

THIEF RIVER FALLS RESERVOIR

RED LAKE WATERSHED DISTRICT PROJECT #63

1995 RESERVOIR DRAWDOWN REPORT

JANUARY 1996

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision, and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

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Chapter 1

1.0 INTRODUCTION

The municipal dam on the Red Lake River in Thief River Falls creates a reservoir of 135 acres. This reservoir is used by the City for water supply and hydro-power generation. The reservoir is also used extensively for recreation. Much concern has been raised in recent years by the public, and their elected officials, that sediment and excessive weed growth are reducing the benefits of the reservoir. A report was prepared in 1992 by the Red Lake Watershed District which assessed the condition of the reservoir and identified a number of maintenance techniques to address reservoir problems.

A number of public meetings were held to discuss the 1992 report and the various reservoir maintenance techniques. A multi-agency task force chose to proceed with a reservoir drawdown project on May 13, 1993, and sent a letter of intent to the MnDNR (the letter is attached in Annex A). The drawdown was chosen to address the problems associated with sediment deposits which have accumulated within the reservoir. The City of Thief River Falls received a Department of Natural Resources Protected Waters Permit on September 20, 1993.

A trial drawdown was completed from October 29 through November 1, 1994. Observations made during the 1994 trial drawdown helped to guide work done during the 1995 drawdown. The City began a 60 day pool drawdown on August 14, 1995.

This report provides a summary of activities which took place during the drawdown. The goals and results of the drawdown are discussed, as well as the methods of monitoring and analysis that were used.

Chapter 2

2.0 PROJECT GOALS

Problems identified in the Thief River Falls Reservoir are tied to two phenomenon. These are dense weed growth and sediment deposition. Sediment deposition has reduced the storage volume of the reservoir by approximately 20 percent. A lush growth of weeds and algae, in combination with sediment deposits, is restricting many of the recreational uses of the reservoir.

Even though erosion and sedimentation rates are low in the Thief River Falls contributing area, the cumulative effects upon the reservoir are significant. The reservoir doesn't have adequate storage volume to allow sediment to accumulate indefinitely. Periodically the reservoir will require maintenance to address the sediment problems.

The overall goal of the 1995 drawdown was to consolidate the sediment deposits. Drying and draining the sediment will cause the sediment to consolidate. Sediment consolidation will reduce the volume of sediment within the reservoir and will increase the water depth in areas where the sediments settle. Reducing the sediment volume extends the useful life of the reservoir and frees up space in the reservoir for water storage and other uses (fish habitat, etc.).

Another goal of the drawdown was to reduce aquatic plant growth. Reducing plant growth will allow more of the reservoir to be used for recreation (swimming, boating, fishing, etc.). Consolidating existing sediments may reduce aquatic plant growth. Increasing the depth of the reservoir by consolidating the sediments may reduce the amount of light which reaches rooted aquatic plants--limiting their growth. A drawdown also exposes the plants to drying and possibly freezing which may be damaging to them, especially lake species. Extensively drying certain plants (particularly non-rooted species) will effectively eliminate them. This is most likely a short-term control measure because most aquatic plants reproduce from seeds or plant fragments which both the Thief and Red Lake Rivers will continue to supply.

An ancillary benefit of the drawdown was the opportunity to perform construction within the reservoir. Work included the clean-up of debris to improve safety for reservoir users. With the water level lowered, access for public and private construction became much easier and cost effective.

Chapter 3

3.0 PROJECT OVERVIEW

The Thief River Falls reservoir was drawn down during a 60 day period. The reservoir water level was lowered on August 14 and maintained at a lower than normal pool level for approximately 60 days. The reservoir was restored to its normal operating level on October 13.

3.1 POOL LOWERING

The drawdown commenced on August 14, 1995. The gates on the Thief River Falls municipal dam were incrementally opened to allow controlled water discharge through the dam. The pool was initially lowered by approximately four feet to elevation 1111 over an 8 hour period. Following the excavation around the 1927 dam, and the installation of an additional water supply pump, the pool was lowered by an additional three to four feet. At this point water was allowed to flow freely through the open gates of the dam. The lowest level reached was approximately elevation 1107--which is eight feet below the normal pool level.

3.2 EXCAVATE 1927 DAM ABUTMENT

During the trial drawdown of October 29 - November 1, 1994, we verified that remnants of the 1927 dam were restrictive to flow. The dam remnants limited the effectiveness of a drawdown by creating an obstruction just upstream from the current 1946 municipal dam. The old dam remnants obstructed the flow in the river and limited the amount the reservoir could be lowered--to approximately four feet below the normal reservoir level.

On August 14, 1995 the City of Thief River Falls, and their contractor Charles Hedeem, Inc., excavated a channel around the east abutment of the 1927 dam. Soil, rock-filled timber cribs, and debris were removed from an area approximately 50 feet wide and 200 feet long. The channel was constructed with a bottom elevation of approximately 1104 feet M.S.L., which lowered the flowline of the river by approximately 5 to 6 feet. The excavation reduced the flow obstruction caused by the 1927 dam remnants. The channel allowed the reservoir level to be lowered an additional three to four feet beyond levels previously achieved.

3.3 WATER SUPPLY

The City of Thief River Falls uses the reservoir for a water supply. Water flows from the reservoir, through an intake pipe, to

a pumping station. Water is pumped from the station into the water treatment plant. Lowering the reservoir level exposed the intake line and reduced the flow of water into the pumping station. There was concern that at reservoir levels below elevation 1111, the reduced flow to the pumping station could cause the pumps to cavitate--reducing their efficiency and possibly damaging the pumps.

In order to lower the reservoir below elevation 1111, while maintaining the required flow into the pumping station, city crews temporarily installed an additional pump. This pump was installed on August 25, 1995 and used for the remainder of the drawdown period. The temporary pump experienced mechanical problems on September 21 and 22. The reservoir level was raised to elevation 1111 to allow water to flow into the water plant while the temporary pump was out of service.

3.4 UPSTREAM DAMS

Operators of dams upstream of Thief River Falls were notified of the drawdown and encouraged to consider the drawdown when planning releases and discharge rates. The U.S. Army Corps of Engineers operates the dam on the Red Lake River at Red Lake. The U.S. Fish and Wildlife Service operates a number of dams on tributaries to the Thief River at Agassiz National Wildlife Refuge. The Minnesota Department of Natural Resources operates the Thief Lake Dam. The Red Lake Watershed District operates the Moose River, and Good Lake Projects. These agencies managed the timing and discharge of water from their dams, within operational constraints, to cooperatively reduce the flow at Thief River Falls. The combined efforts of the group served to lessen the flow in Thief River Falls, which was beneficial to the reservoir project.

3.5 PUBLIC RELATIONS, NOTIFICATION, SAFETY

Staff of the City of Thief River Falls and officers of the Red-Thief Reservoir Association notified the public of the drawdown through the use of news releases, and public announcements. Local media informed the public of the details of the project, as well as permit requirements for individual construction projects within the reservoir.

City crews closed the swimming beach, closed public boat accesses throughout the reservoir, and posted "closed to public access" notices on adjacent public property. The Pennington County Sheriffs Department also issued warnings to citizens about the danger associated with walking on the exposed mud flats (sediment deposits). On August 24, a 9 year old boy was rescued after he became mired in the loose sediments.

3.6 MONITORING

Staff of the City of Thief River Falls and the Red Lake Watershed District monitored water levels within the reservoir during the drawdown. The reservoir water level during the drawdown is shown in Figure 1. Figure 2 shows a profile of the Red Lake River within Thief River Falls. A profile of the water level within the reservoir during the drawdown is shown in Figure 2--as well as the normal reservoir level and flood profiles. The profile during the drawdown shows that the reservoir water level was approximately 2 feet higher at Finsbury Park than at the dam. The Figure 2 base profiles are from the Pennington County Flood Insurance Study.

Weather records were obtained from the Minnesota Department of Natural Resources State Climatology office in St. Paul. Flow records for the Thief and Red Lake Rivers were obtained from the U.S. Geological Survey.

Chapter 4

4.0 RESULTS

Sections 4.1 to 4.4 discuss the results of the drawdown, and Sections 5.1 and 5.2 discuss the flow and weather conditions during the drawdown. The following are brief summaries of these sections:

There was a slight reduction in the elevation and volume of sediment within the reservoir. Results indicate that sediments consolidated by about .1 feet on the Red Lake River and about .2 feet on the Thief River. Sediment volume was reduced by about 5 to 10%.

The movement of sediment probably had a greater effect on sediment reduction within localized areas than consolidation.

The drawdown most likely will show short-term affects to the aquatic plant growth.

With the improved access provided by the drawdown many construction activities took place.

Lowering the water exposed the problem, and allowed the public a chance to view the sediment deposits within the reservoir.

The weather during the drawdown period was close to the long term averages for temperature and precipitation.

Flow during the drawdown was higher than we would have preferred, which resulted in less drainage and drying of sediments than we had hoped for.

4.1 SEDIMENT

Sediment consolidation was the overall goal of the drawdown. The survey results showed there was a slight reduction in the elevation, cross-sectional area, and volume of sediment within the reservoir. Results indicate that sediments consolidated by about .1 feet on the Red Lake River and about .2 feet on the Thief River. Sediment volume was reduced by about 5 to 10%. This is discussed in greater detail in Section 5.3.

The movement of sediment probably had a greater effect on sediment reduction within localized areas than consolidation. The erosion and slumping of some sediment deposits moved substantial amounts of sediment into the main river channels. We think it is likely that much of the translocated sediments were swept out of the reservoir, although it is possible that some of the material was redeposited. The cross sections that were performed after the reservoir was filled provide an average estimate of sediment reduction. Sediment reduction could involve both sediment consolidation and movement.

4.2 WEEDS

Another goal of the drawdown was to reduce aquatic plant growth. Reducing plant growth will allow more of the reservoir to be used for recreation (swimming, boating, fishing, etc.). Consolidating existing sediments may reduce aquatic plant growth by increasing the depth of the reservoir. Increasing the depth may reduce the amount of light which reaches rooted aquatic plants--limiting their growth. A drawdown also exposes plants to drying and possibly freezing which may be damaging to them, especially lake species. Extensively drying certain plants (particularly non-rooted species) will effectively eliminate them. This is most likely a short-term control measure because most aquatic plants reproduce from seeds or plant fragments which both the Thief and Red Lake Rivers will continue to supply.

The next few growing seasons will determine how effective the drawdown was in reducing the intense weed growth. The drawdown most likely will show short-term affects to the aquatic plant growth. Most floating plant species will probably re-establish themselves in the backwater areas within 1 or 2 growing seasons. Also most rooted plants will propagate again within the next few growing seasons if intense drying or freezing didn't kill their roots.

4.3 CONSTRUCTION

With the improved access provided by the drawdown many construction activities took place. Private parties worked on their shoreline property and river banks. Public construction projects which took advantage of the drawdown include the following:

City of Thief River Falls:

- Excavated a channel around 1927 dam;
- Placed rock riprap at Fire Hall, Technical Services, and adjacent to Riverwalk;
- Replaced trash racks at intake to hydro generator units at the powerplant;
- Removed sheet piling from old raw water intake to restore the riverbank and improve site safety.

Pennington County:

- Inspected and maintained bridges crossing the Thief River;
- Sentence to Service cleaned up debris within reservoir.

Red Lake Watershed District:

- Placed rock riprap at Lafave Park.

Minnesota Department of Transportation

- Inspected and maintained 3rd Street and 8th Street bridges; work included removal of steel piling from bridge pier remnant and removal of debris beneath the bridges.

4.4 EDUCATION

A very important benefit that also resulted from the drawdown was public education. Lowering the water exposed the problem, and allowed the public a chance to view the sediment deposits within the reservoir. The historic river channel was easily identifiable. Many people commented on interesting things they observed such as the "rock pile" by the 8th Street Bridge (possibly a remnant structure from log sorting operations). The pilings for the abandoned electric railroad crossing of the Thief River near Long's Bridge were exposed, and allowed its location to be verified.

Chapter 5

5.0 DATA AND ANALYSIS

5.1 FLOW

The flow passing through the reservoir during a drawdown is directly related to the stage in the reservoir. Opening the gates on the dam allow the stored water to be drained from the reservoir. Channel characteristics and the rate of flow determine stage within the emptied reservoir -- just as in an undammed river. Low flow and corresponding low water levels provide the best conditions for draining and drying sediments. Flow during the drawdown was higher than we would have preferred, which resulted in less drainage and drying of sediments than we had hoped for.

The U.S. Geological Survey (USGS) maintains continuous stream gaging stations on the Red Lake River at Highlanding and the Thief River near Thief River Falls. We have received provisional records of streamflow for the drawdown period from the USGS. Figures 3 and 4 are hydrographs which show river flows on corresponding dates. Several monthly exceedance frequencies are also plotted on Figures 3 and 4. Flow duration-frequency curves for the Thief and Red Lake Rivers are included in Annex B.

Table 5.1

Month	Red Lake River		Thief River	
	Streamflow (cfs)	Exceedance Frequency %	Streamflow (cfs)	Exceedance Frequency %
Aug. Mean	659	41	106	17
Aug. Min.	519	51	40	27
Aug. Max.	710	38	177	13
Sept. Mean	459	51	82.5	22
Sept. Min.	371	57	57	25
Sept. Max.	667	40	210	14
Oct. Mean	523	43.5	Not available	Not available
Oct. Min.	435	50		
Oct. Max.	646	40		

Both rivers had flows which exceeded the median daily flows during the drawdown period. Flows in the Thief River were high--well above the median flows. Flows in the Red Lake River were closer to median flows for the period, but the mean and maximum flows did exceed the median. Table 5.1 lists the mean, minimum, and maximum daily flows for each month of the drawdown. The exceedance

frequency corresponding to each flow rate is also shown in the table. The exceedance frequency means that the listed flow is equalled or exceeded this percent of the time. For example the maximum August 1995 flow in the Red Lake River has an exceedance frequency of 38%--which means that for all records of August flows only 38 percent of the recorded flows equalled or exceeded that flow.

5.2 WEATHER

The weather during a drawdown affects the drying of sediments and affects the control of exposed aquatic plants. Hot, dry weather aids a drawdown by increasing the drying of sediments and plants. Dry weather is also likely to correspond to reduced river flows and reservoir stages. The weather during the drawdown period was close to the long term averages for temperature and precipitation.

We received data on daily temperature and precipitation from the Minnesota Department of Natural Resources State Climatology office in St. Paul. The data cover the drawdown period and provide daily high and low temperatures and precipitation. These data are provided in Annex C.

5.2.1 Temperature

Figure 5 shows high, low and mean daily temperatures for the drawdown period as well as average temperatures for this period.

Figure 6 shows average daily temperatures for August, September, and October 1995 as well as the period of record. Observed temperatures in September appeared to be typical for the period of record. August temperatures were about 2°F warmer than the long term averages, and October temperatures were generally cooler than the long term averages.

Freezing temperatures occurred on the following dates:

9/20	28°F
9/21	32°F
9/22	26°F

Freezing temperatures may have been damaging to exposed aquatic plants. Coincidentally, the temporary water supply pump was out of service on September 21 and 22. The water level was increased three to four feet to elevation 1111 during this period--which may have inundated and protected some plants from freezing.

5.2.2 Precipitation

Figure 7 shows the months and corresponding precipitation amounts recorded at the Thief River Falls gage. Monthly rainfall totals are shown for August, September and October 1995 as well as the average rainfall for the 1951 to 1972 period. Rainfall in Thief River Falls appeared to be near the average for these months.

5.3 SURVEYS

The reservoir was surveyed before and after the drawdown. Ten cross sections were measured on the Red Lake River and five were done on the Thief River. Locations for the cross sections were chosen from data obtained from the 1991 cross sections of the reservoir. Survey locations that showed major sediment deposits were repeated. Figure 8 shows the location of each cross section. Control points were established on both banks of the river for each cross section so they could be repeated on the same alignment. Cross sections were performed using a boat and Geodimeter total station survey equipment. The total station was used to determine the location of the boat along each cross-section. A level rod was used to measure water depth to the top of the sediment. A conventional level was used to determine the water surface elevation throughout the reservoir for vertical control.

Most of the cross sections were surveyed from a boat with alignment directed from the shore. The location of measurements were repeated within reasonable accuracy. Precise replication of measurement location is most critical at points where the river bottom changes a lot within a small distance, such as transitional points between the sediment deposits and the main channel. Slight differences in boat alignment near these points allow a larger opportunity for error. We believe that these errors will cancel out since a similar number of measurements should be slightly higher or lower than those taken during earlier surveys. Slight differences in boat location in the flat bay areas should have little or no effect on the results of the surveys. We also expect results from the bay areas to be the primary indicator of sediment change.

Annex D shows the results of the before and after surveys of the reservoir. Average reduction in sediment depth in the Red Lake River was 0.25 feet and reduction in the Thief River was 0.29 feet. Some measurements show large decreases or increases in sediment depth which may skew the average values. Median reductions on the Red Lake River were .1 feet and on the Thief River were .2 feet. Large changes in measurements are probably located at transitional points. Other large changes are in areas where sloughing or erosion occurred near the main river channel. Changes in sediment depth measured across the broad deposit areas agree closely with the averages.

Sediment reduction was also analyzed on a volumetric basis. Annex E shows the results of this analysis. Data obtained from the 1991 survey of the reservoir was used for determining the firm bottom of the river. The before and after surveys were used to outline the top of sediment at each cross section. The average end area method was used to determine the sediment volume throughout the reservoir. Measurements which appear to be obvious errors (due to a shift in boat alignment, etc.) were omitted from the cross sections for the area calculations. The goal was to obtain a reasonable estimate of sediment consolidation. The results indicate approximately a 10% reduction in the Red Lake River sediment volume and an 11% reduction in the Thief River sediment volume. The method used in this analysis may overstate the sediment reduction slightly. This is a result of the assumption to disregard measurements which indicated an increase in sediment. Consideration of all measurements would probably result in a calculated sediment reduction ranging from about 5 to 10%. A 5 to 10% reduction in sediment volume extends the life of the reservoir by 2 to 3 years.

5.4 WEEDS

While surveying each cross section of the reservoir, the plant species compositions and intensity were noted in a log book. Annex F provides the compilation of these results. At certain locations intense growths of specific plant types were identified and measured in relation to control points. Later, we will re-inspect these control locations to assess how the drawdown affected specific species of plants within the reservoir.

5.5 SEDIMENT ANALYSIS

Sediment samples were taken during the drawdown at similar locations as were previously sampled in 1991. A 4 inch PVC pipe was again used to collect the sample. This was forced into the sediment. The open end was capped to prevent the sample from falling out as it was withdrawn.

As another measure of whether the sediment consolidated, the moisture content and the density of each sample was determined. The data is shown in Annex G. This information was compared to the previous sample results. The density of each sample was expected to increase during the drawdown indicating the sediment had consolidated. This, however, was not found to be the case.

We have reviewed our sampling procedures, testing methods, and results with soil physicists from the University of Minnesota. Our results were explained to be an aberration due to variances in density of the in-place sediments, and as a result of sampling a small data set. It is evidently coincidental that the results appear to be somewhat uniformly shifted from what was expected.

5.6 PHOTOS

Photos were taken by staff of the City of Thief River Falls and the Red Lake Watershed District to show conditions before and after the drawdown. These included both aerial and ground photos of the reservoir.

A continuous video of the shoreline of both the Red Lake River and the Thief River was completed by the City of Thief River Falls. This video was made in the fall of 1994 during the temporary drawdown.

5.7 VISUAL AND EMPIRICAL RESULTS

In general, most of the sediment deposits did not appear to have dried sufficiently to allow a great deal of consolidation. In some areas the surface dried and cracks formed in the sediment. Many areas remained wet and damp. Reservoir water levels achieved were only slightly below many of the deposits, especially when the reservoir was being held at elevation 1111. Figure 9 shows a typical cross-section of the reservoir. This typical section shows the sediment deposits and water levels at elevation 1108 and 1111.

During the drawdown Red Lake Watershed District staff performed cross-section surveys and soil testing on selected sediment deposits. Most areas did not dry enough to support a man's weight. The surveyors wore snow shoes to support their weight while walking on the deposits. Since much of the sediment remained wet and loose, consolidation was probably limited.

Some areas of the reservoir, especially along the Thief River, had large sediment deposits slump and slide into the main river channel. Sediment erosion also was noticeable, particularly near Finsbury Park on the Red Lake River. Due to the higher velocities and tractive forces present within the main river channels, we think it is likely that much of the translocated sediments were swept out of the reservoir, although it is possible that some of the material was redeposited. Sliding and erosion of sediments may have very significant benefits in localized areas. Some of these areas will easily be recognized as having reduced sediment and increased depth.

Chapter 6

6.1 SUGGESTIONS FOR OTHER DRAWDOWNS

The following suggestions are provided for consideration if the Thief River Falls reservoir is to be drawn down in the future. In retrospect, these are some of the things we would consider doing different in a future drawdown. Clearly other considerations such as water supply, recreation, and cost, play a role in decisions regarding a drawdown. If the drawdown goal is to consolidate sediments and control aquatic plants, the following may improve the effectiveness of a drawdown.

Drier Conditions:

It's hard to predict the weather, but conducting a drawdown during a drought is sure to result in better conditions. A drought would typically cause reduced river flows and result in a lower water level. Less precipitation and warmer, drier conditions would cause better drying of sediments and plants.

Longer Duration Drawdown:

Extending the time of a drawdown would allow for additional drainage and drying of sediments, and extend the time aquatic plants are exposed to the elements.

Include Freezing:

Extending a drawdown through periods of freezing temperatures will likely increase the control of aquatic plants--especially lake species.

Old Dam:

Increase excavation around the old dam to further reduce the obstruction it causes. The work done in 1995 allowed the reservoir level to be lowered three to four feet below previously attainable levels, but the reservoir level above the old dam was still about one foot higher than the level at the current dam. Additional excavation would further reduce the obstruction and corresponding backwater effects.

Pumps:

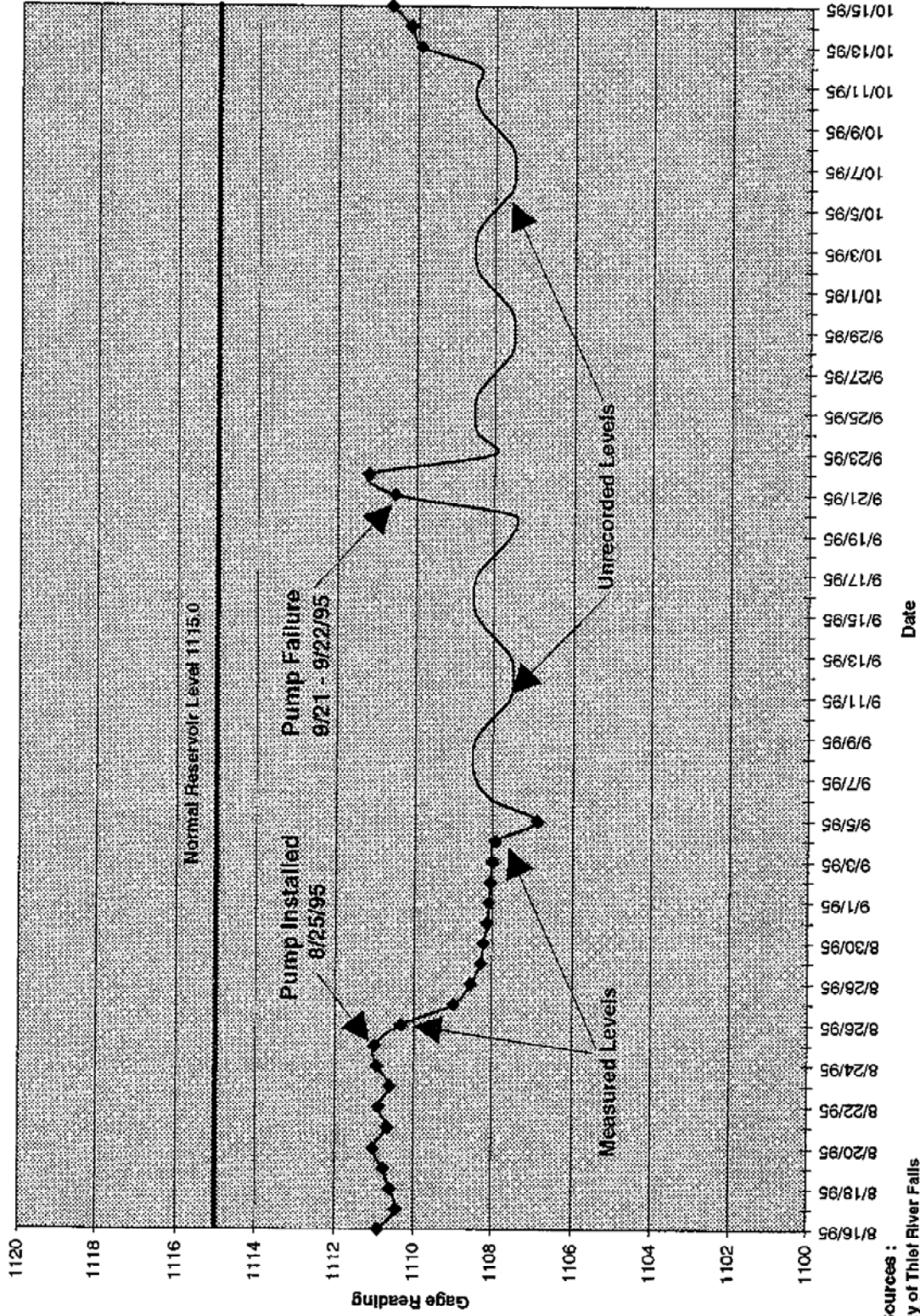
Install temporary water supply pumps prior to commencing a drawdown. This will remove the need for maintaining reservoir levels which provide gravity flow of water to the water plant pumping station.

Monitoring:

These monitoring suggestions will improve the effectiveness of monitoring the results of a drawdown, but won't improve the drawdown effectiveness.

- Install a continuous water level recorder within the reservoir.
- Install settlement plates to measure settlement or translocation of deposits.
- Record precise locations of sediment or plant sampling.
- Conduct surveys of sediment deposits before and after the drawdown using either a cable-stayed boat, or winter surveys on ice, to allow precise replication of measurements.

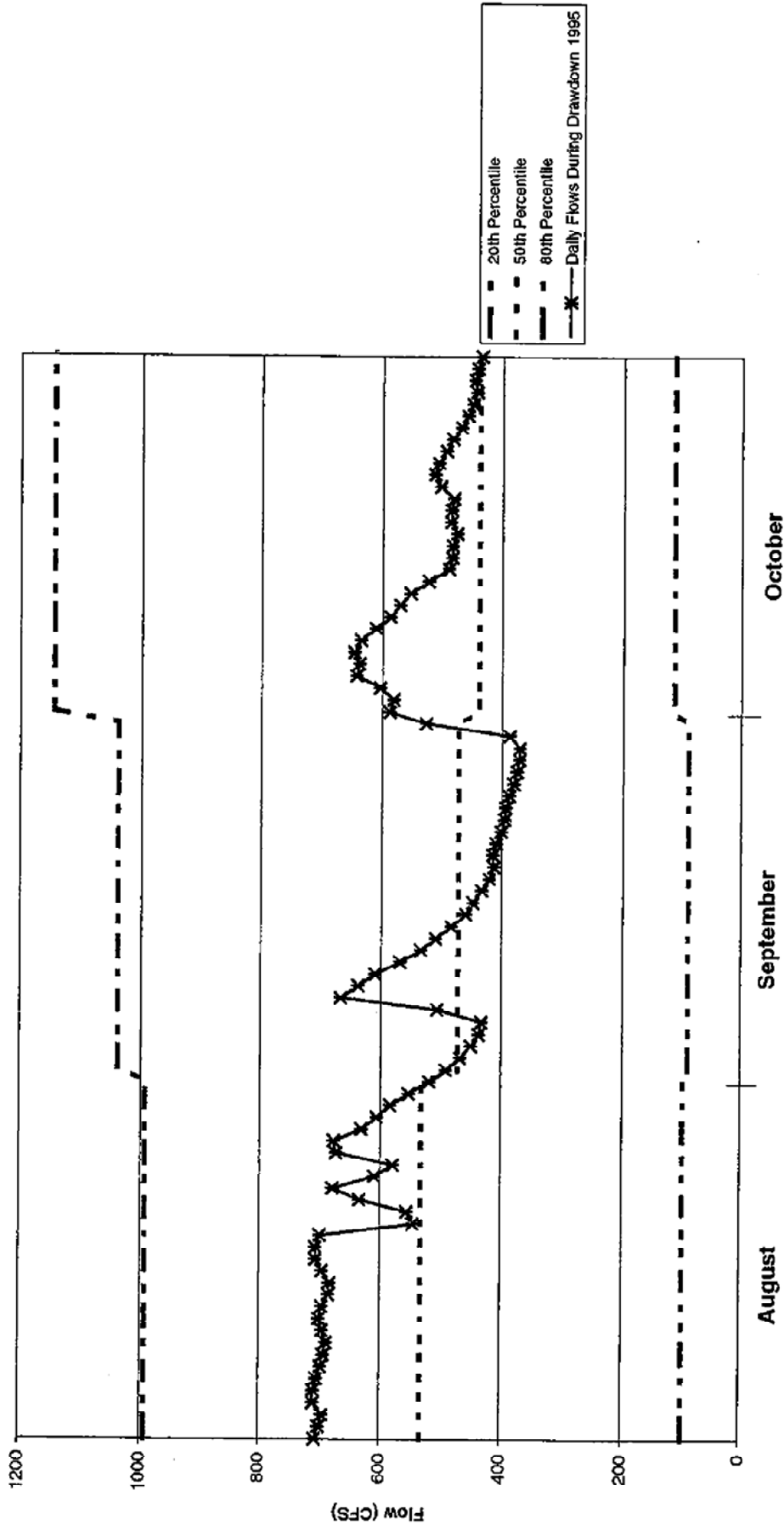
Reservoir Elevations During Drawdown



Sources :
City of Thiel River Falls
Red Lake Watershed District

Figure 1

RED LAKE RIVER AT HIGHLANDING



Source :

United States Geological Survey

Figure 3

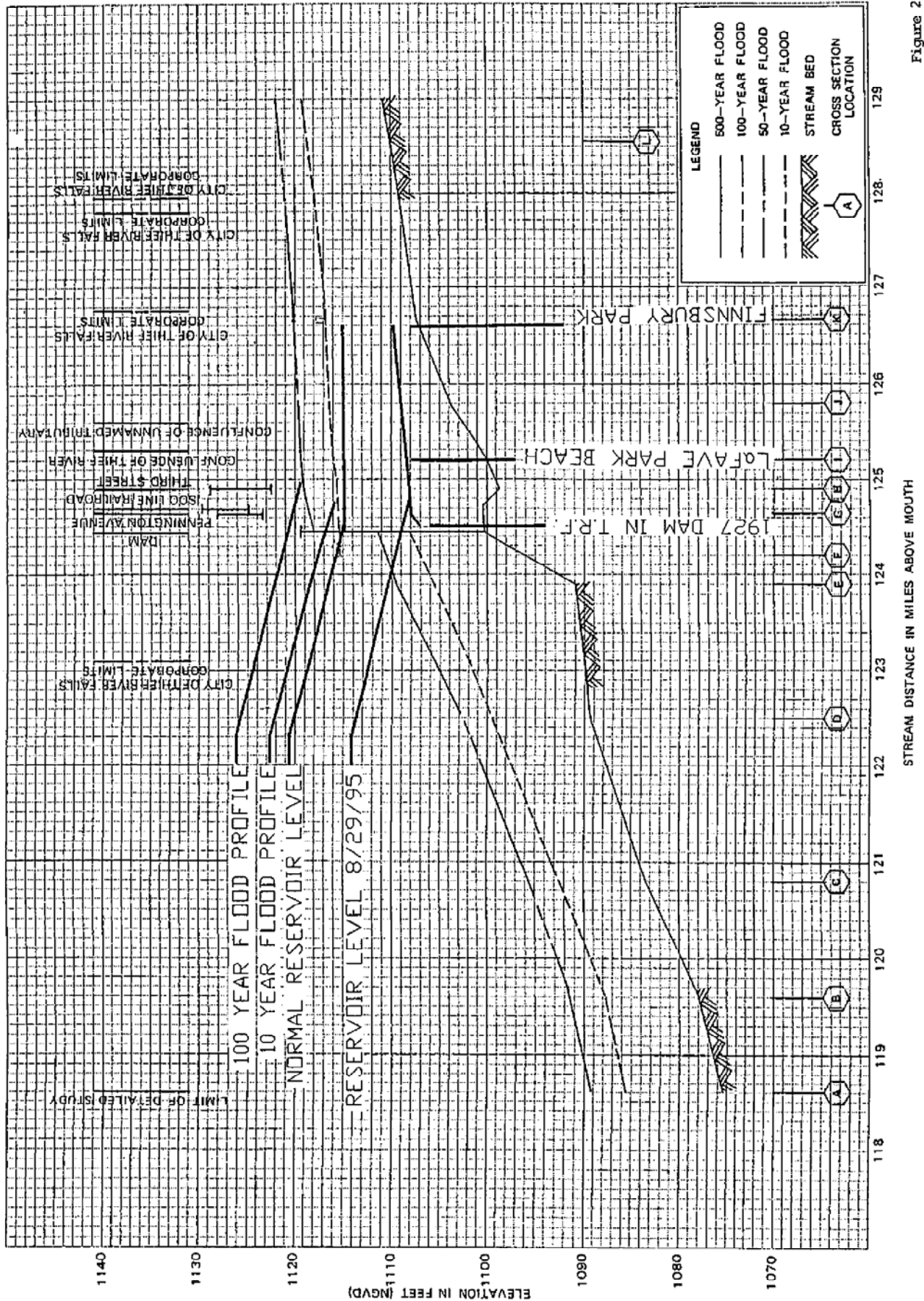


Figure 2