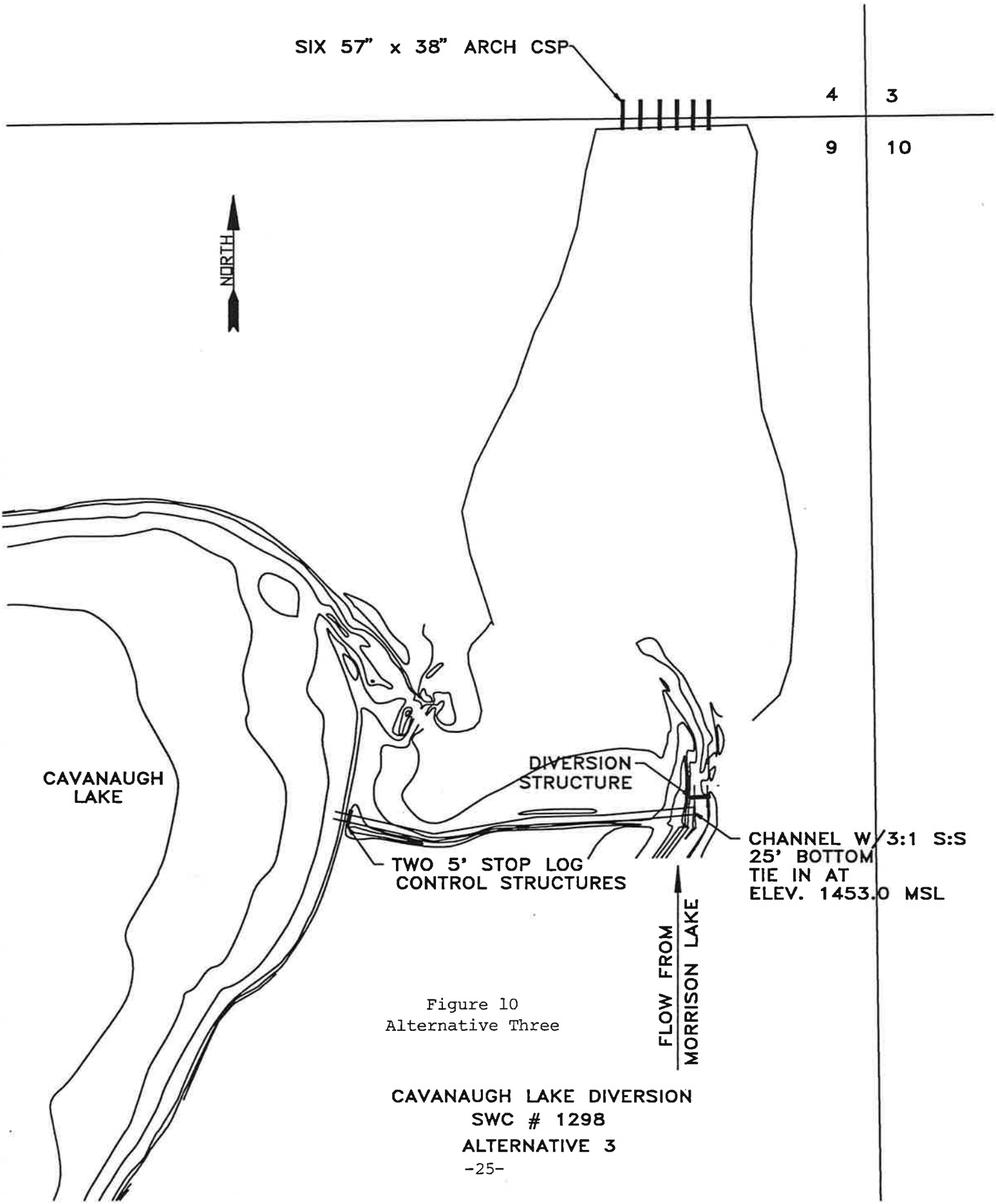


Figure 10
Alternative Three

CAVANAUGH LAKE DIVERSION
SWC # 1298
ALTERNATIVE 3

The time required to fill Cavanaugh Lake is dependent on the level of the lake. Table 5 lists the time that will be required for Cavanaugh Lake to fill for various starting lake levels. The times were calculated assuming a constant water level of 1456.6 msl in the Morrison Lake outlet channel. The filling time for Alternative Three is greater than the filling time for Alternative One because the diversion channel for Alternative Three is longer, which results in higher head losses.

Table 5 - Filling Time for Alternative Three

Initial Lake Level (msl)	1453.7 msl Lake Level: Water Volume Required (acre-ft)	1453.7 msl Lake Level: Time Required (days)	1454.7 msl Lake Level: Water Volume Required (acre-ft)	1454.7 msl Lake Level: Time Required (days)
1450.0	1480.5	5.4	1918.0	7.0
1451.0	1097.2	4.0	1534.7	5.6
1452.0	714.0	2.6	1151.5	4.2
1453.0	294.0	1.1	731.5	2.7
1453.7	0.0	0.0	437.5	1.6
1454.7	-	-	0.0	0.0

Alternative Three is estimated to cost $75,000. This cost estimate applies for both the 1453.7 msl and 1454.7 msl lake levels. Table 6 contains a cost estimate for Alternative Three.

Table 6 - Preliminary Cost Estimate for Alternative Three

Item	Quantity	Unit	Unit Price	Total
Mobilization	1	LS	$5,000.00	$ 5,000
Stripping and Spreading Topsoil	10,000	SY	0.25	2,500
Construct Diversion Structure				
(a) Sheet Pile	230	LF	25.00	5,750
(b) Concrete	29	CY	300.00	8,700
(c) Reinforcing Steel	4,060	Lbs	0.50	2,030
(d) 72"x54" Slide Gate	4	Ea.	4,200.00	16,800
(e) Miscellaneous Materials	1	LS	1,000.00	1,000
Construct Control Structure				
(a) Excavate Channel	4,000	CY	1.30	5,200
(b) Sheet Pile	130	LF	25.00	3,250
(c) Concrete	14	CY	300.00	4,200
(d) Reinforcing Steel	1,960	Lbs	0.50	980
(e) Rock Riprap	15	CY	25.00	375
(f) Miscellaneous Materials	1	LS	1,000.00	1,000
Seeding	2	Ac.	300.00	600
Subtotal				$57,385
Contingencies			(+/- 10%)	5,871
Contract Administration			(+/- 10%)	5,872
Engineering			(+/- 10%)	5,872
Total				$75,000

VI. OPERATING PLAN

An operating plan will need to be developed to regulate the closure of the gates on the Cavanaugh Lake diversion structure for various outflows from Morrison Lake. The goal of the operating plan will be to maintain a water level of 1456.6 msl upstream of the diversion structure. A water level of 1456.6 msl will be maintained since a higher water level will overtop the dikes along the northeast corner of Cavanaugh Lake. A portion of the dike along the northeast corner of the lake will need to be raised approximately 1-foot to facilitate this water level.

The operating plan will vary for each alternative. The operating plan will regulate the closure of the gates on the diversion structure depending on the depth of flow passing over the Morrison Lake outlet structure. A rating curve for the outlet structure was developed using the weir formula. Table 7 contains a preliminary operating plan for Alternative One. In developing the operating plan, the six slide gates were numbered. The west gate was given number 1 and the east gate was given number 6.

Table 7 - Preliminary Operating Plan
for Alternative One

Depth of Flow Over Morrison Lake Outlet Weir (feet)	Condition of Slide Gates on Diversion Structure
0.80 (or less)	All Gates Closed
1.20	Gates 2, 3, 4, 5, and 6 closed
1.50	Gates 3, 4, 5, and 6 closed
1.65	Gates 4, 5, and 6 closed
1.80	Gates 5 and 6 closed
1.90	Gate 6 closed

VII. LAND AND WATER RIGHTS

The three alternatives that were considered during this investigation will involve the flooding of private land and/or construction on private land. Alternative One will inundate approximately 100 acres of land in the NE¼, Section 9, T 155 N, R 64 W. Alternative Two will also inundate approximately 100 acres of land in the NE¼, Section 9, T 155 N, R 64 W. An additional 2 acres of land will be required to construct the channel to Cavanaugh Lake for Alternative Two. Alternative Three will also require approximately 2 acres of land to construct the channel to Cavanaugh Lake. No additional land will be inundated for Alternative Three. All of the affected land will require easements or will need to be purchased.

A water use permit will be required for the water that will be diverted into Cavanaugh Lake. This permit can be obtained from the North Dakota State Engineer. A Section 404 Permit, required through the Clean Water Act, will also be necessary for any excavation or fill placement in a wetland. Section 404 Permits are issued by the U.S. Army Corps of Engineers.

The diversion of water from the Morrison Lake outlet channel into Cavanaugh Lake will prevent the diverted water from ultimately reaching Devils Lake. Although the volume of water that will be diverted into Cavanaugh Lake is small compared to the volume of water in Devils Lake, opposition to the project may arise.

VIII. SUMMARY

The feasibility of diverting water from the Morrison Lake outlet channel into Cavanaugh Lake has been examined. The Morrison Lake outlet channel lies approximately 1,000 feet east of Cavanaugh Lake in Section 9, T 155 N, R 64 W. The ability to divert additional water into Cavanaugh Lake will provide a more stable water level which will be beneficial to the lake's fishery.

Three alternatives to divert water into Cavanaugh Lake were considered during the investigation. Alternative One involves constructing a concrete headwall on the six 57-inch by 38-inch arch culverts through the road between Section 4 and Section 9, T 155 N, R 64 W, and installing slide gates to act as a diversion structure. The control structure for Alternative One will consist of two 5-foot wide stop log structures at the location of the existing inlet structure, located at the northeast corner of Cavanaugh Lake. The invert of the control structure will be set at elevation 1453.7 msl. The estimated cost of Alternative One is $52,000. This cost applies for both the 1453.7 msl and 1454.7 msl lake levels.

Alternative Two also involves constructing a concrete headwall on the six 57-inch by 38-inch arch culverts through the road between Section 4 and Section 9, T 155 N, R 64 W, and installing slide gates to act as a diversion structure. A 25-foot wide channel with 3:1 side slopes will be constructed along the property line (fence line) between the NW¼NE¼, Section 9, T 155 N, R 64 W, and the SW¼NE¼, Section 9, T 155 N, R 64 W, to convey flow into

Cavanaugh Lake. The control structure will consist of two 5-foot wide stop log structures at the west end of the channel. The invert of the control structure will be set at elevation 1453.7 msl. Alternative Two is estimated to cost $68,000. This cost applies for both the 1453.7 msl and 1454.7 msl lake levels.

Alternative Three involves constructing a gated stop log structure, containing four 72-inch by 54-inch slide gates, in the Morrison Lake outlet channel to act as a diversion structure. The structure will be located downstream of a dike extending from the Morrison Lake outlet channel to Cavanaugh Lake in Section 9, T 155 N, R 64 W. A 25-foot wide channel with 3:1 side slopes will be constructed along the dike to convey flow into Cavanaugh Lake. The control structure will consist of two 5-foot wide stop log structures at the downstream end of the channel. The invert of the control structure will be set at elevation 1453.7 msl. Alternative Three is estimated to cost $75,000. This cost applies for both the 1453.7 msl and 1454.7 msl lake levels.

IX. RECOMMENDATIONS

Three alternatives were considered as part of this investigation. Alternative One is the cheapest alternative, but it will affect a significant amount of private land. The private land that will be affected by Alternative One will require easements or will need to be purchased. Alternative Two is slightly more costly than Alternative One and will affect additional private land to construct the diversion channel. Alternative Three is the most costly alternative, but will affect the least amount of private land. If flood easements can be obtained, it is recommended that Alternative One be pursued, if not, Alternative Three is recommended. The decision to proceed with this project is the responsibility of the Ramsey County Water Resource Board.

APPENDIX A - Copy of Agreement

SWC Project #1298
August 28, 1992

A G R E E M E N T

Investigation of the Diversion
of Water into Cavanaugh Lake

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter Commission, through its Secretary, David A. Sprynczynatyk; the North Dakota State Game and Fish Department, hereinafter Department, through its Director, Lloyd Jones; and the Ramsey County Water Resource District, hereinafter District, through its Chair, Robert Garske.

II. PROJECT, PURPOSE, AND LOCATION

The District and Department have requested the Commission to investigate the feasibility of diverting water from the Morrison Lake outlet channel into Cavanaugh Lake. The purpose of the project is to provide Cavanaugh Lake with additional water to improve the fishery located in the lake. The Project is located in Section 9, Township 155 North, Range 64 West.

III. PRELIMINARY INVESTIGATION

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

1. A field survey of the project area, including a topographic survey of the proposed diversion site, a topographic survey of the lake shoreline, and soundings of the lake bottom to determine area-capacity information;

2. A preliminary design of a structure to divert water into Cavanaugh Lake;

3. A preliminary cost estimate for the proposed diversion structure; and

4. A written report documenting the findings of the investigation.

IV. COSTS

The District and Department shall each deposit $1,500 with the Commission to help defray the field costs associated with this investigation.

V. RIGHTS-OF-ENTRY

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 agrees to indemnify and hold harmless the State of North Dakota, the Commission, the Department, and any employees or agents of those entities, from all claims for damages to property, rights or persons, as a result of any act or omission by the District, its agents, contractors, or employees. In the event a suit is initiated or judgment entered against the State of North Dakota, the Commission, the Department, or any of their employees or agents, the District shall indemnify them for all costs and expenses, including legal fees, and any judgment arrived at or satisfied or settlement entered, to the extent that such cost and expenses are caused by or resulting from any act or omission by the District, its agents, contractors or employees.

VII. MERGER CLAUSE

This agreement constitutes the entire agreement between the parties. No waiver, consent, modification nor change of terms of

this agreement shall bind either party unless in writing, signed by the parties, and attached hereto. Such waiver, consent, modification or change, if made, shall be effective only in the specific instance and for the specific purpose given. There are no understandings, agreements, or representations, oral or written, not specified herein regarding this agreement.

NORTH DAKOTA STATE WATER COMMISSION
By:
DAVID A. SPRYNCZYNATYK
Secretary

NORTH DAKOTA GAME AND FISH DEPARTMENT
By:
LLOYD JONES
Director

WITNESS:

WITNESS:

DATE: 9/29/92

DATE: 9/21/92

RAMSEY COUNTY WATER RESOURCE DISTRICT
By:
ROBERT GARSKE
Chair

WITNESS:

DATE: 9-2-92

APPENDIX B - Symbols and Abbreviations

Symbols and Abbreviations

CMP - Corrugated Metal Pipe

HEC - The Hydrologic Engineering Center

msl - mean sea level

cfs - cubic feet per second

T 155 N - Township 155 North

R 64 W - Range 64 West

SWC - State Water Commission