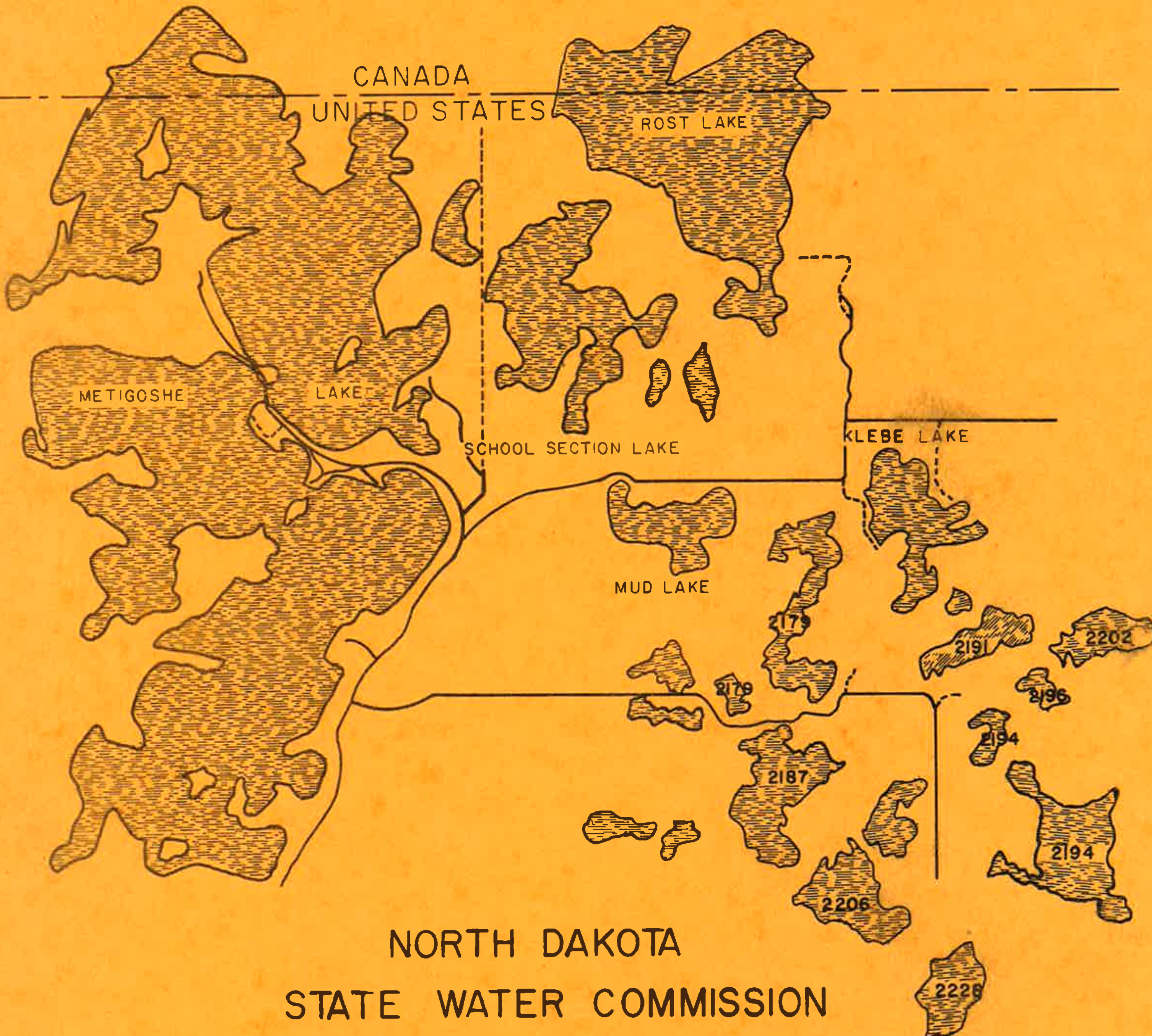
PRELIMINARY ENGINEERING REPORT

LAKE METIGOSHE SUPPLEMENTAL WATER SUPPLY

S.W.C. PROJECT NO. 330



NORTH DAKOTA

STATE WATER COMMISSION

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PRELIMINARY ENGINEERING REPORT

LAKE METIGOSHE SUPPLEMENTAL
WATER SUPPLY STUDY

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North Dakota State Water Commission
State Office Building
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Prepared for the
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EXECUTIVE SUMMARY

Lake Metigoshe is the most popular of the lakes located in the Turtle Mountains. The lake and the land surrounding it provides an important source of recreation.

Much concern has been raised over the fluctuating level of the lake. Because of this concern an alternative source of water was investigated.

Lake Metigoshe has a total drainage area of 59 square miles. Because of the hilly terrain however, a portion of this area does not contribute runoff to Lake Metigoshe. Instead, the runoff ponds in several small lakes. This is the situation for a 3.8 square mile area located east of Lake Metigoshe. As proposed, channels would connect these upstream lakes, allowing them to drain into Rost-School Section Lake. A dam would be constructed below School Section Lake to store the runoff. In years when Lake Metigoshe falls below its control elevation, water would be discharged from Rost-School Section Lake into Lake Metigoshe. While attempting to stabilize the level of Lake Metigoshe, Rost-School Section Lake would be allowed to be drained completely.

Two alternatives were looked at. Alternative 1, estimated to cost $390,000, would have channels constructed so that all the upstream lakes would be controlled at the elevation shown on the 1956 quadrangle map. Alternative 2, with an estimated cost of $825,000, consists of excavating a channel to such a depth that all the upstream lakes would be drained.

Starting in 1956, actual precipitation and evaporation records were used to determine the effect that this system would have on the elevation of Lake Metigoshe, if it had been in place. For Alternative 1, it was found that the upstream lakes provided very little runoff. In fact, nearly the same results would be obtained if the upstream channels were not constructed. Only Rost-School Section Lake Dam and the short channels connecting Rost Lake, School Section Lake, Lake McDonald, and Lake Metigoshe would need to be constructed. Neither alternative would be able to stabilize Lake Metigoshe at its control elevation during the second of two consecutive dry years. Almost all the storage of Rost-School Section Lake would be discharged into Lake Metigoshe during the first dry year. No supplemental water would be available during the second dry year. Historically, these are the only years that the level of Lake Metigoshe has dropped much distance below its control elevation. This is the period that supplemental water is needed the most. None would be available.

Also, from tests taken in May 1982, the water quality of these lakes is poor. Phosphate and nitrogen levels are actually higher than found in Lake Metigoshe. Conditions would be expected to improve after the initial discharge. The water quality of this area, however, would still not be better than the quality of Lake Metigoshe.

If the Oak Creek Water Resource Board decides that the main goal of this project is to improve conditions when the normal elevation of Lake Metigoshe is much more than 0.5 foot below its control elevation then neither alternative is recommended.

If it is decided that a serious problem exists when the normal elevation of Lake Metigoshe is within 0.5 foot of its control elevation, only constructing School Section Lake Dam and only the short channels connecting Rost Lake, School Section Lake, Lake McDonald, and Lake Metigoshe would provide the most benefit compared to the costs. This construction is estimated to cost $100,000, $95,000 for School Section Lake Dam and $5,000 for the channels.

Only limited benefits could be expected by this construction. Rost-School Section would be severely drawn down during many years. Also, environmental problems and Canadian concerns should be taken into account.

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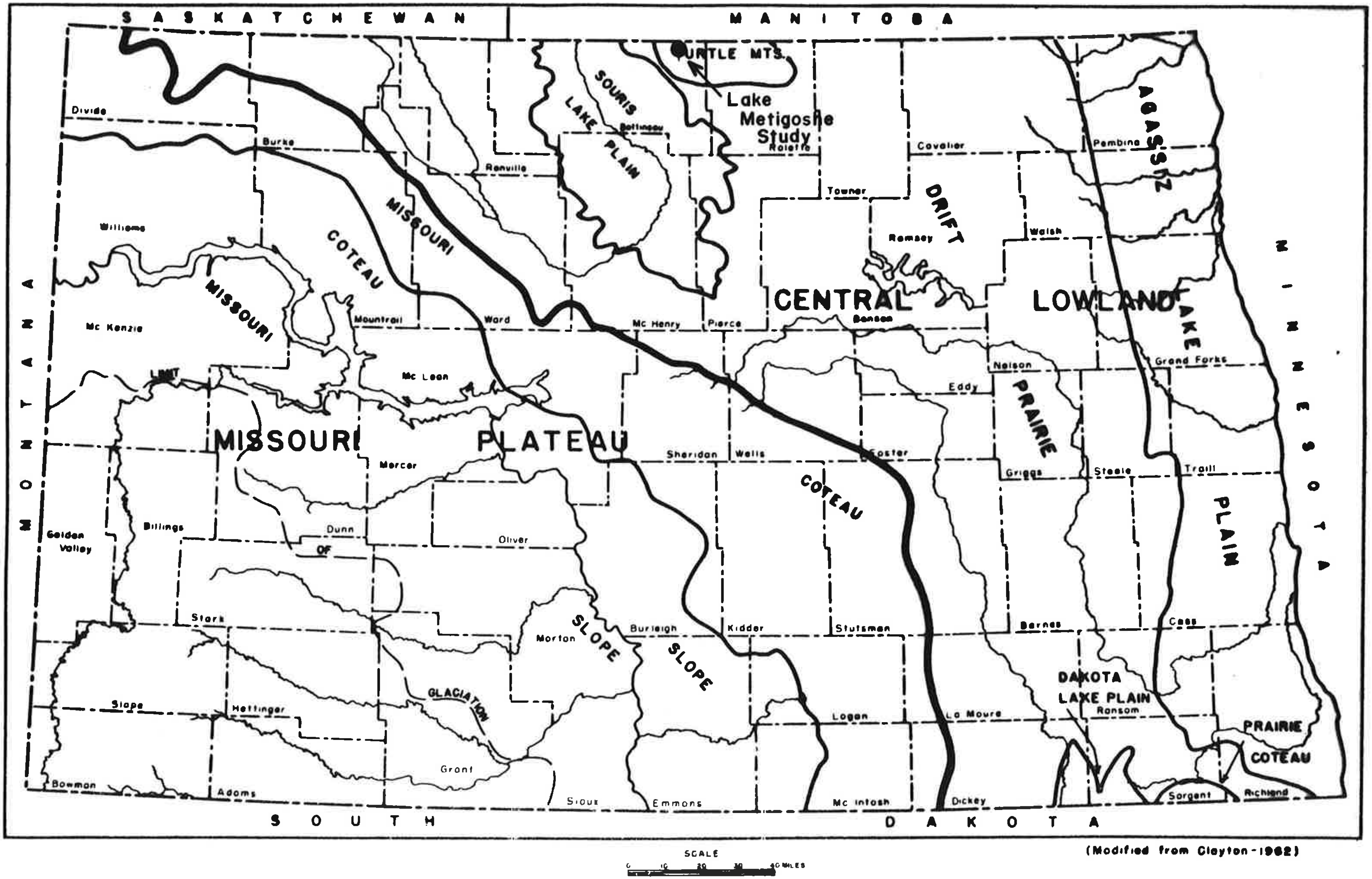
I. INTRODUCTION

PURPOSE

Lake Metigoshe is located on the U.S.-Canadian Border in Bottineau County, which is located in north-central North Dakota. Figure 1 shows its location within the state. It is one of many lakes that exist in the Turtle Mountains. Being one of the largest and deepest, it is the most popular. Many people enjoy the recreational opportunities the lake provides.

Over the years, there have been numerous times when the level of Lake Metigoshe was below its control elevation of 2138 msl. This decrease in water level is caused by evaporation. Due to the relatively small area contributing runoff to the lake, in many years there isn't enough runoff to maintain the lake's level. This causes the lake level to fluctuate. A very dry year can lower the water level. The reduction can be so great that a normal spring runoff will not fill the lake. This problem was realized as far back as 1931.

Lake Metigoshe and the land surrounding it is a popular recreation area. At present, there are over 1,000 cabins along its shoreline. There are also two Bible Camps, a Boy Scout Camp, and a State Park located there. The lake provides summertime opportunities for water-related activities including boating, sailing, water skiing, fishing, and swimming. Also, the forested area surrounding the lake is good for hunting, hiking, and camping. During the winter the lake provides opportunities for cross country skiing, snowmobiling, and ice fishing.



(Modified from Clayton-1962)

FIGURE I – LOCATION OF LAKE METIGOSHE SUPPLEMENTAL WATER SUPPLY STUDY

Because of these activities, the popularity of Lake Metigoshe is increasing.

The fact that there are over 1,000 cabins, three camps, and a State Park shows that there is a considerable investment in the lake. It is understandable that the cabin owners are concerned about fluctuating lake levels. They would like to see the lake level stabilized. This would improve recreational activities which in turn maintains or increases the value of their investment.

Cabin owners are also very concerned about the quality of the water in Lake Metigoshe. They believe that providing a supplemental water supply for the lake will enable fresh water to enter the lake when it is needed. It is felt that this would help maintain good water quality.

A hydrological investigation of the area east of Lake Metigoshe was performed. There are numerous small lakes that could be tapped to provide supplemental water for Lake Metigoshe (Figure 2). This supply of water, if available, could be used to help stabilize the lake levels during dry years and help improve water quality.

SCOPE

This report attempts to identify possible areas that could contribute water to Lake Metigoshe. Information was gathered from USGS 7½ minute quadrangle maps. A number of surveys have been done in the area. The most recent and comprehensive survey was done in 1962 and is the one used for this preliminary report. Using this information, a hydrologic study was done of the area. This amounted to estimating flows into the various lakes, flood routing the lakes, and determining the flows from the lakes for channel design. These channels would carry

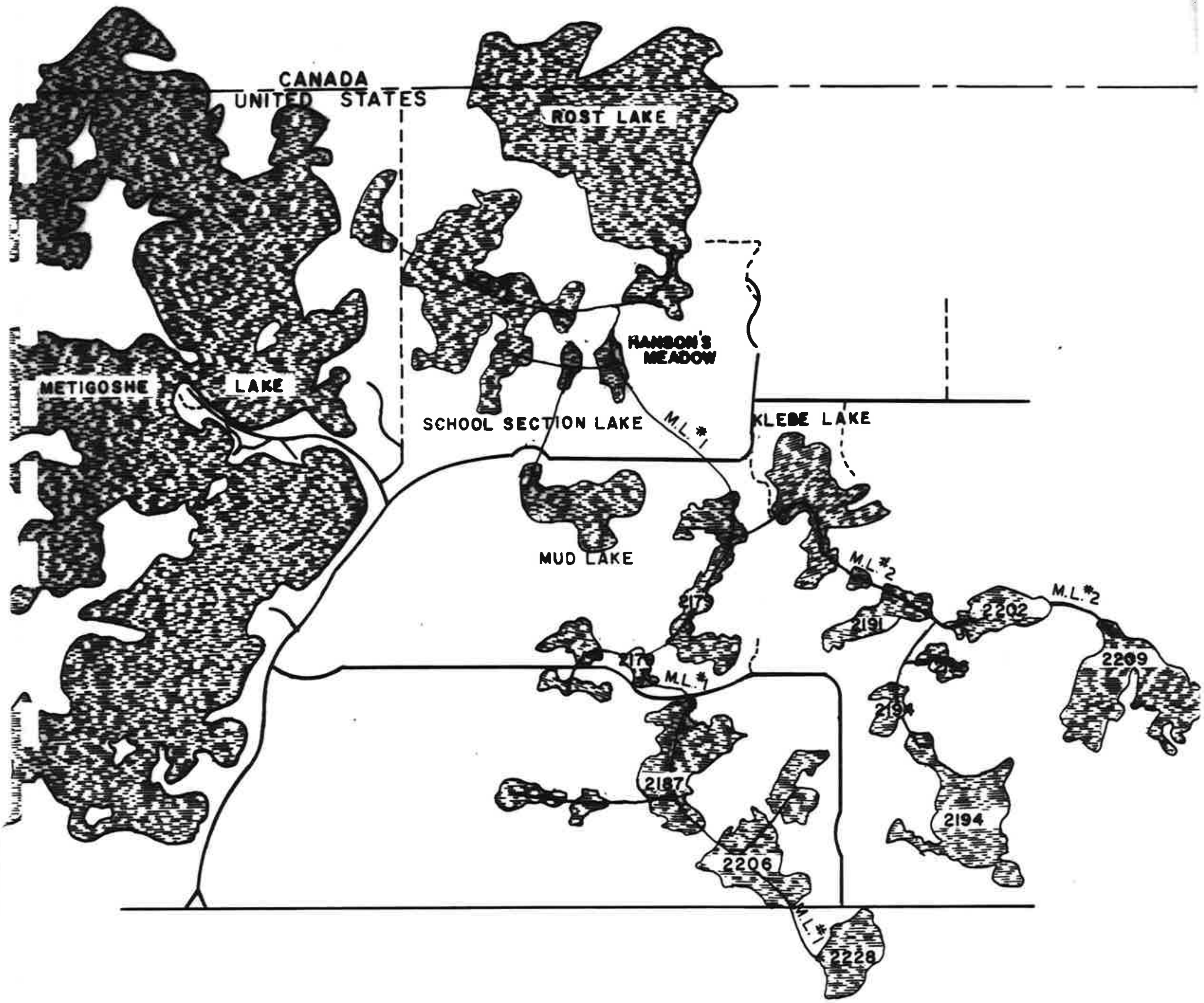


FIGURE 2

LAKE METIGOSHE SUPPLEMENTAL WATER SUPPLY PLAN excess water from these lakes into a reservoir at School Section and Rost Lakes.

A water balance study was also done. The study looked at the amount of runoff that could be collected by a system of channels. Runoff was compared to expected evaporation from the proposed reservoir, which includes School Section and Rost Lake. This was done to see whether the increased level of School Section and Rost Lakes could be maintained.

Two alternatives were looked at for the design of the system of drainage channels. The intent of Alternative 1 was to allow excess water flowing into the numerous upstream lakes to be drained away. This means that the lakes would not be entirely drained. In order for the lakes to drain naturally, they would have to be raised by a considerable amount. The drainage channels would allow water to drain when the lakes get above their normal level.

All the lakes within this upstream area would be completely drained with Alternative 2. Channels would be constructed with the bottom elevation as low as the lowest point of each lake. Therefore, all runoff would drain directly into Rost and School Section Lake.

Preliminary design for the channels, lake control structures, and the dam at the outlet to School Section Lake were done. Included in this report are cost estimates for the preliminary design of both alternatives. Also included is a summary and recommendations of what can be done.

II. STATEMENT OF PROBLEM

BACKGROUND

The problem of fluctuating lake levels and insufficient runoff into Lake Metigoshe was realized in 1931. In that year, the State Engineer, Robert Kennedy, wrote a report on the lake.

Kennedy began his report by describing the natural beauty that abounds in the area around Lake Metigoshe. He also stated that the popularity of the area was increasing. This was based on statistics showing increased sales of fishing licenses in the area as well as the fact that 408 cabin sites were platted along the lake. At the time of his report there were already 70 cabins along the lake. Much of the lake's increase in popularity was attributed to the construction of a new road into the area.

He also mentioned that the number of fish in the lake changed with changes in the water level. Fishing was the main activity on Lake Metigoshe. If it was bad, the popularity of the lake decreased. This hurt businesses near the lake and in the surrounding towns. Therefore, Kennedy related an economic loss to reduced water levels in Lake Metigoshe.

Lake Metigoshe's problem, according to Kennedy, was its limited watershed. Being only about 59 square miles, it did not have the potential for a lot of runoff. The watershed also consists of numerous small lakes. Kennedy noted that in order for many of these lakes to contribute water downstream, their levels would have to rise considerably. Therefore, there is a lot of dead storage in the watershed. The State Engineer wanted to make this dead storage in the tributary lakes available to Lake Metigoshe.

In order to tap some of this dead storage, Kennedy proposed two projects. The first was a drainage canal between Rost Lake and Lake Metigoshe. According to Kennedy's report, Rost Lake would have to rise 3 feet before it would start running downstream. This amounts to a dead storage of 1,228 acre-feet. If this were available to Lake Metigoshe, it would raise the lake 9 inches. The second project involved building a dam across the channel draining Rost Lake. It was to be located at the outlet to School Section Lake. This reservoir would occupy 800 acres and store 7,390 acre-feet.

In April of 1949, a petition was presented to the State Water Commission by area citizens. It requested the Water Commission to aid in stabilizing the banks on some roads and to investigate the stabilization of the lake levels. This was to be accomplished by a system of dams, canals, gates and general channel maintenance. During the summer of 1949, surveys were made to investigate the possibility of constructing a dam in the channel between Rost Lake and Lake Metigoshe. It was intended that excess flows be impounded behind the dam and released when water was needed in Lake Metigoshe to compensate for evaporation losses.

Water was seeping out of the Lake Metigoshe spillway structure in July of 1950. At that time it was discovered that the structure was in a state of disrepair. It evidently was seeping at a rate large enough to affect the lake level. Therefore, in November of 1950, the original 40-foot weir was lengthened to 70 feet. This was accomplished by placing 15-foot extensions on each end of the existing weir. These extensions were gravity sections constructed out of rubble concrete and having the same shape as the original weir. Seepage was also coming through the center 10-foot length of the original weir. This section of the weir had a notch 8 feet long and 1 foot deep. To correct this seepage, a wall of sheet piling, 6 feet deep, was driven across the upstream side of the structure in this problem area. Also, this part of the weir was replaced by a gravity section of rubble concrete and the notch was eliminated. A June, 1949 survey, indicated that the weir was at elevation 2138.04 msl. The notch in the weir was at elevation 2137.0 msl.

In April of 1953, inquiries were again presented to the State Water Commission regarding a retention dam. Evidently, at this time the investigation started in 1949 was looked into further. The project ran into some problems in securing easements from landowners. There were also problems in getting approval from State and Federal concerns. Since Rost Lake is on the U.S.-Canada border and the proposed reservoir would raise Rost Lake, there were problems with the Dominion of Canada. Costs for the two projects proposed by Robert Kennedy were estimated in December of 1954. At that time, the drainage canal between Rost Lake and Lake Metigoshe via Hanson's Meadow was estimated to cost $9,040. Construction of the dam between the two lakes was estimated to cost $29,665. This dam had a proposed control elevation of 2155.0 msl.

Sharpe Lake, located upstream of Lake Metigoshe on Canada Creek, was investigated in 1955 as a possible alternative to store water for Lake Metigoshe. In February of 1955, surveys were made of the Sharpe Lake area. The plan was to store water in Sharpe Lake by raising its elevation. A diversion ditch was planned to carry excess water to the Rost Lake Reservoir if it was needed. In this way, water from the Sharpe Lake drainage area could be stored in both Sharpe Lake and the proposed Rost Lake Reservoir.

Milo Hoisveen, State Engineer, made some comments to the State Water Commission about this plan. He mentioned that some of the farmers around the lake were contacted and asked about their views on raising Sharpe Lake. The landowners generally were in favor of raising Sharpe Lake but did not approve of draining it again for the benefit of other lakes. In order for the plan to work, Sharpe Lake would have to be at least partially drained to provide water for Lake Metigoshe. Therefore, Milo recommended that the Sharpe Lake Dam not be built. Instead, he suggested that the Lake Metigoshe watershed be improved. This proposed improvement involved the drainage of the smaller lakes and collecting the runoff in the Rost Lake Reservoir.

Despite Mr. Hoisveen's recommendation, the Sharpe Lake Dam was constructed in 1958. It raised the level of the lake 10 feet. The proposed diversion to Rost Lake was not built since the Rost Lake Dam was not constructed.

In 1960, the Lake Metigoshe Improvement Association requested a study of the Lake Metigoshe watershed. The purpose of the study was to find additional water for the lake and evaluate the feasibility of providing this water. It was proposed to improve a portion of the watershed that entered Lake Metigoshe from School Section Lake and Lake McDonald. This would have involved ditching or clean up of the natural drainage ways from Lake McDonald through School Section Lake and Hanson's Meadow to Rost Lake. Also, included was the improvement of the channel between Mud Lake and School Section Lake. Gates were to be installed in the control structure on the outlet to School Section Lake. (This earthen embankment has since washed out.) This would allow a drawdown of School Section Lake to an elevation of 2135 msl. A gated structure was also proposed for the outlet to Hanson's Meadow. Rost Lake was to have a two-way control structure. This would enable flows into Hanson's Meadow to be diverted into Rost Lake. It would also allow water to be released from Rost Lake when it was needed in Lake Metigoshe.

The watershed area of Lake Metigoshe was surveyed during the winter of 1961-1962. This survey included profiles between many of the lakes, a site topography for the Hanson's Meadow control structure and a site topography for the Rost Lake control structure. This information was used to develop costs for the proposed improvements and therefore evaluate the project's feasibility.

It was determined that a drainage system would not be feasible. The amount of work required to achieve this drainage was more than the benefit that could be derived from it. Merril Rivinius, Investigation Engineer at the time, stated that accelerated drainage in the noncontributing areas would increase the yield of water from the basin. According to him, this would be equal to the amount of normal evaporation of the areas which he estimated to be 1260 acre-feet. This is not necessarily true.

In the fall of 1961, a new outlet structure was constructed for Lake Metigoshe.

During the late 1960's, cabin owners along Lake Metigoshe started to be concerned about the quality of water in the lake. The North Dakota Water Resources Research Institute did a study of the lake in 1971. They looked at the amount of bacteria present in the water over the course of the summer. It was found that large concentrations of bacteria existed in the lake. This was especially true during periods of heavy use. An attempt was made in 1972 to locate the source of the bacteria. The North Dakota Water Resources Research Institute started a five-year study to determine the lake's water quality.

The lake has had problems with excess nutrients and stagnate water. This problem is quite evident during low runoff years. Many areas become very weedy and the surface sometimes is covered with algae. A major source of the nutrients was thought to be the numerous cabins along the lake. Therefore, a sewer district was proposed in 1972. The plan was finally approved in 1980. In order to freshen up the water in the south lake, it was proposed in 1973 to install a pipe through the Rugby Point narrows. It was hoped that this would allow some circulation in the southern part of the lake. The pipe was never installed.

In the fall of 1972, there was some concern over what the lake level should be. Some people wanted flashboards added to the outlet structure to increase the level by a half-foot. They felt that this would improve boating and fishing. This proposed use of flashboards brought up questions as to how the lake level should be managed. It also brought up questions as to how the Sharpe Lake Reservoir should be managed to benefit Lake Metigoshe. During the discussions of using water from Sharpe Lake to maintain the level of Lake Metigoshe, Canadian interests claimed that the Oak Creek Water Resource Board did not have a valid license to operate the Sharpe Lake Reservoir. This licensing question has been brought up many times since 1972 and has not been resolved.

In June of 1979, the Oak Creek Water Resource Board requested the State Water Commission to investigate the feasibility of getting additional water for Lake Metigoshe from the School Section Lake drainage area. A copy of the agreement is included in Appendix A.

III. ROST-SCHOOL SECTION LAKE

Hydrology

The portion of the non-contributing Lake Metigoshe watershed located east of the lake has a total drainage area of 10.3 square miles (Figure 2). Even after completion of the proposed project, 1.3 square miles of this will not contribute runoff during most years. Therefore, the increase in the normal contributing drainage area will amount to 9.0 square miles. Presently, 5.2 square miles of this area runs directly into Rost Lake or School Section Lake. The remaining 3.8 square miles consists of numerous lakes that presently contribute little, if any, runoff. By constructing channels, this 3.8 square mile area is proposed to be drained into Rost and School Section Lake. It would then be available to provide water for Lake Metigoshe.

Under existing conditions the lakes within the 3.8 square mile area would have to rise significantly before any outflows would result. At the levels shown on the quadrangle map (1956), there are 543 acres of lake surface in the area proposed to be drained.

The 3.8 square mile area was broken into a number of subbasins. For Alternative 1, runoff from each subbasin was estimated for the 10 year event by using the tabular hydrographs in the North Dakota Hydrology Manual. These are based on a 24-hour, type 1 distribution storm. The hydrograph ordinates listed are for an area of 1 square mile and are based on time of concentration and hydrograph family. A hydrograph family was chosen by determining the rainfall depth for a 24-hour storm and the curve number for the subbasin. The rainfall depth, varying according to the frequency of the storm, was determined from rainfall maps included in the North Dakota Hydrology Manual. A curve number was determined from the physical features that affect runoff from the subbasin.

Flows from the subbasin are greatly reduced due to the effects of storage in the numerous lakes. Peak flows discharging from the lakes, in the area proposed to be drained, range from 0.2 cfs to 1.8 cfs for the 10-year event. This compares to peak inflows to the lakes ranging from 3 cfs to 103 cfs for the 100-year event. These flow rates, of course, are dependent on the individual subbasin areas and the conditions found in them. The flow rate in the channels between the lakes was estimated by adding runoff from the land between the lakes to the discharge from the upstream lakes.

A similar method was used to determine the peak discharge during a 10-year event for Alternative 2. A peak discharge curve, based on a 24-hour, type 1 distribution storm, was used from the North Dakota Hydrology Manual. The discharge is dependent on time of concentration and hydrograph family. Both the 24-hour rainfall amount and curve number are used to determine which hydrograph family to use. When determining the curve number, it was assumed that the lakes were completely drained.

At the upstream end of the drainage area, peak flows during the 10-year event are as low as 3 cfs. However, because there are no lakes to provide storage, the flows join and rapidly increase as they proceed downstream. Near the entrance to Rost-School Section Lake, the peak discharge is as high as 80 cfs. The flow rates for each alternative were used to design the proper channel width.

Water Budget

As with any proposed reservoir project, the major concern is whether the proposed reservoir will receive sufficient runoff to maintain the water level. While precipitation falling directly on the reservoir, and running off the watershed, adds to the water stored in the reservoir, evaporation from the water surface is constantly taking water away. If the losses from evaporation are greater than the runoff coming into the reservoir, the lake level will not be maintained. Therefore, there would be little or no water available to supplement Lake Metigoshe.

Each year has varying amounts of precipitation, thus varying the amount of runoff expected. Evaporation rates also vary from year-to-year. In order to determine whether there is enough runoff to maintain the level of the proposed reservoir, it is necessary to decide what frequency event should be looked at. Normally, in reservoir design, the runoff having an 80 percent chance of occurring in a year is compared to the estimated evaporation. If evaporation is less than the 80 percent chance runoff, the reservoir will realize a net increase of water and the water level will be maintained.

The amount of runoff flowing into the Rost-School Lake reservoir was estimated by looking at the precipitation records for the City of Bottineau. These records were available since 1955 (See Appendix B).

Evaporation records, during this same time period were available for Devils Lake and Langdon (Appendix B). It was assumed that the evaporation at the project site would be similar. From this information, a Log Pearson Type III method was used to calculate the 80 percent and 50 percent chance of annual evaporation and precipitation. Also, the average values were calculated. The results are as shown below:

	80%	50%	Average
Precipitation (in.)	12.8	16.4	17.7
Evaporation (in.)	24.1	26.0	26.1

Much of the precipitation falling on land is lost to infiltration and transpiration. Therefore, not all of this water would contribute to the lake volume. As shown on the annual yield map in the North Dakota Hydrology Manual, runoff from land contributes 15 acre-feet per square mile for an 80 percent chance event. Land runoff was assumed to relate to precipitation by a runoff factor. This factor was found by dividing the runoff obtained during the 80 and 50 percent chance by the precipitation obtained during the same frequency event.

Inflow to a lake consists of precipitation falling directly on the lake and runoff from the surrounding land. Evaporation is responsible for the majority of the losses. These losses are dependent on the surface area of the lake. A larger surface area will cause a greater volume of water to be lost to evaporation.

According to the May 1977 report by the North Dakota Water Resources Research Institute, approximately two percent of the total inflow to Lake Metigoshe is due to groundwater infiltration. Most of this infiltration occurs at the shallower depths of the lake. Water flows away from the lake at the deeper sections. It is possible that the same conditions occur at Rost Lake and the upstream lakes. This may stabilize the level of these lakes during dry periods. These dry periods could also cause the elevation of the water-table to decrease. Groundwater may then flow away from the lakes, causing the lake levels to recede. Due to these uncertainties, groundwater inflow is neglected.

Alternative 1

A drainage channel would connect each of the numerous lakes within the 3.8 square mile drainage area. The lakes would not be drained, but rather controlled at the elevation shown on the quadrangle map and Figure 2. Any excess water would then be discharged into Rost-School Section Lake. Assuming that these lakes are at the elevation shown on the quad map, they would comprise 543 acres of the 3.8 square mile area.

For this alternative, a determination of the water balance for the upstream area was made separately. This was done by using the actual yearly evaporation and precipitation amounts, compiled since 1955. On a yearly basis, the amount of discharge obtained was determined by calculating the change in lake elevation due to precipitation and evaporation.

Optimum conditions were assumed for these lakes. It was assumed that each lake was at its control elevation at the beginning of 1955. Therefore, any increase in the water elevation would cause outflow to Rost-School Section Lake. The effects of precipitation and evaporation were determined by using the surface area which the lake had at the beginning of each year.

As shown in Table 1, runoff from these lakes will only be received during 6 of the 26 years. This runoff, occurring only during the wetter years, would contribute to Rost-School Section Lake. During the drier years, the upstream lake's elevation gets as much as 1.8 feet below the control elevations. Nearly 1400 acre-feet of water, equivalent to an elevation change of 1.8 feet, must be added to these lakes before any runoff to Rost-School Section Lake would occur.

The elevations shown on the quad map, for these lakes, are the

TABLE 1

Lakes Upstream of Rost-School Section Lake
Alternative 1

Year	Lake El. (msl)	Area (acres)	Storage (ac-ft)	Runoff (ac-ft)	Evap. (ac-ft)	Discharge (ac-ft)	End of Year Storage (ac-ft)
1955	1000*	543	2300	1431	1162	269	2300
1956	1000	543	2300	638	1033		1905
1957	999.5	449	1905	472	849		1528
1958	999.0	360	1528	289	751		1066
1959	998.4	251	1066	1287	541		1812
1960	999.4	427	1812	467	913		1366
1961	998.8	322	1366	286	744		908
1962	998.2	213	908	741	387		1262
1963	998.6	297	1262	813	584		1491
1964	998.9	351	1491	842	798		1535
1965	999.0	362	1535	1128	734		1929
1966	999.5	455	1929	962	879		2012
1967	999.6	475	2012	557	1131		1438
1968	998.9	339	1438	1464	661		2241
1969	999.9	529	2241	1063	1103		2201
1970	999.9	520	2201	1174	1141		2234
1971	999.9	527	2234	2285	1180	1039	2300
1972	1000	543	2300	1239	1214	25	2300
1973	1000	543	2300	2239	1248	991	2300
1974	1000	543	2300	1741	1281	460	2300
1975	1000	543	2300	2629	1181	1448	2300
1976	1000	543	2300	872	1406		1766
1977	999.3	417	1766	947	957		1760
1978	999.3	414	1760	641	1034		1367
1979	998.8	322	1367	401	733		1035
1980	998.3	244	1035	1408	545		1898

*Assumed elevation

elevations where a natural balance exists between inflow and evaporation. During very wet years, the lakes may be at a slightly higher elevation. However, during dry years the lake elevations would decrease.

By constructing a drainage channel, with the control elevation to be the same elevation as shown on the quad maps, any excess water is drained off. Therefore, the lake level is never allowed to get much higher than this control elevation, as it could under normal conditions. During dry years, evaporation may draw the lake level down lower than under the normal condition.

The amount of land runoff, precipitation falling directly on the lake, and evaporation from these lakes was determined to be:

	80%	50%
Land Runoff (acre-feet)	89	276
Precipitation on Lakes (acre-feet)	409	529
Evaporation (acre-feet)	691	927

Evaporation would exceed total inflow by 193 acre-feet during the 80 percent year and by 122 acre-feet during the 50 percent year.

For the 4.5 square mile area which contributes directly to Rost Lake, a water budget was also calculated. It was assumed that the water elevation at the beginning of 1955 would be 2144 msl, as shown on the quad map. At this elevation, the lake would have a surface area of 360 acres. (An area-capacity curve for the lake is shown in Figure 3.) It was also assumed that the proposed dam, on the downstream side of School Section Lake, was in place. It would have a control elevation of 2150 msl. The amount of water obtained from the 3.8 square mile area upstream, would be added to the total inflow of the lake.

Starting in 1955, the elevation of Rost-School Section Lake was determined, assuming that Alternative 1 was in place. As shown in Table

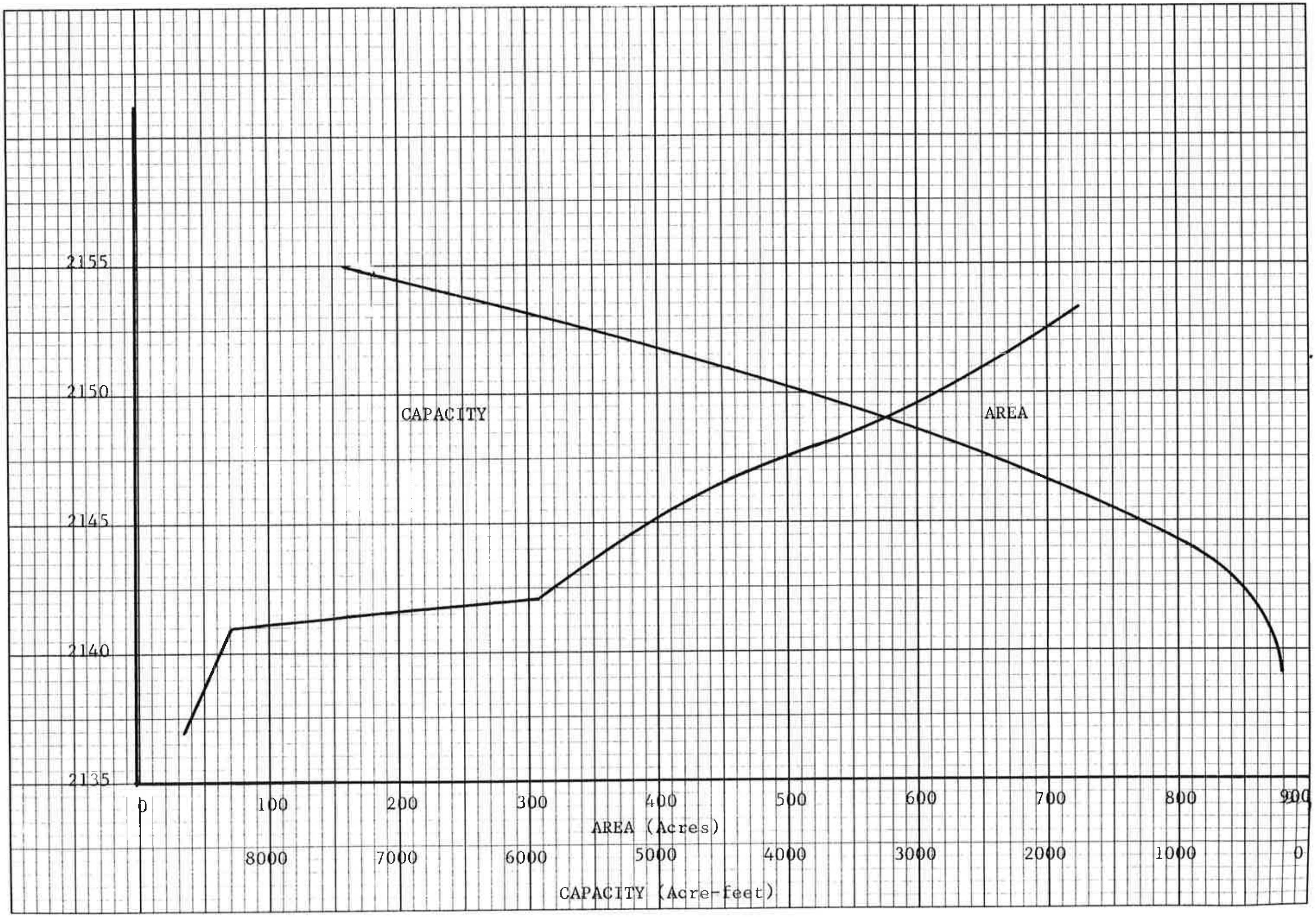


FIGURE 3 - AREA - CAPACITY CURVE FOR ROST-SCHOOL SECTION LAKE DAM

2, for the 26 years of record, there would be 5 years when water would overflow the spillway. These are 1971 through 1975, all very wet years. Other than these wet years, the elevation of the lake varies widely. Total inflow and evaporation for the 80 and 50 percent chance years was determined to be:

	80%	50%
Inflow from Upstream Lakes (acre-feet)	0	2
Land Runoff (acre-feet)	123	380
Precipitation on Lakes (acre-feet)	484	694
Evaporation (acre-feet)	827	1030

Evaporation would exceed total inflow by 220 acre-feet during the 80 percent chance of occurrence. This shows that the lake would not be able to maintain itself at its control elevation. During the 50 percent chance, inflow would exceed evaporation by 46 acre-feet.

Alternative 2

For this alternative, all the upstream lakes were completely drained. Rost-School Section Lake was assumed to have an initial elevation of 2144.0 msl, and a water surface area of 360 acres. The total land area contributing to the lake is 8.3 square miles. By using the historical evaporation and precipitation values, starting in 1955, the water budget can be determined as if this alternative was in place.

Table 3 shows the water balance from 1955 to 1980. As shown, all but one of the years from 1965 to 1975 have water discharging over the spillway. This was a period in which the precipitation was much higher than normal. The lake elevation is fairly erratic during the remaining years, changing in elevation by several feet during a 1 year period.

In order to see if Rost-School Section Lake could maintain its

TABLE 2

Rost-School Section Lake
Including Upstream Lake Runoff
Alternative 1

Year	Lake El.	Area	Storage	Upstream Discharge	Rost L. Runoff Land	Rost L. Runoff Lake	Evap.	Spillway Discharge	End of Year Storage
1955	2144	360	1000	269	763	611	771		1872
1956	2146.2	438	1872		75	473	833		1587
1957	2145.5	410	1587		55	396	775		1263
1958	2144.8	383	1263		32	283	799		779
1959	2143.5	349	779		1099	660	752		1786
1960	2145.8	423	1786		57	420	905		1358
1961	2145.0	392	1358		38	314	906		804
1962	2143.6	350	804		545	536	636		1249
1963	2144.7	382	1249		499	575	751		1572
1964	2145.4	408	1572		448	597	927		1690
1965	2145.7	420	1690		716	704	852		2258
1966	2147.0	474	2258		426	689	915		2458
1967	2147.4	494	2458		69	529	1177		1879
1968	2146.2	438	1879		1087	838	854		2956
1969	2148.5	540	2950		420	786	1125		3031
1970	2148.6	560	3031		517	867	1228		3187
1971	2148.8	579	3187	1039	1570	1258	1276	1928	3850
1972	2150.0	618	3850	25	529	969	1381	142	3850
1973	2150.0	618	3850	991	1453	1338	1420	2362	3850
1974	2150.0	618	3850	460	977	1168	1458	1147	3850
1975	2150.0	618	3850	1448	1841	1459	1344	3404	3850
1976	2150.0	618	3850		235	797	1600		3282
1977	2149.0	576	3282		444	859	1322		3263
1978	2148.9	575	3263		182	704	1437		2712
1979	2148.0	530	2712		71	571	1206		2148
1980	2146.7	462	2148		1198	913	1032		3227

TABLE 3

Rost-School Section Lake
Including Upstream Area
Alternative 2

Year	Lake El.	Area	Storage	Runoff Land	Runoff Lake	Evap.	Spillway Discharge	End of Year Storage
1955	2144.0	360	1000	1408	611	771		2248
1956	2147.0	473	2248	221	511	899		2081
1957	2146.5	450	2081	104	435	851		1770
1958	2145.9	427	1770	61	316	891		1256
1959	2144.7	384	1256	1984	726	828		3138
1960	2148.8	565	3138	107	561	1208		2598
1961	2147.7	515	2598	71	412	1190		1891
1962	2146.2	434	1891	971	665	788		2739
1963	2148.0	528	2739	898	795	1038		3394
1964	2149.2	582	3394	796	852	1323		3719
1965	2149.8	610	3719	1286	1023	1237	941	3850
1966	2150.0	618	3850	766	898	1193	471	3850
1967	2150.0	618	3850	124	662	1472		3164
1968	2148.8	570	3164	1976	1090	1112	1268	3850
1969	2150.0	618	3850	771	900	1288	383	3850
1970	2150.0	618	3850	936	956	1355	537	3850
1971	2150.0	618	3850	2953	1364	1384	2933	3850
1972	2150.0	618	3850	1020	969	1381	608	3850
1973	2150.0	618	3850	2800	1338	1420	2718	3850
1074	2150.0	618	3850	1883	1168	1458	1593	3850
1975	2150.0	618	3850	3547	1459	1344	3662	3850
1976	2150.0	618	3850	452	797	1600		3499
1977	2149.4	594	3499	845	883	1363	14	3850
1978	2150.0	618	3850	347	757	1544		3410
1979	2149.3	590	3410	133	635	1342		2836
1980	2148.2	540	2836	2205	1067	1206	1052	3850

level, the inflow and evaporation were determined for the 80 and 50 percent occurrences.

	80%	50%
Land Runoff (acre-feet)	236	717
Precipitation on Lake (acre-feet)	580	815
Evaporation (acre-feet)	1000	1219

Evaporation would exceed total inflow by 184 acre-feet during the 80 percent chance. According to the usual guidelines, this would show that there is not adequate inflow to maintain the water surface elevation of Rost-School Section Lake. During the 50 percent chance, total inflow provides a surplus of only 313 acre-feet over evaporation.

IV. STABILIZING LAKE METIGOSHE

By looking at Rost Lake by itself, without being concerned with discharging into Lake Metigoshe, insufficient inflow is available - during the 80 percent chance to maintain its control elevation of 2150.0 msl. This is true for both Alternative 1 and 2. This is the normal procedure to determine whether adequate water is available for a proposed reservoir. Using these guidelines, the project should not be constructed due to an inadequate volume of inflow.

Because of the nature of this project, calculations were carried further. The entire system was looked at. It was determined how much water was required to raise Lake Metigoshe to its control elevation, 2138.0 msl. Through the use of a low level drawdown system, installed at an elevation of 2140.0 msl, the water level in Rost-School Section Lake, could be discharged into Lake Metigoshe. In this manner, the level of Lake Metigoshe could be stabilized.

Under existing conditions, Lake Metigoshe receives a small amount of discharge from the 4.5 square mile area around Rost Lake and School Section Lake. With the proposed dam in place, this water would be stored in Rost-School Section Lake, rather than entering Lake Metigoshe. This volume of water would have been accounted for in the earlier calculations for Rost-School Section Lake. Therefore, if the proposed dam was in place, and no discharge from Rost-School Section Lake, the level of Lake Metigoshe would have been slightly reduced, due to this reduction in flow.

In order to determine the volume of flow which Lake Metigoshe had received from this area, since 1955, a water balance was performed. School Section Lake was assumed to be at an elevation of 2144.0 at the beginning of this period. This is the elevation shown on the quadrangle map and also was assumed to be the elevation which water will begin to outflow to Lake Metigoshe.

As shown in Table 4, Lake Metigoshe should have received flow from School Section Lake during the majority of the years. During the drier years, the level of School Section Lake recedes. Then Lake Metigoshe would not benefit from any inflow from this area.

Table 5 shows the historical end of year elevations of Lake Metigoshe. Even during the lowest period of this 26 years of record, 1958, the elevation of Lake Metigoshe was only 1.5 feet below its outlet elevation. For several years of record during the early 1970's, the end of year water elevation was higher than the outlet elevation of 2138.0. Either the lake was still discharging or flashboards were in place.

The elevation of Lake Metigoshe was adjusted by subtracting the inflow which it had received from the School Section Lake area. This amount of inflow would not have entered Lake Metigoshe had the proposed dam been constructed. During some years, this flow had no effect on the end of the year elevation of Lake Metigoshe because water was going over the outlet structure. Even without this additional flow, much water would have discharged from Lake Metigoshe. For these years, no alteration to the water level were necessary. For years when Lake Metigoshe did not overflow its outlet structure, a correction was made to the end of year water surface elevation. The elevation was lowered according to the volume of water that would have been retained in the proposed Rost-School Section Lake. The area-capacity curve for Lake Metigoshe, Figure 4, was used to determine the altered elevation.

TABLE 4

School Section Lake
Runoff-vs-Evaporation

Year	Lake El. (msl)	Area (acres)	Storage (ac-ft)	Runoff Land (ac-ft)	Runoff Lake (ac-ft)	Evap. (ac-ft)	Discharge To Lake Metigoshe (ac-ft)	End of Year Storage (ac-ft)
1955	2144.0	360	1000	763	611	711	603	1000
1956	2144.0	360	1000	77	389	685		781
1957	2143.5	349	781	57	337	660		515
1958	2142.5	320	515	33	237	667		118
1959	2137.5	40	118	1195	76	86	303	1000
1960	2144.0	360	1000	58	357	770		645
1961	2143.1	335	645	39	268	774		178
1962	2138.7	51	178	592	78	93		755
1963	2143.4	342	755	510	515	672	108	1000
1964	2144.0	360	1000	448	527	818	157	1000
1965	2144.0	360	1000	732	604	730	606	1000
1966	2144.0	360	1000	436	523	695	264	1000
1967	2144.0	360	1000	70	386	857		599
1968	2142.8	330	599	1136	631	644	722	1000
1969	2144.0	360	1000	439	524	750	213	1000
1970	2144.0	360	1000	554	557	790	321	1000
1971	2144.0	360	1000	1682	795	806	1671	1000
1972	2144.0	360	1000	581	565	805	341	1000
1973	2144.0	360	1000	1595	780	827	1548	1000
1974	2144.0	360	1000	1073	680	849	904	1000
1975	2144.0	360	1000	2021	850	783	2088	1000
1976	2144.0	360	1000	258	464	932		790
1977	2143.5	348	790	485	517	799		994
1978	2144.0	360	994	195	441	899		731
1979	2143.3	349	731	76	376	794		389
1980	2141.5	180	389	1307	356	402	650	1000

TABLE 5

Elevation of Lake Metigoshe

Year	December Elevation of Lake Metigoshe	Maximum Elevation of Lake Metigoshe	Overflow Over Weir (ac-ft)	Inflow From School Section Lake (ac-ft)	Lake Metigoshe El. w/o SS Lake Inflow	Volume Required to* Raise Lake Metigoshe to El. 2138.0
1955	2137.95	2139.00	11,660	603	2137.95 1/	91 2/
1956	2137.96	2138.54	4,820		2137.96	73 2/
1957	2137.57	2138.28	1,220		2137.57	778 2/
1958	2136.47	2137.87	0		2136.47	1960 3/
1959	2137.76	2137.76	0	303	2137.56	0 3/
1960	2137.53	2139.01	4,840		2137.53	850 2/
1961	2136.77	2137.87	0		2136.77	1600 3/
1962	2137.47	2137.72	0		2137.47	373 3/
1963	2137.32	2138.71	1,400	108	2137.32	1222 2/
1964	2137.92	2138.43	130	157	2137.90	181 2/
1965	2138.02	2138.64	2,670	606	2138.02 1/	0 2/
1966	2137.44	2138.45	2,350	264	2137.44	1009 2/
1967	2137.71	2138.11	0		2137.71	524 2/
1968	2138.05	2138.33	364	722	2137.81	344 2/
1969	2137.82	2139.25	6,290	213	2137.82 1/	326 2/
1970	2137.74	2139.00	1,580	321	2137.74 1/	468 2/
1971	2138.18	2138.96	1,940	1671	2138.18	0 2/
1972	2137.66	2139.05	5,890	341	2137.66	614 2/
1973	2138.10	2138.17	36	1548	2137.11	1597 2/
1974	2138.10	2139.13	6,910	904	2138.10	0 2/
1975	2138.25	2139.70	17,520	2088	2138.25	0 2/
1976	2137.59	2139.60	10,520		2137.59	740 2/
1977	2137.34	2137.86	0		2137.34	776 3/
1978	2136.80	2137.75	0		2136.80	1417 3/
1979	2136.70	2137.91	0		2136.70	1800 3/
1980	2136.76	2136.97	0	650	2136.20	550 3/

* Assuming that the previous years requirements were met.

1/ Inflow from School Section Lake assumed not to affect lake level. It is discharged over weir.

2/ Water had discharged over weir during that year. Water required is from top of weir (El. 2180) to Dec. Level.

3/ Water had not discharged over weir. Water required is the difference in the maximum elevation and the December elevation of that year.

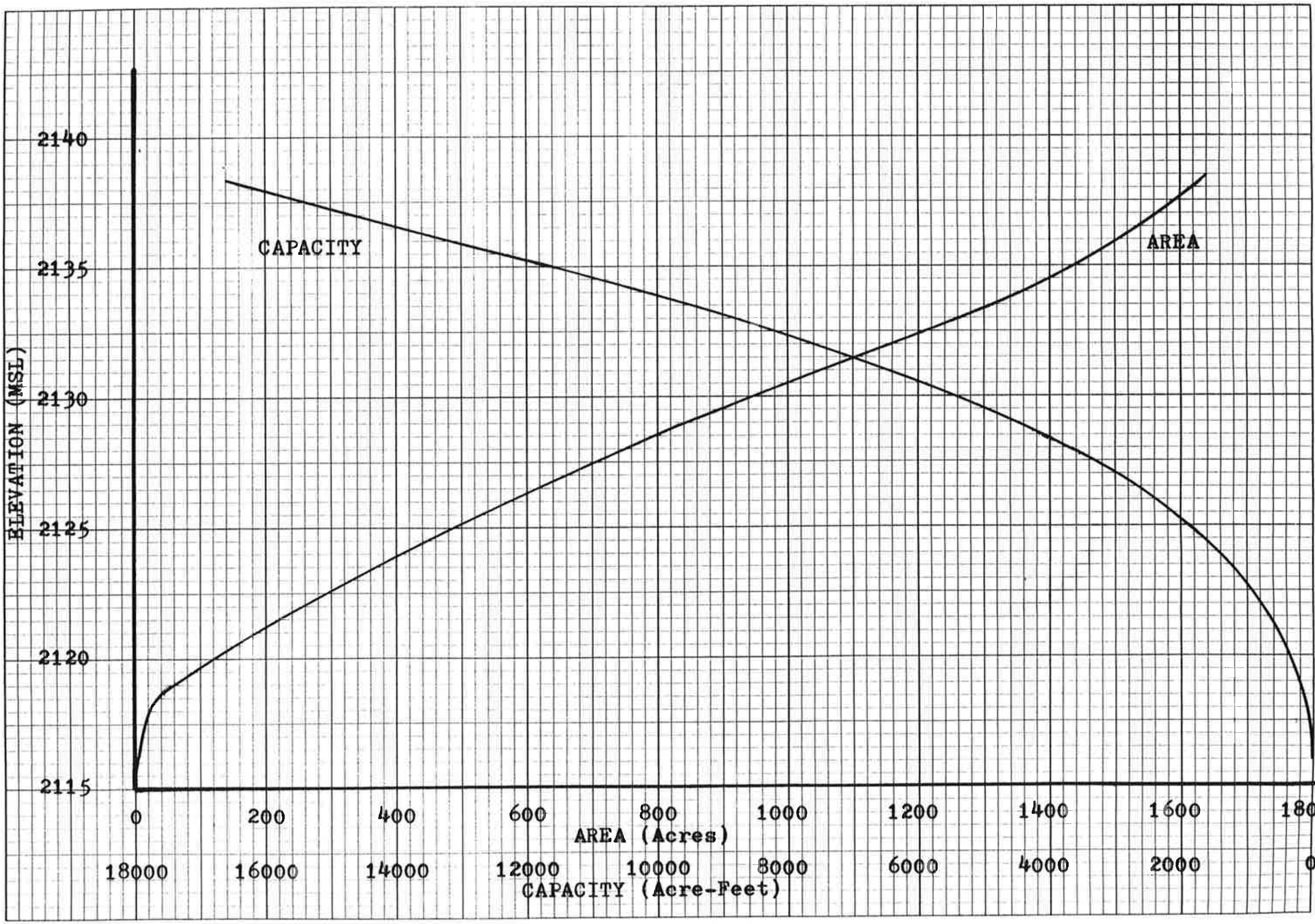


FIGURE 4 - AREA - CAPACITY CURVE FOR LAKE METIGOSHE

The yearly volume of water required to raise Lake Metigoshe to its control elevation was determined by looking at its end of the year elevation. If the lake discharged during the year, the volume of water needed to raise it from its end of year elevation to its control elevation of 2138 msl was found from the area-capacity curve. An increase in the previous year's elevation would have no affect on the present year's elevation, during these years, because excess water was discharged anyway. During the years that the lake had not discharged, however, an increase in the previous year's elevation would also cause the present year's elevations to increase. The additional increase in elevation required would then be the difference between the maximum elevation and the December elevation of that year.

The main goal of this project was to stabilize the level of Lake Metigoshe. This was to be accomplished by discharging the stored water in Rost-School Section Lake into Lake Metigoshe. The low level drain would be opened during the late summer in hopes of bringing Lake Metigoshe up to its control elevation. The yearly volume of water required to do this was shown in Table 5.

For both Alternative 1 and 2, a water budget analysis was run, starting in 1955. Rost-School Section Lake was allowed to be drawn completely down to elevation 2140.0 msl. This was done whenever Lake Metigoshe was in need of this much water. Due to the uncertainty of conditions, no additional inflow was assumed to be available from Sharpe Lake. The water budget analysis was run on a yearly basis. The area of Rost Lake at the end of each year was used to determine the amount of evaporation for the following year. This would tend to paint an optimistic picture of the entire project. In the actual world, spring runoff would increase the size of Rost-School Section Lake. This increased area would cause more evaporation which would reduce the volume of water available to Lake Metigoshe.

Alternative 1

As shown in Table 6, during years in which a small amount of inflow is needed by Lake Metigoshe, Rost Lake is capable of providing it. However, during the years when Lake Metigoshe is in the most need of additional runoff, very little is available from Rost Lake. As can be seen, the level of Rost Lake is drawn down severely during a relatively dry year. If the following year is dry, Rost Lake will have no surplus water for Lake Meitogshe. This is the time when the surplus water is most in demand. During the very dry years, Rost Lake is only capable of providing a very small amount of water. Figures 5 and 6 show the effects on the elevations of Rost-School Section Lake and Lake Metigoshe.

During the average year, the level of Lake Metigoshe does not suffer much decline in elevation. Additional water for Lake Metigoshe is needed only during the more extreme years when evaporation greatly exceeds inflow. It is during these drier years that the level of Lake Metigoshe is the lowest.

A water balance was determined for Rost-School Section Lake. With units of acre-feet, the results for the 80 and 50 percent chance of occurrence are shown below.

	80%	50%
Inflow from Upstream Lakes	0	2
Land Runoff	128	398
Precipitation Falling Directly on Rost Lake	167	398
Evaporation from Rost Lake	269	612
Volume Required by Lake Metigoshe	1362	242

TABLE 6

Rost-School Section Lake
Supplementing Lake Metigoshe
Alternative 1

Year	Rost Lake Elevation (msl)	Rost Lake Area (ac-ft)	Rost Lake Storage (ac-ft)	Runoff into Rost Lake Upstream (ac-ft)	Runoff into Rost Lake Land (ac-ft)	Runoff into Rost Lake Lake (ac-ft)	Evap. (ac-ft)	Discharge Weir (ac-ft)	Discharge Drawdown (ac-ft)	End of Year Storage (ac-ft)	Possible El. of Lake Metigoshe (msl)
1955	2144.0	360	1000	269	763	611	711		91	1781	2138.00
1956	2145.8	422	1781		75	456	803		73	1436	2138.00
1957	2145.2	400	1436		55	387	756		778	344	2138.00
1958	2141.2	110	344		35	81	229		6 1/	225	2136.90
1959	2140.0	62	225		1195	117	134		16	1387	2138.00
1960	2145.0	391	1387		58	388	836		772 1/	225	2137.96
1961	2140.0	62	225		42	50	143		0 1/	174	2136.90
1962	2138.7	51	174		592	78	93		373	378	2138.00
1963	2141.5	168	378		510	494	645		512 1/	225	2137.66
1964	2140.0	62	225		498	91	141		181	492	2138.00
1965	2142.3	315	492		748	528	639		0	1129	2138.02
1966	2144.4	375	1129		436	545	724		1009	377	2138.00
1967	2141.5	168	377		75	180	400		7 1/	225	2137.71
1968	2140.0	62	225		1235	119	121		344	1114	2138.00
1969	2144.4	373	1114		439	543	777		326	993	2138.00
1970	2144.0	361	993		554	559	792		468	846	2138.00
1971	2143.7	352	846	1039	1682	777	788		0	3556	2138.18
1972	2149.5	600	3556	25	542	941	1341		614	3109	2138.00
1973	2148.7	564	3109	991	1489	1222	1296	1665	0 2/	3850	2138.00
1974	2150.0	618	3850	460	953	1168	1458	1123	0	3850	2138.10
1975	2150.0	618	3850	1448	1886	1459	1344	3449	0	3850	2138.25
1976	2150.0	618	3850		241	797	1600		740	2548	2138.00
1977	2147.6	510	2548		454	758	1170		776	1814	2138.00
1978	2146.0	430	1814		191	552	1127		1205 1/	225	2137.86
1979	2140.0	62	225		76	67	141		2 1/	225	2136.79
1980	2140.0	62	225		1280	123	138		1265 1/	225	2137.13

1/ Adequate discharge was not availabe to raise Lake Metigoshe to El. 2138.0 msl.
2/ The large spring discharge increased the level of Lake Metigoshe enough so that no additional fall discharge would be required. The elevation of Lake Metigoshe would still be 2138.0 msl.

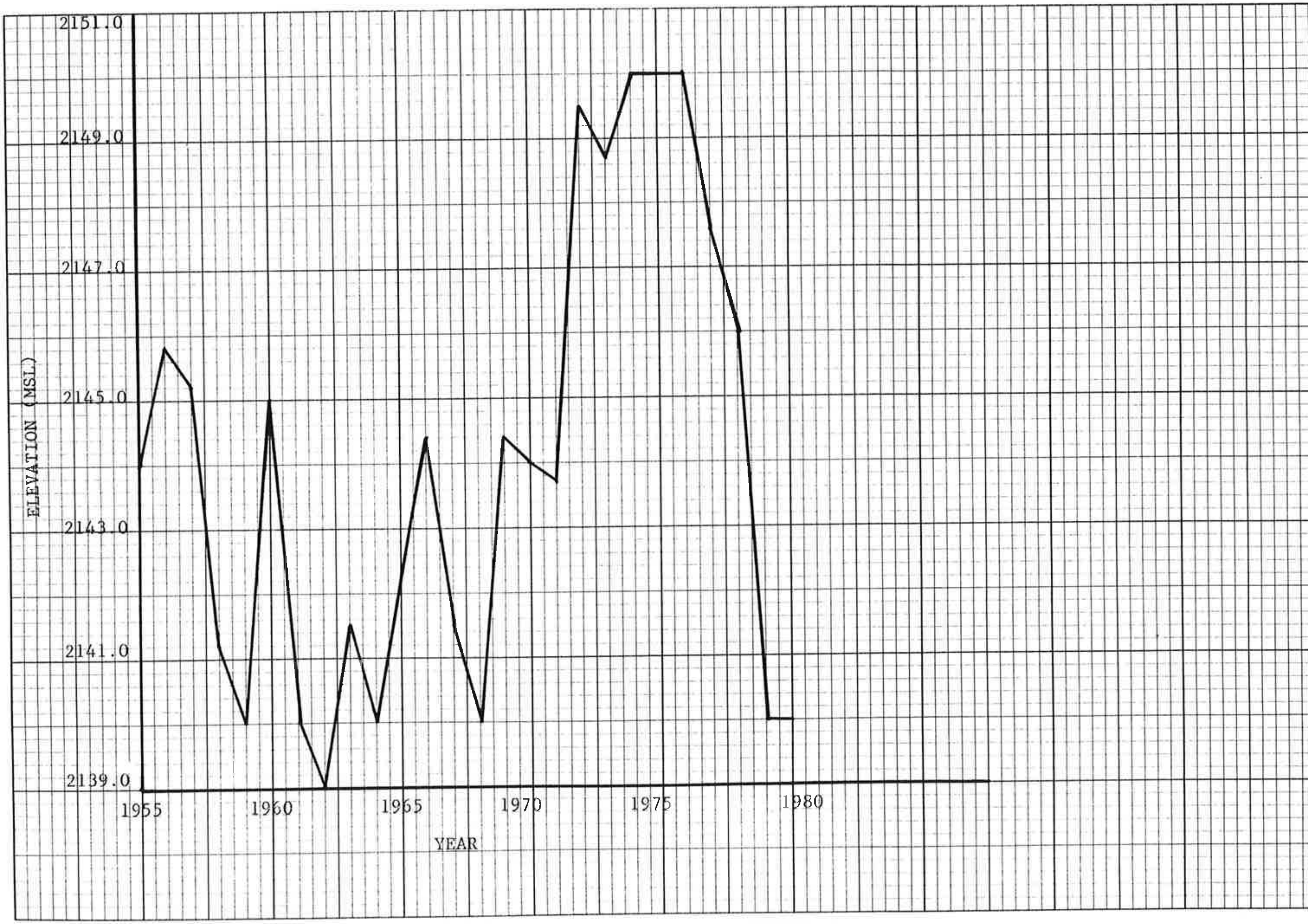


FIGURE 5 - ROST-SCHOOL SECTION LAKE ELEVATIONS FOR ALTERNATIVE 1

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FIGURE 6 - LAKE METIGOSHE ELEVATIONS FOR ALTERNATIVE 1

Only 26 acre-feet, when 1,362 acre-feet were required, would be available to Lake Metigoshe during the 80 percent chance of occurrence. This small amount of inflow would have no affect on the water surface elevation of Lake Metigoshe. During the 50 percent chance of occurrence, 186 acre-feet of the 242 acre-feet required by Lake Metigoshe would be available. There seems to be no urgent need for surplus water during this frequency event. When requiring 242 acre-feet of water, the water elevation of Lake Metigoshe would only be 0.2 foot below its control elevation.

Evaporation losses were very small for Rost-School Section Lake. Through the use of its low level drawdown system, the water surface elevation of Rost-School Section Lake was greatly lowered. Therefore, its surface area was also greatly reduced, causing this reduction in evaporation. Because very little could be maintained in Rost-School Section Lake, surplus water available to Lake Metigoshe would also be greatly reduced.

Because such a small amount of runoff is normally received from the upstream lakes, almost identical results would be achieved if the upstream channels were not constructed. Only Rost-School Section Lake Dam and the channels connecting Rost Lake, School Section Lake, Lake McDonald, and Lake Metigoshe would need to be constructed to get these results.

Alternative 2

By using the same procedure, a water balance was determined for the case in which all the upstream lakes were drained. All units are in acre-feet.

	80%	50%
Precipitation Falling Directly on Rost Lake	353	646
Land Runoff to Rost Lake	231	720
Evaporation From Rost Lake	615	1063
Weir Outlet From Rost Lake	0	2
Lake Metigoshe Demand	1362	242

Lake Metigoshe requires 1,362 acre-feet of excess runoff during the 80 percent chance. Yet, evaporation from Rost-School Section Lake exceeds total inflow by 31 acre-feet. Rost-School Section Lake could provide the entire demand of Lake Metigoshe during the 50 percent chance. But, again, there is no real need for surplus water during this event.

As shown in Table 7, there would be a sufficient supply of water to raise Lake Metigoshe to its control elevation for most years. During these years, however, Lake Metigoshe does not require much surplus water. It is during the period of two consecutive dry years that the level of Lake Metigoshe is greatly reduced. Because the level of Rost-School Section Lake would be drawn down during the first of these dry years, there would be no surplus water available to stabilize the level of Lake Metigoshe during the second dry year. This is the time when the surplus water is needed the most. It would not be available. This is what happens during 1958, 1961, and 1979. The effects on the elevations of Rost-School Section Lake and Lake Metigoshe are shown graphically in Figures 7 and 8.

TABLE 7

Rost-School Section Lake
Supplementing Lake Metigoshe
Alternative 2

Year	Rost Lake Elevation (msl)	Rost Lake Area (acres)	Rost Lake Storage (ac-ft)	Runoff Land (ac-ft)	Runoff Lake (ac-ft)	Evap. (ac-ft)	Spillway Discharge Weir (ac-ft)	Spillway Discharge Drawdown (ac-ft)	End of Year Storage (ac-ft)	Revised El. of Lake Metigoshe (msl)
1955	2144.0	360	1000	1408	611	771		91	2157	2138.00
1956	2146.8	465	2157	140	502	884		73	1842	2138.00
1957	2146.1	432	1842	101	418	816		778	767	2138.00
1958	2143.4	342	767	61	253	713		143 1/	225	2136.98
1959	2140.0	62	225	2103	117	134		0	2311	2138.00
1960	2147.1	480	2311	106	476	1026		850	1017	2138.00
1961	2144.2	365	1017	70	292	843		311 1/	225	2137.11
1962	2140.0	62	225	1042	95	113		373	876	2138.00
1963	2143.8	355	876	921	534	698		1222	411	2138.00
1964	2141.9	280	411	836	410	636		181	840	2138.00
1965	2143.7	352	840	1351	590	714		0	2067	2138.02
1966	2146.5	450	2067	785	654	869		1009	1628	2138.00
1967	2145.6	412	1628	128	441	981		524	692	2138.00
1968	2143.2	338	692	2051	646	659		344	2386	2138.00
1969	2147.2	482	2386	790	702	1005		326	2547	2138.00
1970	2147.6	505	2547	996	781	1108		468	2748	2138.00
1971	2148.0	529	2748	2990	1168	1185	1871	0	3850	2138.18
1972	2150.0	618	3850	1020	969	1381	608 2/	614	3236	2138.00
1973	2149.0	575	3236	2836	1245	1322	2145	0 3/	3850	2138.10
1974	2150.0	618	3850	1883	1168	1458	1593	0	3850	2138.10
1975	2150.0	618	3850	3547	1459	1344	3662	0	3850	2138.25
1976	2150.0	618	3850	453	797	1600		740	2760	2138.00
1977	2148.0	530	2760	856	787	1216		776	2411	2138.00
1978	2147.3	490	2411	352	600	1224		1417	722	2138.00
1979	2143.4	342	722	138	368	778		225 1/	225	2136.94
1980	2140.0	62	225	2260	123	138		2245 1/	225	2137.94

Attempted to stabilize Lake Metigoshe at El. 2138.00

1/ Adequate discharge was not available to raise Lake Metigoshe to El. 2138.0.

2/ Rost Lake discharged over weir. This discharge did not increase the end of year elevation of Lake Metigoshe, as it also was overflowing its weir. Fall discharge also needed.

3/ Such a large spring discharge increased the level of Lake Metigoshe enough so that no additional fall discharge would be required. Elevation of Lake Metigoshe would still be 2138.0.

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FIGURE 7 ROST-SCHOOL SECTION LAKE ELEVATIONS FOR ALTERNATIVE 2

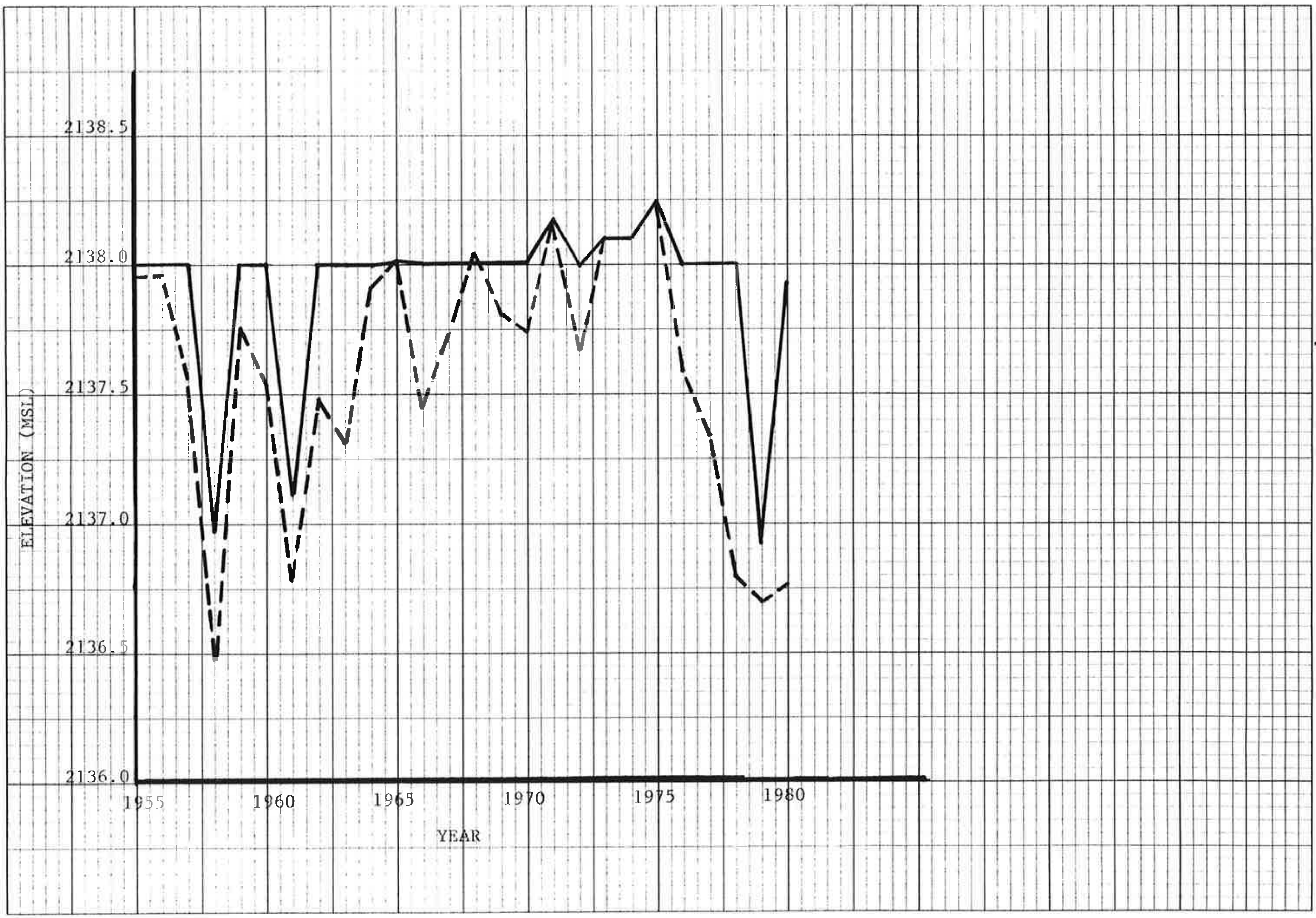


FIGURE 8 - LAKE METIGOSHE ELEVATIONS FOR ALTERNATIVE 2

V. ENVIRONMENTAL ASSESSMENT

Any environmental impacts, caused by this project, must be taken into account. By constructing a dam downstream from School Section Lake, a reservoir will be created. This reservoir would include the area of School Section Lake, Rost Lake, and Hanson Meadow. An additional amount of State Park land, hay land, and many trees would be flooded.

Under Alternative 1, a drainage ditch would connect the upstream lakes at the elevation shown on the quadrangle map. This may cause these lakes to be slightly lower than normal during dry periods. Excess water during wet periods would be drained off, not allowing the water elevation to get as high as it normally would.

All the upstream lakes would be completely drained with Alternative 2. Permission would have to be granted by the landowners in order to drain these lakes. State permission may be required if the lakes are meandered. Many of these lakes may presently be used as watering holes for cattle.

Many trees would have to be cleared to construct the channel between each lake. Each affected landowners permission would have to be obtained in order to construct the channel. By draining, or possibly even lowering these upstream lakes, the water-table level may be lowered. Water may seep from the water-table to the drainage channel.

Rost-School Section Lake would have to be severely drawn down during the drier years. This may not be acceptable to some agencies. Also, because a portion of this lake is in Canada, Canadian concerns will have to be taken into account.

VI. WATER QUALITY

During May, 1982, the North Dakota State Department of Health conducted water quality tests for several of the lakes which are proposed to be drained. These results, shown in Appendix C, indicate that the water quality is poor within these lakes. In fact, the concentrations of phosphate and nitrogen are higher in these lakes than they are in Lake Metigoshe. These are the primary causes of algae and weed growth.

By draining these lakes, all this poor quality water would be discharged to Rost-School Section Lake, and finally Lake Metigoshe. After this initial discharge, the water quality coming into Rost-School Section Lake may improve. However, it is hard to determine the extent of this improvement. Much of these nutrients come from water running off nutrient rich soil and land which was fertilized. Wetland soils have retained a large amount of these nutrients. These nutrients will be carried off by the runoff flowing over it. Therefore, even after the initial discharge, runoff from this area would still be expected to be fairly high in nitrogen and phosphate.

Apparently, the water quality of Lake Metigoshe would not be improved by any inflow from these lakes. In fact, at least for the first year, this inflow would actually tend to reduce the quality of Lake Metigoshe. Increased levels of nitrogen and phosphate would cause additional growth of algae and weeds. Water quality from these upstream lakes would improve somewhat after the first year. However, it is doubtful whether the quality of this water would ever become better than the quality existing within Lake Metigoshe. After a period of time, the water quality of each source would probably be the same.

VII. DESIGN

Rost-School Section Lake Dam

This structure would be identical whether Alternative 1 or 2 was in place. Figure 9 is a cross section through the spillway of the dam proposed at the outlet to School Section Lake. Set at an elevation of 2160 msl, the crest of the dam will be constructed with a top width of 12 feet. This will result in a structure 460 feet long and with a height of 21 feet above the stream bottom. Approximately 12,000 cubic yards of dirt will be required for the embankment. Both the upstream and downstream embankment slopes are proposed to be constructed with a 3H:1V slope. Riprap will protect the upstream slope from an elevation of 2140 msl to 2155 msl.

Proposed with a 10 foot width and 3H:1V side slopes, a cutoff trench is to be constructed below the entire length of the dam. This trench should extend downward until solid material is reached. At this time, a depth of 10 feet has been proposed for this trench. Depending on the existing soil conditions, the dimensions of this trench are subject to change. Soil conditions, predominate with sand and gravel, would increase potential foundation problems. Soil borings should be taken to see if these conditions exist at the proposed site.

To be constructed at a control elevation of 2150 msl, the service spillway will consist of a 3-foot by 3-foot reinforced concrete inlet structure with a 10-foot drop. Approximately 110 feet of 30-inch RCP would be installed for the spillway pipe. At the outlet, the spillway pipe will have an invert elevation of 2139.0 msl. Rock riprap will be installed to protect the plunge pool, which is proposed to be constructed at the outlet. This plunge pool would dissipate the hydraulic

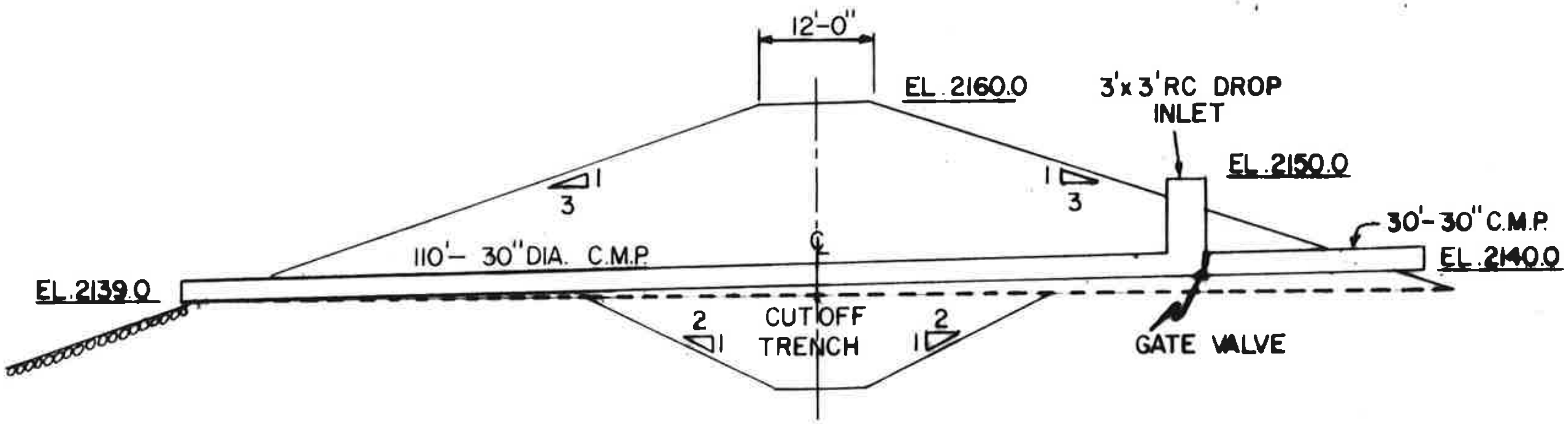


FIGURE 9 - SCHOOL SECTION LAKE DAM
(SECTION THRU SPILLWAY)
SCALE: 1" = 20'

energy of the discharging flows.

With an outlet at an elevation of 2140 msl, a low level drawdown pipe will consist of 30 feet of 30-inch RCP. At the point where this pipe attaches to the drop inlet, a gate valve will be in operation. Opening this valve will allow water to discharge from Rost Lake to Lake Metigoshe.

Within a natural saddle north of the dam site, the emergency spillway will be constructed. With a control elevation around 2155 msl, the maximum cut through this area would be 10 feet. Excavation for the emergency spillway, with a width of 200 feet and 3H:1V side slopes, would be required for approximately 500 feet. Whether Alternative 1 or 2 were to be constructed, the same construction would be required for Rost-School Section Lake Dam. The cost estimate for this structure is shown in Table 8. This does not include the cost of obtaining land. The cost of this structure will be included in the cost for Alternative 1 and 2.

Alternative 1

Peak flows between each lake were obtained for the 10-year event. Channels between each lake were designed to keep the velocity of these flows below 2.5 feet per second. Although the bottom width varied, all the channels were designed with 3H:1V side slopes. Figure 10 shows a typical cross section of the channel.

For the portion of Lateral C-1, extending from Lake 2179 upstream to the first slough above it, a channel with a 10-foot bottom width was designed. An 8-foot bottom width is adequate for the remainder of Mainline 1 and its lateral branches. All of Mainline 2 and all its

TABLE 8

Preliminary Cost Estimate

School Section Lake Dam

	Item	Quantity	Unit	Unit Price	Total
1.	Stripping, Salvaging, and Spreading Topsoil	25,000	S.Y.	0.20	$ 5,000
2.	Cutoff Trench Excavation	5,200	C.Y.	2.00	10,400
3.	Borrow Excavation	12,000	C.Y.	1.50	18,000
4.	Concrete	50	C.Y.	300.00	15,000
5.	30" Dia. RCP and Cradle	140	L.F.	55.00	7,700
6.	Rock Riprap	400	C.Y.	25.00	10,000
7.	Rock Riprap Filter	150	C.Y.	10.00	1,500
8.	Seeding	10	Acre	200.00	2,000
9.	Water	250	1,000 Gal.	3.00	750
10.	Trash Rack and Misc. Metal (valve, etc.)		L.S.	2,000.00	2,000
		Subtotal			$72,350
		Contingencies			7,550
		Engineering			7,550
		Contract Administration			7,550
		Total			$95,000

Note: Does not include the price to obtain land

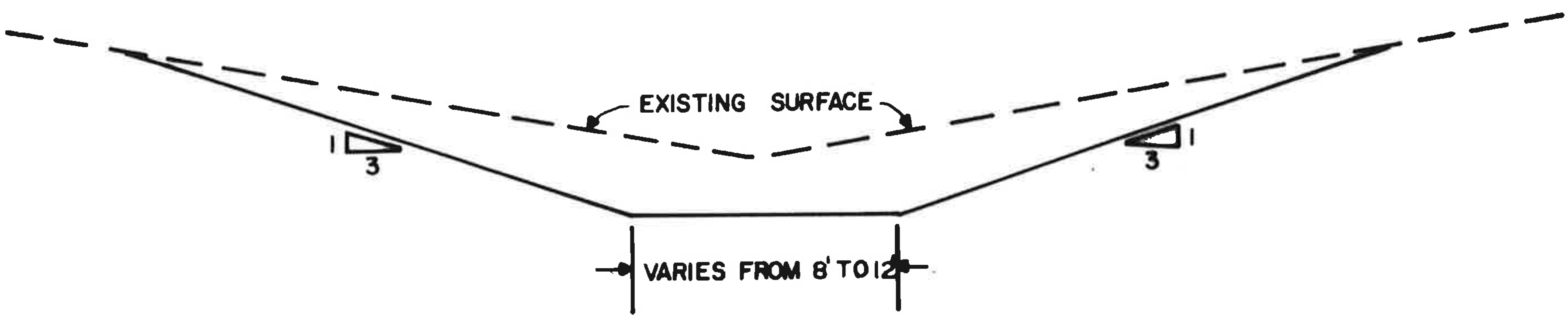


FIGURE 10 – TYPICAL CHANNEL CROSS SECTION
NOT TO SCALE

lateral branches were proposed with an 8-foot bottom width. Each outlet was selected at the elevation that the lake is shown on the quadrangle maps. Control structures, as shown in Figure 11, should be constructed at the outlets to Lake 2187 and Lake 2202. These structures will prevent erosion of the outlet, ensuring that the same outlet elevation will be maintained. They will consist of a 5-foot high embankment with an 8-foot top width and 3H:1V side slopes. Placed at the base of this embankment, the outlet structure will consist of a 30-inch diameter CMP. Roadways will be used as a control structure below Lake 2189, Lake 2179, and Mud Lake. Depending on their size and condition, the existing culverts may have to be replaced and the roads built up. Additional earthwork may also be required on the roadways at the edge of Lake 2187, School Section Lake, between Lake 2194, and between the sloughs on Lateral C-1.

A drop structure, as shown in Figure 12, will be required below Lake 2206 due to the steep slopes of the existing ground. A 13-foot riser, consisting of a 30-inch CMP, will be installed at the outlet to the lake. Approximately 200 feet of 30-inch CMP will be installed to transfer runoff from the riser to the downstream channel.

The cost estimate for this alternative is shown in Table 9. This does not include the cost for acquiring title for land. Included in the $390,000 cost is the construction of Rost-School Section Lake Dam.

If only Rost-School Section Lake Dam and the channels connecting Rost Lake, School Section Lake, Lake McDonald, and Lake Metigoshe, the total cost is estimated to be $100,000. This includes $95,000 for the dam and $5,000 for the channels.

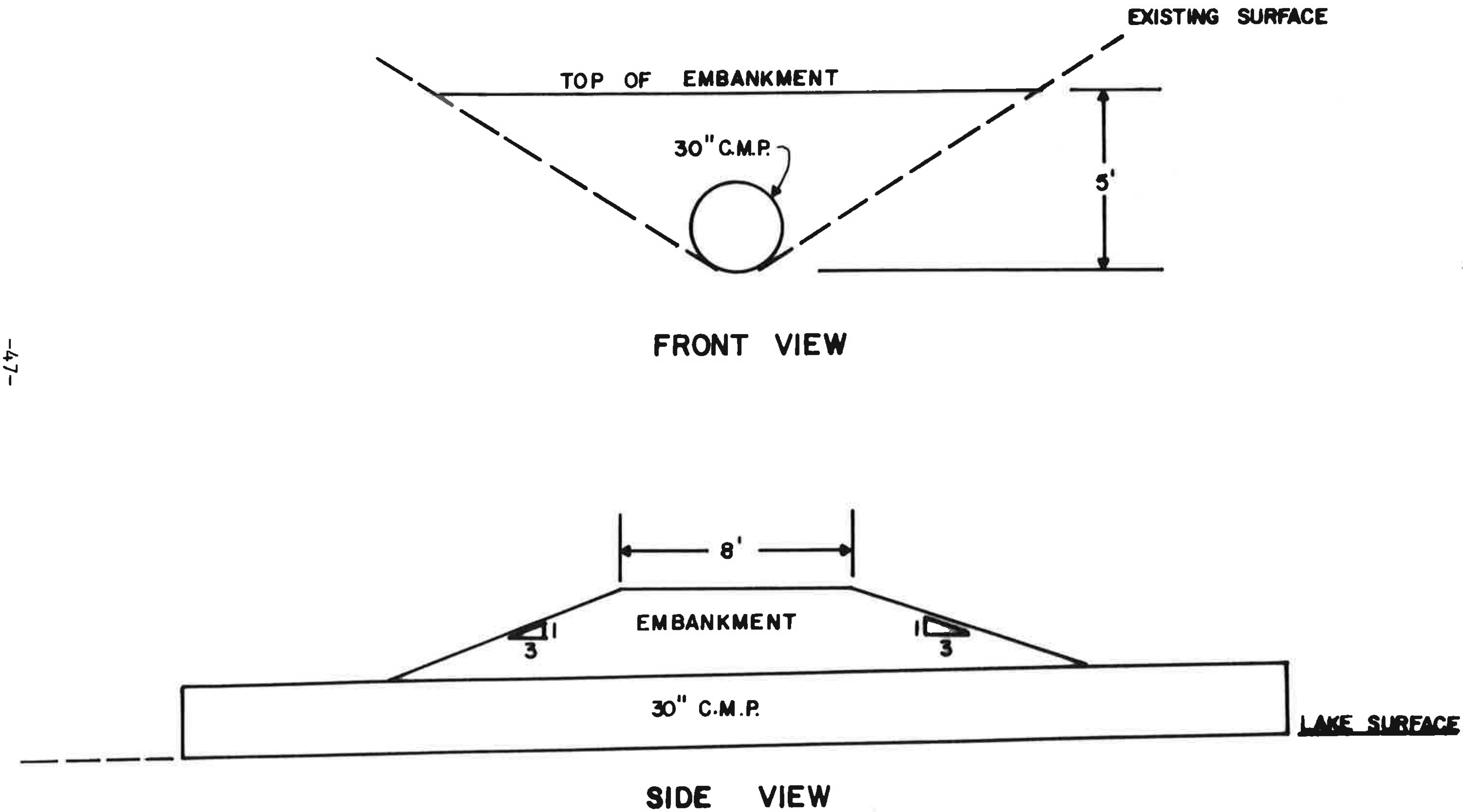


FIGURE 11 - TYPICAL CONTROL STRUCTURE
NOT TO SCALE

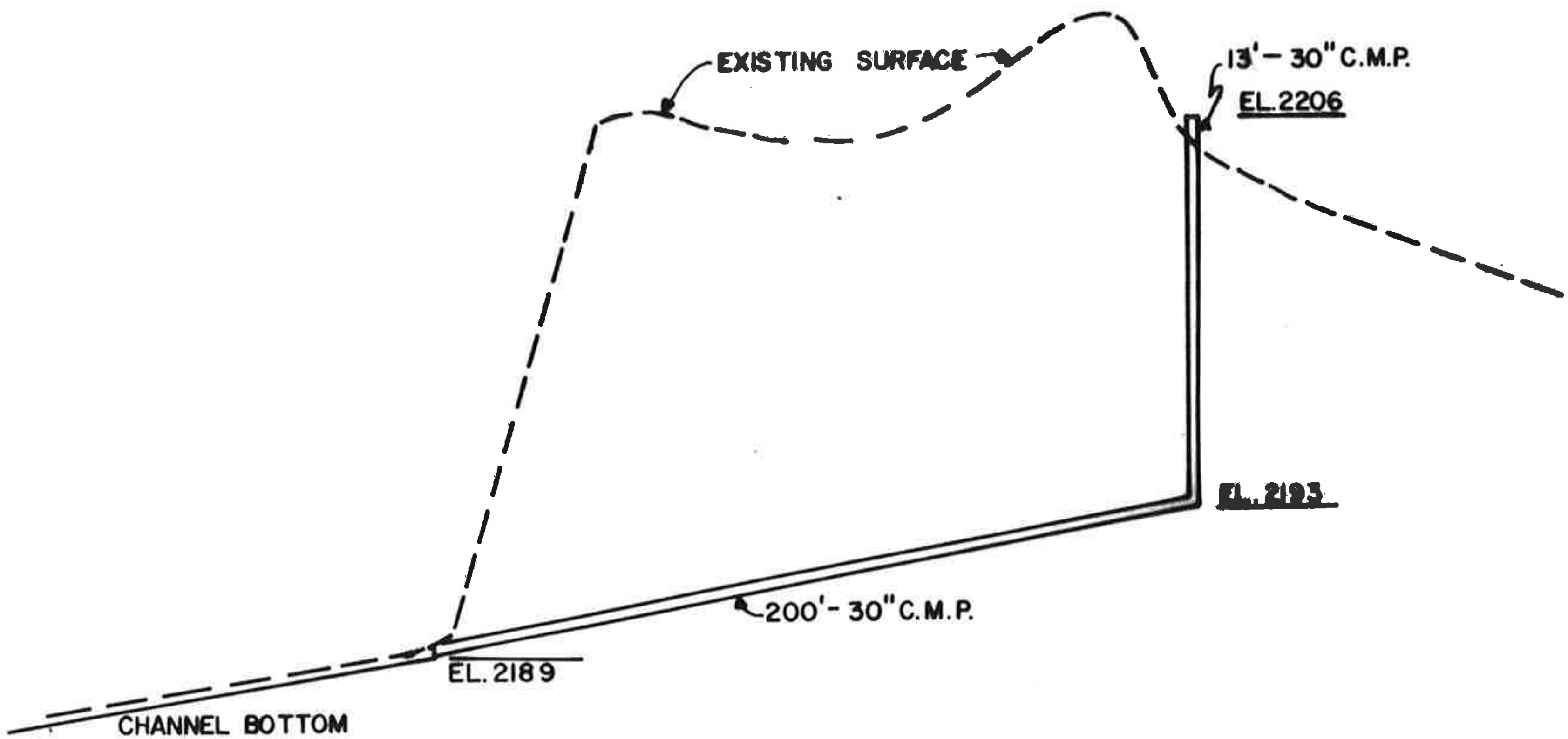


FIGURE 12-DROP STRUCTURE AT LAKE 2206

NOT TO SCALE

TABLE 9

Preliminary Cost Estimate

Alternative 1

	Item	Quantity	Unit	Unit Price	Total
1.	School Section Lake Dam		L.S.	72,350	$ 72,350
2.	Drop Structure	1	Structure	25,000	25,000
3.	Stripping, Salvaging, and Spreading Topsoil	105,000	S.Y.	0.20	21,000
4.	Excavation	90,000	C.Y.	1.75 *	157,500
5.	30" Diameter CMP	350	L.F.	35.00	12,250
6.	Earthwork (Control Structures)	4,000	C.Y.	1.25	5,000
7.	Rock Riprap	50	C.Y.	25.00	1,250
8.	Rock Riprap Filter	25	C.Y.	10.00	250
9.	Seeding	30	Acres	200.00	6,000
			Subtotal		$300,600
			Contingencies		29,800
			Engineering		29,800
			Contract Administration		29,800
			Total		$390,000

* Note: Does not include price to obtain land. All quantities for School Section Lake and drop structure below Lake 2206 were totaled separately.

Alternative 2

The channel bottom will be excavated to an elevation which will drain all the upstream lakes. Starting at School Section Lake and proceeding upstream to Lake 2179, a 12-foot bottom width will be required on Mainline 1. An 8-foot bottom width will be adequate on the remainder of the channels. An additional volume of excavation will be required due to the greater depth of cut. A 30-inch diameter pipe will be required to be installed through 6 different roadway crossings.

A concrete drop structure would be installed downstream of Lake 2179. This will allow the amount of excavation to be greatly reduced within this stretch.

As shown in Table 10, this alternative is estimated to cost $825,000. This cost estimate includes the cost of constructing Rost-School Section Lake Dam, but does not include the cost for acquiring title for land.

TABLE 10

Preliminary Cost Estimate

Alternative 2

	Item	Quantity	Unit	Unit Price	Total
1.	School Section Lake Dam		L.S.	$ 72,350	$ 72,350
2.	Drop Structure	2	Structure	29,000	58,000
3.	Stripping, Salvaging, and Spreading Topsoil	115,000	S.Y.	0.20	23,000
4.	Excavation	263,800	C.Y.	1.75	461,650
5.	30" Diameter CMP	210	L.F.	35.00	7,350
6.	Rock Riprap	50	C.Y.	25,000	1,250
7.	Rock Riprap Filter	25	C.Y.	10.00	250
8.	Seeding	48	Acres	200.00	9,600
			Subtotal		$633,450
			Contingencies		63,850
			Engineering		63,850
			Contract Administration		63 850
			Total		$825,000

VIII. CONCLUSIONS AND RECOMMENDATIONS

The level of Lake Metigoshe, with a drainage area of 59 square miles, has had a history of fluctuating over the years. The possibility of providing an alternative source of water was investigated.

A dam would be constructed at the downstream side of School Section Lake. Channels would be constructed to the small lakes upstream of Rost-School Section Lake. Presently, this 3.8 square mile area does not contribute to the inflow of Rost-School Section Lake. The channels would allow the runoff from this area to flow into Rost-School Section Lake.

It was thought that excess water could be stored in Rost-School Section Lake until summer. At this time, the level of Lake Metigoshe is normally below its outlet elevation. Water could then be discharged into Lake Metigoshe from Rost-School Section Lake. This would help stabilize Lake Metigoshe at the full pool elevation.

Two alternatives were looked at. Alternative 1, with an estimated cost of $390,000, involves constructing the channels so that all the upstream lakes would be controlled at the elevation shown on the 1956 quad map. Alternative 2, estimated to cost $825,000, consists of excavating a channel to such a depth that all the upstream lakes would be drained.

Actual precipitation records from Bottineau and evaporation records from Devils Lake were used to determine the volume of runoff which could have been stored in Rost-School Section Lake. It was found that Rost-School Section Lake would not receive enough runoff from the 80% chance precipitation to maintain its control elevation of 2150 with either Alternative 1 or 2 in place. Normally a reservoir should receive enough runoff to maintain its control elevation during the 80% chance of precipitation.

Slightly more inflow than evaporation occurs for both alternatives during the 50% chance.

Calculations were carried further, by allowing water to be discharged into Lake Metigoshe. A hypothetical case was assumed. Starting in 1955, a water balance was determined assuming that Rost-School Section Lake Dam was in place. Runoff, evaporation, and the resulting elevation of Rost-School Section Lake were calculated. Lake Metigoshe was then filled to its control elevation by discharging water from Rost-School Section Lake. This process was continued from 1955 to 1979. Rost-School Section Lake was allowed to be drained all the way to 2140 msl. During the 80% chance of runoff, a very small percentage of the volume required for Lake Metigoshe was available. With Alternative 1, 77% of the volume required by Lake Metigoshe could be supplied during the 50% chance. Alternative 2 could supply the entire demand. Very little water, however, would be required by Lake Metigoshe during this event.

Only during the very wet years is any runoff received from the upstream lakes, with Alternative 1. Therefore, nearly the same benefit would be obtained by only constructing the School Section Lake Dam and channels between Rost Lake, School Section Lake, and Lake Metigoshe. By eliminating the upstream channels, and only constructing the dam, cost of construction would be reduced from $390,000 to $100,000. This cost would include $95,000 for the dam and $5,000 for the channels. Benefits would be limited in either case, however. In order to provide any surplus water to Lake Metigoshe, Rost-School Section Lake would have to be severely drawn down during most years. Therefore, the quantity of surplus water available would be very limited. On the average, enough surplus water would be available to increase the normal water elevation of Lake Metigoshe by 0.3 foot. During some of the very dry years, however, little or no surplus water would be available.

Whenever the normal water elevation of Lake Metigoshe is within 0.5 foot of its control elevation, the proposed Alternative 2 should be able to provide enough supplemental water to fill the lake to the control elevation. If the normal lake elevation of Lake Metigoshe is more than 0.5 foot below the control elevation, however, adequate water may not be available to raise the lake level to its control elevation.

Generally, Rost-School Section Lake could be drawn down during the summer of the year. For that year, the level of Lake Metigoshe could be raised to a suitable level. If the following year is dry, no supplemental water will be available. This is the time when Lake Metigoshe is normally low. Even with Alternative 2 in place, the elevation of Lake Metigoshe would be low.

From tests taken in May 1982, it was found that the water quality of these upstream lakes are poor. The phosphate and nitrogen levels are higher in these lakes than they are in Lake Metigoshe. Those nutrients may be due to water runoff from fertilized land. Many of these nutrients are retained in the wetland soils. Over the years, runoff will carry these nutrients downstream, into Lake Metigoshe. Although it is expected that the water quality would improve after the initial discharge, it still would not be better than the quality of Lake Metigoshe.

Supplemental water would not be available when it is needed the most. The level of Lake Metigoshe is not seriously lowered until the second of two consecutively dry years. All the surplus water from Rost-School Section Lake would have been discharged into Lake Metigoshe during the previous year. No surplus would be available during the second dry year. That is the period of time that it was thought that this project would provide some benefit.

If a serious problem does not exist when the elevation of Lake Metigoshe is less than 0.5 foot below its control elevation, then it is recommended that neither Alternative 1 or 2 be constructed. Neither alternative would be able to provide a great deal of water during the years when Lake Metigoshe is much more than 0.5 foot below its control elevation. This period would be the second of two consecutive dry years.

If a serious problem does exist when the elevation of Lake Metigoshe is less than 0.5 foot below its control, then either constructing School Section Lake Dam or Alternative 2 would at least partially alleviate this problem. Due to the limited runoff obtained from the upstream area, it is recommended that the upstream channels described in Alternative 1, not be constructed. Neither choice will provide an excellent solution to the entire problem, however. By itself, School Section Lake could usually provide adequate surplus water whenever Lake Metigoshe is less than 0.5 foot below its control elevation. During the drier years, however, very little surplus water would be available. Alternative 2 could almost assure being able to fill Lake Metigoshe during those years when its normal water elevation is less than 0.5 foot below its control elevation. Some surplus water would even be available during the drier years, except for the second of two consecutive dry years. Its large cost of construction, however, would seem to outweigh the benefits. Only constructing School Section Lake Dam would seem to provide the most benefit, as compared to the cost of construction.

Being the most familiar with the area, the Oak Creek Water Resource Board would be in the best position to decide when a water shortage problem is evident on Lake Metigoshe. That decision would determine the appropriate course of action. The environmental impacts should be discussed further, before any construction were to occur. Canadian concerns will also have to be weighed.

APPENDIX A

Preliminary Investigation Agreement

SWC Project #330
January 8, 1980

AGREEMENT

PRELIMINARY INVESTIGATION BY THE NORTH DAKOTA STATE WATER COMMISSION

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vern Fahy and the Board of Commissioners, Oak Creek Water Management District, hereinafter referred to as the Board, acting through its Chairman, Lyle Knoepfle.

II. PROJECT, LOCATION AND PURPOSE

The Board has requested the Commission to investigate and determine the feasibility of supplying supplemental water to Lake Metigoshe from Rost Lake and School Section Lake during low water periods at Lake Metigoshe. This investigation shall be conducted on Rost Lake in Section 25, Township 164 North, Range 75 West, and Sections 30 and 31, Township 164 North, Range 74 West and shall include the channel between these two lakes, and the channel between School Section Lake and Lake Metigoshe.

The purpose of this investigation is to determine the condition and adequacy of the channels between the Lakes included in the study, and to assess the hydrologic characteristics of the Lakes to determine the water availability for diversion from one Lake to another. In addition, a preliminary design of structures required to divert this water and a cost estimate for these improvements shall be made.

III. PRELIMINARY INVESTIGATION

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

1. Review of Field Surveys - to gather cross sectional and profile data. If necessary, new field surveys will be made.
2. Hydrologic Analysis - to determine water availability in the Lake.
3. Preliminary Design.
4. Preliminary Cost Estimate.
5. Conclusions and Recommendations.

Subsurface exploration and design work for the final design and specification stage shall not be made under this agreement.

IV. DEPOSIT - REFUND

The Board shall deposit $1,000.00 with the Commission to partially pay the costs of the investigation. Upon completion of the investigation outlined herein, upon receipt of a request from the Board to terminate the investigation, or upon a breach of this agreement by any 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 landowner to allow the Commission to enter upon his property to conduct field surveys which may be required for the investigation.

VI. INDEMNIFICATION

The Board hereby accepts responsibility for and holds the Commission free from all claims and damages to public and private properties, rights or persons arising out of this investigation. In the event a suit is initiated or judgment rendered against the Commission, the Board shall indemnify it for any judgment arrived at or judgment satisfied.

VII. CHANGES TO AGREEMENT

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

BOARD OF COMMISSIONERS
OAK CREEK WATER MANAGEMENT DISTRICT

____
Lyle Knoepfle
Chairman

____
Date

NORTH DAKOTA STATE WATER COMMISSION

____
Vernon Fahy
State Engineer

____
Date

Distribution
Board
SWC Project #330
SWC Accountant
SWC Director of Engineering

APPENDIX B

Precipitation and Evaportion Records

PRECIPITATION AT BOTTINEAU, ND (INCHES)

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1955	0.86	0.25	1.33	1.07	1.98	3.99	4.55	2.32	2.33	0.50	0.91	0.28	20.37
1956	0.31	0.19	0.49	0.08	1.87	3.96	1.98	1.87	0.46	0.27	1.20	0.28	12.96
1957	0.22	0.25	0.34	1.16	1.19	3.28	1.21	1.48	0.44	1.69	0.25	0.09	11.60
1958	0.35	0.29	0.26	0.10	0.01	1.18	4.02	0.66	0.70	0.43	0.71	0.17	8.88
1959	0.16	0.43	0.17	0.20	2.32	3.86	2.16	6.55	3.22	2.76	0.73	0.14	22.70
1960	0.38	0.14	0.31	1.03	3.56	0.98	1.53	3.28	0.16	0.07	0.17	0.30	11.91
1961	0.25	0.59	0.04	1.07	1.18	0.85	1.15	0.51	3.77	T	0.07	0.13	9.61
1962	0.30	0.29	0.35	0.61	3.55	3.52	3.66	3.62	0.15	1.51	0.49	0.33	18.38
1963	0.05	0.19	0.29	2.52	3.55	4.62	3.49	1.08	1.38	0.45	0.08	0.36	18.06
1864	0.06	0.28	0.22	1.58	2.84	4.38	2.38	2.87	1.75	0.20	0.76	0.24	17.56
1965	0.07	T	0.05	0.59	4.72	3.31	5.01	2.37	3.25	0.07	0.44	0.24	20.12
1966	0.14	0.12	0.38	1.63	1.97	4.19	3.04	3.67	0.56	0.70	0.57	0.47	17.44
1967	1.12	0.23	1.03	2.99	0.84	1.36	0.27	1.15	0.41	1.72	0.42	1.31	12.85
1968	0.66	0.04	0.14	0.87	0.90	1.35	4.93	10.52	2.28	0.69	0.46	0.11	22.95
1969	1.10	1.24	0.39	0.44	1.51	4.38	2.62	2.37	0.12	2.50	0.08	0.72	17.47
1970	0.20	0.43	0.71	1.95	2.33	2.63	4.69	0.78	2.40	1.34	0.46	0.65	18.57
1971	0.82	T	1.36	1.33	1.99	7.66	4.00	0.76	3.17	4.61	0.57	0.22	26.49
1972	1.01	0.78	1.45	0.92	1.89	3.84	1.77	3.98	2.05	0.57	0.21	0.35	18.82
1973	T	0.22	0.21	1.32	1.67	4.77	3.63	2.77	8.34	1.08	0.99	0.99	25.99
1974	1.00	0.31	0.52	2.04	4.36	0.78	6.32	5.34	0.47	0.59	0.16	0.79	22.68
1975	0.55	0.20	1.85	7.30	2.14	3.30	3.68	2.21	3.04	1.97	0.91	1.18	28.33
1976	0.34	2.31	1.18	0.89	0.50	4.55	2.60	2.01	0.10	0.54	0.05	0.41	15.48
1977	0.49	0.39	T	T	4.34	2.33	2.79	1.44	3.52	0.51	0.67	1.35	17.83
1978	0.44	0.37	0.12	0.83	2.85	1.11	3.35	2.16	1.04	0.47	0.77	1.88	14.69
1979	0.11	0.84	1.36	2.38	1.44	0.79	1.51	0.82	1.94	0.61	0.59	0.53	12.92
1980	1.11	0.88	0.64	0.25	0.74	3.70	2.12	7.33	4.42	1.40	0.85	0.27	23.71
Av.	0.46	0.42	0.57	1.30	2.10	3.11	2.98	2.82	1.93	1.02	0.51	0.49	17.70

LAKE EVAPORATION AT DEVILS LAKE+ AND LANGDON, ND

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1955+	0.00	0.00	0.25	2.74	4.17	3.77	4.92	4.48	2.94	1.73	0.69	0.00	25.69
1956+	0.00	0.00	0.25	1.93	3.60	4.91	3.95	3.87	1.89	1.73	0.69	0.00	22.82
1957+	0.00	0.00	0.25	1.86	3.70	3.28	5.31	4.10	1.76	1.73	0.69	0.00	22.68
1958+	0.00	0.00	0.25	2.71	5.22	3.76	3.92	4.10	2.56	1.73	0.69	0.00	25.03
1959+	0.00	0.00	0.25	2.82	3.63	4.35	5.36	4.76	2.27	1.73	0.69	0.00	25.86
1960+	0.00	0.00	0.25	2.43	4.12	4.59	5.12	3.91	2.82	1.73	0.69	0.00	25.66
1961+	0.00	0.00	0.25	2.17	4.20	6.36	4.55	5.69	2.09	1.73	0.69	0.00	27.73
1962+	0.00	0.00	0.25	2.40	2.47	3.76	4.15	3.75	2.60	1.73	0.69	0.00	21.80
1963+	0.00	0.00	0.25	1.95	3.76	3.98	4.59	3.89	2.75	1.73	0.69	0.00	23.59
1964+	0.00	0.00	0.25	2.43	4.23	4.67	5.05	4.41	2.86	2.68	0.69	0.00	27.27
1965+	0.00	0.00	0.25	2.43	4.23	4.45	4.63	3.91	1.75	1.99	0.69	0.00	24.33
1966+	0.00	0.00	0.25	1.82	4.10	4.21	4.32	3.28	3.11	1.39	0.69	0.00	23.17
1967+	0.00	0.00	0.25	2.43	4.23	4.45	5.64	5.43	3.75	1.71	0.69	0.00	28.58
1968+	0.00	0.00	0.25	2.43	3.83	3.47	4.83	3.96	2.70	1.24	0.69	0.00	23.40
1969+	0.00	0.00	0.25	2.43	4.23	3.47	4.65	4.73	2.83	1.73	0.69	0.00	25.01
1970+	0.00	0.00	0.25	2.43	4.23	5.09	5.07	4.47	2.74	1.35	0.69	0.00	26.32
1971	0.00	0.00	0.25	2.43	4.23	4.00	4.98	5.47	3.09	1.73	0.69	0.00	26.87
1972	0.00	0.00	0.25	2.43	3.96	5.53	4.60	4.71	2.92	1.73	0.69	0.00	26.82
1973	0.00	0.00	0.25	2.43	4.23	5.25	6.10	4.06	2.84	1.73	0.69	0.00	27.58
1974	0.00	0.00	0.25	2.43	4.23	6.27	5.43	4.53	2.75	1.73	0.69	0.00	28.31
1975	0.00	0.00	0.25	2.43	3.24	3.99	6.41	4.59	2.76	1.73	0.69	0.00	26.09
1976	0.00	0.00	0.25	2.43	4.23	5.88	6.07	5.64	4.15	1.73	0.69	0.00	31.07
1977	0.00	0.00	0.25	2.43	6.47	4.73	5.37	3.64	2.23	1.73	0.69	0.00	27.54
1978	0.00	0.00	0.25	2.43	5.23	5.66	4.90	5.58	3.51	1.73	0.69	0.00	29.98
1979	0.00	0.00	0.25	2.43	4.23	5.54	5.48	3.99	2.96	1.73	0.69	0.00	27.30
1980	0.00	0.00	0.25	2.43	5.52	5.73	5.01	3.41	2.11	1.73	0.69	0.00	26.80
Av.	0.00	0.00	0.25	2.43	4.23	4.67	5.05	4.41	2.75	1.73	0.69	0.00	26.21

APPENDIX C

Water Quality Test Results

NORTH DAKOTA
STATE DEPARTMENT OF HEALTH
State Capitol
Bismarck, North Dakota 58505

M. A. K. Lommen, M.D., R.P.E.
State Health Officer

December 16, 1982

Environmental Health Section
Missouri Office Building
1200 Missouri Avenue
Bismarck, North Dakota 58501

Paul D. Urban, P.E.
Investigation Engineer
ND State Water Commission
900 East Boulevard
Bismarck, ND 58505

Dear Paul:

Concerning the State Water Commission's Plan No. 330 on supplementing flows to Lake Metigoshe, this Department evaluated the proposal in the context of anticipated trophic response.

On May 10 and 11, 1982, seven of these lakes and wetlands were visited to conduct the cursory limnological examination and to collect samples for major cation/anion analysis as well as nutrient concentrations. The accompanying map and laboratory sheets identify the water bodies visited as well as the chemical composition at the time of sampling.

Generally, the water quality in these water bodies was poor, relative to the water quality of Lake Metigoshe. This project would result in an increase in the level of primary productivity in Lake Metigoshe, thereby exacerbating its eutrophic condition.

A quantification of increased primary productivity could not be projected from these data without additional information on hydraulic loading rates, shoreline erosion calculations, and total nitrogen concentrations.

At this time, it appears the benefits realized from an increase in water levels for Lake Metigoshe are not commensurate with the anticipated degradation in water quality.

In the event this project is transferred to the Commission's active project list, we welcome the opportunity to work closely with you in exploring alternatives for improving the water quality of Lake Metigoshe.

If you have any questions concerning this evaluation, please feel free to contact me.

Sincerely,

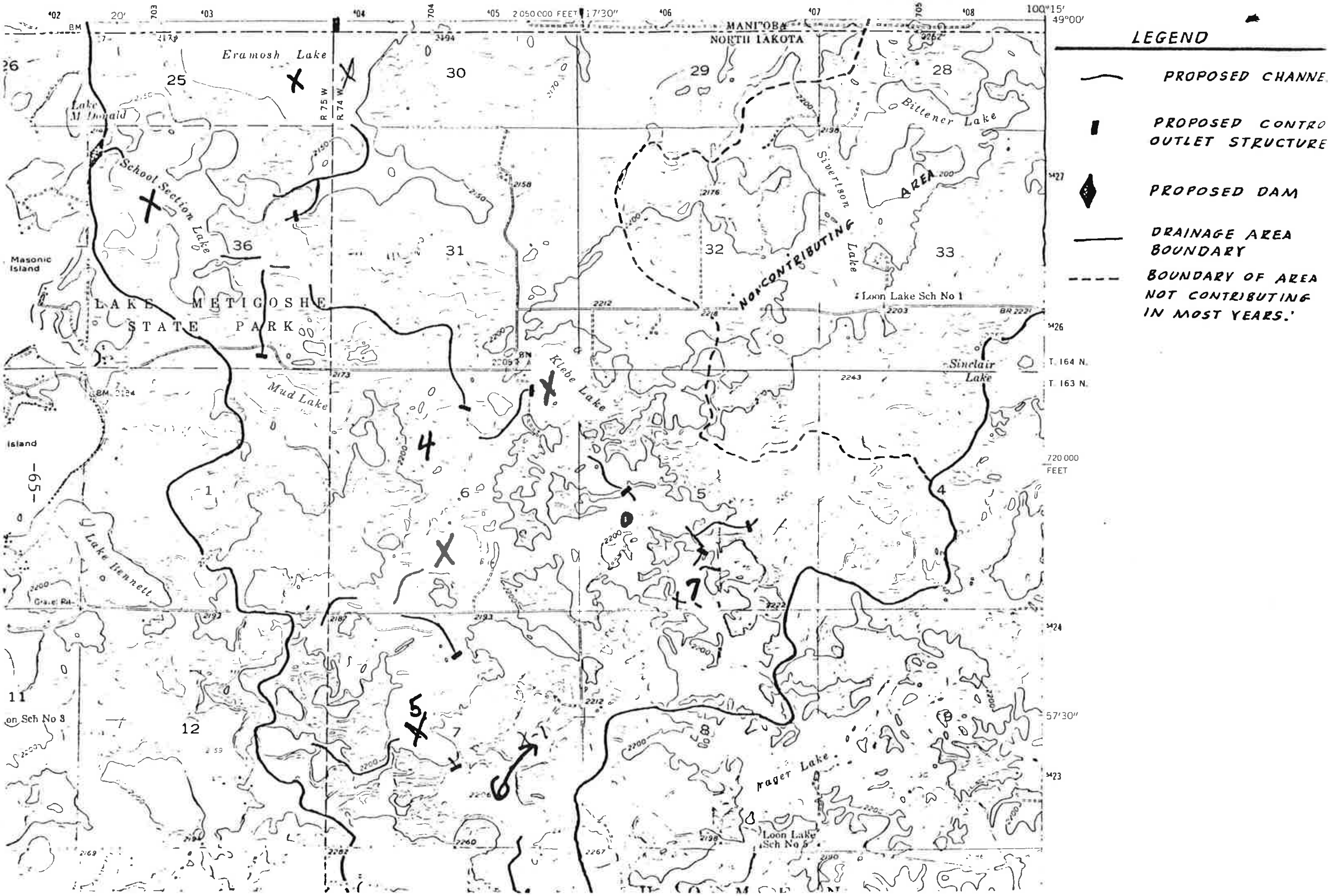
Mike Sauer

Michael T. Sauer
Limnologist
Water Supply & Pollution Control

MTS:lre
Enc.

Environmental Enforcement 701-224-3234
Environmental Engineering 701-224-2348
Environmental Sanitation 701-224-2382
Environmental Waste Management & Research 701-224-2366
Water Supply & Pollution Control 701-224-2354

METIGOSHE LAKE QUADRANGLE
NORTH DAKOTA--BOTTINEAU CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Public Health Laboratory County:

LOG NUMBER: 82- 2220
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/10/82
TIME OF COLLECTION: 1700
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted]E

Parameter	Value		Analysis Date	Time	
Total Alkalinity (CaCO3)	224.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	240.	mg/l	5/13/82	1230	*
Calcium	27.0	mg/l	5/13/82	000	
Carbonate (CO3)	17.	mg/l	5/13/82	1230	*
Chloride	0.00	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	254.	mg/l			
Iron	0.12	mg/l	5/13/82	000	
Magnesium	45.5	mg/l	5/13/82	000	
pH	8.8		5/13/82	1230	*
Potassium	20.3	mg/l	5/13/82	000	
Sodium	7.00	mg/l	5/13/82	000	
Percent Sodium	5.6	%			
Sulfate as SO4	76.	mg/l	6/ 7/82	900	
Total Dissolved Solids	310.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	5.93				
Anion Sum	6.07				
Difference	0.144				
Percent Error	1.19	%			
Sodium Adsorption Ratio	0.19				
Conductivity	514.	umhos/cm	5/13/82	930	*
Nitrate as N	0.010	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: ____________________

Public Health Laboratory

Public Health Laboratory County:

LOG NUMBER: 82- 2219
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/10/82
TIME OF COLLECTION: 1800
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted]

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	214.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	246.	mg/l	5/13/82	1230	*
Calcium	28.0	mg/l	5/13/82	000	
Carbonate (CO3)	8.	mg/l	5/13/82	1230	*
Chloride	0.00	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	273.	mg/l			
Iron	0.12	mg/l	5/13/82	000	
Magnesium	49.5	mg/l	5/13/82	000	
pH	8.5		5/13/82	1230	*
Potassium	15.0	mg/l	5/13/82	000	
Sodium	7.00	mg/l	5/13/82	000	
Percent Sodium	5.2	%			
Sulfate as SO4	92.	mg/l	6/ 7/82	900	
Total Dissolved Solids	320.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	6.17				
Anion Sum	6.22				
Difference	0.043				
Percent Error	0.35	%			
Sodium Adsorption Ratio	0.18				
Conductivity	519.	umhos/cm	5/13/82	930	*
Nitrate as N	0.011	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: ______________________________

Public Health Laboratory

Public Health Laboratory County:

LOG NUMBER: 82- 2225
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/10/82
TIME OF COLLECTION: 1500
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted]

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	217.	mg/l			
Ammonia as N	0.060	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	266.	mg/l	5/14/82	730	*
Calcium	27.5	mg/l	5/13/82	000	
Carbonate (CO3)	0.	mg/l	5/14/82	730	*
Chloride	7.50	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	286.	mg/l			
Iron	0.12	mg/l	5/13/82	000	
Magnesium	53.0	mg/l	5/13/82	000	
pH	8.0		5/14/82	730	*
Potassium	30.6	mg/l	5/13/82	000	
Sodium	8.00	mg/l	5/13/82	000	
Percent Sodium	5.7	%			
Sulfate as SO4	108.	mg/l	6/ 7/82	900	
Total Dissolved Solids	366.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	6.88				
Anion Sum	6.83				
Difference	-.05				
Percent Error	-.37	%			
Sodium Adsorption Ratio	0.21				
Conductivity	591.	umhos/cm	5/13/82	930	*
Nitrate as N	0.012	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: ________________________

Public Health Laboratory

North Dakota State Department of Health
Public Health Laboratory   County:

LOG NUMBER: 82- 2224
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/11/82
TIME OF COLLECTION: 0000
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted] SHORE SAMPLE (4)

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	197.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	241.	mg/l	5/14/82	730	*
Calcium	33.0	mg/l	5/13/82	000	
Carbonate (CO3)	0.	mg/l	5/14/82	730	*
Chloride	2.50	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	230.	mg/l			
Iron	0.13	mg/l	5/13/82	000	
Magnesium	36.0	mg/l	5/13/82	000	
pH	7.8		5/14/82	730	*
Potassium	16.4	mg/l	5/13/82	000	
Sodium	4.50	mg/l	5/13/82	000	
Percent Sodium	4.1	%			
Sulfate as SO4	63.	mg/l	6/ 7/82	900	
Total Dissolved Solids	274.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	5.24				
Anion Sum	5.33				
Difference	0.095				
Percent Error	0.90	%			
Sodium Adsorption Ratio	0.13				
Conductivity	464.	umhos/cm	5/13/82	930	*
Nitrate as N	0.012	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: Rod Rietz
Public Health Laboratory

Public Health Laboratory County:

LOG NUMBER: 82- 2223
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/11/82
TIME OF COLLECTION: 0000
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted] (5)
Comment: DRAINAGE STUDY

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	264.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	323.	mg/l	5/14/82	730	*
Calcium	46.0	mg/l	5/13/82	000	
Carbonate (CO3)	0.	mg/l	5/14/82	730	*
Chloride	0.00	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	277.	mg/l			
Iron	0.12	mg/l	5/13/82	000	
Magnesium	39.5	mg/l	5/13/82	000	
pH	7.8		5/14/82	730	*
Potassium	14.7	mg/l	5/13/82	000	
Sodium	6.00	mg/l	5/13/82	000	
Percent Sodium	4.5	%			
Sulfate as SO4	46.	mg/l	6/ 7/82	900	
Total Dissolved Solids	311.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	6.20				
Anion Sum	6.25				
Difference	0.053				
Percent Error	0.43	%			
Sodium Adsorption Ratio	0.16				
Conductivity	528.	umhos/cm	5/13/82	930	*
Nitrate as N	0.011	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: ________________________

Public Health Laboratory

LOG NUMBER: 82- 2221
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/11/82
TIME OF COLLECTION: 0000
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: [redacted] LAKE METIGOSHE (6)
Comment: DRAINAGE STUDY

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	270.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	330.	mg/l	5/13/82	1230	*
Calcium	44.0	mg/l	5/13/82	000	
Carbonate (CO3)	0.	mg/l	5/13/82	1230	*
Chloride	2.50	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	266.	mg/l			
Iron	0.18	mg/l	5/13/82	000	
Magnesium	38.0	mg/l	5/13/82	000	
pH	7.8		5/13/82	1230	*
Potassium	18.9	mg/l	5/13/82	000	
Sodium	5.50	mg/l	5/13/82	000	
Percent Sodium	4.3	%			
Sulfate as SO4	32.	mg/l	6/ 7/82	900	
Total Dissolved Solids	303.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	6.06				
Anion Sum	6.14				
Difference	0.078				
Percent Error	0.64	%			
Sodium Adsorption Ratio	0.15				
Conductivity	524.	umhos/cm	5/13/82	930	*
Nitrate as N	0.010	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: Rod Rieff
Public Health Laboratory

Public Health Laboratory   County:

LOG NUMBER: 82- 2222
STATION DESIGNATION: UNASSIGNED SAMPLING SITE
STATION CODE: 388000
COLLECTED BY: MIKE SAUER/DENNIS FEWLESS
DATE OF COLLECTION: 5/11/82
TIME OF COLLECTION: 0000
DATE RECEIVED: 5/12/82
TIME RECEIVED: 1430
Comment: ([redacted]E (7)

Parameter	Value		Analysis Date	Analysis Time	
Total Alkalinity (CaCO3)	209.	mg/l			
Ammonia as N	[redacted]	mg/l	6/10/82	900	*
Bicarbonate (HCO3)	256.	mg/l	5/13/82	1230	*
Calcium	33.0	mg/l	5/13/82	000	
Carbonate (CO3)	0.	mg/l	5/13/82	1230	*
Chloride	0.00	mg/l	5/24/82	1300	
Total Hardness (as CaCO3)	205.	mg/l			
Iron	0.11	mg/l	5/13/82	000	
Magnesium	30.0	mg/l	5/13/82	000	
pH	8.1		5/13/82	1230	*
Potassium	11.2	mg/l	5/13/82	000	
Sodium	5.00	mg/l	5/13/82	000	
Percent Sodium	5.0	%			
Sulfate as SO4	25.	mg/l	6/ 7/82	900	
Total Dissolved Solids	230.	mg/l			
Total Phosphate as P	[redacted]	mg/l	6/ 3/82	800	
Cation Sum	4.63				
Anion Sum	4.72				
Difference	0.092				
Percent Error	0.99	%			
Sodium Adsorption Ratio	0.15				
Conductivity	408.	umhos/cm	5/13/82	930	*
Nitrate as N	0.012	mg/l	6/10/82	900	*

* EXCEEDS EPA HOLDING TIME -- RESULT NOT VALID

Approved by: ______________________________

Public Health Laboratory