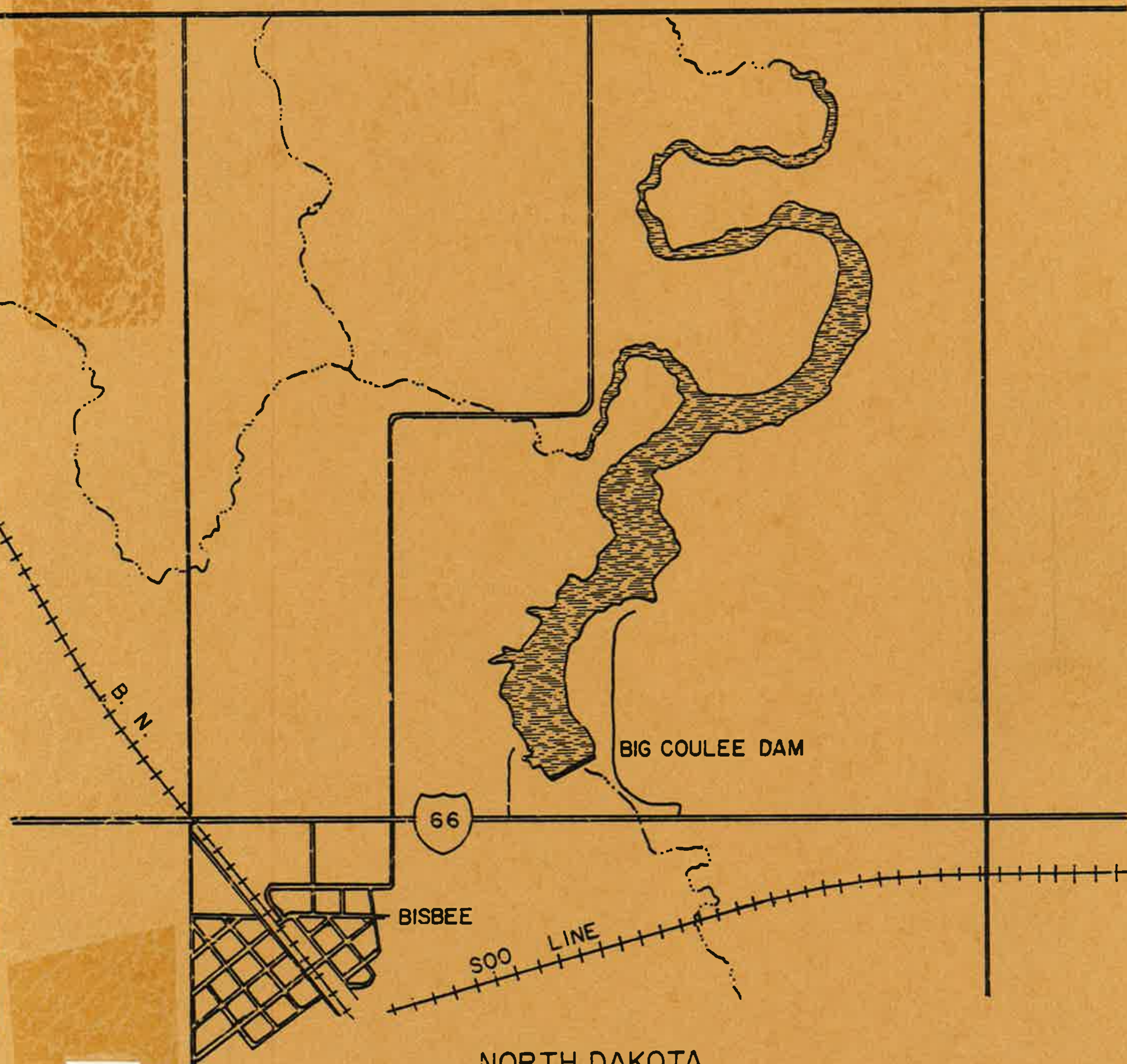
PRELIMINARY ENGINEERING REPORT

RAISING OF BIG COULEE DAM

PROJECT NO. 1418



NORTH DAKOTA

STATE WATER COMMISSION

NOV. 1981

PRELIMINARY ENGINEERING REPORT

RAISING OF BIG COULEE DAM
SWC PROJECT #1418

NOVEMBER, 1981

North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505

PREPARED BY:

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RANDY GJESTVANG
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Prepared for the
Towner County Water Resource Board

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North Dakota State Water Commission
900 EAST BOULEVARD • BISMARCK, ND 58505-0187 • (701)224-2750 • FAX (701)224-3696

WATER DEVELOPMENT DIVISION
(701) 224-2752

February 14, 1991

Honorable Margo Helgerson
Mayor of Westhope
PO Box 412
Westhope, ND 58793

RE: SWC Project #1267

Dear Mayor Helgerson:

In considering your request for cost-sharing for the Westhope Dam project, I have reviewed the Preliminary Engineering Report prepared by Toman Engineering. Before the project can be considered for cost-sharing, there are several concerns which must be addressed.

As stated in the report, the dam, as proposed, would be classified as a Class III dam under the North Dakota Dam Design Guidelines. The freeboard requirement for a Class III dam in North Dakota is a 30 percent PMP flood. This means that the dam must be able to pass a flood equal to 30 percent of the Probable Maximum Precipitation without overtopping. This would be approximately a 6 1/2-inch rainfall. The engineering report mentioned nothing about an emergency spillway or the performance of the dam during floods. I should also point out that there are velocity requirements for emergency spillways listed in the North Dakota Dam Design Guidelines as well. An adequate emergency spillway could vastly increase the cost of the proposed dam.

The main concern is that the preliminary engineering report be sufficiently detailed to provide a good cost estimate. This cost estimate is needed to determine the level of cost-share required from each entity. Once we are satisfied that all requirements have been addressed, your specific cost-share request will be submitted to the State Water Commission for consideration.

Sincerely,

James Lennington

James Lennington, P.E.
Water Resources Engineer

JL:dm
cc: Toman Engineering

MESSAGE DISPLAY

To Dale
To Dave
To Cary
BC JIM LENNINGTON

From: JIM LENNINGTON
Postmark: Apr 30,91 2:11 PM Delivered: Apr 30,91 2:11 PM

Subject: Westhope Dam

Message:
Westhope is considering constructing a multi-purpose reservoir to the south of town. They have been discussing cost sharing for this project with us. There is a big problem with this proposal in that there is a strong probability that a water use permit application would be denied. The location they are proposing for the dam is on a tributary to the Souris. I discussed the possibility of transferring all or some of the appropriation the town currently has out of the refuge pool to the dam site with Gordon and Bob White. They informed me that this would not be possible. I have a meeting scheduled tomorrow in Westhope and I'm wondering what I should tell them about their proposal. Any suggestions would be welcome.

------========X==============

RALEIGH DAM - SWC PROJECT

ABSTRACT OF BIDS OPENED 1:30 P[illegible]

5% of 290,633.00 = $14,531.65 May 6, 1988

ITEM / BIDDER * Major Item		Dakota Dirt Moving Box 131 McLaughlin, SD 57642	
1. Mobilization	LS	$7,200.00	$ 7,200.00
2. Control and Removal of Water	LS	2,000.00	2,000.00
3. Stripping Topsoil	60,000 SY	.24	14,400.00
4. Trench Excavation *	10,900 CY	1.40	15,260.00
5. Borrow For Earthfill *	94,000 CY	.90	84,600.00
6. Water For Compaction	2,500 M GAL	5.50	13,750.00
7. Foundation Drain Installation	LS	6,840.00	6,840.00
8. Concrete *	297 CY	266.00	79,002.00
9. Reinforcing Steel *	59,650 LB	.49	29,228.50
10. Rock Riprap Filter Bedding	700 CY	6.00	4,200.00
11. Rock Riprap *	1,400 CY	12.00	16,800.00
12. Miscellaneous Metals	LS	3,900.00	3,900.00
13. Low Level Drawdown Installation	LS	9,990.00	9,990.00
14. Gate Installation	LS	500.00	500.00
15. Seeding	7.5 AC.	395.00	2,962.50
TOTAL	——→		$290,633.00

DEAD COLT CREEK DAM, SWC PROJECT #1671
ABSTRACT OF BIDS OPENED 2:00 P.M., APRIL 22, 1983

*Corrected

ITEM / BIDDER		Moorhead Construction Co. P. O. Box 878 Moorhead, MN 56560		Kern & Tabery, Inc. Rural Route 2, Box 54 Wadena, MN 56482		Central Excavating Co. P. O. Box 1074 Bismarck, ND 58502-1074	
1. Clearing & Grubbing	3 Acres	2,144.00	6,432.00	500.00	1,500.00	730.00	2,190.00
2. Strip & Spread Topsoil	250,000 SY	.21	52,500.00	.25	* 62,500.00	.20	50,000.00
3. Dewatering	LS	48,000.00	48,000.00	10,000.00	10,000.00	30,000.00	30,000.00
4. Excavation	71,265 CY	1.17	83,380.05	1.00	71,265.00	2.00	*142,530.00
5. Embankment	430,600 CY	.97	417,682.00	.75	*322,950.00	.95	409,070.00
6. Imp. Clay Blanket	56,800 CY	.95	53,960.00	1.25	71,000.00	1.16	65,888.00
7. Water for Compaction	11,500 M Gal	.58	6,670.00	4.00	46,000.00	.10	1,150.00
8. Concrete	375 CY	187.66	70,372.50	187.66	70,372.50	255.00	95,625.00
9. Reinforcing Steel	64,445 LB	.39	25,133.55	.39	25,133.55	.44	28,355.80
10. Install 48" Pipe	336 LF	15.89	5,339.04	15.89	5,339.04	37.35	12,549.60
11. Ductile Iron Pipe	100 LF	57.99	5,799.00	57.99	5,799.00	53.00	5,300.00
12. PVC Pipe	450 LF	11.13	5,008.50	11.13	5,008.50	10.40	4,680.00
13. ACP - 6" Perforated	390 LF	9.57	3,732.30	9.57	3,732.30	12.90	5,031.00
14. ACP - 6" Non-Perforated	525 LF	7.46	3,916.50	7.46	3,916.50	9.50	4,987.50
15. Drain Fill Material	760 CY	15.17	11,529.20	9.00	6,840.00	17.25	13,110.00
16. Rock Riprap	5,675 CY	14.86	84,330.50	30.00	170,250.00	20.00	113,500.00
17. Rock Riprap Filter Bed	1,900 CY	4.02	7,638.00	10.00	19,000.00	4.25	8,075.00
18. Gate Installation	LS	1,873.00	1,873.00	1,873.00	1,873.00	300.00	300.00
19. Miscellaneous Metals	LS	11,208.00	11,208.00	11,208.00	11,208.00	10,200.00	10,200.00
20. Seeding	50 Acres	214.40	10,720.00	150.00	7,500.00	236.00	11,800.00
TOTAL		* $915,224.14		* $921,187.39		$1,011,311.90	

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FIGURES

PLATES

APPENDIX

I. INTRODUCTION

Big Coulee Dam is a multi-purpose dam located in Towner County. It provides the municipal water supply for the City of Bisbee, North Dakota and also is a recreational area for the community. Since its initial filling in 1969, the damsite has required a large amount of maintenance. The service spillway has a relatively small capacity, resulting in frequent use of the emergency spillway. This has caused some erosion to the emergency spillway. In addition to these problems, the quality of the water in the reservoir has been deteriorating.

On April 30, 1980, the State Water Commission entered into an agreement with the Towner County Water Resource District. The purpose of this agreement was to study the feasibility of raising the control elevation of Big Coulee Dam in order to improve conditions for boating and fishing. This involved studying the costs to build a new principal spillway, plug the old drawdown pipe, and possible modifications to the emergency spillway. To improve the water quality, the Board wanted the modifications to include a low-level (hypolimnetic) water quality control structure. A copy of the agreement is included in Appendix A.

The hydrology of the watershed was re-evaluated in order to determine the inflow to the reservoir. The inflow was flood routed through several sizes of service spillways set at different control elevations. This was done to find the most feasible structure capable of adequately handling the inflow.

The as-built topographic map is included in this report as Plate 1. This reflects the various changes which happened over the life of the structure. The history of the problems associated with the dam was reviewed. A description of the geology and hydrology of the watershed was also presented. This report summarizes the results obtained from the flood routing of the reservoir.

Preliminary cost estimates were presented for the alternatives proposed. These alternatives handled the design flows with a minimum of discharge over the emergency spillway. Final plans and a more complete cost estimate would be prepared after the project would be authorized and construction is imminent.

II. DESCRIPTION OF SITE

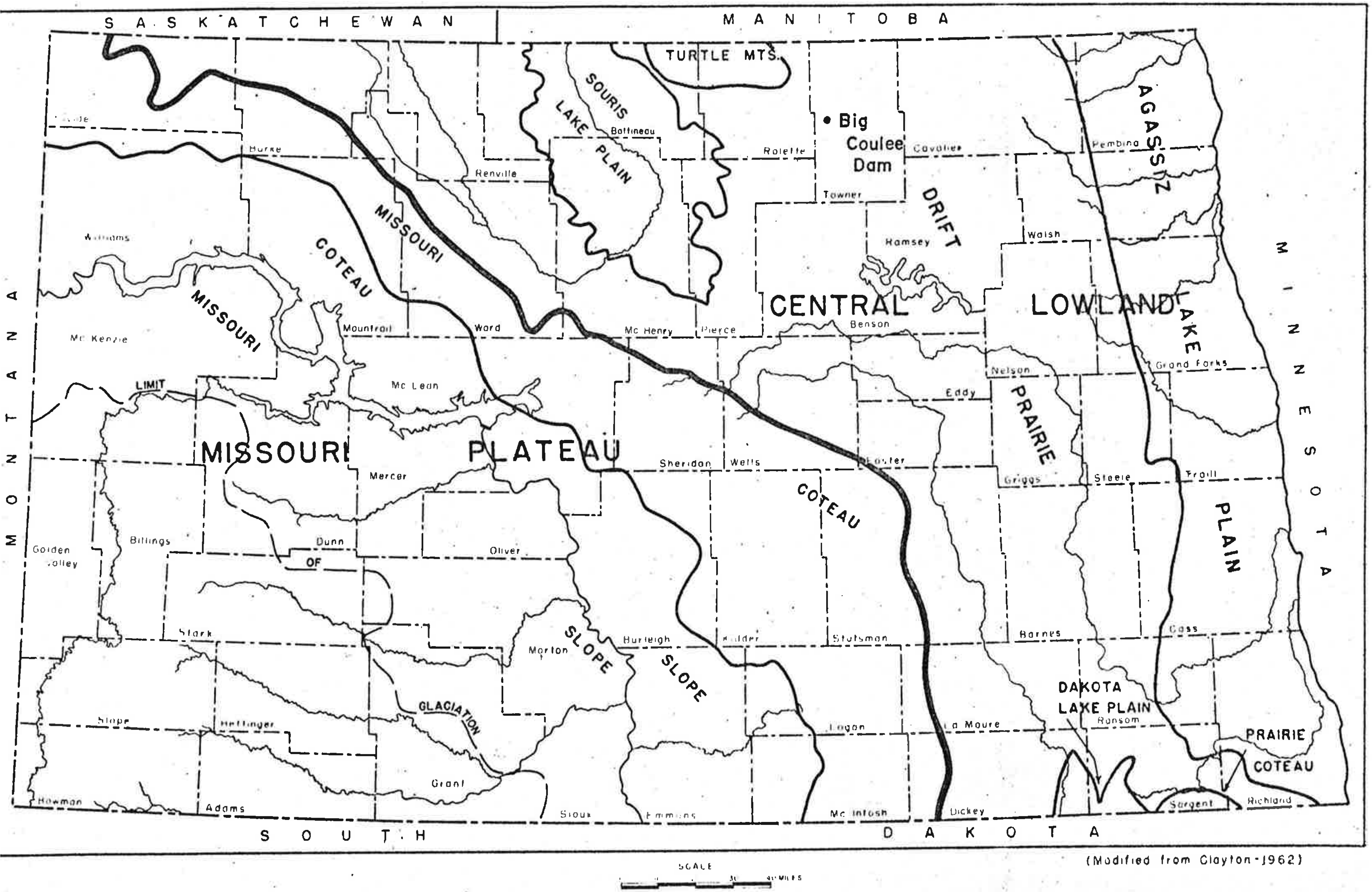
Big Coulee Dam is located in Section 36, Township 160 North, Range 68 West in Towner County. The City of Bisbee, North Dakota, is approximately 3/4 mile southwest from the dam. Big Coulee Dam is on the Big Coulee, which is a tributary of the Mauvais Coulee and in the Devils Lake Basin. Figure 1 is a map showing the general location of the dam and the surfical geology of the area.

Big Coulee Dam is a 37-foot high earth-fill dam. At the present control elevation of 1572 MSL, it has a reservoir capacity of 1,630 acre-feet while inundating an area of 195 acres. The reservoir has a maximum depth of 24 feet and an average depth of 8.4 feet. A drainage area of 108 square miles supplies inflow to the reservoir. An area capacity curve of the reservoir is shown in Figure 2.

The slope of the main channel above the dam is approximately 7 feet per mile. Downstream the slope flattens out to 4 feet per mile. Within two or three miles downstream the topography of the land also flattens out. This causes Big Coulee to become wide and sluggish as it flows in a south-southeasterly direction.

The very upper reaches of the drainage area extend to the eastern slopes of the Turtle Mountains near the town of St. John. The Turtle Mountains, in this area, have so many sloughs and kettles that very little of the area actually contributes to the runoff collected at Big Coulee Dam. Plate 2 depicts Big Coulee Dam and its total watershed.

The surfical geology of the Basin Area is primarily of glacial origin. This area is located in the Central Lowland Province (Fenneman, 1938, p.559) and the Drift Prairie as designated by Simpson (1929, p.4). Surfical deposits in the dam site area consist entirely of glacial drift. The drift deposits are composed predominantly of fill and are similar in visual appearance, but differ



(Modified from Clayton-1962)

Figure 1 – LOCATION OF BIG COULEE DAM AND PHYSIOGRAPHIC PROVINCES OF THE AREA

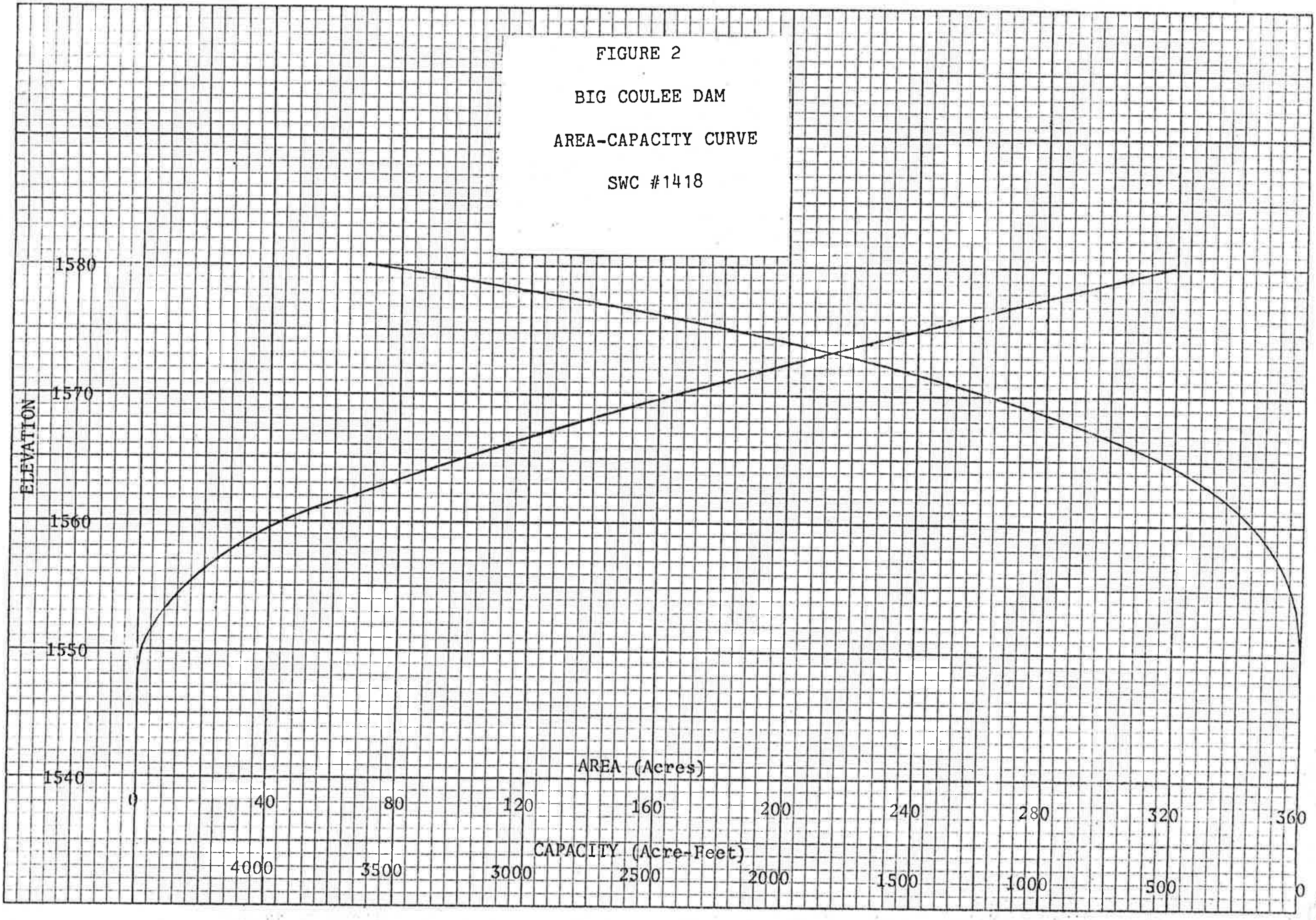
46 0782

FIGURE 2

BIG COULEE DAM

AREA-CAPACITY CURVE

SWC #1418



somewhat in texture and composition. Pierre Shale of the Cretaceous Age is the predominant type of bedrock in the area. The present creek occupying Big Coulee is a recent stream with a drainage area of 108 square miles above the impoundment.

The embankment is a zoned rolled earth-fill dam with a clay core. It originally was 931 feet long with a top width of 12 feet and a volume of 82,191 c.y. The upstream slope was 3H:1V while the downstream slope was 2H:1V. A 10-foot wide berm was added about 12 feet below the top along the right half of the embankment on the downstream side. This berm has a 4H:1V slope. The top of the embankment is at an elevation of 1585.0 MSL. A 10-foot wide clay core trench runs the entire length of the embankment and extends below the permeable sands into a clay loam soil. Riprap covers the upstream slope from elevation 1566.0 MSL to 1579.0 MSL. Plate 1 shows the topography of the entire damsite area.

The emergency spillway is at an elevation of 1577.0 MSL. It is an uncontrolled grassed spillway with 3H:1V side slopes. Although the majority of the emergency spillway is 200 feet wide, the controlling point is 181 feet wide. The steepest portion of the emergency spillway has a slope of 3.5 percent.

A concrete drop inlet, a 54-inch corrugated steel pipe, and a concrete outlet structure are the components of the service spillway. The inlet structure controls the elevation of the reservoir at 1572.0 MSL. It consists of a reinforced concrete drop structure with inside dimensions of 8 feet by 8 feet. The floor of the structure is 8 feet below the spillway crest. The conduit consists of 109 feet of 54-inch,10-gauge Helically Corrugated Galvanized Steel Pipe. An open concrete box, 10 feet long and 6 feet wide, serves as the outlet structure. No energy dissipators are present in this structure. There is a 4-foot cutoff wall on the outlet end to prevent the structure from being undermined. A low level outlet, consisting of 156 feet of 10-inch, 10-gauge welded steel pipe, discharges into the outlet structure. A gate valve, located 8 feet from the outlet, controls the flow through this pipe. Double rail piping and fittings serve as the trash rack.

III. STATEMENT OF PROBLEM

BACKGROUND

Initial interest in the construction of Big Coulee Dam began with a request for survey on October 8, 1965. Borings were taken during mid-July of 1966 and the bid opening was on July 31, 1968. All work, except for seeding, was completed on December 4, 1968. The project was dedicated on June 23, 1969.

Construction of Big Coulee Dam was sponsored by the City of Bisbee, the Towner County Park Board, the State Game and Fish Department, the State Outdoor Recreation Agency, the Bureau of Outdoor Recreation, and the State Water Commission. Actual construction of the dam cost $107,693, recreation facilities cost $17,214, investigation and design costs were $6,442, and the cost of land was $27,500. Included in the total cost was $32,251 allocated for contract and related costs incurred during the 1969 flood damage repair.

The initial filling of the dam was on April 11, 1969. Water was flowing over the emergency spillway five hours after the service spillway had been overtopped. The roar of the water was noticeable to the residents of Bisbee. The flow peaked with a seven-foot head on the service spillway weir and two feet of flow over the emergency spillway. The maximum flow over the emergency spillway, which was 130 feet wide with 3H:1V side slopes, was estimated to be between two and three thousand cubic feet per second. This large discharge caused serious erosion to the unseeded earthen emergency spillway. Towner County equipment made emergency repairs to the spillway. The spillway was closed by dozing large piles of frozen material across the spillway. The equipment was in operation from April 15 through April 17. After closure, the service spillway was able to handle the receding flow.

Following this emergency action, the prime contract was extended to include repairing the badly scoured emergency spillway. The bottom width of the emergency spillway was widened from 130 feet to 200 feet. (Although the main portion is 200 feet wide, the controlling width was measured to be 181 feet.) The slope of the emergency spillway was reduced in order to lower the velocity of any water flowing over it. Total costs for repair and revision of the emergency spillway amounted to $32,251.

Grouting the entire length of the service spillway pipe in order to fill all voids which had been created by leakage of the joints was recommended after an inspection on June 19, 1969. It was also recommended that the joints be sealed with either internal expanding pressure bands or welding the joints. Internal expanding bands were installed on the joints of the helical corrugated steel pipe in July of 1969.

An inspection on April 17, 1970, revealed that the black dirt blanket had slid down the slope of the clay sub-base. The embankment location is ideal for collecting huge snow drifts on the downstream slope. The grass cover had not obtained sufficient root depth to stop the black dirt from sliding when saturated by the melting drifts.

It was discovered on May 22, 1970, that there were two cracks in the headwall of the service spillway. These were repaired in 1971 by driving steel piling along each edge of the headwall and bracing across the top to support and strengthen the headwall. Water had again overtopped the emergency spillway during the spring of 1970.

During the spring of 1971, a flow of 6 inches, or 200 cfs, was observed over the emergency spillway. An inspection on August 18, 1971 revealed that the 54-inch diameter service spillway pipe had deformed to an average size of 50 inches by 57 inches.

An inspection on May 9, 1974, revealed that the topsoil had slid along a 150-foot section of the downstream slope. Water at a depth of 1.5 feet had flowed over the emergency spillway during that spring causing some damage. The eroded areas were repaired during that year.

It was revealed that the topsoil on the downstream slope had again slid when an inspection was made on May 6, 1976. The ND Army National Guard commenced repairs on the embankment on August 28, 1976. They started repairing the emergency spillway and stabilizing the downstream embankment by adding material to change the slope to 4H:1V. This fill extended from the right side of the service spillway outlet to the right abutment. Work continued through late fall with weekend drills and was continued the following year during June and July. The compacted fill was brought up to within 12 feet of the top of the embankment and left as a berm. The topsoil was then replaced over the new fill material.

An inspection on June 14, 1977, revealed that almost all of the asphalt coating had peeled off the service spillway pipe. Corrosion was taking place along the bottom 1/3 of the pipe. A Bitumastic coat was applied during 1977.

Water at a depth of 2.5 feet had flowed over the emergency spillway during the spring of 1979. This large discharge caused a great deal of erosion to the emergency spillway. Over half of the topsoil was washed away. Several pits were formed within the emergency spillway. Repairs were made at a cost of $10,180.

There was a discrepancy in what was thought to be the elevations of the different components of the dam. The correct elevations and dimensions of the damsite were obtained from a survey conducted in August of 1980 for this report. An inspection of the spillway pipe on December 29, 1980 revealed that the first joint required additional sealer. A concentration of rust was present on Joint 3.

EXISTING AND ANTICIPATED PROBLEMS

The maintenance costs for Big Coulee Dam have been high. In the dam's 13 year existence, the emergency spillway has been used at least five times. Water has flowed over the emergency spillway in the spring of 1969, 1970, 1971, 1974, and 1979. The emergency spillway suffered a large amount of scour damage during the 1969, 1974, and 1979 floods. Even with a good grass cover, the high velocity of flow caused by a large snowmelt is capable of causing considerable erosion.

According to its history, the service spillway for Big Coulee Dam cannot handle anything greater than a 3-year snowmelt without the emergency spillway being used. At the present elevation of the service spillway, the emergency spillway is used too frequently. Simply raising the level of the existing service spillway would cause water to flow over the emergency spillway more frequently, endangering the dam. If the control elevation of the reservoir were to be raised, a complete new service spillway would have to be constructed. It should be designed so that the emergency spillway is not used during the 25-year snowmelt. For larger runoffs, the velocity of flow over the emergency spillway should be kept small in order to prevent scouring.

The downstream embankment was originally constructed with a 2H:1V slope. The right half of this embankment suffered an annual sloughing problem until corrective measures were taken in 1976 and 1977. The embankment has apparently been stabilized by these efforts. Raising the control elevation of the reservoir could cause the portion of the embankment that is still at a 2H:1V slope to become unstable. Although minor seepage exists currently, the increased water pressure may cause greater seepage through the dam.

The service spillway consists of an 8-foot by 8-foot weir with a 54-inch CMP leading from it. The pipe, set at a steep slope of 13.67 percent, cannot maintain full pipe flow for any length of time. When flowing under partially full conditions, high velocities are obtained due to the steepness of the pipe. This high velocity causes the water to entrain air, thus swelling in volume and filling the pipe. The increased wetted perimeter creates greater frictional resistance and reduces the flow rate. This causes the air to become separated from the water. The flow then returns to a partially full condition. This process, called slugging, is repeated continuously. It is the cause of the loud roar occasionally heard by Bisbee residents. The slugging effect causes a large pressure differential within the pipe. Strong vibrations are produced, which can jar the pipe from its position.

There has been some deterioration of the metal spillway pipe. Rusting has been evident on the bottom 1/3 of the pipe and at the joints. The Bitumastic coating appears to be retarding this process at the present time. There has been some leakage at the joints which could cause the soil supporting the pipe to be washed away. Due to the weight of the soil above it, the pipe has deformed to an average size of 50 inches by 57 inches. This pipe will probably have to be replaced in the future.

The low level drawdown pipe also presents a problem. The gate valve is located near the outlet end of the dam. This allows the pipe, which extends below the dam, to contain water under pressure. There is the potential for this pipe to rust out and cause a large amount of seepage. This could easily come to the surface and cause extensive erosion or failure of the structure.

The City of Bisbee has received poor quality water from the reservoir. This is due to eutrophication and the stratification of the water in the reservoir. Stagnant water concentrates on the bottom while the fresher water stays on top and is discharged downstream through the spillway. A low level (hypolimnetic) water quality control structure could be constructed to help alleviate this problem. This structure would discharge the stagnant water from the bottom, allowing the reservoir to be freshened by inflows. The water quality of the reservoir would improve, due to an increase in the dissolved oxygen and a decrease in nutrients which cause algae.

At the present elevation of the reservoir, pleasure boating is only possible in the area of the original coulee. The average depth at present is 8.4 feet. This would be increased to 8.9 feet if the control elevation were raised 2 feet. An average depth of 9.7 feet would be obtained if the reservoir were raised 4 feet. There would still be a large amount of shallow areas. However, the area accessible to boating would increase.

Under the reservoir's present conditions, many of the fish do not survive through the winter. The poor quality of the water may be as big a contributor to this problem as the shallow depth is.

IV. HYDROLOGY

DISCUSSION OF THE STUDY

The hydrology of the entire Big Coulee watershed was analyzed using the TR-20 computer program which was developed by the U.S. Conservation Service. It was used to determine the peak elevations, peak inflow, and peak discharges of various frequency storms. The program formulates a mathematical, hydrologic model of the watershed. This is based on the following data: the amount of rainfall, rainfall distribution, soil type, land use, and the hydraulic characteristics of the stream channels and drainage area.

The Big Coulee watershed extends from the dam northwestward to include the eastern slopes of the Turtle Mountains near the town of Saint John. It includes 108 square miles of drainage area. In order to obtain more accurate data to input into the TR-20 program, the watershed was divided into 22 sub-basins. Each of these sub-basins has its own distinct drainage boundaries except for four divisions within the Turtle Mountains. These regions were separated from the remaining sub-basins because of the differences in topography. They are comprised of several sloughs and kettles which are capable of storing most of the runoff. For the input on the TR-20 program, a reduction in the effective runoff was made in order to account for this storage capacity.

Cross sections were taken at several points along the main channel of Big Coulee. The surface roughness and type of vegetative growth was noted for each cross-section in order to obtain a roughness coefficient (n). The slope, n-value, and the dimensions of the channel for each cross-section were input into an open channel program utilizing Manning's formula. The output from this program provided the area and discharge at 1/2 foot intervals for each cross-section. This was put into the TR-20 program.

No special allowances were made for points where the creek crossed roads utilizing culverts for drainage. These crossings do not impede the flow to any measurable degree because the water can easily overtop the road. The only crossing that could back up the flow an appreciable amount is the two 7-foot diameter culverts under the railroad tracks in Section 1, Township 161 North, Range 69 West. The rate of flow through these culverts was taken into account on the TR-20 program.

A general land use description of the watershed, with the exception of the Turtle Mountain Sub-basins, is as follows:

Pasture	41%
Small Grain	39%
Fallow	18%
Farmsteads and Roads	2%

The divisions within the Turtle Mountains are predominantly woods and pasture land. About 40% of the area is sloughs and kettles.

The rate of flow over the emergency spillway was determined by inputting an n-valve and the dimensions into an emergency spillway rating curve program. The discharge through the service spillway was determined by using formulas for weir flow, orifice flow, and full pipe flow.

The TR-20 program produced output of the inflow into the reservoir. This inflow was flood routed through several shapes of service spillways set at different control elevations. This was done to find the most feasible structure that will meet the recommended guidelines. These results showed the peak elevations and discharges for each situation.

STUDY RESULTS

The TR-20 computer program showed that all floods due to spring snowmelts were greater than those due to rainfall. These results are supported by the fact that all the larger floods at Big Coulee Dam have occurred during the snowmelt period. The computer results also confirm that the two 7-foot diameter culverts in Section 1, Township 161 North, Range 69 West cause water to back up behind them. The discharge rate from the drainage area upstream from this point is controlled by the flowrate through these culverts. This control point causes the peak inflow at Big Coulee Dam to be reduced.

Table 1 shows the peak inflow to the reservoir for various frequency snowmelts as obtained from the TR-20 model. The peak reservoir elevation and peak discharges through the service spillway and emergency spillway are also shown for the present conditions at Big Coulee Dam. The velocity of flow over the emergency spillway is also shown in order to see if scouring would occur. The results obtained from the computer program appear to closely coincide with the actual conditions experienced at Big Coulee Dam.

Any revisions made to the service spillway at Big Coulee Dam should meet certain design requirements in order to ensure the safety of the dam. No flow should be allowed to pass over the emergency spillway during a 25-year snowmelt. For events larger than the 25-year snowmelt, the velocity of flow over the emergency spillway should be limited so that scouring does not occur. The velocity at which scouring occurs is dependent on the type of soil and grass cover. For the conditions at Big Coulee Dam, scouring will occur when the velocity is in the range of 4 feet per second to 6 feet per second. The velocity of flow should not be allowed to exceed this range. The present weir and conduit are not capable of meeting these requirements. An entirely new service spillway would have to be constructed if the reservoir elevation were to be raised.

TABLE 1

ROUTING RESULTS FOR EXISTING CONDITIONS

Control Elevation	Frequency of Snowmelt	Inflow (cfs)	Elevation of Reservoir	Discharge of Service Spillway (cfs)	Discharge of Emergency Spillway (cfs)	Velocity in Emergency Spillway(fps)
	10 year snowmelt	1,622	1578.8	561	960	6.4
1572 MSL	25 year snowmelt	1,822	1579.0	565	1,170	7.0
	50 year snowmelt	2,436	1579.5	654	1,700	8.1
	100 year snowmelt	3,143	1580.1	740	2,480	9.4

All values shown are the peak values for that frequency snowmelt.

Emergency spillway at an elevation of 1577.0 MSL.

A service spillway, at each proposed control elevation, was found that would meet the suggested requirements. The results obtained by routing the inflow of the reservoir through each service spillway showed whether it could adequately handle the flow. These results are shown in Table 2. A cost estimate was completed for the construction of a service spillway at each control elevation. It was found that there would be a relatively small difference in the cost of constructing a service spillway which would raise the control elevation of the reservoir by 1 foot or 2 feet. Therefore, the 1 foot rise was disregarded.

Additional land would have to be acquired if the control elevation were raised more than 2 feet. Plate 3 shows the boundaries of the land that have been acquired around the reservoir. It also shows the land inundated under the present conditions and with a two foot and four foot rise in the reservoir elevation. The emergency spillway would also have to be raised in order to control the amount of water flowing over it. This would increase the chance of water overtopping its banks in the NW 1/4 of Section 31, Township 160 North, Range 67 West. This water could spread over a large area. A small dike could be built at the low area to prevent this from happening. The same situation exists whether the reservoir were raised 3 feet or 4 feet. Therefore, raising the reservoir 3 feet will not be listed as an alternative.

Figure 3 is a hydrograph of the inflow into Big Coulee Dam for the 25-year snowmelt. The discharges under current conditions and with a 2 foot and 4 foot rise in the reservoir elevation are also shown in the hydrograph. The outflow rates were nearly identical whether the reservoir was raised 2 feet or 4 feet. One line represents both discharges on the hydrograph.

A dam is considered unsafe if it cannot pass one-half of the Probable Maximum Flood (PMF) without overtopping occurring. About 75 percent of the PMF passes before overtopping occurs under the current conditions of the dam. A

TABLE 2

ROUTING RESULTS FOR PROPOSED MODIFICATIONS

Control Elevation	Frequency of Snowmelt	Inflow (cfs)	Elevation of Reservoir	Discharge of Service Spillway (cfs)	Discharge of Emergency Spillway (cfs)	Velocity in Emergency Spillway(fps)
	10 year snowmelt	1,622	1576.9	1,600	0	0
1574 MSL[1]	25 year snowmelt	1,822	1577.1	1,770	30	1.7
	50 year snowmelt	2,436	1577.6	2,230	160	3.2
	100 year snowmelt	3,143	1578.2	2,540	475	4.8
	10 year snowmelt	1,622	1578.9	1,580	0	0
1576 MSL[2]	25 year snowmelt	1,822	1579.1	1,735	30	1.7
	50 year snowmelt	2,436	1579.6	2,200	160	3.2
	100 year snowmelt	3,143	1580.0	2,667	353	4.4

All values shown are the peak values for that frequency snowmelt.

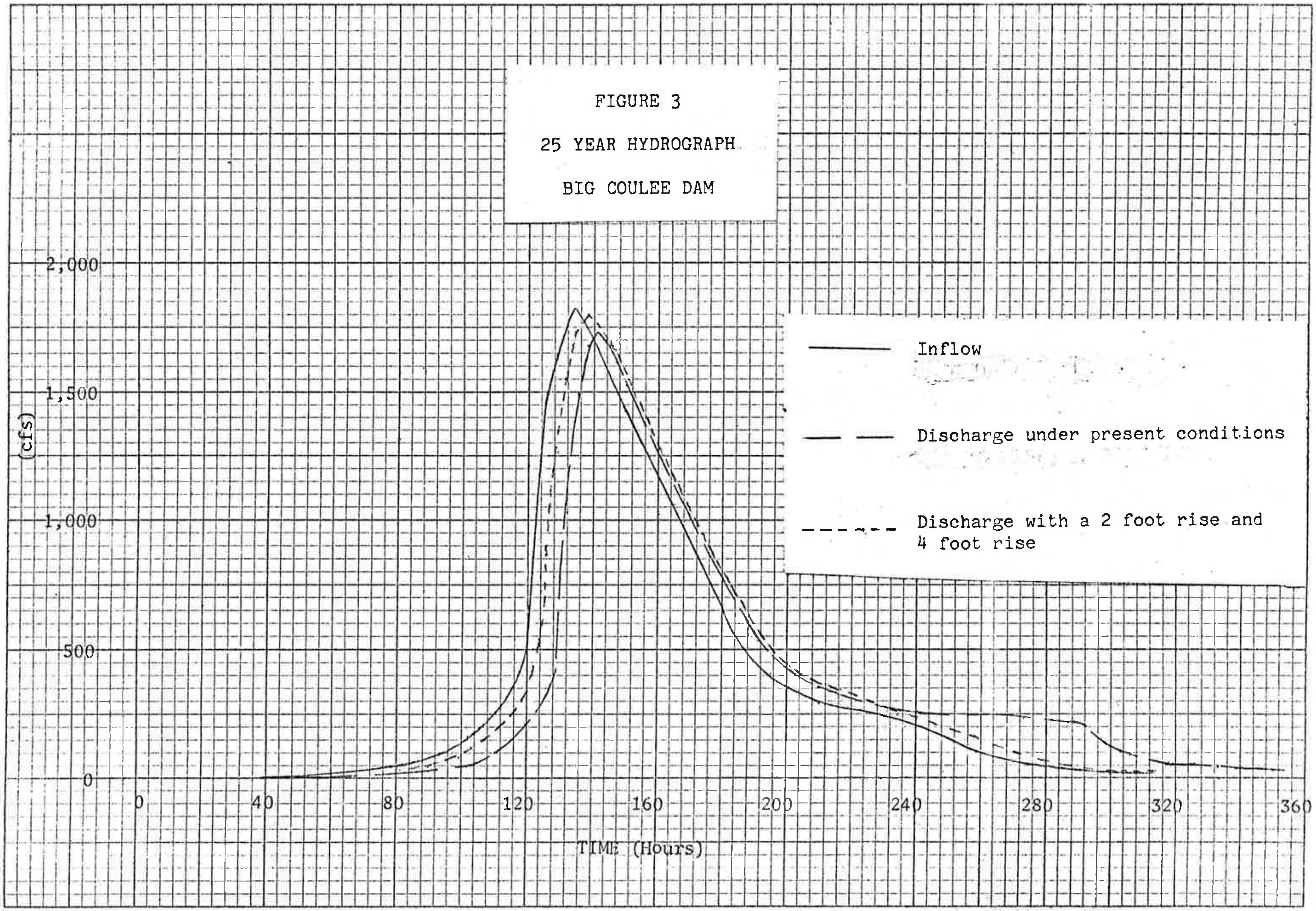
[1]Emergency spillway at an elevation of 1577.0 MSL.

[2]Emergency spillway at an elevation of 1579.0 MSL.

FIGURE 3

25 YEAR HYDROGRAPH

BIG COULEE DAM



maximum of 0.85 feet overtops the dam upon occurrence of the PMF. Water would flow over the top of the dam for 11.2 hours. The PMF was routed through the service spillways proposed for construction if the reservoir was raised 2 feet or 4 feet above the existing control elevations. Water did not flow over the top of the dam for either of these situations.

V. ALTERNATIVES

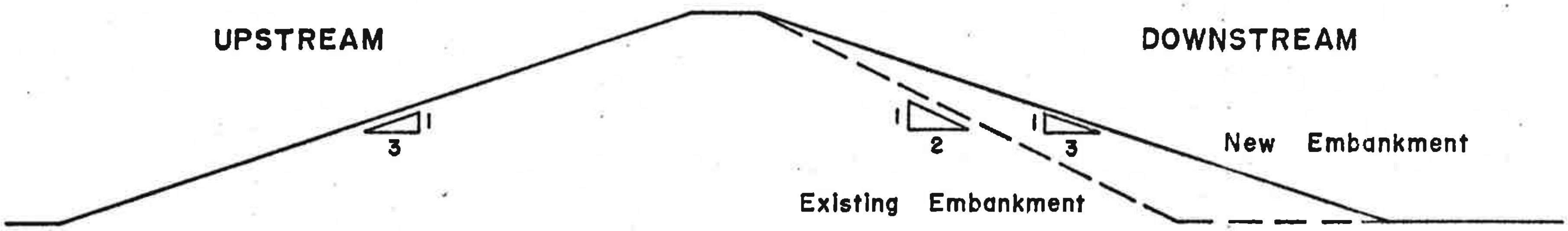
All the possible combinations of spillways have been narrowed down to the three most feasible solutions. These alternatives are dependent on the elevation of the reservoir. The Towner County Water Resource District has the option of doing nothing at the present time, install a service spillway which would raise the elevation of the reservoir by 2 feet, or to construct a spillway with a control elevation 4 feet higher than the current elevation.

Several changes should be made if a service spillway is constructed. The portion of the downstream embankment which is currently at a 2H:1V slope should be changed to a 3H:1V slope in order to ensure the stability of the embankment. Plate 4 shows the area of the embankment where the slopes are to be changed. Figure 4 shows the changes that should be made for the different conditions of the downstream embankment. The 54-inch CMP and the low level drain should be removed. A low level (hypolimnetic) water quality control structure could be constructed. A Saint Anthony Falls (SAF) stilling basin, complete with energy dissipators, should be constructed for the outlet structure.

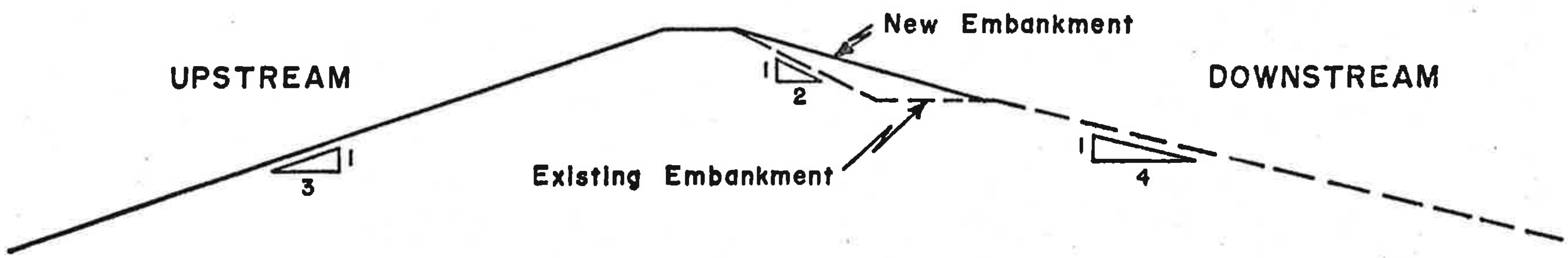
ALTERNATIVE 1

The first choice available to the Board is to do nothing at the present time. Although there are no initial costs, the costs to maintain the dam in good condition could become very high. The service spillway pipe has been deteriorating. It will most likely have to be replaced in the future. The emergency spillway is vulnerable to scouring damage due to the high velocity of water frequently flowing over it.

Raising the control elevation of the reservoir by installing flashboards on the service spillway, would jeopardize the safety of the dam. This procedure would increase the frequency that the emergency spillway would be used. The velocity of flow, and chance of scouring occurring on it, would also be increased.



TYPICAL CROSS-SECTION BETWEEN STA. 0+00 AND STA. 5+00



TYPICAL CROSS-SECTION BETWEEN STA. 5+00 AND STA. 9+31

Figure 4

Therefore, the likelihood of the dam being washed out would increase.

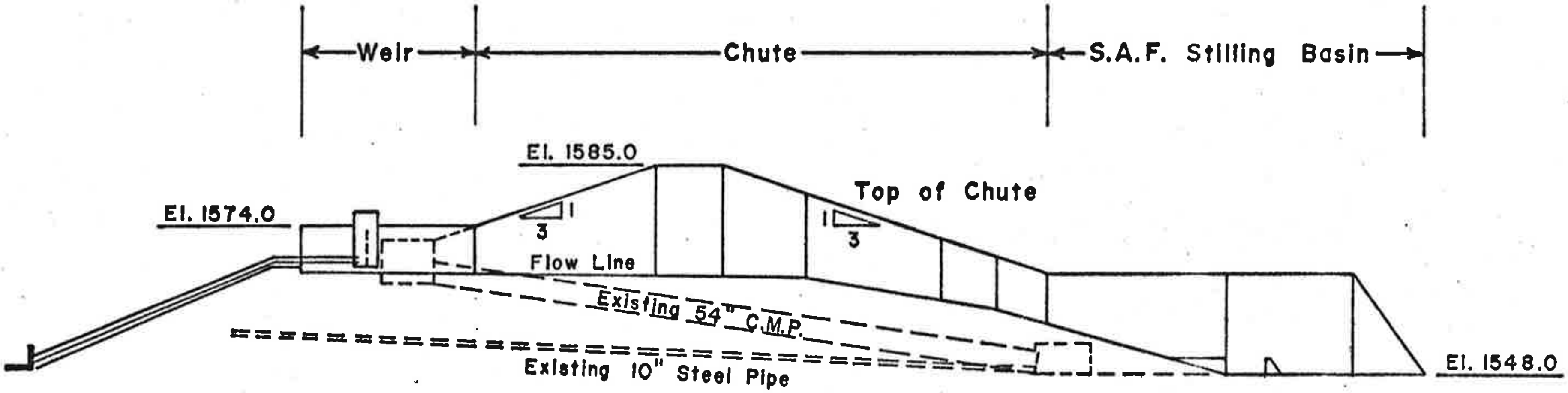
ALTERNATIVE 2

A 30 foot by 30 foot weir with a 30-foot wide chute could be constructed at a control elevation of 1574 MSL. This chute is shown in Figure 5. This would constitute a 2 foot rise in the elevation of the reservoir. The area that the water inundates would increase from 195 acres to 226 acres while the storage capacity would change from 1,630 acre-feet to 1,998 acre-feet. This would increase the average depth of the reservoir from 8.4 feet to 8.9 feet. The peak elevation of the reservoir and peak discharge through the service spillway and emergency spillway for different frequency storms are shown in Table 2.

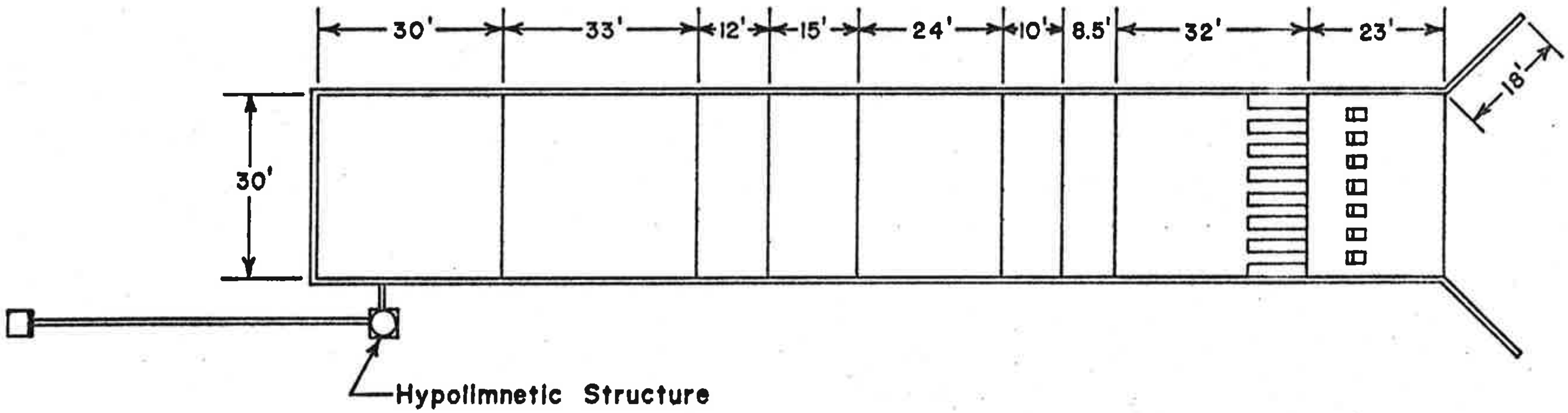
This alternative is estimated to cost $370,000. The breakdown of these costs are shown in Table 3. The cost of acquiring land is not included in this estimate. Title would have to be acquired for an additional 17.33 acres. A flood easement is currently in effect for this land. Water would permanently cover this area if the spillway were constructed at an elevation of 1574 MSL. A flood easement should be obtained for land which would be temporarily inundated by the 100 year snowmelt. Approximately 50 acres is below this elevation of 1578.2 MSL. As shown in Plate 3, the majority of this land is located along the upper reaches of the reservoir, although there are several small areas which extend beyond the boundaries of the land originally acquired for the reservoir.

ALTERNATIVE 3

A 30 foot by 30 foot weir with a 30-foot wide chute could also be installed at an elevation of 1576 MSL. This would allow a 4 foot rise in the elevation of the reservoir. A 2 foot rise in the emergency spillway, to 1579 MSL, would be required in order to meet the recommended guidelines for this project. The



ELEVATION



PLAN

Figure 5 - 30 FOOT WIDE CHUTE

Scale: 1"=30'

TABLE 3

PRELIMINARY COST ESTIMATE - ALTERNATIVE 2

2 FOOT RISE IN THE CONTROL ELEVATION OF BIG COULEE DAM

	ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	Drainage		L.S.	5,000.00	$ 5,000
2.	Site Preparation and Restoration		L.S.	4,000.00	4,000
3.	Coffer Dam	8,000	C.Y.	1.50	12,000
4.	Salvaging and Spreading Topsoil	12,000	S.Y.	0.20	2,400
5.	Earthwork (pipe recovery & chute preparation)	3,500	C.Y.	2.00	7,000
6.	Earthwork (achieve 3:1 slopes)	4,000	C.Y.	1.50	6,000
7.	Concrete (sidewalls)	300	C.Y.	300.00	90,000
8.	Concrete (base slab)	300	C.Y.	250.00	75,000
9.	Resteel	84,000	Lbs	0.50	42,000
10.	Sheet Piling	300	L.F.	20.00	6,000
11.	Structural Piling		L.S.	7,000.00	7,000
12.	Rock Riprap	400	C.Y.	20.00	8,000
13.	Rock Riprap Filter Material	150	C.Y.	10.00	1,500
14.	Low Level Drawdown System		L.S.	8,000.00	8,000
15.	Underdrainage		L.S.	6,000.00	6,000
16.	Seeding	2	Acres	150.00	300
17.	Sodding	300	S.Y.	8.00	2,400
18.	Water	200	1,000 Gal.	3.00	600
19.	Demolition and Removal		L.S.	2,500.00	2,500
			Subtotal		$285,700
			Contingencies		27,300
			Construction Inspection		28,500
			Contract Administration		28,500
			TOTAL		$370,000

Does not include cost of acquiring land

steepest slope of the emergency spillway should not be increased when the fill is added. A steeper slope on the emergency spillway would allow the velocity of flow to increase. The area inundated by the reservoir would increase from 195 acres to 257 acres while the capacity would increase from 1630 acre-feet to 2481 acre-feet. This alternative would increase the average depth of the reservoir from 8.4 feet to 9.7 feet. Table 2 shows the results obtained from routing the inflow of various frequency snowmelts through this structure.

A low area exists in the NW 1/4 of Section 31, Township 160 North, Range 67 West (See Plate 3). Water could overtop this area when the reservoir reaches its peak elevation during the annual snowmelt. This water would then spread across the countryside. Apparently there was no problem with water overtopping this point during the 1979 snowmelt. Water was flowing over the emergency spillway at a depth of 2.5 feet during that spring. Therefore, no overtopping should occur at this low area below an elevation of 1579.5 MSL. With this alternative in operation, the 100-year snowmelt would produce a peak reservoir elevation of 1580 MSL. A small dike could be built to prevent any high water from flowing over this area.

The increased control elevation of the reservoir would cause the beach and boat launching ramp at the recreational site to be inundated by the normal pool. The water level would be near the edge of the parking area. Modification could be made at an estimated cost of $4,000.

This alternative is estimated to cost $390,000. The costs are broken down into individual items in Table 4. The cost of acquiring land and modifying the beach area are not included in this estimate. At this stage of planning, the only difference in cost between the construction of alternative 2 and 3 is due to the earthwork involved in raising the elevation of the emergency spillway and constructing the dike. The higher control elevation also requires more land to

TABLE 4

PRELIMINARY COST ESTIMATE - ALTERNATIVE 3

4 FOOT RISE IN THE CONTROL ELEVATION OF BIG COULEE DAM

	ITEM	QUANTITY	UNIT	UNIT PRICE	TOTAL
1.	Drainage		L.S.	5,000.00	$ 5,000
2.	Site Preparation and Restoration		L.S.	4,000.00	4,000
3.	Coffer Dam	8,000	C.Y.	1.50	12,000
4.	Salvaging and Spreading Topsoil	17,000	S.Y.	0.20	3,400
5.	Earthwork (pipe recovery and chute preparation)	3,500	C.Y.	2.00	7,000
6.	Earthwork (achieve 3:1 slopes, dike, emergency spillway revision)	10,000	C.Y.	1.50	15,000
7.	Concrete (sidewalls)	300	C.Y.	300.00	90,000
8.	Concrete (base slab)	300	C.Y.	250.00	75,000
9.	Resteel	84,000	Lbs.	0.50	42,000
10.	Sheet Piling	300	L.F.	20.00	6,000
11.	Structural Piling		L.S.	7,000.00	7,000
12.	Rock Riprap	700	C.Y.	20.00	14,000
13.	Rock Riprap Filter Material	250	C.Y.	10.00	2,500
14.	Low Level Drawdown System		L.S.	8,000.00	8,000
15.	Underdrainage		L.S.	6,000.00	6,000
16.	Seeding	4	Acres	150.00	600
17.	Sodding	300	S.Y.	8.00	2,400
18.	Water	300	1,000 Gal.	3.00	900
19.	Demolition and Removal		L.S.	2,500.00	2,500
			Subtotal		$303,300
			Contingencies		26,700
			Construction Inspection		30,000
			Contract Administration		30,000
			TOTAL		$390,000

Does not include cost of acquiring land

be purchased. As shown in Plate 3, the reservoir elevation of 1576 MSL would extend beyond the boundaries of the land originally purchased for the reservoir. Approximately 36 acres of land will have to be acquired at various points along the reservoir. Currently, 17.33 acres of this amount is included in flood easement. Flood easements should be obtained for any other land surrounding the reservoir which is below an elevation of 1580 MSL. This is the elevation that a 100-year snowmelt would attain. Eighty acres of land are included in this designation. The majority of this acreage is in the upper portions of the reservoir.

VI. SUMMARY AND RECOMMENDATIONS

SUMMARY

Big Coulee Dam provides the municipal water supply for the City of Bisbee. The quality of the water has been poor. The reservoir also serves as a recreational area for the community. Recently some problems have arisen. Local residents have complained that pleasure boating is only possible in the area of the original coulee. Many of the fish do not survive through the winter. The 54-inch metal spillway pipe has been deteriorating. It has deformed due to the weight of the soil above it. Rust is evident on the bottom 1/3 of the pipe. A dangerous situation exists because the valve for the drawdown pipe is on the downstream side of the structure. It could cause severe damage if it breaks. The emergency spillway is susceptible to scouring since water frequently flows over it at high velocities during the spring snowmelt.

The inflow for various frequency snowmelts was obtained with the use of the TR-20 computer program. Flows from a 25-year snowmelt were routed through several combinations of service spillways set at different control elevations. This was done in order to find the most feasible structure which could adequately handle the inflow while allowing an increase in the normal reservoir elevation. Table 5 summarizes the results obtained for the three alternatives.

Three alternatives were looked at in this study. The first alternative involves doing nothing at the present time. This may result in high maintenance costs in the future due to erosion on the emergency spillway. The service spillway pipe has been deteriorating and may have to be replaced in the future. Similarly constructed spillways in the State have experienced problems and have had to be replaced.

The second alternative would raise the control elevation two feet to an elevation of 1574 MSL. In order to raise the control elevation of the reservoir,

TABLE 5

SUMMARY OF ROUTING RESULTS FOR PROPOSED ALTERNATIVES

	Frequency of Snowmelt	Reservoir Elevation	Discharge in Emergency Spillway (cfs)	Velocity in Emergency Spillway (fps)
Alternative 1[1]	25 year	1579.0	1,170	7.0
	100 year	1580.1	2,480	9.4
Alternative 2[1]	25 year	1577.1	30	1.7
	100 year	1578.2	475	4.8
Alternative 3[2]	25 year	1579.1	30	1.7
	100 year	1580.0	353	4.4

All values shown are the peak values for that frequency snowmelt.

[1]Emergency spillway at an elevation of 1577.0 MSL.

[2]Emergency spillway at an elevation of 1579.0 MSL.

a completely new service spillway will have to be constructed. A 30 foot by 30 foot weir with a 30-foot wide chute was found to be the best spillway for this situation. Average depth of the reservoir would increase from 8.4 feet to 8.9 feet. The increased elevation of the reservoir would require that 17.33 acres, currently under flood easement, be bought. A flood easement should be obtained for 50 acres of land below the 100-year flood elevation of 1578.2. This alternative is estimated to cost $370,000, not including land costs.

Alternative 3 consists of constructing the same 30 foot by 30 foot weir and 30-foot wide chute at a control elevation of 1576 MSL. This would provide an average depth of 9.7 feet. The emergency spillway would have to be raised 2 feet to an elevation of 1579 MSL. A small dike would have to be constructed in the NW 1/4 of Section 31, Township 160 North, Range 67 West. Plate 3 shows the location of this low area. Without a dike, water could overtop this region and spread out over a large area of land during the 100-year snowmelt. Thirty-six acres of land will have to be purchased to accommodate the larger reservoir area. A flood easement is currently in effect for 17.33 acres of this. Flood easements should be obtained for 80 acres of land below the 100-year flood elevation of 1580. The estimated cost for this alternative, not including the cost of obtaining land, is $390,000.

Included in the costs for alternative 2 and 3 are several changes which should be made if a new service spillway is constructed. The 54-inch CMP and low level drain should be removed. Installation of low level (hypolimnetic) water quality control structure would help improve the water quality by removing stagnant water from the bottom of the reservoir. A Saint Anthony Falls (SAF) stilling basin, complete with energy dissipators, should be constructed for the outlet structure. The portion of the downstream embankment which is currently at a 2H:1V slope should be modified so the slopes are 3H:1V to ensure the stability of the embankment.

RECOMMENDATIONS

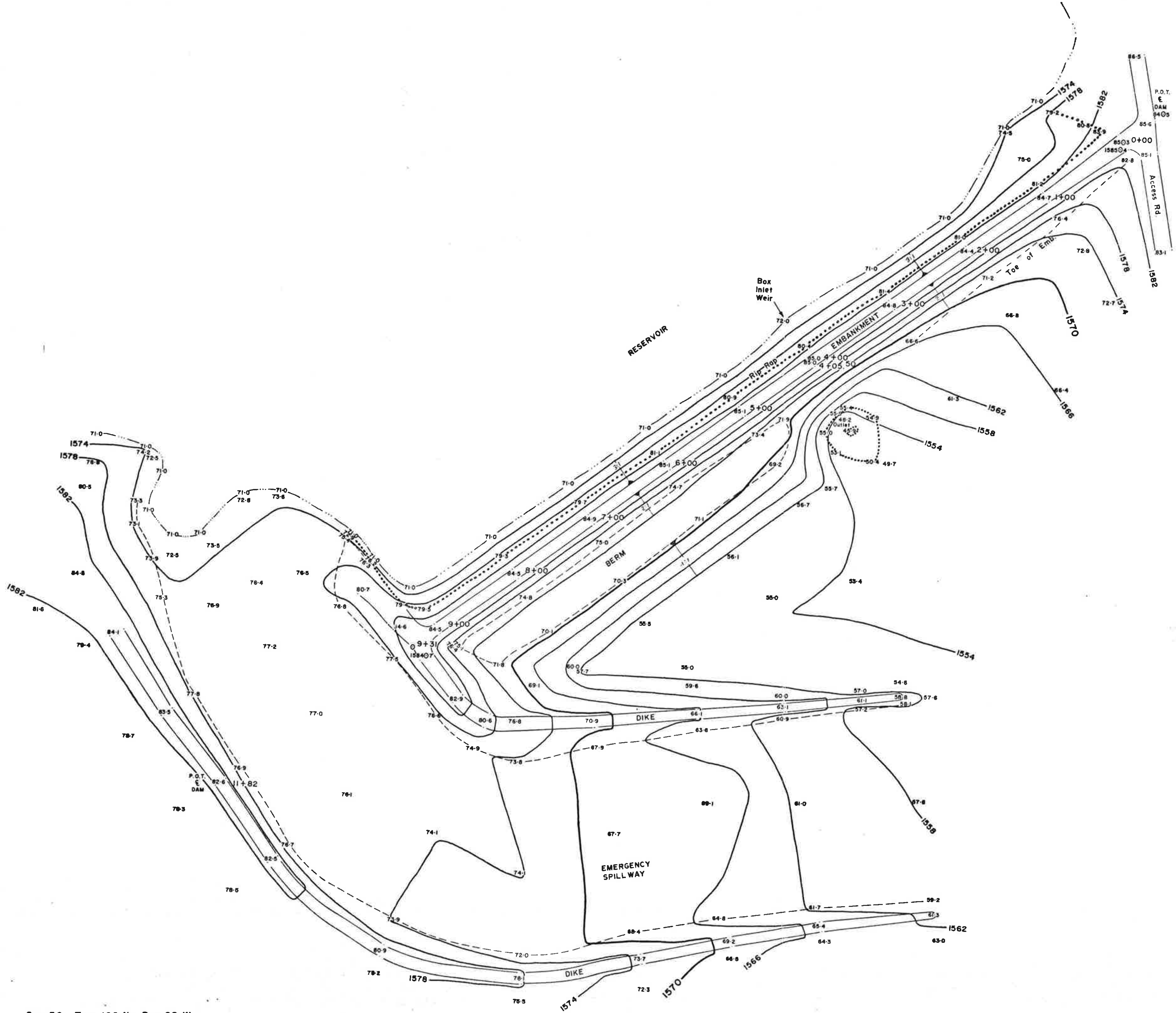
The three alternatives presented in this report are all viable, although some may be more desirable than others. Several problems currently exist with the water quality and the operation of the Big Coulee reservoir. Therefore, alternative 1, do nothing, would be of no value.

Alternative 2, the two foot increase, would improve the water quality of the reservoir. The peak water levels, due to runoff, would be less than those for the existing conditions since the capacity of the spillway would be increased. In addition, use of the emergency spillway would be reduced and the velocity of flow over it would be reduced during the larger snowmelts. The greater reservoir depth would increase the area available to boating.

Alternative 3, the four foot increase, would also improve the water quality of the reservoir. It would provide a larger area for boating than alternative 2. The average depth of the reservoir would also increase. Use of the emergency spillway and the velocity of flow over it during the larger snowmelts would be reduced to the same level as obtained in alternative 2. Excluding the cost of acquiring land, this alternative would cost about six percent more than alternative 2.

Although alternative 3 appears to be the best choice, a problem exists due to the higher water level. The normal pool would completely inundate the beach and boat launch area. The water level would extend close to the bath houses and parking lot (see Plate 3). The peak water levels would be about the same as for the existing conditions. A portion of the parking lot may be inundated during the peak level. The remainder of the recreation area should not be affected. Possibly, the beach could be extended to a higher elevation or moved to a different location. This modification was estimated to cost $4,000.

The Towner County Water Resource Board must decide what alternative it deems the most feasible. Deterioration may cause some spillway improvement to be required in the near future. Therefore, the first alternative is not recommended. Although alternative 3 is the most costly, it is recommended as the preferred alternative. The Board must weigh the value of improving the depth of the reservoir while losing part of the existing recreation area.



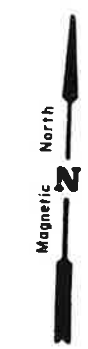


PLATE I

SHEET OF

NORTH DAKOTA STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 1418

BIG COULEE DAM

SITE TOPOGRAPHY - AS BUILT

COUNTY TOWNER DATE 8-7-80

SURVEYED: E.D.S. CHECKED BY: P.D.U. SUBMITTED:

Sec. 36, Twp. 160 N., Rge. 68 W.

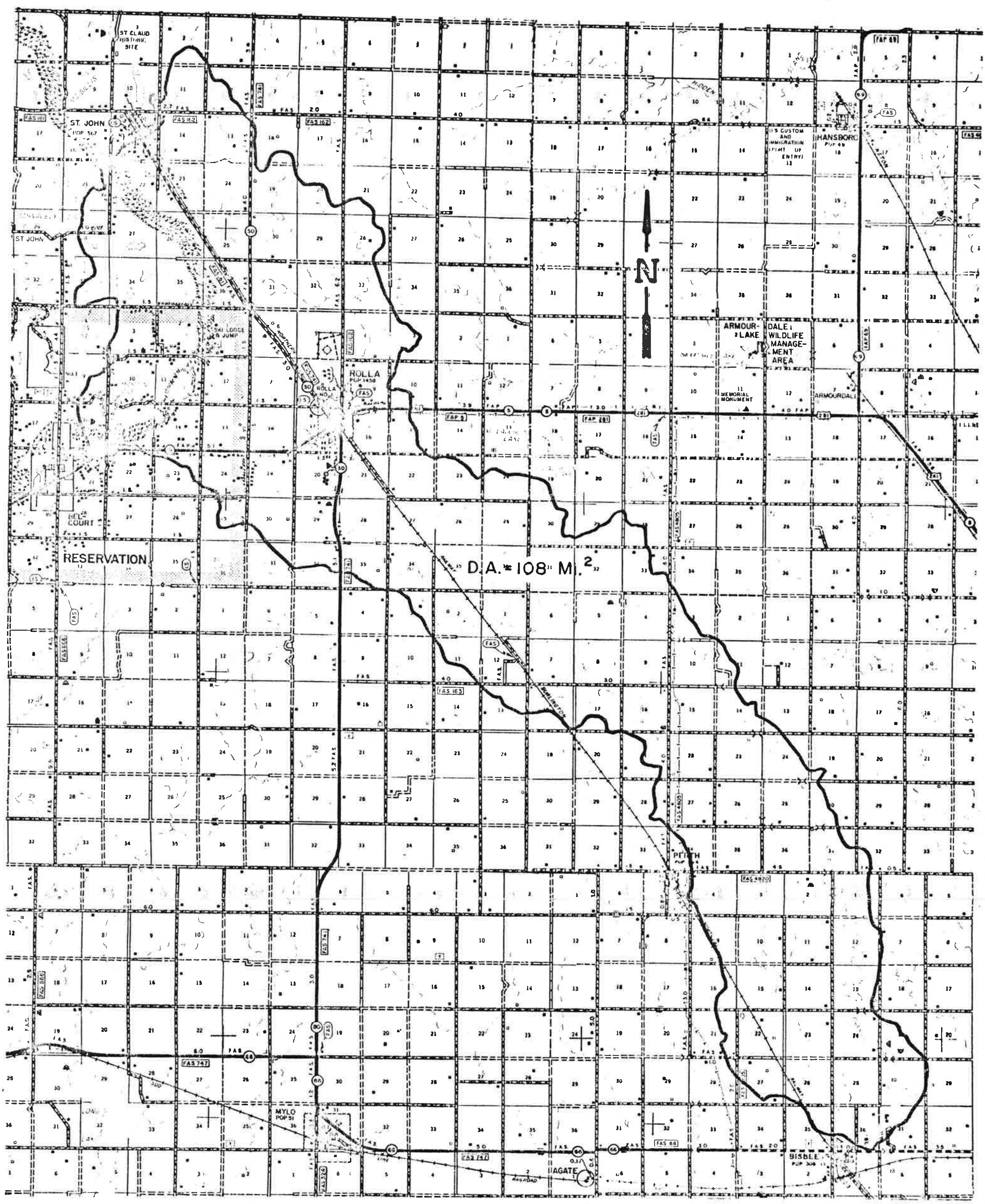
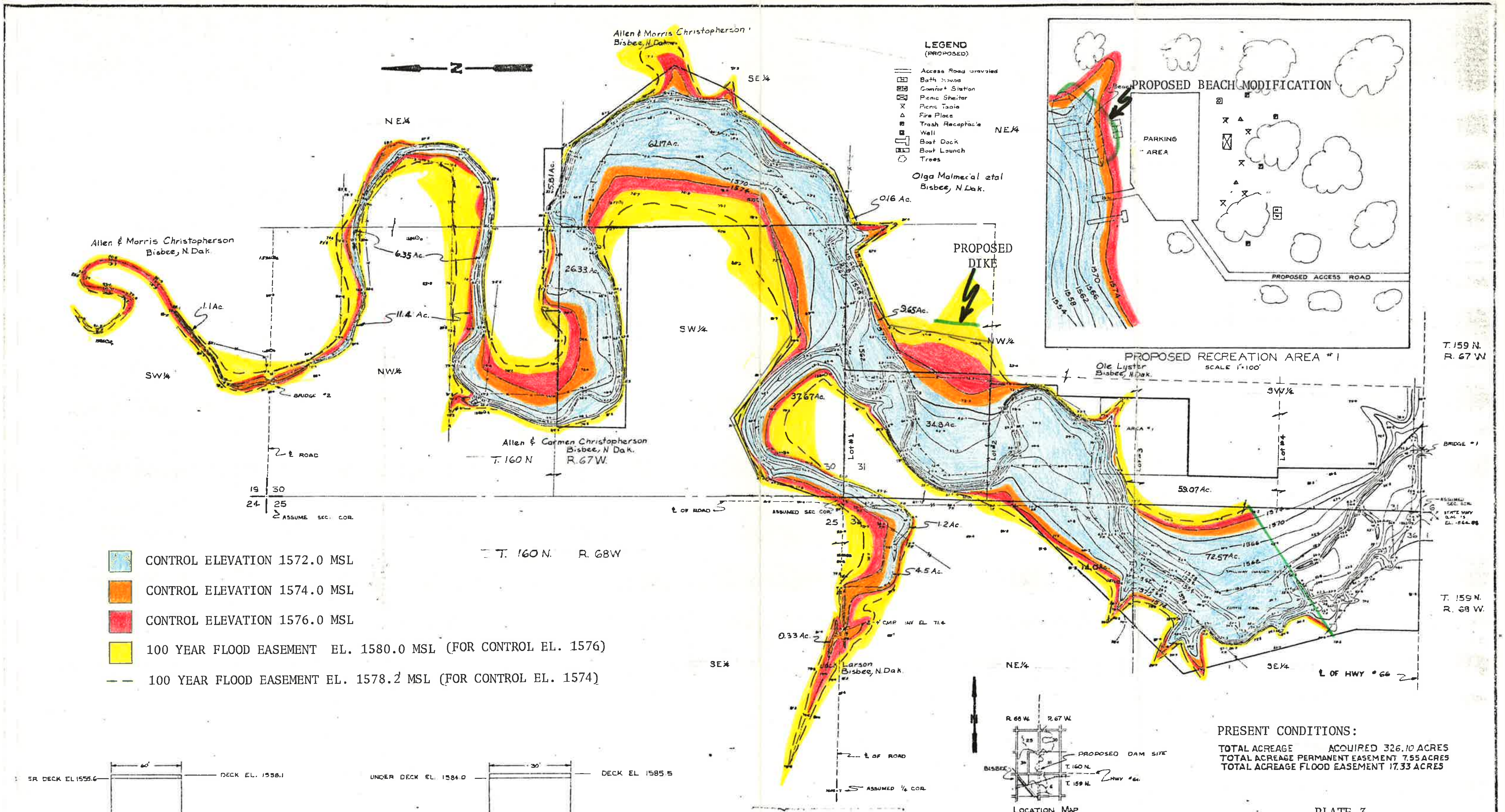


PLATE 2 - DRAINAGE AREA FOR BIG COULEE DAM



AREA CAPACITY TABLE

EL	ACRES	ACRE FEET
1574	225.8	1,998.2
1570	167.6	[illegible]
1566	108.6	659.0
1562	67.1	307.6
1558	30.6	112.2
1554	[illegible]	27.[illegible]
1550	1.4	1.4
1548	0	0

PLATE 3

SHEET 1 OF 2 REVISED 1/29/68 ME

NORTH DAKOTA
STATE WATER COMMISSION
BISMARCK, NORTH DAKOTA

PROJECT NO. 1418

BIG COULEE DAM

AREA INUNDATED BY RESERVOIR

COUNTY TOWNER DATE 12-15-65

SURVEYED: EDS CHECKED BY: SUBMITTED:
DRAWN: OKK. DESIGNED BY: APPROVED:

DRAWING NO. 6488-1418-1 SCALE 1" = 400'

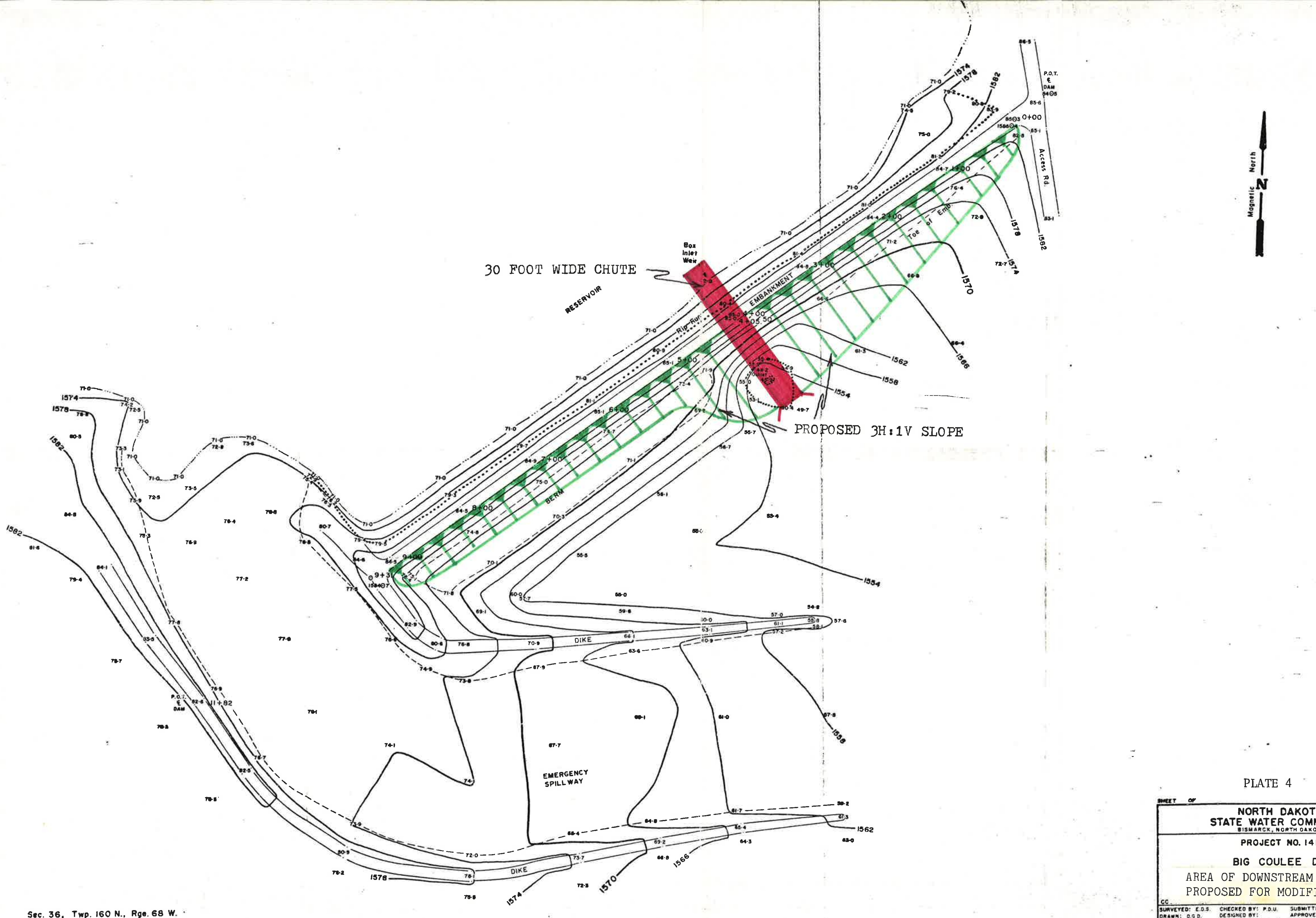


PLATE 4

SHEET OF

NORTH DAKOTA STATE WATER COMMISSION

BISMARCK, NORTH DAKOTA

PROJECT NO. 1418

BIG COULEE DAM

AREA OF DOWNSTREAM EMBANKMENT PROPOSED FOR MODIFICATION

SURVEYED: E.D.S. CHECKED BY: P.D.U. SUBMITTED:

DRAWN: D.G.D. DESIGNED BY: APPROVED:

DRAWING NO. 9218-1418-23 SCALE 1"=50'