

Corey Lake Intercounty Drain Engineering Report



Prepared for:
**Corey Lake Intercounty Drain
Drainage Board**
December 4, 2019

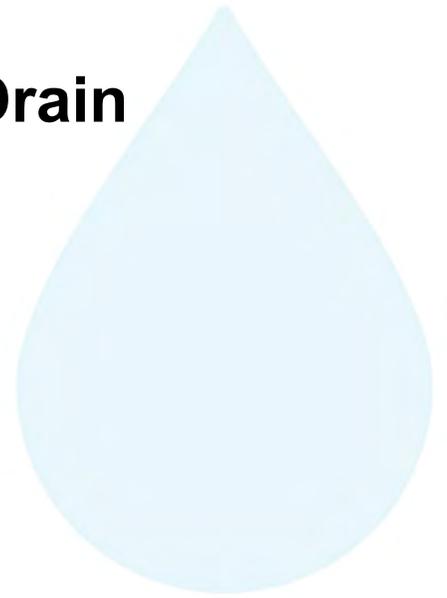


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INTRODUCTION

Purpose of Study

A petition for maintenance and improvements to the Corey Lake Intercounty Drain (Drain) under Chapter 8 of the Michigan Drain Code (Act No. 40, Public Acts of 1956, as amended) was filed by 18 freeholders of land within St. Joseph County on July 8, 2019. The petition was determined practicable by the Corey Lake Intercounty Drain Drainage Board (Board) on August 20, 2019. Landowners voiced concerns over high water levels and flooding in Corey Lake, Clear Lake and Long Lake, failing infrastructure (lake control structures and conduits), and lack of adequate drainage outlet(s). Long Lake residents complained of flooding and would like a gravity outlet. Clear Lake residents are concerned about the volume and quality of stormwater pumped from Long Lake as well as lack of an adequate outlet for Clear Lake. Residents from Harwood Lake indicated they had no issues with water levels and are adamantly against receiving storm water from Long Lake. Some residents consider the channel connecting Corey Lake to Kaiser Lake to be the primary outlet for Corey Lake (since under normal precipitation years, groundwater naturally flows toward Kaiser Lake) and view the Drain as an overflow during major precipitation events.



Corey Lake near channel to Kaiser Lake



Looking north toward Clear Lake control structure.

Land & Resource Engineering (LRE) was retained by the Board on September 24, 2019 to conduct an engineering study in preparation for the Hearing of Necessity, scheduled for December 4, 2019. The purpose of the study is to assess flooding issues along the various lakes, identify impairments/deficiencies in the current drainage system and evaluate feasible alternatives to better connect and regulate water levels (including a potential gravity outlet for Long Lake). The findings and recommendations of our engineering study are presented in this report.

Watershed Description

The Corey Lake Intercounty Drain Drainage District (District) encompasses 8,563.9 acres in Sections 11-14 and 23-26 of Newberg Township, Cass County and Sections 7-8, 16-21 and 28-33 of Fabius Township, St. Joseph County as shown in [Exhibit B-2](#). The watershed includes the roughly 630 acre Corey Lake, 90 acre Kaiser Lake, 105 acre Mud Lake, 230 acre Clear Lake, 210 acre Long Lake and 90 acre Harwood Lake. In addition, the Corey Lake Intercounty Drain serves as an outlet for Profile Lake and the Profile Lake Drain, which are also located within the District.

Land use consists of dense residential cottages around the various lakes, with the remaining area consisting of agricultural lands, large residential tracts, and forested / wetland areas. M-60 cuts east to west across the southern tip of the District. Soils are primarily composed of sands and loams with moderate to high infiltration rates (hydrologic soil group ratings B and A). The topography of the watershed is comprised of rolling hills and depressions with wetland complexes (including lakes). Groundwater flows predominately toward the southeast.

Route and Course

The Corey Lake Intercounty Drain, also known as the Peterson Drain, is a tributary to Mill Creek within the St. Joseph River watershed. The Corey Lake Intercounty Drain serves as the outlet for Corey Lake and the upstream connecting lakes including Long Lake, Clear Lake, Mud Lake, and Kaiser Lake in St. Joseph County as well as Harwood Lake in Cass County. In addition, the Profile Lake Drain (which serves as the outlet for Profile Lake), enters the Corey Lake Intercounty Drain near the east quarter corner of Section 31, Fabius Township, St. Joseph County.

Currently, the Drain is legally established from the east-west quarter line of Section 30, Fabius Township, St. Joseph County to the south line of Section 31, Fabius Township, St. Joseph County (Harder Road). The roughly half-mile stretch of pipe enclosure and open channel from the south shore of Corey Lake to the east-west quarter line of said Section 30 is no longer a public utility (county drain). *Plan Specifications for Cleaning Out Corey Lake Drain*, dated August 26, 1903 required:

- Slopes of the banks to be constructed at a one-foot rise per one-foot run, unless existing banks are well vegetated and don't have to be reshaped.
- Average profile gradient of approximately 0.15%.
- Minimum bottom width to be 3 feet wide downstream of the railroad right-of-way and 2 feet wide upstream of the railroad right-of-way. The now abandoned railroad right-of-way cut across the north 1/2 of Section 31, Fabius Township, St. Joseph County.

Drain History

The Corey Lake Intercounty Drain has a long and storied history, the accounts of which are summarized in several unofficial written histories on-file at the St. Joseph County Drain Commissioner's office. In addition, the law firm of Fahey, Schultz, Burzych and Rhodes prepared a legal opinion for the Drain dated October 30, 2018.

The watercourse south of Corey Lake was originally established as a St. Joseph County intra-county drain in 1867. The Corey Lake Intercounty Drain, consisting of Cass and St. Joseph Counties, was officially established in 1883.

A 1903 petition resulted in the St. Joseph County Circuit Court decreeing that the portion of the Drain lying north of the east-west quarter line of Section 30, Fabius Township, St. Joseph County *"cease to be of any public utility and is therefore void and abandoned so far as being a public or County drain"*. This ruling abandoned the portion of the Drain from Corey Lake to the east-west quarter line of said Section 30.

A failed intercounty drain petition project in 1950 attempted to reverse the 1903 Circuit Court ruling and re-establish the Drain from the east-west quarter line of said Section 30 to Corey Lake. However, after a lengthy legal battle, the petition was ultimately determined not necessary by the previous Board on September 28, 1950.

A subsequent outlet improvement project for Corey Lake was undertaken by the St. Joseph County Board of Supervisors in 1951. The project included construction of the current Corey Lake outlet control structure, 610 linear feet of 36-inch by 22-inch asbestos bonded corrugated metal steel pipe (CMP) arch, several culvert replacements, open channel excavation and related work. Correspondences from the project engineer, T.A. Smith indicate that some of the proposed 36-inch by 22-inch CMP arch may have been replaced with 24-inch pipe to save cost, which is consistent with our field reconnaissance.

Since the 1950's there have been numerous legal actions taken regarding the level of Corey Lake and the connecting lakes. T.A. Smith, the registered civil engineer who worked on the Corey Lake projects in the 1950's stated on November 6, 1952 that *"it should be adopted policy to hold both Corey and Kaiser Lakes rather high in the spring and overflow into the Corey Lake (Intercounty) Drain only when the level gets excessively high, saving all the surplus water possible for the use of Kaiser Lake"*. The current legal lake level of Corey Lake was established at 874-feet NGVD 29 in 1974. An additional control structure (concrete weir / "dam") was constructed in the channel between Corey and Kaiser Lakes in 1974 to help maintain Corey Lake at its legal lake level.

Drainage District Delineation

Historic Drainage District: The Historic District consists of approximately 3,790.2 acres and comprises of land in Section 14 and 23-26 of Newberg Township, Cass County and Section 7-8, 16-21, and 28-30 in Fabius Township, St. Joseph County, Michigan. The Historic District, as shown in [Exhibit B-1 – Lands Added/Removed Map](#), is based on the “*Drainage District Map for Corey Lake Outlet*” prepared by T.A. Smith, dated September 5, 1950. It’s worth noting that the special assessment district from the 1903 Drain project essentially included those parcels bordering the Drain from the revised upstream terminus at the east-west corner line of Section 30 to the south line of Section 31, Fabius Township, St. Joseph County.

Revised Drainage District: Revised District boundaries were developed by Fleis & Vandenbrink in 2019. LRE reviewed the Revised District boundaries using GIS contours provided by Cass and St. Joseph Counties. Micro-topography and depression storage areas that may provide for some infiltration within the larger boundary were included in the Revised District.

The Revised District has been increased to 8,563.9 acres to accurately reflect the contributing drainage area. The Revised District now includes Long Lake, which pumps excess stormwater to Clear Lake as well as lands along the established Drain, south of Corey Lake. Approximately 1,600 parcels are located within the Revised District (roughly 300 in Cass County and 1,300 in St. Joseph County). The Revised District includes 2,590.9 acres (30%) in Newberg Township, Cass County and 5,973.0 acres (70%) in Fabius Township, St. Joseph County, as shown in [Exhibit B-2 – Drainage District Map](#). A total of 4,862.7 acres are recommended to be added to the District and 89.0 acres are recommended to be removed from the District as shown in [Exhibit B-1 – Lands Added/Removed Map](#).



Harwood Lake near control structure



Long Lake looking southwest

EXISTING CONDITIONS

LRE conducted an initial site visit and preliminary survey of lake levels on August 8, 2019. Subsequent field reconnaissance was performed by staff from LRE and Streamside Ecological Services (SES) on November 14, 2019. In Addition, LRE conducted a topographic survey of the Drain and lake control structures / connecting channels between November 11, 2019 and November 18, 2019. [Survey Drawings](#) of the Drain and connecting water courses are enclosed.

COREY LAKE INTERCOUNTY DRAIN

The Corey Lake Intercounty Drain is legal established from the east-west quarter line of Section 30, Fabius Township, St. Joseph County to the south line of Section 31 (Harder Road) in Fabius Township, St. Joseph County. The roughly ½ mile of enclosed pipe and open channel that serves as an outlet for Corey Lake in the northeast quarter of Section 30, Fabius Township, St. Joseph County was abandoned in 1903 and is currently not part of the established Drain.



LRE conducted a field inspection, including topographic survey, of the established Drain to identify impairments including potential hydraulic restrictions, structural deficiencies, erosion and / or sediment buildup. The results of our field reconnaissance confirm that there is sufficient fall throughout the Drain to provide an adequate outlet for Corey Lake and the connecting lakes. The upstream invert of the M-60 culvert, which is more than one mile downstream of Corey Lake, is approximately 12.5-feet below the legal lake level. In addition, the centerline of M-60 is more than 7-feet below the legal lake level of Corey Lake. While the M-60 culvert is prone to debris build-up, which requires frequent maintenance, even if the culvert was completely obstructed and flood waters overtopped M-60, a free discharge could still be provided for Corey Lake.

Although there is sufficient fall from Corey Lake to M-60, several deficiencies were noted that may impede flow and not allow the Drain to function at its optimum performance. The gradient of the Drain varies considerably from being virtually flat in the upper reaches to approximately 0.3% near M-60. More than 2-feet of sediment has built-up in areas upstream (north) of M-60. In addition, there are several private culverts that are improperly set (too high or too low) and are restricting flow. The proposed grade from the preliminary plans by T.A. Smith, that were part of the failed 1950 petition, are shown on the [Survey Drawings](#) and provide a reference to the optimum channel gradient.

LAKE CONTROL STRUCTURES / OUTLETS

In general, Corey Lake serves as the downstream collection point for Harwood Lake, Kaiser Lake, Mud Lake, Clear Lake, and Mud Lake. Harwood Lake in Cass County discharges directly into Corey Lake from the west. Excess water from Long Lake is pumped south into Clear Lake. Clear Lake outlets into Mud Lake which is directly connected to Kaiser Lake. A channel and control structure on the east side of Corey Lake regulates flow between Kaiser / Mud Lakes and Corey Lake. At times, water from Corey Lake can backflow into Kaiser Lake because the groundwater naturally flows to the southeast. Details of the surveyed lake control structures and connecting channels from Corey Lake, Kaiser Lake and Clear Lake are provided in the [Survey Drawings](#) and [Appendix 3](#).

Corey Lake Outlet: The control structure and outlet for Corey Lake was constructed in the early 1950's. Subsequent repairs and modifications appear to have been made over the last 60 to 70-years but much of the original infrastructure remains in place, though nearing the end of its service life. The pipe diameters vary along the roughly 760-foot outlet enclosure from a 36-inch by 22-inch CMP arch at Corey Lake to 24-inch CMP and ultimately 36-inch CMP at the downstream outlet. The degree of head build-up at the inlet to the control structure relative to the amount of flow observed in downstream drainage structures would indicate that there may be partial failures or obstructions within the pipe system. Sink holes were noted around each drainage structure, indicating that the drainage structures or pipe joints are not properly sealed and allowing sediment to enter the system. In addition, sediment build-up and obstructions (including private culverts in poor condition or improperly set relative to the channel bottom) along the downstream open channel create tailwater conditions, which commonly submerge the outlet pipe and limit the capacity of the control structure (thereby raising water levels in Corey Lake).



Sinkhole near basin at Sta. 63+50



Submerged outlet pipe near Sta. 60+00

On August 5, 1974, the legal lake level of Corey Lake was lowered from 874.5-feet to 874-feet above sea level, based on the National Geodetic Vertical Datum of 1929 (NGVD 29). There is more than 4-feet of fall from the legal lake level to the outlet pipe invert, which is more than 760 linear feet downstream (south) of Corey Lake. During the time of our survey on November 18, 2019, the water surface elevation of Corey Lake was 875.14-feet NGVD 29 and the steel boards (stop logs) were set a crest elevation of 874.45-feet, which is approximately 6-inches above the legal lake level. Interestingly, historic records indicate that Corey Lake residents expressed concerns in the 1980's that the steel boards were set too high (to an elevation of 874.5-feet).



Corey Lake Control Structure to Drain

Corey Lake – Kaiser Lake Connection:

The legal lake level of Kaiser Lake was set at an elevation of 874.5-feet NGVD 29 on August 21, 1953. A control structure (“dam”) was constructed in 1974 along the channel connecting Corey Lake and Kaiser / Mud Lakes, between the east side of Corey Lake and Shafer Brothers Road. The intent of the control structure was to allow for the release of excess water from Corey Lake into Kaiser Lake, during times of low water in Kaiser Lake. The concrete structure is in poor condition. It appears as though stop logs may have been utilized at some point to regulate water levels but no longer function. The bottom of the roughly 8-foot wide concrete control structure is approximately 873.8-feet NGVD 29. Much of the concrete structure is covered in sediment and a large sediment bar / leaf debris has formed at the confluence with Corey Lake, which appears to be further restricting flow.



Kaiser – Corey Control Structure: filled with sediment and leaves



Corey – Kaiser channel looking east from Shafer Brothers Road

Water was observed flowing from Corey Lake to Kaiser Lake during the time of our survey on November 18, 2019. The surveyed elevation of Corey Lake was 875.14-feet NGVD 29 (more than 1-foot above the legal lake level), while the surveyed elevation of Kaiser Lake was at approximately the legal lake level of 874.5-feet NGVD 29. As previously discussed, the natural groundwater flow within the area is to the southeast (toward Kaiser Lake). As a result, it is difficult to manage Kaiser Lake at the legal lake level, without increasing the water surface in Corey Lake. Historically, Corey Lake and Kaiser Lake were established at the same legal lake level (from 1953 to 1974). Some historic reports even recommended that the legal level of Kaiser Lake should be set lower than Corey Lake.

Clear Lake Outlet: The legal lake level of Clear Lake was set at an elevation of 874.75-feet NGVD 29 on October 29, 1953. The control structure and outlet for Clear Lake consists of a 20-inch by 20-inch steel orifice set at an elevation of 872.47-feet NGVD 29 with upstream debris catcher steel grate. The orifice regulates flow through a 24-inch CMP set at an adverse grade, which discharges into a 30-inch CMP that crosses under Coon Hollow Road and ultimately flows south into Mud Lake. The controlling elevation (high-point in the outlet pipe system) is the 30-inch CMP outlet, just south of Coon Hollow Road, which has an invert elevation of 874.14-feet NGVD 29.



The current outlet control structure and pipe system does not efficiently convey flow from Clear Lake to Mud Lake because it relies on the invert (bottom) of the downstream pipe system to control water levels in Clear Lake, which cannot be adjusted. The current system design can only convey approximately 1 cubic foot per second (CFS) or 450 gallons per minute (GPM), while maintaining legal lake levels. As a result, head pressure must build-up (the water must rise) in Clear Lake in order to convey higher flows through the pipe system.



During the time of our survey on November 18, 2019, the water surface elevation of Clear Lake was approximately 875.4-feet NGVD 29, which is approximately 8-inches above the legal lake level. The elevation in Mud Lake downstream (south) of Coon Hollow Road (approximately 300-feet from Clear Lake) was approximately one-foot lower at roughly 874.5-feet. It is our understanding that Long Lake recently ran the pump into Clear Lake for 4-days at approximately 1,800 to 2,000 GPM (4 to 4.5 CFS), which would explain why levels in Clear Lake are still high. These field observations confirm our hydraulic analysis in that the current outlet system does not efficiently convey flow from Clear Lake to Mud Lake.



Long Lake: The legal lake level of Long Lake was set at an elevation of 887-feet NGVD 29 on May 16, 1952. Long Lake has no natural outlet. A pump system was installed in the 1950's and replaced in the 1980's to convey 1,800 to 2,000 GPM (4 to 4.5 CFS) from Long Lake to the wetland complex on the north side of Clear Lake, west of the intersection of Clear Lake Road and Lone Tree Road. At maximum output, the pump can lower water levels roughly ½-inch per day.

The St. Joseph County Drain Commissioner (SJCDC) controls pumping operations from Long Lake to Clear Lake. Given the limited capacity of the Clear Lake outlet, pumping from Long Lake to Clear Lake is only conducted when water levels in Clear Lake are no more than 6-inches above the legal level of Clear Lake (i.e. so long as the water surface of Clear Lake is below 875.25-feet NGVD 29). A study evaluating potential outlet alternatives for Long Lake was conducted in the 1980's, a copy of which is provided in [Appendix 4](#).

Harwood Lake: The legal lake level of Harwood Lake was set at an elevation of 877-feet NGVD 29 on March 15, 1932. The outlet control structure consists of a 5-foot wide weir with crest elevation of 878.35-feet NGVD 29. It should be noted that the control structure is more than one-foot above the legal lake level and the elevation of the water surface on November 18, 2019 was 878.69-feet. The control structure has a free discharge into the channel / culvert that crosses under Corey Lake Road (County Line Road) and into the west end of Corey Lake in Section 19, Fabius Township, St. Joseph County. It is our understanding that residents along Harwood Lake do not have any water level or water quality issues and desire no modifications to be made that would adversely impact Harwood Lake. As a result, Harwood Lake was not evaluated in detail as part of our study.

PRELIMINARY ECOLOGICAL ASSESSMENT

LRE contracted Streamside Ecological Services, Inc. (SES) to perform a preliminary ecological assessment using existing information to determine what data is available and what data must be collected to justify proposed improvements to the Drain or lakes.

SES obtained data and/or reports from Michigan Department of Natural Resources – Fisheries Division (MDNR); Michigan Department of Environment, Great Lakes and Energy (EGLE); Michigan Clean Water Corp (MiCorps) and Long Lake residents. Based upon the data found to date, the aquatic communities of Long, Clear and Corey Lakes appear to be quite similar in nature, with a few exceptions discussed below. Results of water quality monitoring in Long and Clear Lakes show similarities in chemical composition; no data were found for Corey Lake. A summary of the preliminary water quality data is provided below in [Table 1](#).



Table 1 – Preliminary Water Quality Data

	Long Lake	Clear Lake	Corey Lake	Notes
alkalinity (mg/L)	98	120		
TP (mg/L)	0.011	0.011		
chlorophyll a (mg/L)	0.0039	0.0089		
Secchi depth (ft)	15.5	15.5		
Stratification (ft)	12	12		
Invasive plants	Eurasian water milfoil; curly leaf pondweed; Cabomba	Eurasian water milfoil; curly leaf pondweed; starry stonewort; Cabomba	Eurasian water milfoil; curly leaf pondweed. Treated in 2019 for first time in over a decade	Confirm presence of Cabomba and starry stonewort in Corey, or develop solution that will not result in transfer
Invasive animals	none documented	none documented	zebra mussels	
Fish possibly impacting permit	muskellunge		cisco	Develop solution that will not result in muskellunge escaping Long; Water temperature and dissolved oxygen must remain suitable in Corey (deeper water has to be cold and well oxygenated)
Recommendation			Survey for starry stonewort and Cabomba; Test alkalinity, TP, chlorophyll a, secchi depth	

Regarding the possibility of reducing flooding of Long Lake by transferring water into either Clear or Corey Lakes, the following issues must be considered:

- Obtain or collect water chemistry data from Corey Lake to assure that no degradation would occur under project alternatives. Based upon existing data, neither Long nor Clear Lakes have major issues with water quality, in terms of excessive nutrients. Thus, it is unlikely that project alternatives would have a negative impact on the water quality of Corey Lake. EGLE may, however, request water quality data for Corey Lake as part of the permitting process. This data cannot be collected until late spring/early summer of 2020.
- The water temperature and dissolved oxygen profile of Corey Lake must remain unchanged, since the lake is known to harbor the state threatened cisco (require water temperature below 68°F with at least 3 ppm of dissolved oxygen). Based upon existing data, there is no reason to expect that water from either Long or Corey Lake would be excessively warm or depleted of oxygen, though MDNR Fisheries may request assurance as part of the permitting process.
- Confirm the presence of starry stonewort and Cabomba in Corey Lake, invasive species known to occur in both Long and Clear Lakes. If the species are not present in Corey, it is unlikely that an EGLE permit will be issued without assurance that the project alternatives will prevent the spread of these species. Surveys could be completed in late spring/early summer of 2020.
- Long Lake is stocked with muskellunge by the DNR. Transfer of the species should be prevented.



In addition, wetland data must be collected, specific to project alternatives. The alternatives must not have negative impacts to the size or quality of wetlands, unless compensatory mitigation is possible.

HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic and hydraulic analysis was performed to review the hydraulic capacity of the Drain as well as various lake level control structures and evaluate proposed conveyance improvement alternatives to better regulate water levels. Data from our hydrologic and hydraulic analysis are provided in [Appendix 2](#).

The study area was broken down into sub-catchments for hydrologic analysis purposes. Peak discharges for a range of 24-hour rainfall events including the 1-, 2-, 5-, 10-, 25-, 50-, and 100-year storm (100%, 50%, 20%, 10%, 4%, 2% and 1% return frequencies) were obtained at critical design locations, including the lake outlets. Peak Discharges for locations with contributing areas greater than 2 square miles were provided by the Environment Great Lakes and Energy (EGLE) Hydrologic Studies and Dam Safety Unit. Peak Discharges for locations with contributing drainage areas less than 2 square miles were calculated using the methods prescribed by the EGLE report *Computing Flood Discharges for Small Ungaged Watersheds* (Sorrell, 2010).

The EGLE flows do not account for the storage within each lake, which help to attenuate flows dramatically. As a result, the actual flow rates coming out of each lake are significantly lower than those predicted by EGLE.

In order to better analyze flow dynamics, LRE developed a hydrologic model of the watershed using HydroCAD computer software. The pond and flood-routing capabilities of the software allowed us to more accurately account for storage volume in the chain of lakes and more accurately predict estimated peak flows for various rainfall frequency events. In addition, the hydrologic model allows us to evaluate the effectiveness of various improvement alternatives in terms of reducing flooding, improving drainage and regulating water levels between lakes.

A summary of the existing 100-year floodplain elevations for each lake are provided for both LRE's hydrologic model as well as historically published values from the Michigan Department of Environmental Quality (now EGLE) in [Table 2](#). During rainfalls of greater magnitude and reduced frequency, such as the 100-year rainfall event (5.28-inches in 24-hours), the chain of lakes consisting of Corey Lake, Kaiser Lake, Mud Lake and Clear Lake act more as a uniform body of water; thereby, equalizing water levels between lakes. The EGLE 100-year floodplain elevations were most likely computed without the use of pond routing hydrologic software, which explains the higher predicted peak water surface elevations.

Table 2 - 100-Year Floodplain Elevations

Location	Legal Level (NGVD 29)	100-Year Floodplain (NGVD 29)	
		EGLE / Year	LRE Model
Corey Lake	874.0-ft	878.5-ft / 2000	876-ft
Kaiser Lake	874.5-ft	Same as Corey	876-ft
Clear Lake	874.75-ft	876.5-ft / 1995	875.9-ft
Long Lake	887.0-ft	*892.0-ft / 1991	NA
Harwood Lake	877.0-ft	NA	880-ft

Regulating the court ordered water levels between lakes is difficult given the dynamic relationship as well as seasonal variations in terms of precipitation, evaporation, infiltration and groundwater water. As the *Corey, Kaiser, Mud and Clear Lakes Level Control Preliminary Engineering Investigation* by the Michigan Department of Conservation Engineering and Architecture, and dated July 1953 stated “*Natural conditions will not permit holding one lake within a few hundredths of a foot above or below an established level ... but it should be possible to maintain generally satisfactory levels if the whole group of lakes is considered in the operational procedures for the several control units and connecting channels*”. A summary of the outlet flow rate for each lake during both observed (surveyed) conditions on November 18, 2019 as well as existing conditions when all lakes are at their legal level are provided below in [Table 3](#).

Table 3 – Flow Rate at Lake Outlet Control Structures

Location	Legal Level		11/18/19 Level	
	Lake Elev. (NGVD 29)	Flow Rate (CFS)	Lake Elev. (NGVD 29)	Flow Rate (CFS)
Corey Lake	874-ft	0 (Below Weir)	875.14-ft	15 to Drain
Kaiser Lake	874.5-ft	5 to Corey	874.49-ft	-5 from Corey
Clear Lake	874.75-ft	1 to Mud	875.40-ft	> 4 to Mud
Long Lake	887-ft	NA	887.22-ft	0 (Pump Off)
Harwood Lake	877-ft	0 (Below Weir)	878.69-ft	4 to Corey

Note – 1 cubic foot per second (CFS) is approximately equal to 450 gallons per minute (GPM)

EVALUATION OF ALTERNATIVES

The goals of our engineering study based on input from residents within the District and the Board include:

1. Ensure the Corey Lake Intercounty Drain provides an adequate outlet for the District, including the chain of lakes.
2. Investigate alternatives to better manage legal lake levels within Corey Lake and the connecting lakes.
3. Review the feasibility of providing a gravity outlet for Long Lake.

Numerous alternatives or combinations thereof were considered to accomplish these goals. Following are four of the alternatives that we evaluated in detail.

Alternative 1 – Do Nothing

The established Corey Lake Intercounty Drain currently stops more than ½ mile short (south) of Corey Lake. Neither the Corey Lake control structure nor the more than 760 linear feet of outlet pipe are currently under the jurisdiction of the Board. Under the “Do Nothing” scenario, individual lake associations would continue to be responsible for the maintenance and operation of their respective lake control structures and outlets. The “do nothing” alternative may be acceptable if property owners within the District determine that the current water level fluctuations are acceptable, or the proposed improvements are too costly.

Alternative 2 – Extend Drain to Corey Lake

Numerous deficiencies including sediment deposition, failing pipes and culverts, and other obstructions were identified along both the Drain and Corey Lake outlet, upstream (north) of M-60. The primary focus of Alternative 2 is to provide an adequate, free discharge outlet for Corey Lake, which will help to better manage water levels in connecting lakes. Alternative 2 consists of extending the Drain to Corey Lake and more than one-mile of maintenance and improvements from M-60 to Corey Lake. Below is a list of major elements included in Alternative 2.

Drain Extension: The Drain would be legally extended from the current upstream terminus at the east-west quarter line of Section 30, Fabius Township, St. Joseph County to the current control structure at Corey Lake. The Drain extension would require at least 2 permanent easements and a resolution from the St. Joseph County Road Commission to locate the Drain within the Corey Lake Road right-of-way.

Open Channel Excavation: Approximately 6,000 linear feet of open channel excavation is proposed from M-60 to the pipe outlet, south of Corey Lake Road. An average of 2-feet of sediment will be removed from the Drain to provide grade similar to the 1950 proposal. A trapezoidal channel with minimum bottom width of 3-feet, average depth of 4-feet, 2:1 (H:V) side slopes, and 0.1% grade is capable of conveying approximately 100 CFS, which is more than necessary to provide an adequate outlet for Corey Lake and the upstream contributing drainage area. It should be noted that the private and public culverts will act as the limiting factor in regard to the capacity of the Drain.

Culvert Replacement: Deteriorated/undersized crossings would be replaced with 36-inch diameter culverts, with capacities similar to that of the proposed open channel. Replacement of the M-60 culvert should be considered and reviewed with the Michigan Department of Transportation (MDOT). LRE has a strong working relationship with MDOT and it's likely that MDOT funds would be available to cover this cost.

Storm Sewer Replacement: Approximately 760-feet of deteriorated storm sewer would be replaced with 36-inch storm sewer to increase the outlet capacity from Corey Lake by more than 50% and provide for approximately 25 to 30 CFS discharge during normal legal lake levels (assuming stop logs were removed).

Control Structure: Assuming the outlet pipe is replaced and enlarged, the existing control structure will need to be reconfigured and weir opening lengthened to provide a greater hydraulic opening. In addition, the operation of stop logs in regard to the legal lake level should be reviewed. Work on the control structure could be assessed directly to residents with access to Corey Lake.



Culvert Obstruction near Sta. 40+50



Drainage Structure near Sta. 63+50

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 2 is approximately \$520,000. Please note that this estimated cost does not include administrative, land/easement acquisition or financing costs. A detailed project cost breakdown is provided in [Appendix 1](#).

Alternative 3 – Extend Drain and Improve Lake Connections

Alternative 3 includes all the work proposed in Alternative 2 along with improved connections between Clear, Mud, Kaiser and Corey Lakes to better manage lake levels. Additional items of work beyond the scope of Alternative 2 include:

Drain Extension: The Drain would be legally extended from the current upstream terminus at the east-west quarter line of Section 30, Fabius Township, St. Joseph County through Corey Lake, Kaiser / Mud Lakes, and into Clear Lake. The Drain extension would require at least 7 permanent easements and a resolution from the St. Joseph County Road Commission to locate the Drain within county road right-of-way.

Corey Lake to Kaiser Lake: At a minimum the channel, including concrete control structure (“dam”) should be cleaned-out of sediment and debris to restore it’s designed hydraulic capacity. While maintaining the legal lake level in Kaiser Lake is nearly impossible without increasing the water surface in Corey Lake above its legal lake level, improvements could be made to the channel to improve the hydraulic connection between the lakes. Removal of the existing control structure (“dam”) and replacement with an adjustable weir that allows for a significantly deeper channel would help equalize water levels between Corey Lake and Kaiser Lake.



Channel between Kaiser / Mud Lakes

Clear Lake to Mud Lake: The current outlet from Clear Lake does not provide sufficient capacity to convey discharges from Long Lake during pumping operations without increasing the water surface of Clear Lake above its legal lake level. The installation of a 30-inch diameter (minimum) pipe outlet set at a deeper grade (873-ft +/- NGVD 29) with adjustable in-line weir would allow for up to 10 CFS (4,500 GPM) to be conveyed under normal legal lake level conditions.



Clear Lake outlet – pipes set too high

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 3 is approximately \$695,000. Please note that this estimated cost does not include administrative, land/easement acquisition or financing costs. A detailed project cost breakdown is provided in [Appendix 1](#).

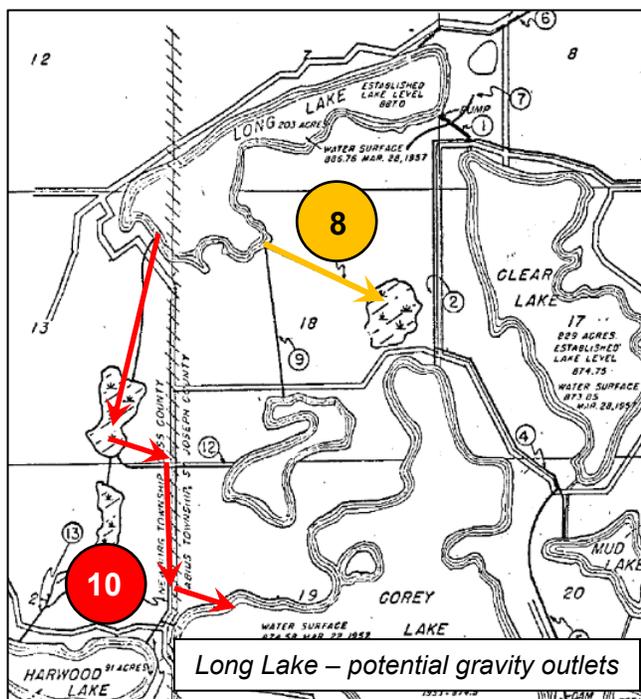
Alternative 4 – Long Lake Gravity Outlet

Alternative 4 includes all the work proposed in Alternative 3 with the addition of a gravity outlet from Long Lake. Additional items of work beyond the scope of Alternative 3 include:

Drain Extension: The Drain would be legally extended from the current upstream terminus at the east-west quarter line of Section 30, Fabius Township, St. Joseph County through Corey Lake, Kaiser / Mud Lakes, Clear Lake, and into Long Lake. The Drain extension would require at least 5 permanent easements and a resolution from the St. Joseph County Road Commission to locate the Drain within county road right-of-way.

Long Lake Gravity Outlet: A study was conducted in the 1980's to evaluate potential outlets (both pump and gravity) from Long Lake, a copy of which is included in [Appendix 4](#). Harwood Lake property owners are insistent that they will not accept any drainage from Long Lake. This eliminates the vast majority of the gravity outlets from the 1980's study. However, the following options are still feasible:

- Option 8 (with direction bore instead of pump): There is approximately 10-feet of fall from the legal level of Long Lake to the wetland complex, north of Coon Hollow Road, which is hydraulically connected to Corey Lake. The proposed alignment would extend from Long Lake, near the intersection of Walnut Drive and Oak Drive, southeast across the agricultural fields and into the wetland complex, north of Coon Hollow Road. This alternative would require more than 1,600 linear feet of boring through depths of up to 45-feet.
- Option 10: Provides for a gravity outlet along Corey Lake (County Line) Road to the west end of Corey Lake, near the Corey Lake Marina.



Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 4 is approximately \$1,600,000 based on the modified Option 8. Please note that this estimated cost does not include administrative, land/easement acquisition or financing costs. A detailed project cost breakdown is provided in [Appendix 1](#).

RECOMMENDATIONS & IMPLEMENTATION

LRE will work with the Board to develop a final project scope, if the petition is found necessary. We tentatively recommend proceeding with Alternative 3 as the most cost-effective way to better manage lake levels and provide an adequate outlet for the District. Implementation of the recommended scope of improvements to the Drain, as presented in this report, requires consideration of the following:

Easement Acquisition: Additional easements will be required along the proposed Drain extension to access and complete the work.

Permitting: The proposed Drain extension will require an Environment Great Lakes and Energy permit pursuant to Part 301, Inland Lakes and Streams and Part 303, wetlands protection of the Natural Resources and Environmental Protection Act, PA 451 of 1994 (NREPA).

Legal Lake Levels: Lake control structure improvements may be separate from actual Intercounty Drain Project. Given that Harwood Lake and Corey Lake are routinely operating above their legal lake level and Kaiser Lake is rarely operating up to its legal lake level, adjustments to the legal lake levels may be considered independently of the Drain project through Part 307, Inland Lake Levels, of NREPA.

Drainage District Revisions: The District should be revised as shown in [Exhibits B-1 and B-2](#) to accurately reflect the contributing drainage area. Project costs would be apportioned between counties and assessed to municipal entities, including MDOT, as well as roughly 1,600 private properties.

Final Design and Construction: Establish a project schedule, complete the final design and prepare contract documents for bidding and construction.

Exhibits



2121 3 Mile Rd.

Walker, Michigan 49544

Phone: 616.301.7888

www.LREMI.com

EXHIBIT A

COREY LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT

TOWNSHIP OF NEWBERG
CASS COUNTY, MICHIGAN

TOWNSHIP OF FABIUS
ST. JOSEPH COUNTY, MICHIGAN

THE DESCRIPTION OF THE COREY LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT CONSISTS OF ALL THAT LAND LOCATED IN SECTIONS 11-14 AND 23-26 OF TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN AND SECTIONS 7-8, 16-21 AND 28-33 OF TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN BOUNDED BY A LINE DESCRIBED AS FOLLOWS:

BEGINNING AT A POINT ON THE EAST LINE OF SECTION 25, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN AT THE NORTHEAST CORNER OF SAID SECTION;
THENCE NORTH 85° 05' 02" WEST 738.87 FEET;
THENCE NORTH 45° 26' 32" WEST 25.45 FEET TO THE NORTH LINE OF SECTION 25, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN AT A POINT 758 +/- FEET WEST OF THE NORTHEAST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 45° 26' 32" WEST 396.01 FEET INTO SECTION 24, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;
THENCE SOUTH 53° 57' 13" WEST 453.81 FEET;
THENCE SOUTH 53° 57' 13" WEST 19.93 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 1375 +/- FEET WEST OF THE SOUTHEAST CORNER OF SAID SECTION;
THENCE NORTH 90° 00' 00" WEST 1416.21 FEET ALONG THE SOUTH LINE OF SAID SECTION;
THENCE NORTH 55° 00' 11" WEST 579.97 FEET;
THENCE SOUTH 40° 15' 27" WEST 427.70 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 1681 +/- FEET EAST OF THE SOUTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING SOUTH 40° 15' 27" WEST 1105.46 FEET INTO SECTION 25, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;
THENCE SOUTH 73° 01' 24" WEST 702.95 FEET;
THENCE SOUTH 20° 23' 33" WEST 686.63 FEET;

THENCE SOUTH 50° 04' 43" WEST 80.63 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 1772 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;

THENCE CONTINUING SOUTH 50° 04' 43" WEST 436.64 FEET INTO SECTION 26, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;

THENCE SOUTH 02° 56' 55" EAST 954.13 FEET;

THENCE SOUTH 54° 25' 45" WEST 1347.70 FEET;

THENCE NORTH 13° 54' 17" WEST 4.16 FEET;

THENCE SOUTH 46° 46' 36" WEST 0.79 FEET;

THENCE NORTH 24° 12' 17" WEST 54.85 FEET;

THENCE NORTH 72° 06' 15" WEST 198.18 FEET;

THENCE SOUTH 56° 02' 58" WEST 61.32 FEET;

THENCE NORTH 59° 22' 19" WEST 381.89 FEET;

THENCE SOUTH 86° 00' 10" WEST 234.37 FEET;

THENCE NORTH 02° 14' 14" WEST 199.61 FEET;

THENCE NORTH 07° 43' 47" WEST 185.07 FEET;

THENCE NORTH 57° 30' 27" EAST 215.59 FEET;

THENCE NORTH 62° 44' 51" EAST 194.15 FEET;

THENCE NORTH 09° 06' 56" EAST 181.61 FEET;

THENCE NORTH 20° 19' 33" WEST 337.28 FEET;

THENCE SOUTH 57° 09' 46" WEST 305.09 FEET;

THENCE NORTH 01° 46' 37" EAST 300.21 FEET;

THENCE NORTH 10° 41' 22" WEST 543.64 FEET;

THENCE NORTH 74° 33' 35" WEST 762.55 FEET;

THENCE NORTH 56° 43' 07" WEST 99.23 FEET;

THENCE SOUTH 89° 48' 08" WEST 158.39 FEET;

THENCE NORTH 45° 54' 24" WEST 247.29 FEET;

THENCE NORTH 62° 41' 59" WEST 167.85 FEET;

THENCE SOUTH 82° 41' 54" WEST 268.09 FEET;

THENCE NORTH 79° 13' 57" WEST 925.65 FEET;

THENCE NORTH 12° 27' 13" EAST 169.41 FEET;

THENCE NORTH 25° 41' 50" WEST 115.35 FEET;

THENCE NORTH 31° 15' 53" EAST 603.05 FEET;

THENCE NORTH 19° 02' 22" WEST 384.21 FEET;

THENCE NORTH 88° 07' 34" WEST 339.24 FEET;

THENCE NORTH 15° 42' 00" EAST 62.67 FEET TO THE NORTH LINE OF SAID SECTION AT A POINT 268 +/- FEET EAST OF THE NORTHWEST CORNER OF SAID SECTION;

THENCE CONTINUING NORTH 15° 42' 00" EAST 591.65 FEET INTO SECTION 23, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;

THENCE NORTH 58° 11' 11" WEST 473.65 FEET;

THENCE NORTH 00° 31' 31" EAST 1339.71 FEET;

THENCE NORTH 27° 52' 42" EAST 501.08 FEET;

THENCE NORTH 40° 14' 02" WEST 356.07 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 2397 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;
THENCE NORTH 00° 57' 51" EAST 1213.01 FEET ALONG THE WEST LINE OF SAID SECTION;
THENCE NORTH 15° 31' 29" EAST 383.31 FEET;
THENCE NORTH 78° 47' 34" EAST 410.20 FEET;
THENCE SOUTH 80° 19' 55" EAST 992.35 FEET;
THENCE NORTH 24° 09' 33" EAST 615.65 FEET;
THENCE NORTH 42° 21' 19" WEST 429.04 FEET TO THE NORTH LINE OF SAID SECTION AT A POINT 1466 +/- FEET EAST OF THE NORTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 42° 21' 19" WEST 353.10 FEET INTO SECTION 14, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;
THENCE NORTH 64° 17' 06" EAST 1087.74 FEET;
THENCE SOUTH 86° 39' 39" EAST 579.70 FEET;
THENCE NORTH 05° 16' 50" EAST 186.86 FEET;
THENCE NORTH 79° 43' 35" WEST 321.94 FEET;
THENCE NORTH 10° 50' 51" WEST 778.82 FEET;
THENCE NORTH 39° 03' 08" EAST 1286.36 FEET;
THENCE NORTH 79° 32' 05" EAST 735.32 FEET;
THENCE NORTH 72° 54' 49" EAST 1011.34 FEET;
THENCE NORTH 48° 05' 23" WEST 524.11 FEET;
THENCE NORTH 33° 22' 45" EAST 1511.28 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 479 +/- FEET SOUTH OF THE NORTHEAST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 33° 22' 45" EAST 110.74 FEET INTO SECTION 13, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;
THENCE NORTH 08° 37' 48" WEST 376.85 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 14 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 08° 37' 48" WEST 13.94 FEET INTO SECTION 14, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN TO THE NORTH LINE OF SAID SECTION AT A POINT 2 +/- FEET WEST OF THE NORTHEAST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 08° 37' 48" WEST 162.27 FEET INTO SECTION 11, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;
THENCE NORTH 82° 08' 15" EAST 28.32 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 164 +/- FEET NORTH OF THE SOUTHEAST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 82° 08' 15" EAST 962.80 FEET INTO SECTION 12, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;

THENCE NORTH 17° 09' 14" EAST 269.92 FEET;
THENCE NORTH 12° 51' 10" EAST 445.14 FEET;
THENCE NORTH 47° 44' 55" EAST 193.91 FEET;
THENCE NORTH 50° 56' 17" WEST 102.80 FEET;
THENCE NORTH 02° 18' 28" WEST 65.23 FEET;
THENCE SOUTH 87° 21' 16" EAST 306.76 FEET;
THENCE NORTH 61° 31' 16" EAST 90.39 FEET;
THENCE SOUTH 73° 00' 43" EAST 209.02 FEET;
THENCE NORTH 45° 44' 09" EAST 108.46 FEET;
THENCE NORTH 70° 51' 11" EAST 135.33 FEET;
THENCE NORTH 54° 20' 20" EAST 74.92 FEET;
THENCE NORTH 16° 12' 26" EAST 164.12 FEET;
THENCE NORTH 01° 10' 32" WEST 234.54 FEET;
THENCE SOUTH 86° 50' 29" EAST 314.70 FEET;
THENCE NORTH 46° 03' 08" EAST 132.93 FEET;
THENCE NORTH 81° 21' 25" EAST 52.62 FEET;
THENCE SOUTH 33° 12' 17" EAST 160.50 FEET;
THENCE SOUTH 79° 41' 31" EAST 131.58 FEET;
THENCE SOUTH 21° 58' 19" EAST 279.25 FEET;
THENCE NORTH 66° 41' 38" EAST 144.70 FEET;
THENCE SOUTH 57° 05' 01" EAST 208.50 FEET;
THENCE NORTH 70° 15' 17" EAST 70.94 FEET;
THENCE NORTH 07° 48' 37" WEST 139.51 FEET;
THENCE NORTH 25° 05' 43" EAST 176.11 FEET;
THENCE NORTH 65° 18' 35" WEST 195.76 FEET;
THENCE NORTH 36° 26' 52" EAST 271.23 FEET;
THENCE NORTH 59° 52' 23" EAST 223.35 FEET;
THENCE NORTH 26° 06' 50" EAST 245.85 FEET;
THENCE NORTH 35° 14' 55" EAST 134.82 FEET;
THENCE SOUTH 62° 51' 19" EAST 119.32 FEET;
THENCE NORTH 72° 18' 54" EAST 131.11 FEET;
THENCE NORTH 22° 11' 06" WEST 283.78 FEET;
THENCE NORTH 52° 49' 40" EAST 286.84 FEET;
THENCE NORTH 41° 13' 03" EAST 74.62 FEET;
THENCE NORTH 84° 17' 32" EAST 128.43 FEET;
THENCE NORTH 06° 49' 38" WEST 142.89 FEET;
THENCE SOUTH 60° 11' 53" EAST 65.28 FEET;
THENCE NORTH 76° 05' 36" EAST 195.98 FEET;
THENCE NORTH 31° 29' 14" WEST 138.95 FEET;
THENCE NORTH 28° 59' 37" EAST 36.58 FEET;
THENCE NORTH 53° 15' 38" EAST 174.63 FEET;
THENCE NORTH 22° 55' 24" EAST 105.64 FEET;
THENCE SOUTH 72° 01' 31" EAST 203.26 FEET;
THENCE NORTH 43° 43' 22" EAST 283.67 FEET;
THENCE NORTH 40° 36' 23" WEST 237.21 FEET;

THENCE NORTH 70° 10' 19" EAST 543.67 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 1198 +/- FEET SOUTH OF THE NORTHEAST CORNER OF SAID SECTION;

THENCE CONTINUING NORTH 70° 10' 19" EAST 347.61 FEET INTO SECTION 7, TOWNSHIP 6 SOUTH, RANGE 12 WEST, FABIVS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;

THENCE SOUTH 70° 25' 16" EAST 429.25 FEET;

THENCE NORTH 02° 58' 21" EAST 627.03 FEET;

THENCE SOUTH 70° 45' 31" WEST 459.69 FEET;

THENCE CONTINUING NORTH 53° 16' 35" WEST 406.91 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 509 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;

THENCE NORTH 53° 16' 35" WEST 74.54 FEET INTO SECTION 12, TOWNSHIP 06 SOUTH, RANGE 13 WEST, NEWBERG TOWNSHIP, CASS COUNTY, MICHIGAN;

THENCE NORTH 40° 28' 37" EAST 93.01 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 387 +/- FEET SOUTH OF THE NORTHEAST CORNER OF SAID SECTION;

THENCE CONTINUING NORTH 40° 28' 37" EAST 458.66 FEET INTO SECTION 7, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIVS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN TO THE NORTH LINE OF SAID SECTION AT A POINT 299 +/- FEET EAST OF THE NORTHWEST CORNER OF SAID SECTION;

THENCE SOUTH 88° 51' 06" EAST 3939.50 FEET ALONG THE NORTH LINE OF SAID SECTION;

THENCE SOUTH 01° 02' 07" WEST 315.64 FEET;

THENCE SOUTH 26° 05' 28" WEST 101.81 FEET;

THENCE SOUTH 74° 07' 38" WEST 154.84 FEET;

THENCE SOUTH 01° 04' 42" WEST 521.06 FEET;

THENCE SOUTH 16° 00' 12" WEST 63.97 FEET;

THENCE SOUTH 16° 39' 28" EAST 350.73 FEET;

THENCE SOUTH 47° 41' 11" EAST 166.62 FEET;

THENCE SOUTH 58° 37' 48" EAST 81.35 FEET;

THENCE SOUTH 03° 17' 04" WEST 33.20 FEET;

THENCE SOUTH 14° 26' 58" WEST 151.28 FEET;

THENCE SOUTH 63° 14' 41" WEST 102.39 FEET;

THENCE SOUTH 22° 21' 04" EAST 183.73 FEET;

THENCE NORTH 47° 59' 46" EAST 124.84 FEET;

THENCE NORTH 47° 59' 47" EAST 20.31 FEET;

THENCE NORTH 63° 43' 57" EAST 105.88 FEET;

THENCE NORTH 70° 29' 39" EAST 70.22 FEET;

THENCE NORTH 79° 40' 47" EAST 211.75 FEET;

THENCE SOUTH 68° 41' 10" EAST 86.18 FEET;

THENCE NORTH 76° 41' 28" EAST 104.02 FEET;

THENCE SOUTH 70° 58' 53" EAST 106.07 FEET;

THENCE SOUTH 88° 13' 22" EAST 163.31 FEET;

THENCE SOUTH 51° 43' 59" EAST 205.84 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 1889 +/- FEET SOUTH OF THE NORTHEAST CORNER OF SAID SECTION;

THENCE CONTINUING SOUTH 51° 43' 59" EAST 41.70 FEET INTO SECTION 8, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;

THENCE NORTH 87° 37' 11" EAST 1618.17 FEET;

THENCE SOUTH 01° 14' 18" WEST 831.02 FEET;

THENCE SOUTH 30° 37' 44" EAST 445.84 FEET;

THENCE SOUTH 07° 58' 24" WEST 204.54 FEET;

THENCE NORTH 58° 55' 17" EAST 169.95 FEET;

THENCE NORTH 86° 13' 15" EAST 114.05 FEET;

THENCE SOUTH 40° 24' 27" EAST 831.05 FEET;

THENCE SOUTH 25° 12' 07" WEST 582.52 FEET;

THENCE SOUTH 36° 17' 09" EAST 288.01 FEET;

THENCE SOUTH 44° 03' 18" EAST 820.55 FEET;

THENCE SOUTH 84° 57' 53" EAST 561.24 FEET;

THENCE SOUTH 37° 05' 07" EAST 203.92 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 1486 +/- FEET WEST OF THE SOUTHEAST CORNER OF SAID SECTION;

THENCE CONTINUING SOUTH 37° 05' 07" EAST 1076.32 FEET INTO SECTION 17, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;

THENCE SOUTH 83° 45' 45" EAST 546.13 FEET;

THENCE SOUTH 22° 36' 53" EAST 719.09 FEET TO THE EAST LINE OF SAID SECTION AT A POINT 1540 +/- FEET SOUTH OF THE NORTHEAST CORNER OF SAID SECTION;

THENCE CONTINUING SOUTH 22° 36' 53" EAST 900.43 FEET INTO SECTION 16, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;

THENCE SOUTH 32° 17' 36" WEST 397.19 FEET;

THENCE SOUTH 83° 55' 21" EAST 1043.17 FEET;

THENCE SOUTH 12° 06' 23" EAST 634.10 FEET;

THENCE SOUTH 19° 58' 59" WEST 1181.72 FEET;

THENCE SOUTH 24° 57' 42" EAST 284.29 FEET;

THENCE SOUTH 43° 13' 14" WEST 627.14 FEET;

THENCE SOUTH 41° 49' 10" EAST 30.09 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 656 +/- FEET EAST OF THE SOUTHWEST CORNER OF SAID SECTION;

THENCE CONTINUING SOUTH 41° 49' 10" EAST 443.38 FEET INTO SECTION 21, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;

THENCE SOUTH 01° 13' 29" WEST 941.95 FEET;

THENCE NORTH 64° 39' 45" EAST 266.43 FEET;

THENCE SOUTH 26° 06' 18" EAST 315.67 FEET;

THENCE SOUTH 01° 31' 00" WEST 933.00 FEET;

THENCE SOUTH 30° 53' 04" EAST 210.24 FEET;
THENCE SOUTH 63° 36' 00" EAST 179.73 FEET;
THENCE SOUTH 87° 23' 57" EAST 472.42 FEET;
THENCE SOUTH 42° 38' 06" EAST 114.52 FEET;
THENCE SOUTH 16° 44' 54" WEST 755.71 FEET;
THENCE SOUTH 13° 39' 39" EAST 499.68 FEET;
THENCE SOUTH 55° 39' 19" EAST 766.63 FEET;
THENCE SOUTH 02° 20' 46" WEST 880.92 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 2677 +/- FEET EAST OF THE SOUTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING SOUTH 02° 20' 46" WEST 1735.08 FEET INTO SECTION 28, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;
THENCE SOUTH 41° 02' 29" WEST 649.11 FEET;
THENCE SOUTH 86° 53' 10" WEST 893.57 FEET;
THENCE SOUTH 00° 36' 39" WEST 1239.06 FEET;
THENCE SOUTH 40° 46' 04" WEST 731.09 FEET;
THENCE SOUTH 61° 55' 37" EAST 1090.82 FEET;
THENCE SOUTH 37° 23' 06" WEST 912.81 FEET TO THE SOUTH LINE OF SAID SECTION AT A POINT 1280 +/- EAST OF THE SOUTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING SOUTH 37° 23' 06" WEST 377.86 FEET INTO SECTION 33, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;
THENCE SOUTH 70° 00' 39" WEST 371.44 FEET;
THENCE NORTH 66° 14' 37" WEST 448.40 FEET;
THENCE SOUTH 24° 19' 52" WEST 559.70 FEET;
THENCE SOUTH 72° 01' 11" WEST 76.88 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 788 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING SOUTH 72° 01' 11" WEST 313.56 FEET INTO SECTION 32, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;
THENCE SOUTH 18° 12' 55" EAST 774.81 FEET;
THENCE SOUTH 69° 06' 01" WEST 1196.59 FEET;
THENCE NORTH 40° 06' 23" WEST 655.24 FEET;
THENCE SOUTH 24° 34' 25" WEST 1215.15 FEET;
THENCE SOUTH 72° 11' 29" WEST 283.34 FEET;
THENCE SOUTH 01° 44' 30" EAST 760.60 FEET;
THENCE NORTH 62° 19' 10" WEST 931.21 FEET;
THENCE SOUTH 59° 09' 03" WEST 876.70 FEET;
THENCE SOUTH 35° 00' 38" WEST 725.11 FEET;
THENCE NORTH 86° 13' 43" WEST 265.77 FEET;
THENCE SOUTH 02° 04' 19" EAST 296.09 FEET;

THENCE SOUTH 75° 17' 40" WEST 748.43 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 519 +/- FEET NORTH OF THE SOUTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING SOUTH 75° 17' 40" WEST 15.07 FEET INTO SECTION 31, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN;
THENCE SOUTH 19° 57' 15" WEST 571.38 FEET;
THENCE NORTH 88° 46' 34" WEST 1864.22 FEET ALONG SECTION LINE;
THENCE NORTH 15° 35' 30" WEST 651.99 FEET;
THENCE SOUTH 54° 03' 37" WEST 316.83 FEET;
THENCE NORTH 46° 32' 52" WEST 1586.05 FEET;
THENCE NORTH 18° 28' 19" EAST 287.29 FEET;
THENCE NORTH 62° 36' 57" WEST 624.08 FEET;
THENCE NORTH 24° 05' 09" WEST 476.64 FEET;
THENCE NORTH 19° 25' 48" EAST 417.70 FEET;
THENCE NORTH 71° 43' 43" WEST 454.99 FEET;
THENCE SOUTH 73° 31' 39" WEST 611.67 FEET TO THE WEST LINE OF SAID SECTION AT A POINT 2479 +/- FEET SOUTH OF THE NORTHWEST CORNER OF SAID SECTION;
THENCE NORTH 00° 12' 45" EAST 2477.77 FEET ALONG THE WEST LINE OF SAID TO THE NORTHWEST CORNER OF SAID SECTION;
THENCE CONTINUING NORTH 00° 12' 45" EAST 4330.49 FEET INTO SECTION 30, TOWNSHIP 06 SOUTH, RANGE 12 WEST, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN ALONG THE WEST SECTION LINE;
THENCE NORTH 33° 25' 22" EAST 545.59 FEET;
THENCE NORTH 14° 37' 15" WEST 418.23 FEET;
THENCE NORTH 85° 05' 02" WEST A DISTANCE OF 207.25 FEET TO THE POINT OF BEGINNING;

TOTAL AREA OF THE COREY LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT IS 8563.9 ACRES, MORE OR LESS.

SECTION LINES WERE NOT FIELD VERIFIED. BEARINGS AND DISTANCES ARE BASED ON GIS INFORMATION RECEIVED FROM CASS AND ST. JOSEPH COUNTIES.

Drafted By:
Taylor R. Mantey, PE

Land & Resource Engineering
2121 3 Mile Rd. NW
Walker, MI 49544
616-301-7888

COREY LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT

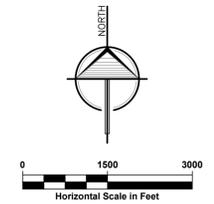
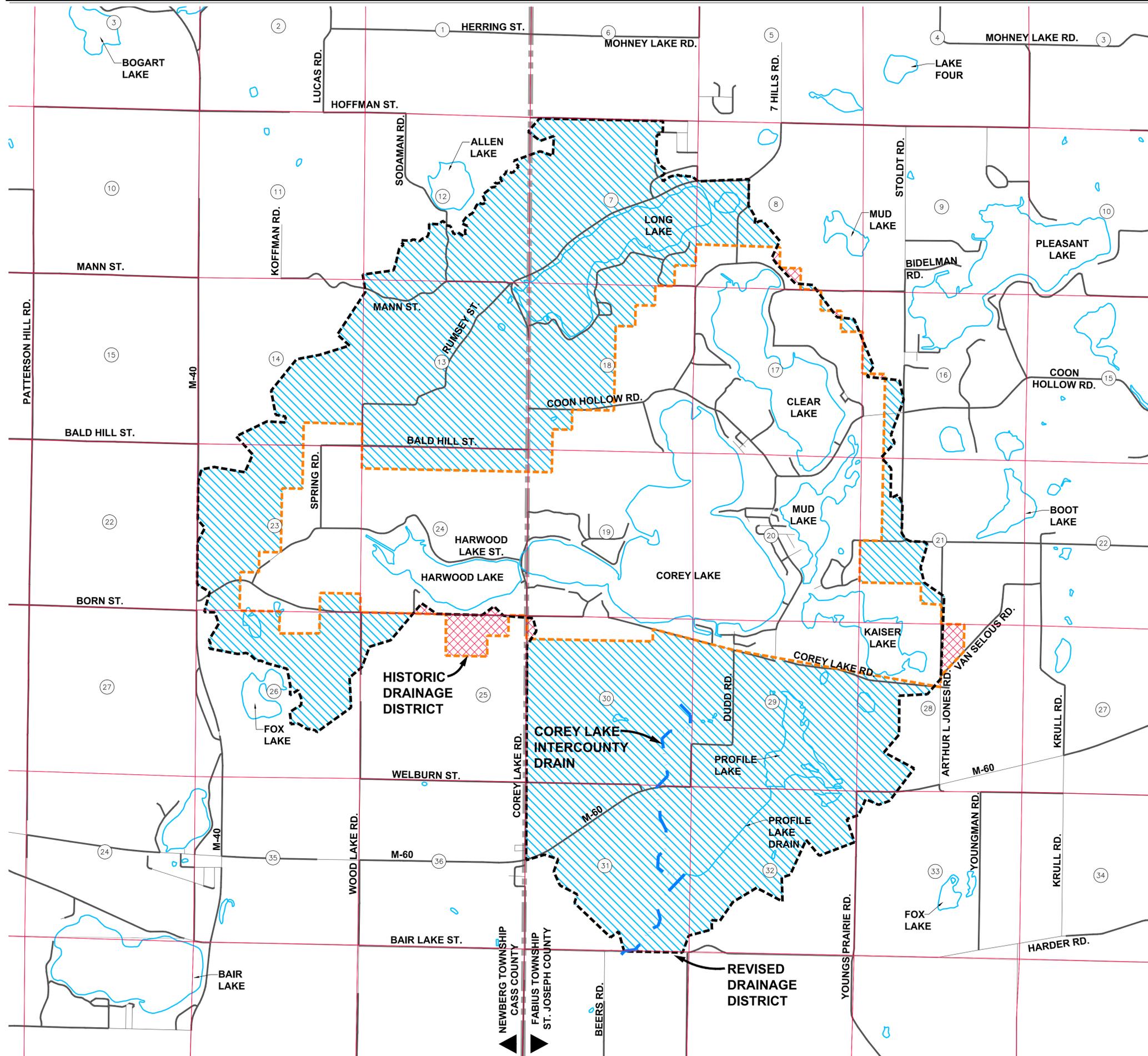
SECTIONS 11-14, 23-26
T6S R13W
NEWBERG TOWNSHIP, CASS COUNTY
&
SECTIONS 7-8, 16-21 & 28-33
T6S R12W
FABIUS TOWNSHIP, ST. JOSEPH COUNTY

DRAIN INFORMATION:

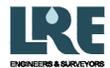
HISTORIC DISTRICT:	3790.2 ACRES
REVISED DISTRICT:	8563.9 ACRES
LANDS ADDED:	4,862.7 ACRES
LANDS REMOVED:	89.0 ACRES

LEGEND

-  LANDS REMOVED
-  LANDS ADDED
-  DRAIN ALIGNMENT
-  HISTORIC DRAINAGE DISTRICT BOUNDARY
-  REVISED DRAINAGE DISTRICT BOUNDARY
-  PARCEL LINES
-  SECTION LINES
-  ROADS
-  COUNTY LINE
-  TOWNSHIP LINE
-  SECTION NUMBERS



LANDS ADDED/REMOVED MAP EXHIBIT B-1

 ENGINEERS & SURVEYORS	2121 3 Mile Rd. NW Walker, MI 49544 Ph: 616-301-7888 www.LREMI.com	PROJECT#: 19-078 DRAWN BY: LGG DATE: 11/2019 QAQC: DJF
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11/2019, 2019 - 11/2019 in Fabius Township, St. Joseph County, Michigan. All rights reserved.

Appendix 1

Preliminary Estimates of Project Cost



2121 3 Mile Rd.

Walker, Michigan 49544

Phone: 616.301.7888

www.LREMI.com

**COREY LAKE INTERCOUNTY DRAIN
ALTERNATIVE 2 - PRELIMINARY ESTIMATE OF PROJECT COST**

By Land & Resource Engineering, November 27, 2019



ENGINEERS & SURVEYORS

Corey Lake Outlet to M-60 Improvements

No.	Item Description	Quantity		Unit Cost	Total Cost
1	Mobilization	1	LS	\$ 25,000.00	\$ 25,000.00
2	Traffic Control	1	LS	\$ 5,000.00	\$ 5,000.00
3	Woody Debris Management	6,000	LF	\$ 4.00	\$ 24,000.00
4	Open Channel Excavation	6,000	LF	\$ 6.00	\$ 36,000.00
5	Culvert, 36-inch (Private, Station 3+00)	40	LF	\$ 100.00	\$ 4,000.00
6	Culvert, 36-inch (Private, Station 10+00)	40	LF	\$ 100.00	\$ 4,000.00
7	Culvert, 36-inch (Private, Station 14+25)	40	LF	\$ 100.00	\$ 4,000.00
8	Culvert, 36-inch (Private, Station 25+00)	40	LF	\$ 100.00	\$ 4,000.00
9	Culvert, 36-inch (Private, Station 40+75)	30	LF	\$ 100.00	\$ 3,000.00
10	Storm Sewer, 36-inch PE	763	LF	\$ 100.00	\$ 76,300.00
11	Manhole, 48-inch Diameter	2	EA	\$ 3,500.00	\$ 7,000.00
12	Riprap End Treatment	200	SY	\$ 75.00	\$ 15,000.00
13	Riprap Side Inlet	2	EA	\$ 2,500.00	\$ 5,000.00
14	Private Crossing Restoration	5	EA	\$ 1,500.00	\$ 7,500.00
15	Paved Road Restoration	1	EA	\$ 7,500.00	\$ 7,500.00
16	Open Channel Seeding	6,750	LF	\$ 2.00	\$ 13,500.00
17	Mulch Blanket	12,000	SY	\$ 2.00	\$ 24,000.00
18	Outlet Control Structure	1	EA	\$ 45,000.00	\$ 45,000.00

Estimated Total Construction Cost \$ 309,800.00

Estimated Engineering (Study though Construction) \$ 100,000.00

Estimated Legal \$ 30,000.00

Estimated Permits \$ 10,000.00

Contingency (~15%) \$ 70,200.00

*** Preliminary Estimate of Project Cost \$ 520,000.00**

* Does not include Administrative, Wetland Mitigation, Floodplain Mitigation, Environmental Remediation, Land Acquisition, Easement Acquisition or Financing Costs.

**COREY LAKE INTERCOUNTY DRAIN
ALTERNATIVE 3 - PRELIMINARY ESTIMATE OF PROJECT COST**

By Land & Resource Engineering, November 27, 2019



Corey Lake Outlet to M-60 Improvements

No.	Item Description	Quantity		Unit Cost	Total Cost
1	Mobilization	1	LS	\$ 25,000.00	\$ 25,000.00
2	Traffic Control	1	LS	\$ 5,000.00	\$ 5,000.00
3	Woody Debris Management	6,000	LF	\$ 4.00	\$ 24,000.00
4	Open Channel Excavation	6,000	LF	\$ 6.00	\$ 36,000.00
5	Culvert, 36-inch (Private, Station 3+00)	40	LF	\$ 100.00	\$ 4,000.00
6	Culvert, 36-inch (Private, Station 10+00)	40	LF	\$ 100.00	\$ 4,000.00
7	Culvert, 36-inch (Private, Station 14+25)	40	LF	\$ 100.00	\$ 4,000.00
8	Culvert, 36-inch (Private, Station 25+00)	40	LF	\$ 100.00	\$ 4,000.00
9	Culvert, 36-inch (Private, Station 40+75)	30	LF	\$ 100.00	\$ 3,000.00
10	Storm Sewer, 36-inch PE	763	LF	\$ 100.00	\$ 76,300.00
11	Manhole, 48-inch Diameter	2	EA	\$ 3,500.00	\$ 7,000.00
12	Riprap End Treatment	200	SY	\$ 75.00	\$ 15,000.00
13	Riprap Side Inlet	2	EA	\$ 2,500.00	\$ 5,000.00
14	Private Crossing Restoration	5	EA	\$ 1,500.00	\$ 7,500.00
15	Paved Road Restoration	1	EA	\$ 7,500.00	\$ 7,500.00
16	Open Channel Seeding	6,750	LF	\$ 2.00	\$ 13,500.00
17	Mulch Blanket	12,000	SY	\$ 2.00	\$ 24,000.00
18	Outlet Control Structure	1	EA	\$ 45,000.00	\$ 45,000.00

Estimated Total Construction Cost \$ 309,800.00

Kaiser to Corey Cleanout + Clear to Mud Improvement

No.	Item Description	Quantity		Unit Cost	Total Cost
19	Mobilization	1	LS	\$ 5,000.00	\$ 5,000.00
20	Traffic Control	1	LS	\$ 5,000.00	\$ 5,000.00
21	Woody Debris Management	800	LF	\$ 5.00	\$ 4,000.00
22	Open Channel Excavation	800	LF	\$ 10.00	\$ 8,000.00
23	Storm Sewer, 30-inch PE	250	LF	\$ 100.00	\$ 25,000.00
24	Manhole, 48-inch Diameter	1	EA	\$ 3,500.00	\$ 3,500.00
25	Outlet Control Structure (Clear Lake)	1	EA	\$ 15,000.00	\$ 15,000.00
26	Outlet Control Structure (Kaiser Lake)	1	EA	\$ 25,000.00	\$ 25,000.00
27	Riprap End Treatment	50	SY	\$ 75.00	\$ 3,750.00
28	Paved Road Restoration	1	EA	\$ 5,000.00	\$ 5,000.00
29	Open Channel Seeding	800	LF	\$ 2.00	\$ 1,600.00
30	Mulch Blanket	1,600	SY	\$ 2.00	\$ 3,200.00

Estimated SubTotal Construction Cost \$ 104,050.00

Estimated Total Construction Cost	\$	413,850.00
Estimated Engineering (Study though Construction)	\$	125,000.00
Estimated Legal	\$	50,000.00
Estimated Permits	\$	15,000.00
Contingency (~15%)	\$	91,381.25
* Preliminary Estimate of Project Cost	\$	695,000.00

* Does not include Administrative, Wetland Mitigation, Floodplain Mitigation, Environmental Remediation, Land Acquisition, Easement Acquisition or Financing Costs.

**COREY LAKE INTERCOUNTY DRAIN
ALTERNATIVE 4 - PRELIMINARY ESTIMATE OF PROJECT COST**

By Land & Resource Engineering, November 27, 2019



Corey Lake Outlet to M-60 Improvements

No.	Item Description	Quantity		Unit Cost	Total Cost
1	Mobilization	1	LS	\$ 25,000.00	\$ 25,000.00
2	Traffic Control	1	LS	\$ 5,000.00	\$ 5,000.00
3	Woody Debris Management	6,000	LF	\$ 4.00	\$ 24,000.00
4	Open Channel Excavation	6,000	LF	\$ 6.00	\$ 36,000.00
5	Culvert, 36-inch (Private, Station 3+00)	40	LF	\$ 100.00	\$ 4,000.00
6	Culvert, 36-inch (Private, Station 10+00)	40	LF	\$ 100.00	\$ 4,000.00
7	Culvert, 36-inch (Private, Station 14+25)	40	LF	\$ 100.00	\$ 4,000.00
8	Culvert, 36-inch (Private, Station 25+00)	40	LF	\$ 100.00	\$ 4,000.00
9	Culvert, 36-inch (Private, Station 40+75)	30	LF	\$ 100.00	\$ 3,000.00
10	Storm Sewer, 36-inch PE	763	LF	\$ 100.00	\$ 76,300.00
11	Manhole, 48-inch Diameter	2	EA	\$ 3,500.00	\$ 7,000.00
12	Riprap End Treatment	200	SY	\$ 75.00	\$ 15,000.00
13	Riprap Side Inlet	2	EA	\$ 2,500.00	\$ 5,000.00
14	Private Crossing Restoration	5	EA	\$ 1,500.00	\$ 7,500.00
15	Paved Road Restoration	1	EA	\$ 7,500.00	\$ 7,500.00
16	Open Channel Seeding	6,750	LF	\$ 2.00	\$ 13,500.00
17	Mulch Blanket	12,000	SY	\$ 2.00	\$ 24,000.00
18	Outlet Control Structure	1	EA	\$ 45,000.00	\$ 45,000.00

Estimated Total Construction Cost \$ 309,800.00

Kaiser to Corey Cleanout + Clear to Mud Improvement

No.	Item Description	Quantity		Unit Cost	Total Cost
19	Mobilization	1	LS	\$ 5,000.00	\$ 5,000.00
20	Traffic Control	1	LS	\$ 5,000.00	\$ 5,000.00
21	Woody Debris Management	800	LF	\$ 5.00	\$ 4,000.00
22	Open Channel Excavation	800	LF	\$ 10.00	\$ 8,000.00
23	Storm Sewer, 30-inch PE	250	LF	\$ 100.00	\$ 25,000.00
24	Manhole, 48-inch Diameter	1	EA	\$ 3,500.00	\$ 3,500.00
25	Outlet Control Structure (Clear Lake)	1	EA	\$ 15,000.00	\$ 15,000.00
26	Outlet Control Structure (Kaiser Lake)	1	EA	\$ 25,000.00	\$ 25,000.00
27	Riprap End Treatment	50	SY	\$ 75.00	\$ 3,750.00
28	Paved Road Restoration	1	EA	\$ 5,000.00	\$ 5,000.00
29	Open Channel Seeding	800	LF	\$ 2.00	\$ 1,600.00
30	Mulch Blanket	1,600	SY	\$ 2.00	\$ 3,200.00

Estimated SubTotal Construction Cost \$ 104,050.00

Gravity Outlet for Long Lake

No.	Item Description	Quantity		Unit Cost	Total Cost
31	Mobilization	1	LS	\$ 10,000.00	\$ 10,000.00
32	Traffic Control	1	LS	\$ 2,500.00	\$ 2,500.00
33	Clearing, Grubbing & Snagging	1,000	LF	\$ 4.00	\$ 4,000.00
34	Open Channel Excavation	1,000	LF	\$ 6.00	\$ 6,000.00
35	Storm Sewer, 12-inch PE	650	LF	\$ 50.00	\$ 32,500.00
36	Manhole, 48-inch Diameter	4	EA	\$ 3,500.00	\$ 14,000.00
37	Outlet Control Structure	1	EA	\$ 15,000.00	\$ 15,000.00
38	Directional Bore, 12-inch	1,600	LF	\$ 300.00	\$ 480,000.00
39	Manhole / Bore Structure (35' Deep)	1	EA	\$ 80,000.00	\$ 80,000.00
40	Riprap End Treatment	50	SY	\$ 75.00	\$ 3,750.00
41	Paved Road Restoration	300	LF	\$ 100.00	\$ 30,000.00
42	Open Channel Seeding	1,000	LF	\$ 2.00	\$ 2,000.00
43	Mulch Blanket	2,000	SY	\$ 2.00	\$ 4,000.00

Estimated SubTotal Construction Cost \$ 683,750.00

Estimated Total Construction Cost \$ 1,097,600.00
Estimated Engineering (Study through Construction) \$ 150,000.00
Estimated Legal \$ 100,000.00
Estimated Permits \$ 50,000.00
Contingency (~15%) \$ 209,640.00
*** Preliminary Estimate of Project Cost \$ 1,600,000.00**

* Does not include Administrative, Wetland Mitigation, Floodplain Mitigation, Environmental Remediation, Land Acquisition, Easement Acquisition or Financing Costs.

Appendix 2

Hydrologic & Hydraulic Calculations



From: [Drew Stoffel](#)
To: [Dan Fredricks](#)
Subject: FW: flood or low flow discharge request (ContentID - 168812)
Date: Monday, October 21, 2019 8:58:56 AM

-----Original Message-----

From: EGLE-wrd-qreq <EGLE-wrd-qreq@michigan.gov>
Sent: Thursday, October 3, 2019 6:30 PM
To: Drew Stoffel <stoffel@lremi.com>
Subject: RE: flood or low flow discharge request (ContentID - 168812)

We have estimated the flood frequency discharges requested in your email of September 12, 2019 (Process No. 20190566), as follows:

Profile Lake Drain at Harder Road, Section 31, T6S, R12W, Fabius Township, Saint Joseph County, has a total drainage area of 15.6 square miles and a contributing drainage area of 10.6 square miles. The 50%, 20%, 10%, 4%, 2%, and 1% chance peak flows are estimated to be 140 cubic feet per second (cfs), 250 cfs, 350 cfs, 550 cfs, 700 cfs, and 900 cfs, respectively. (Watershed Basin No. 34 St. Joseph).

Tributary to Profile Lake Drain at M-60, Section 31, T6S, R12W, Fabius Township, Saint Joseph County, has a total drainage area of 13.1 square miles and a contributing drainage area of 8.4 square miles. The 50%, 20%, 10%, 4%, 2%, and 1% chance peak flows are estimated to be 140 cubic feet per second (cfs), 250 cfs, 350 cfs, 550 cfs, 700 cfs, and 900 cfs, respectively. (Watershed Basin No. 34 St. Joseph).

Tributary to Profile Lake Drain at Corey Lake Outlet, Section 30, T6S, R12W, Fabius Township, Saint Joseph County, has a total drainage area of 12 square miles and a contributing drainage area of 7.4 square miles. The 50%, 20%, 10%, 4%, 2%, and 1% chance peak flows are estimated to be 140 cubic feet per second (cfs), 250 cfs, 350 cfs, 550 cfs, 700 cfs, and 900 cfs, respectively. (Watershed Basin No. 34 St. Joseph).

Tributary to Profile Lake Drain at Shafer Brothers Road, Section 20, T6S, R12W, Fabius Township, Saint Joseph County, has a total drainage area of 2.2 square miles and a contributing drainage area of 2.2 square miles. The 50%, 20%, 10%, 4%, 2%, and 1% chance peak flows are estimated to be 110 cubic feet per second (cfs), 190 cfs, 270 cfs, 400 cfs, 500 cfs, and 650 cfs, respectively. (Watershed Basin No. 34 St. Joseph).

Tributary to Profile Lake Drain at Clear Lake Outlet, Section 17, T6S, R12W, Fabius Township, Saint Joseph County, has a total drainage area of 1.09 square miles and a contributing drainage area of 1.04 square miles. (Watershed Basin No. 34 St. Joseph). Since the drainage area is less than two square miles, a permit is not required under the provisions of the Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). Flood discharges are not provided for unregulated locations. A permit may be required under Part 301, Inland Lakes and Streams, of the NREPA.

Tributary to Profile Lake Drain at Hardwood Lake Outlet, Section 24, T6S, R13W, Newburg Township, Cass County, has a total drainage area of 3.2 square miles and a contributing drainage area of 2.3 square miles. The 50%, 20%, 10%, 4%, 2%, and 1% chance peak flows are estimated to be 45 cubic feet per second (cfs), 100 cfs, 160 cfs, 280 cfs, 400 cfs, and 550 cfs, respectively. (Watershed Basin No. 34 St. Joseph).

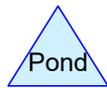
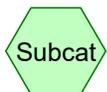
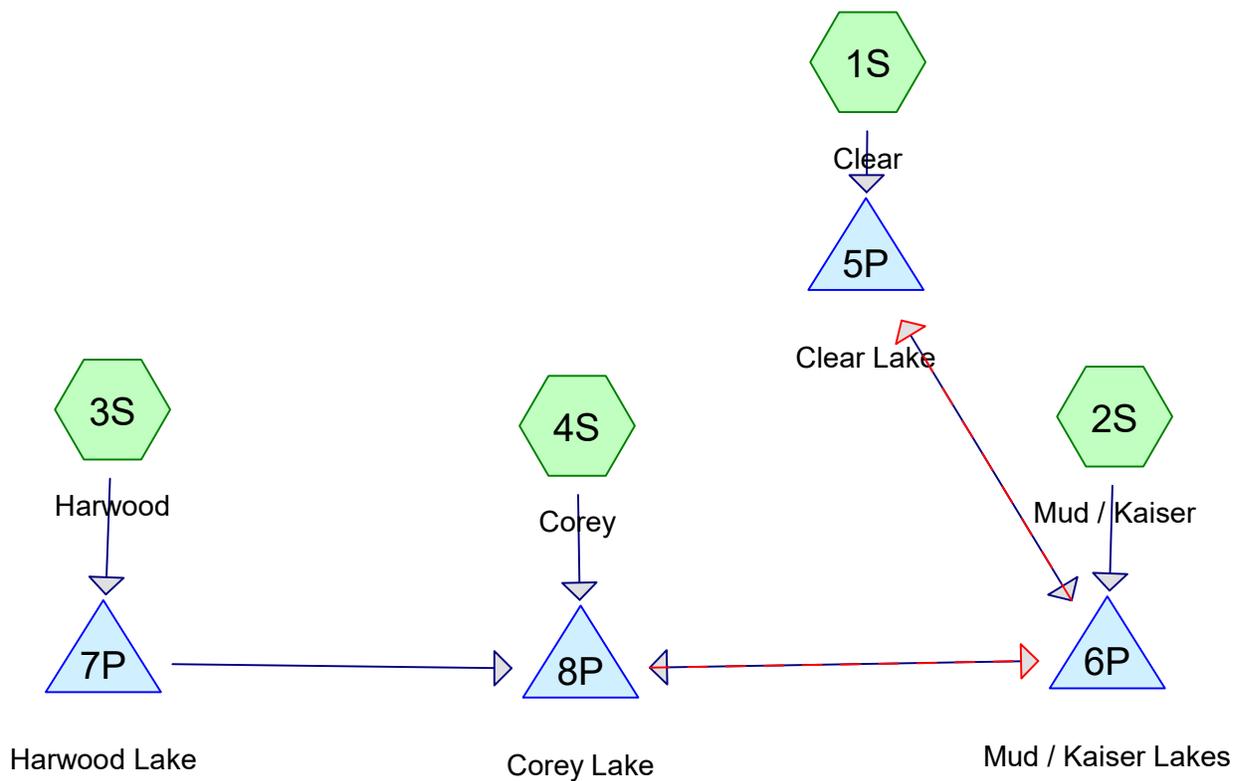
Please include a copy of this letter with your application for permit and indicate whether or not the project is funded under Act 51. These estimates should be confirmed by our office if an application is not submitted within one year. If you have any questions concerning the discharge estimates, please contact Ms. Susan Greiner, Hydrologic Studies and Dam Safety Unit, at 517-284-5579 or by email to GreinerS@michigan.gov. Any questions concerning hydraulic and/or environmental permit issues should be directed to Mr. Jim Watling, Water Resources Division,

Transportation Review Unit, at 517-284-5504 or by email to WatlingJ@michigan.gov.

-----Original Message-----

From: DoNotReply@michigan.gov <DoNotReply@michigan.gov>
Sent: Thursday, September 12, 2019 2:28 PM
To: EGLE-wrd-qreq <EGLE-wrd-qreq@michigan.gov>
Cc: stoffel@lremi.com
Subject: flood or low flow discharge request (ContentID - 168812)

Requestor: Andrew Stoffel
Company: Land and Resource Engineering
Address: 2121 3 Mile Road NW
City: Walker, MI
Zip: 49544
Phone: 6163017888
Date: 2019-09-12
F50percent: Yes
F20percent: Yes
F10percent: Yes
F4percent: Yes
F2percent: Yes
F1percent: Yes
ContactAgency: None Selected
ContactPerson:
Watercourse: Unnamed Outlet to Corey Lake
LocalName: Corey Lake Intercounty Drain
CountyLocation: St. Joseph
CityorTownship: Fabius Township
Section: 17, 19, 20, 30-31
Town: 6S
Range: 12W
Location: Please provide the discharge information for the following locations: #1: The point at which the Corey Lake Inter County Drain crosses Bair Lake Street. Section 31, T6S, R12W #2: The point at which the Corey Lake Inter County Drain crosses M-60. Section 31, T6S, R12W #3: The outlet for Corey Lake. Section 30, T6S, R12W #4: The outlet for Kaiser Lake where it crosses Shafer Brothers Rd. Section 20, T6W, R12W #5: The outlet from Clear Lake into Mud Lake. Section 17, T6S, R12W #6: The outlet from Hardwood Lake into Corey Lake. The Outlet crosses Corey Lake Road, Section 19, T6S, R12W
FFR1: County drain project



Routing Diagram for Corey Lake Existing - baseflow
 Prepared by {enter your company name here}, Printed 12/3/2019
 HydroCAD® 10.00-22 s/n 09958 © 2018 HydroCAD Software Solutions LLC

Corey Lake Existing - baseflow

Prepared by {enter your company name here}

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Page 2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1,472.000	71	Contributing Drainage Area, EGLE CN (3S)
953.600	79	EGLE Area - LRE Area for Clear; EGLE CN (2S)
1,856.000	76	EGLE Contributing Area - Kaiser & Harwood EGLE Areas (4S)
454.400	75	LRE Area and CN (1S)
4,736.000	75	TOTAL AREA

Corey Lake Existing - baseflow

Prepared by {enter your company name here}

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Page 3

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	5P	874.06	874.14	42.0	-0.0019	0.025	30.0	0.0	0.0
2	5P	873.97	873.87	63.0	0.0016	0.025	24.0	0.0	0.0
3	6P	873.87	873.97	63.0	-0.0016	0.025	24.0	0.0	0.0
4	6P	874.14	874.06	42.0	0.0019	0.025	30.0	0.0	0.0
5	7P	874.33	874.16	40.0	0.0043	0.025	36.0	36.0	0.0
6	8P	872.17	871.14	238.0	0.0043	0.025	34.0	24.0	0.0
7	8P	871.14	870.19	193.0	0.0049	0.025	24.0	0.0	0.0
8	8P	870.19	869.53	331.0	0.0020	0.025	36.0	0.0	0.0

Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Printed 12/3/2019

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Time span=5.00-60.00 hrs, dt=0.01 hrs, 5501 points
Runoff by SCS TR-20 method, UH=Michigan-369, Weighted-CN
Reach routing by Sim-Route method - Pond routing by Sim-Route method w/Net Flows

Subcatchment 1S: Clear	Runoff Area=454.400 ac 0.00% Impervious Runoff Depth=2.61" Tc=67.0 min CN=75 Runoff=448.64 cfs 98.924 af
Subcatchment 2S: Mud / Kaiser	Runoff Area=953.600 ac 0.00% Impervious Runoff Depth=2.97" Tc=130.0 min CN=79 Runoff=653.76 cfs 236.380 af
Subcatchment 3S: Harwood	Runoff Area=1,472.000 ac 0.00% Impervious Runoff Depth=2.27" Tc=185.0 min CN=71 Runoff=551.03 cfs 278.310 af
Subcatchment 4S: Corey	Runoff Area=1,856.000 ac 0.00% Impervious Runoff Depth=2.70" Tc=173.0 min CN=76 Runoff=900.59 cfs 417.789 af
Pond 5P: Clear Lake	Peak Elev=875.91' Storage=418.187 af Inflow=453.16 cfs 126.803 af Outflow=6.13 cfs 4.660 af
Pond 6P: Mud / Kaiser Lakes	Peak Elev=875.99' Storage=347.180 af Inflow=674.49 cfs 280.977 af Primary=24.66 cfs 29.412 af Secondary=3.01 cfs 7.328 af Outflow=26.74 cfs 36.740 af
Pond 7P: Harwood Lake	Peak Elev=880.03' Storage=301.560 af Inflow=558.33 cfs 311.482 af Outflow=35.42 cfs 137.630 af
Pond 8P: Corey Lake	Peak Elev=876.01' Storage=949.776 af Inflow=947.15 cfs 722.642 af Primary=15.28 cfs 64.591 af Secondary=20.20 cfs 39.947 af Outflow=30.33 cfs 104.538 af
Total Runoff Area = 4,736.000 ac Runoff Volume = 1,031.403 af Average Runoff Depth = 2.61"	
100.00% Pervious = 4,736.000 ac 0.00% Impervious = 0.000 ac	

Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Subcatchment 1S: Clear

Runoff = 448.64 cfs @ 12.80 hrs, Volume= 98.924 af, Depth= 2.61"

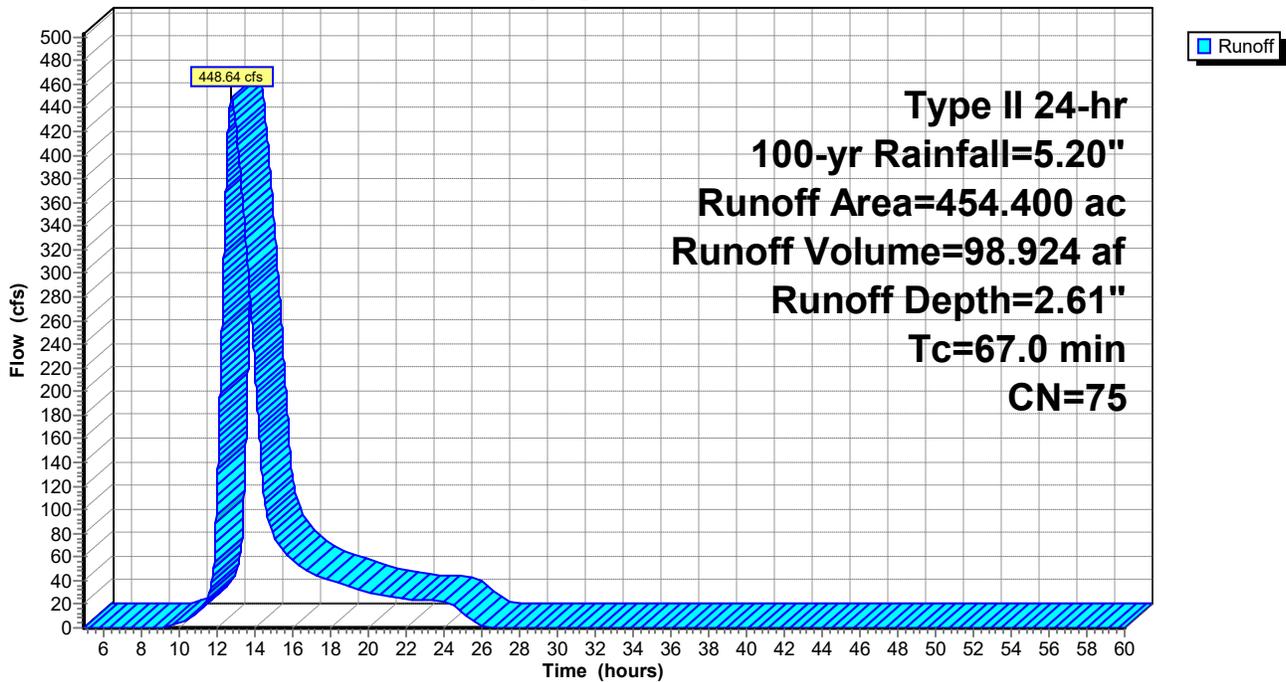
Runoff by SCS TR-20 method, UH=Michigan-369, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=5.20"

Area (ac)	CN	Description
* 454.400	75	LRE Area and CN
454.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
67.0					Direct Entry,

Subcatchment 1S: Clear

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Subcatchment 2S: Mud / Kaiser

Runoff = 653.76 cfs @ 13.58 hrs, Volume= 236.380 af, Depth= 2.97"

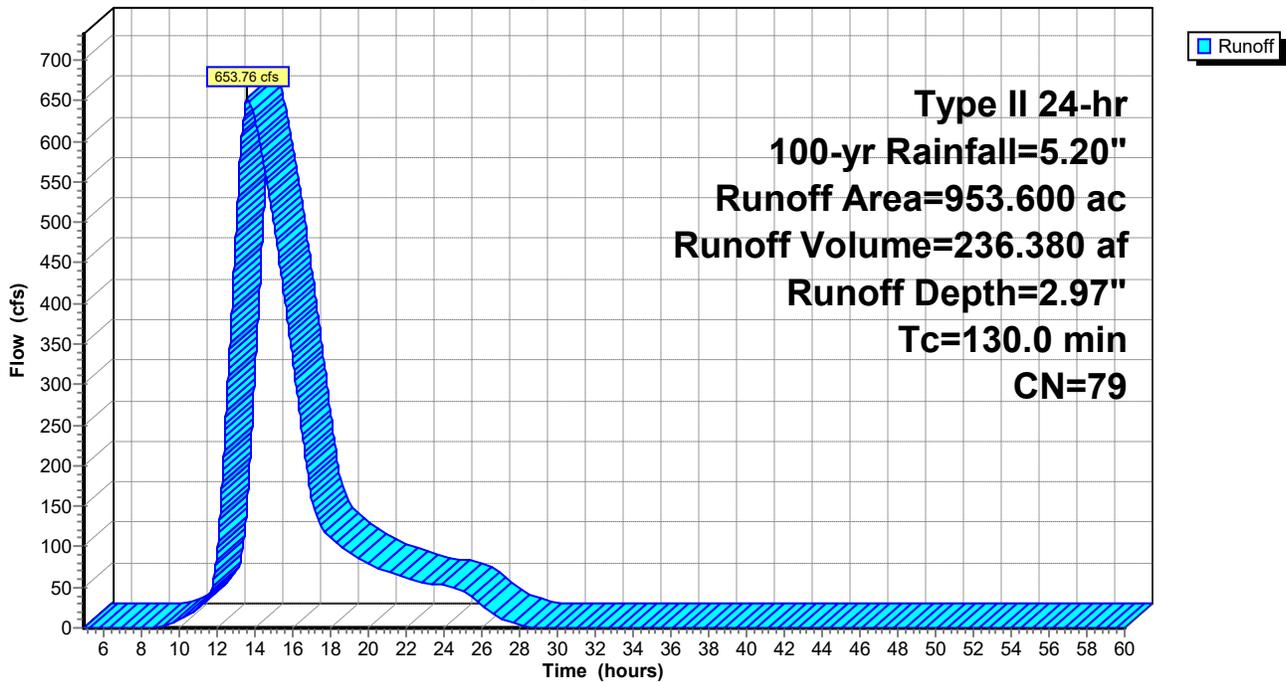
Runoff by SCS TR-20 method, UH=Michigan-369, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=5.20"

Area (ac)	CN	Description
* 953.600	79	EGLE Area - LRE Area for Clear; EGLE CN
953.600		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
130.0					Direct Entry,

Subcatchment 2S: Mud / Kaiser

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Subcatchment 3S: Harwood

Runoff = 551.03 cfs @ 14.39 hrs, Volume= 278.310 af, Depth= 2.27"

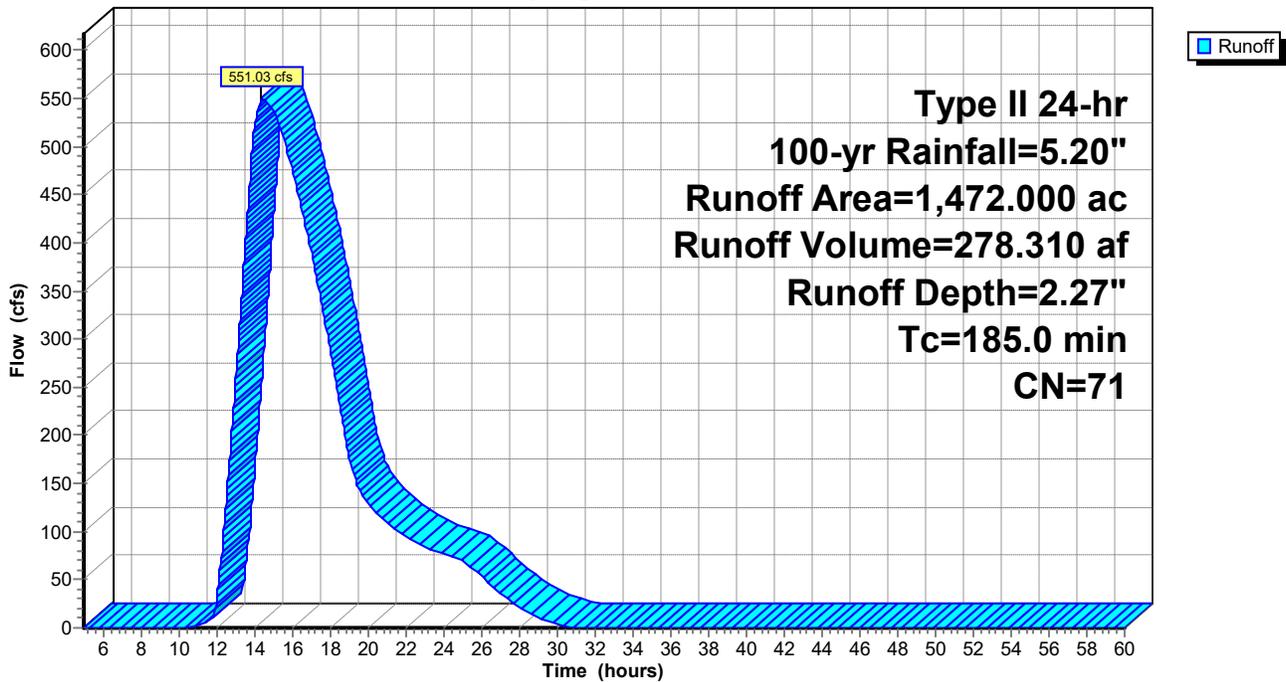
Runoff by SCS TR-20 method, UH=Michigan-369, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=5.20"

Area (ac)	CN	Description
* 1,472.000	71	Contributing Drainage Area, EGLE CN
1,472.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
185.0					Direct Entry,

Subcatchment 3S: Harwood

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Subcatchment 4S: Corey

Runoff = 900.59 cfs @ 14.23 hrs, Volume= 417.789 af, Depth= 2.70"

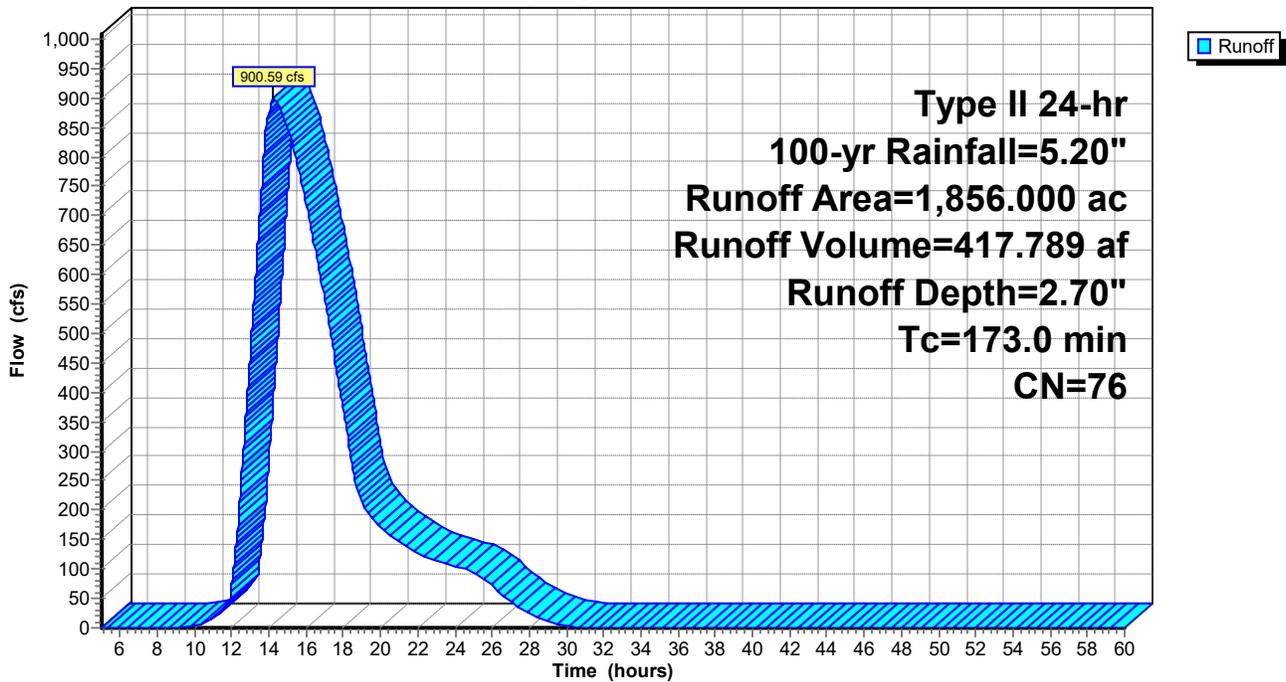
Runoff by SCS TR-20 method, UH=Michigan-369, Weighted-CN, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
Type II 24-hr 100-yr Rainfall=5.20"

Area (ac)	CN	Description
* 1,856.000	76	EGLE Contributing Area - Kaiser & Harwood EGLE Areas
1,856.000		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
173.0					Direct Entry,

Subcatchment 4S: Corey

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Pond 5P: Clear Lake

Inflow = 453.16 cfs @ 12.80 hrs, Volume= 126.803 af, Incl. 4.52 cfs Base Flow
 Outflow = 6.13 cfs @ 14.21 hrs, Volume= 4.660 af, Atten= 99%, Lag= 84.1 min
 Primary = 6.13 cfs @ 14.21 hrs, Volume= 4.660 af

Routing by Sim-Route method w/Net Flows, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs

Starting Elev= 875.40' Surf.Area= 236.913 ac Storage= 296.045 af

Peak Elev= 875.91' @ 60.00 hrs Surf.Area= 238.819 ac Storage= 418.187 af (122.142 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)

Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	874.14'	865.155 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
874.14	233.000	0.000	0.000
875.75	238.000	379.155	379.155
876.75	243.000	240.500	619.655
877.75	248.000	245.500	865.155

Device	Routing	Invert	Outlet Devices
#1	Primary	874.14'	30.0" Round Culvert L= 42.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 874.06' / 874.14' S= -0.0019 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf
#2	Device 1	873.97'	24.0" Round Culvert L= 63.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 873.97' / 873.87' S= 0.0016 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#3	Device 2	872.50'	20.0" W x 20.0" H Vert. Orifice/Grate C= 0.600

Primary OutFlow Max=6.12 cfs @ 14.21 hrs HW=875.66' TW=875.14' (Dynamic Tailwater)

↑ **1=Culvert** (Passes 6.12 cfs of 6.83 cfs potential flow)

↑ **2=Culvert** (Outlet Controls 6.12 cfs @ 2.91 fps)

↑ **3=Orifice/Grate** (Passes 6.12 cfs of 9.64 cfs potential flow)

Corey Lake Existing - baseflow

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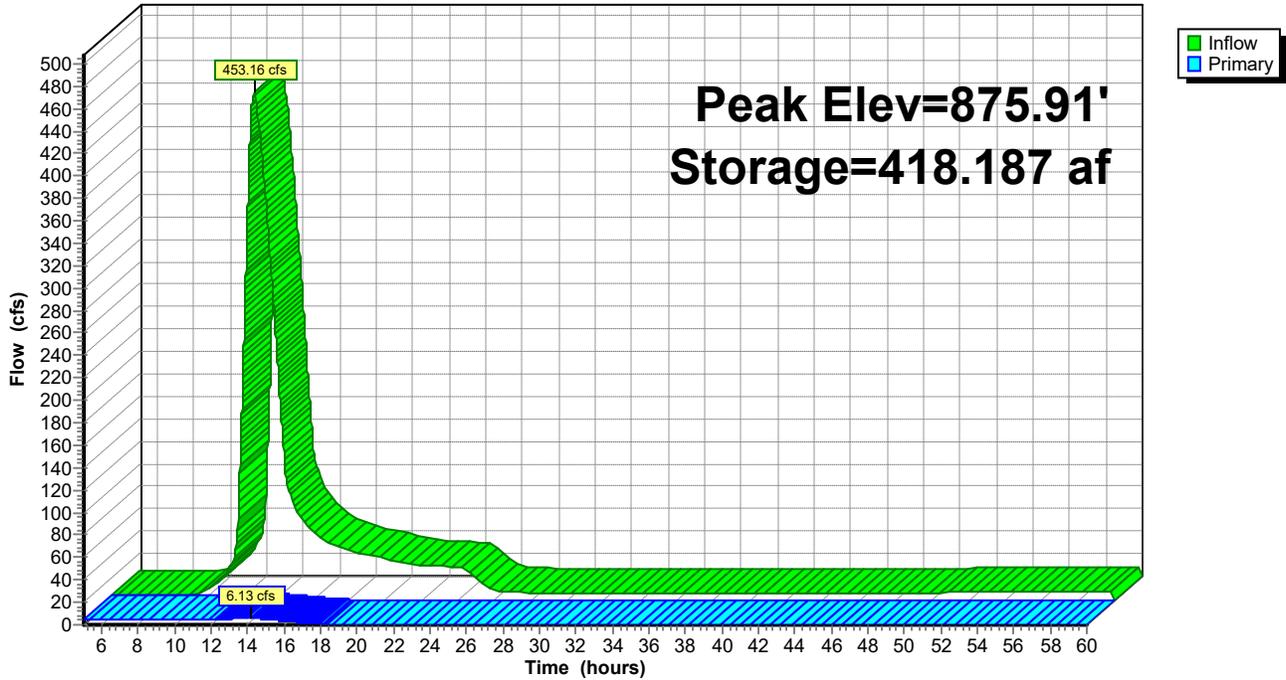
Type II 24-hr 100-yr Rainfall=5.20"

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Pond 5P: Clear Lake

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Pond 6P: Mud / Kaiser Lakes

Inflow = 674.49 cfs @ 13.58 hrs, Volume= 280.977 af
 Outflow = 26.74 cfs @ 21.24 hrs, Volume= 36.740 af, Atten= 96%, Lag= 459.4 min
 Primary = 24.66 cfs @ 20.08 hrs, Volume= 29.412 af
 Secondary = 3.01 cfs @ 60.00 hrs, Volume= 7.328 af

Routing by Sim-Route method w/Net Flows, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
 Starting Elev= 874.49' Surf.Area= 159.741 ac Storage= 102.941 af
 Peak Elev= 875.99' @ 60.00 hrs Surf.Area= 167.411 ac Storage= 347.180 af (244.239 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
 Center-of-Mass det. time= 464.7 min (1,564.3 - 1,099.5)

Volume	Invert	Avail.Storage	Storage Description
#1	873.84'	978.430 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
873.84	157.000	0.000	0.000
875.50	164.000	266.430	266.430
876.50	171.000	167.500	433.930
877.50	178.000	174.500	608.430
878.50	185.000	181.500	789.930
879.50	192.000	188.500	978.430

Device	Routing	Invert	Outlet Devices
#1	Secondary	872.50'	20.0" W x 20.0" H Vert. Orifice/Grate C= 0.600
#2	Device 1	873.97'	24.0" Round Culvert L= 63.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 873.87' / 873.97' S= -0.0016 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#3	Device 2	874.14'	30.0" Round Culvert L= 42.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 874.14' / 874.06' S= 0.0019 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.91 sf
#4	Primary	873.84'	7.5' long x 14.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.64 2.67 2.70 2.65 2.64 2.65 2.65 2.63

Primary OutFlow Max=24.65 cfs @ 20.08 hrs HW=875.81' TW=875.64' (Dynamic Tailwater)
 ↳4=**Broad-Crested Rectangular Weir** (Weir Controls 24.65 cfs @ 1.67 fps)

Secondary OutFlow Max=8.08 cfs @ 60.00 hrs HW=875.99' TW=0.00' (Dynamic Tailwater)
 ↳1=**Orifice/Grate** (Passes 8.08 cfs of 21.70 cfs potential flow)
 ↳2=**Culvert** (Barrel Controls 8.08 cfs @ 3.02 fps)
 ↳3=**Culvert** (Passes 8.08 cfs of 9.82 cfs potential flow)

Corey Lake Existing - baseflow

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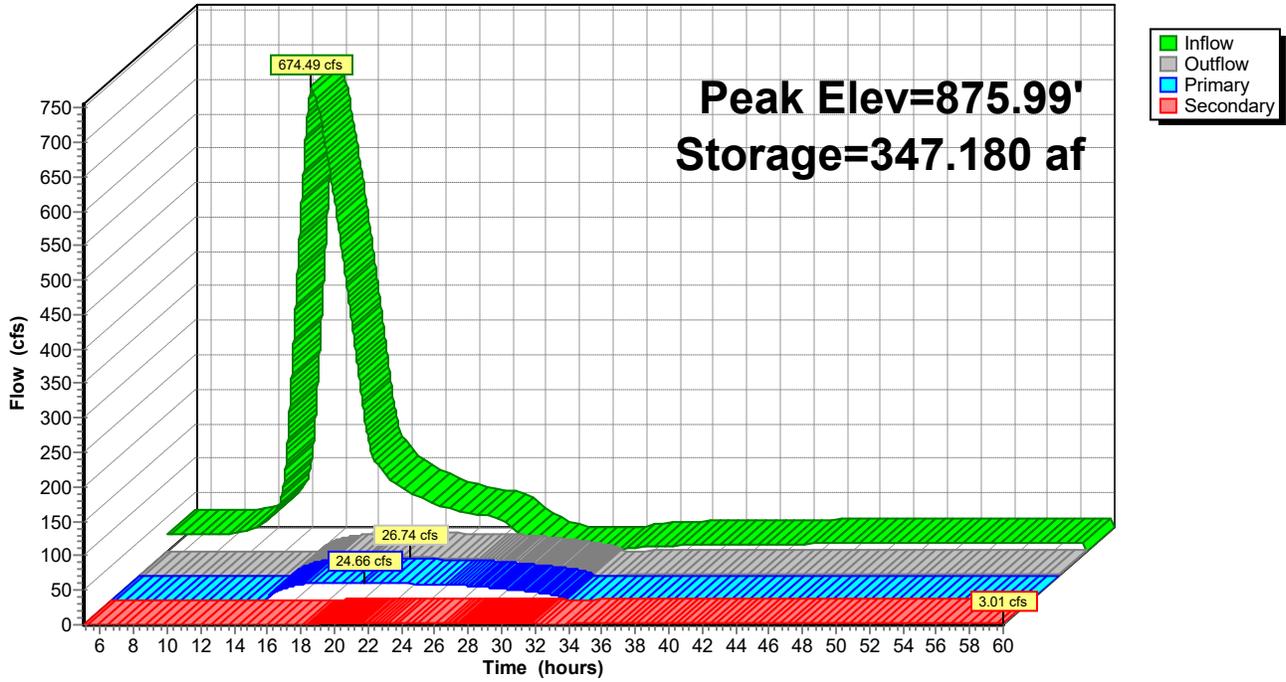
Type II 24-hr 100-yr Rainfall=5.20"

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Pond 6P: Mud / Kaiser Lakes

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Pond 7P: Harwood Lake

Inflow Area = 1,472.000 ac, 0.00% Impervious, Inflow Depth > 2.54" for 100-yr event
 Inflow = 558.33 cfs @ 14.39 hrs, Volume= 311.482 af, Incl. 7.30 cfs Base Flow
 Outflow = 35.42 cfs @ 27.52 hrs, Volume= 137.630 af, Atten= 94%, Lag= 787.4 min
 Primary = 35.42 cfs @ 27.52 hrs, Volume= 137.630 af

Routing by Sim-Route method w/Net Flows, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
 Starting Elev= 878.92' Surf.Area= 124.490 ac Storage= 69.713 af
 Peak Elev= 880.03' @ 27.52 hrs Surf.Area= 5,330.663 ac Storage= 301.560 af (231.847 af above start)

Plug-Flow detention time= 2,102.5 min calculated for 67.905 af (22% of inflow)
 Center-of-Mass det. time= 1,042.0 min (2,170.5 - 1,128.5)

Volume	Invert	Avail.Storage	Storage Description
#1	878.35'	80,283.279 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
878.35	117.630	0.000	0.000
878.45	121.320	11.948	11.948
879.00	125.030	67.746	79.694
880.00	141.070	133.050	212.744
881.00	160,000.000	80,070.535	80,283.279

Device	Routing	Invert	Outlet Devices
#1	Device 2	878.35'	5.3' long Sharp-Crested Rectangular Weir 2 End Contraction(s)
#2	Primary	874.33'	36.0" W x 36.0" H Box Culvert L= 40.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 874.33' / 874.16' S= 0.0043 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 9.00 sf

Primary OutFlow Max=35.42 cfs @ 27.52 hrs HW=880.03' TW=875.82' (Dynamic Tailwater)

↑ **2=Culvert** (Passes 35.42 cfs of 76.30 cfs potential flow)

↑ **1=Sharp-Crested Rectangular Weir** (Weir Controls 35.42 cfs @ 4.24 fps)

Corey Lake Existing - baseflow

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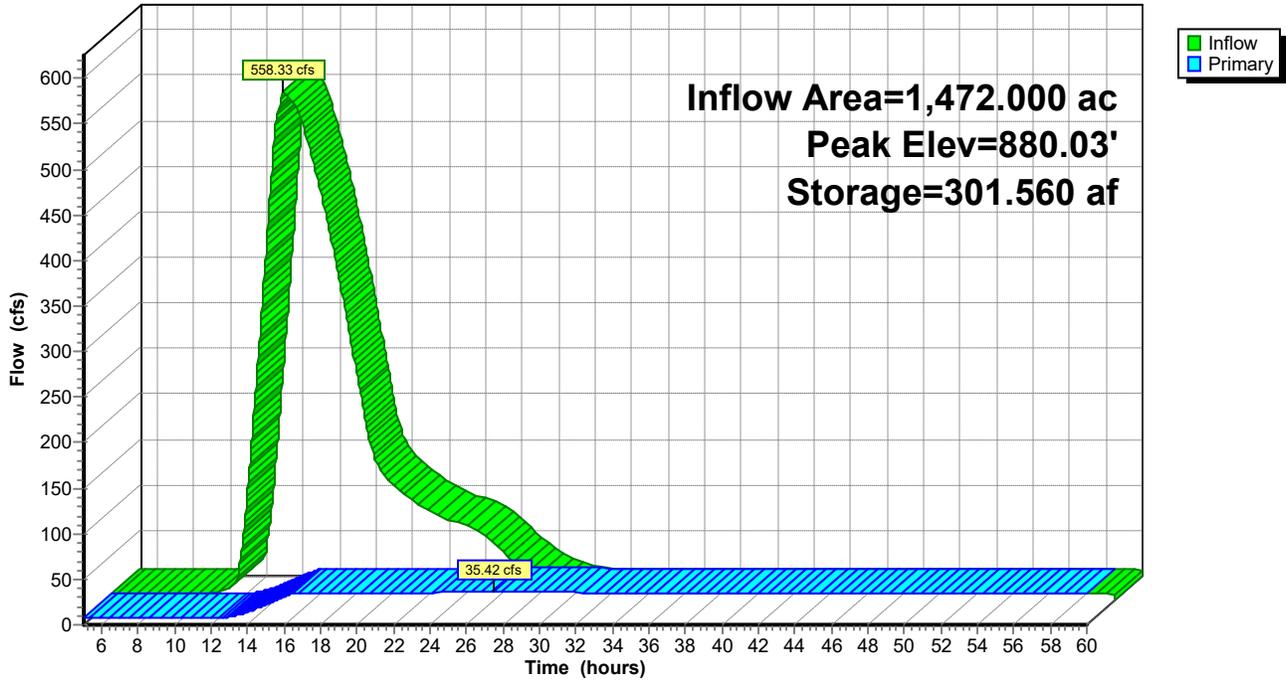
Type II 24-hr 100-yr Rainfall=5.20"

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Pond 7P: Harwood Lake

Hydrograph



Corey Lake Existing - baseflow

Type II 24-hr 100-yr Rainfall=5.20"

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Summary for Pond 8P: Corey Lake

Inflow = 947.15 cfs @ 14.23 hrs, Volume= 722.642 af, Incl. 30.32 cfs Base Flow
 Outflow = 30.33 cfs @ 5.01 hrs, Volume= 104.538 af, Atten= 97%, Lag= 0.0 min
 Primary = 15.28 cfs @ 60.00 hrs, Volume= 64.591 af
 Secondary = 20.20 cfs @ 5.01 hrs, Volume= 39.947 af

Routing by Sim-Route method w/Net Flows, Time Span= 5.00-60.00 hrs, dt= 0.01 hrs
 Starting Elev= 875.00' Surf.Area= 607.000 ac Storage= 331.650 af
 Peak Elev= 876.01' @ 60.00 hrs Surf.Area= 616.097 ac Storage= 949.776 af (618.126 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
 Center-of-Mass det. time= 606.6 min (2,028.0 - 1,421.4)

Volume	Invert	Avail.Storage	Storage Description
#1	874.45'	1,563.650 af	Custom Stage Data (Prismatic) Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
874.45	599.000	0.000	0.000
875.00	607.000	331.650	331.650
876.00	616.000	611.500	943.150
877.00	625.000	620.500	1,563.650

Device	Routing	Invert	Outlet Devices
#1	Device 2	874.45'	7.7' long x 3.10' rise Sharp-Crested Rectangular Weir 2 End Contraction(s)
#2	Device 4	872.17'	34.0" W x 24.0" H, R=17.9"/55.1" Pipe Arch Culvert L= 238.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 872.17' / 871.14' S= 0.0043 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 4.53 sf
#3	Secondary	873.84'	7.5' long x 13.0' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.60 2.64 2.70 2.66 2.65 2.66 2.65 2.63
#4	Device 5	871.14'	24.0" Round Culvert L= 193.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 871.14' / 870.19' S= 0.0049 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 3.14 sf
#5	Primary	870.19'	36.0" Round Culvert L= 331.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 870.19' / 869.53' S= 0.0020 '/' Cc= 0.900 n= 0.025 Corrugated metal, Flow Area= 7.07 sf

Primary OutFlow Max=15.28 cfs @ 60.00 hrs HW=876.01' (Free Discharge)
 ↑5=Culvert (Passes 15.28 cfs of 32.84 cfs potential flow)
 ↑4=Culvert (Barrel Controls 15.28 cfs @ 4.87 fps)
 ↑2=Culvert (Passes 15.28 cfs of 19.07 cfs potential flow)
 ↑1=Sharp-Crested Rectangular Weir (Passes 15.28 cfs of 47.11 cfs potential flow)

Secondary OutFlow Max=20.20 cfs @ 5.01 hrs HW=875.00' TW=874.49' (Dynamic Tailwater)
 ↑3=Broad-Crested Rectangular Weir (Weir Controls 20.20 cfs @ 2.32 fps)

Corey Lake Existing - baseflow

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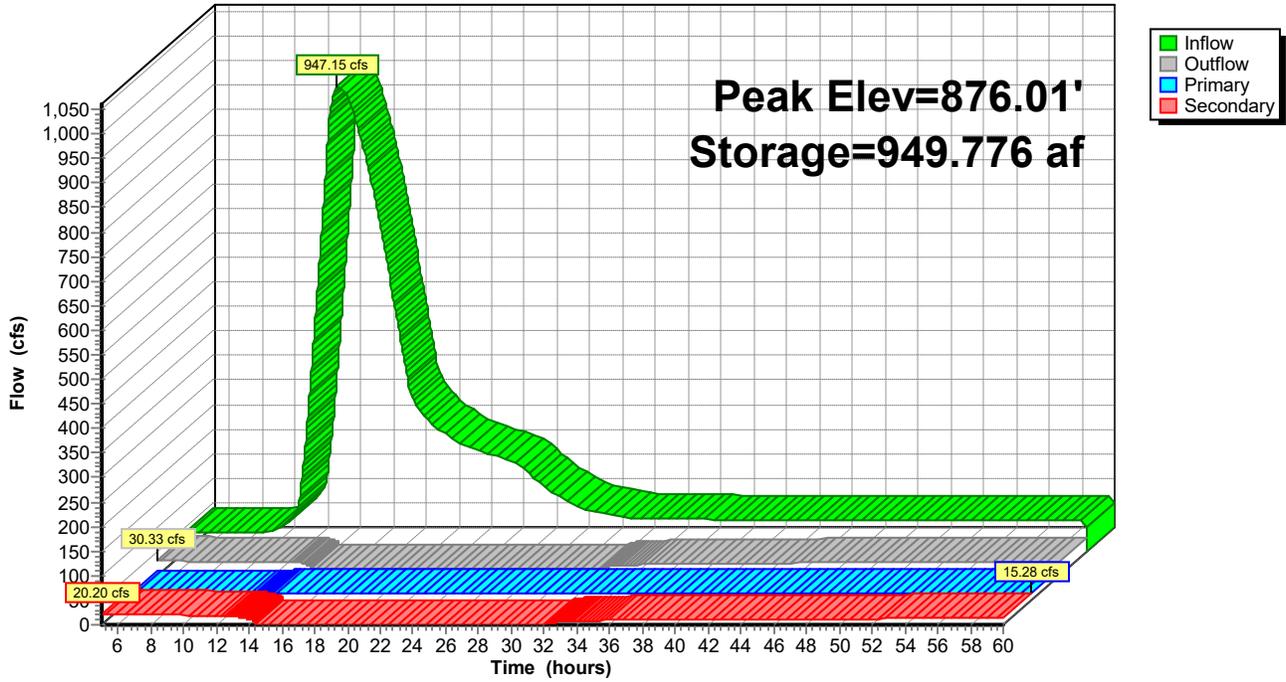
Type II 24-hr 100-yr Rainfall=5.20"

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Pond 8P: Corey Lake

Hydrograph



HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Recurrence

Table 1 - Summary of Culvert Flows at Crossing: M-60

Headwater Elevation (ft)	Discharge Names	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
864.75	2 year	25.12	25.12	0.00	1
867.51	5 year	40.96	38.12	2.64	35
867.60	10 year	59.51	38.46	20.82	6
867.70	25 year	94.20	38.80	54.98	4
867.78	50 year	128.36	39.13	89.17	4
867.87	100 year	170.90	39.47	131.33	3
867.48	Overtopping	37.92	37.92	0.00	Overtopping

Rating Curve Plot for Crossing: M-60

Total Rating Curve

Crossing: M-60

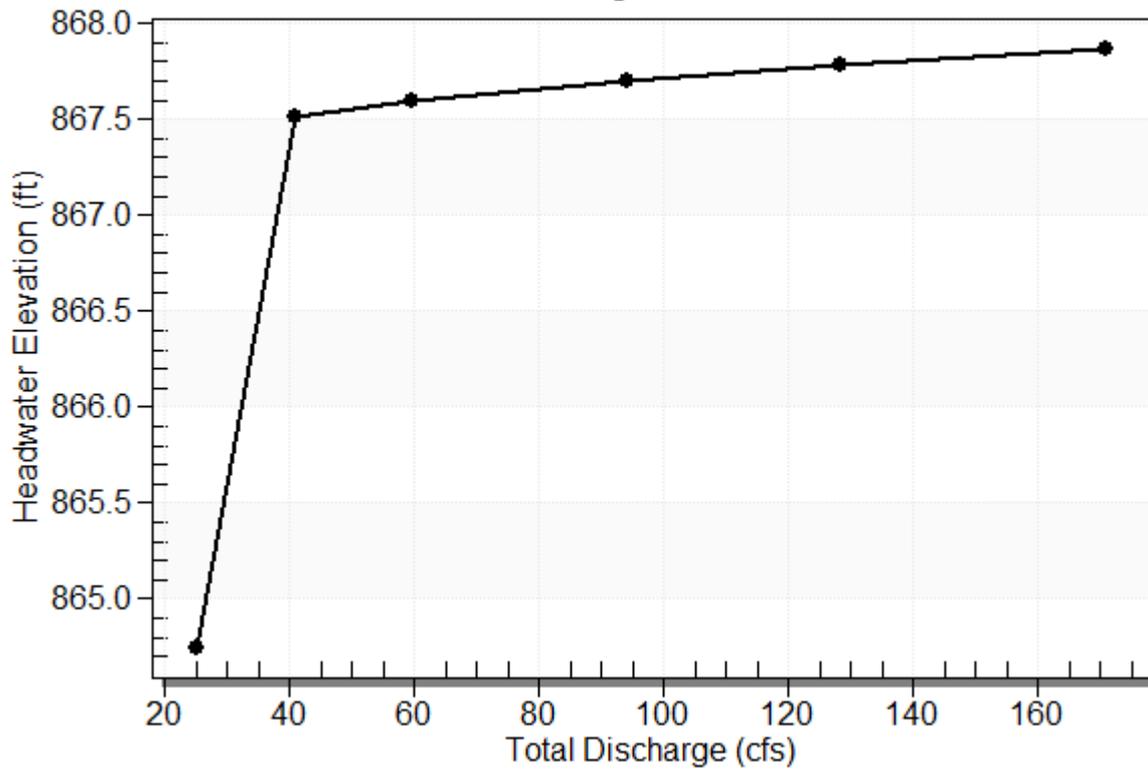


Table 2 - Culvert Summary Table: Culvert 1

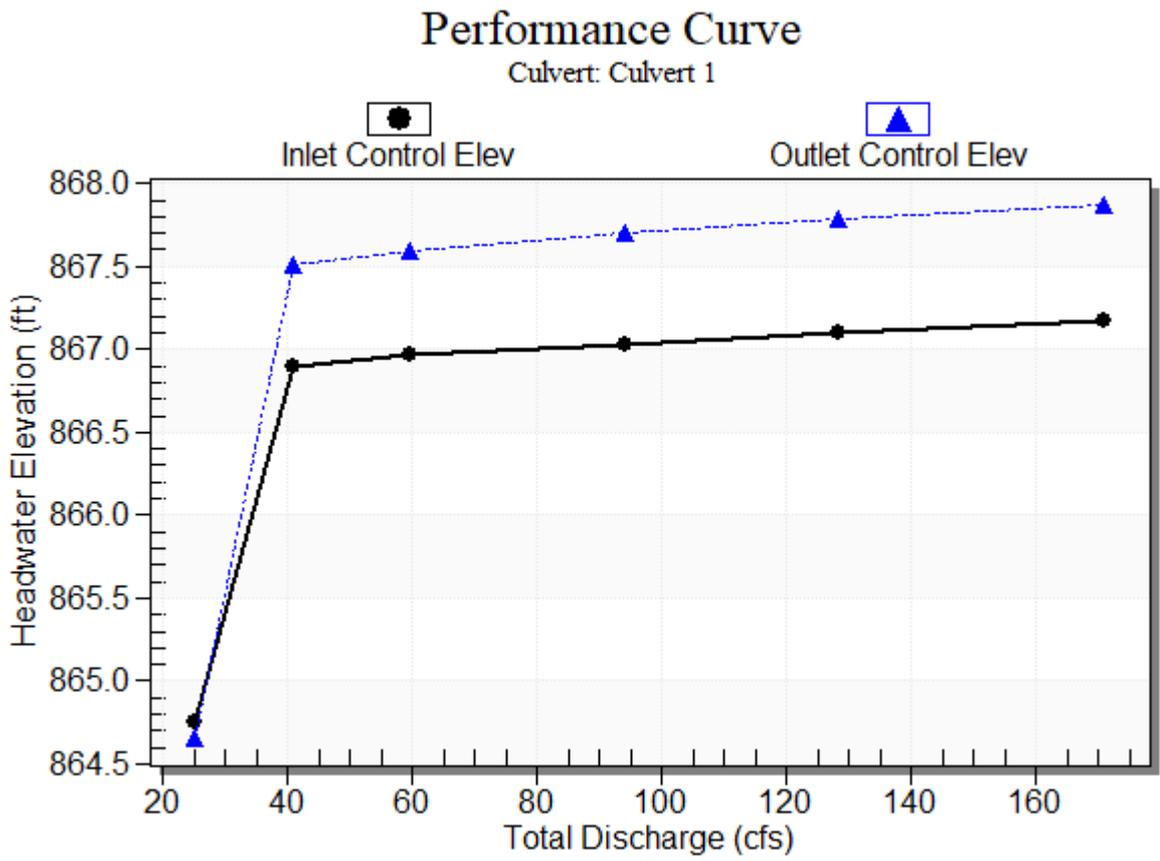
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)
2 year	25.12	25.12	864.75	3.239	3.145	7-M2c	2.000	1.765	1.765	0.520	8.562
5 year	40.96	38.12	867.51	5.385	6.000	7-M2c	2.000	1.947	1.947	0.675	12.223
10 year	59.51	38.46	867.60	5.453	6.088	7-M2c	2.000	1.943	1.943	0.819	12.344
25 year	94.20	38.80	867.70	5.522	6.192	6-FFc	2.000	2.000	2.000	1.034	12.351
50 year	128.36	39.13	867.78	5.588	6.274	6-FFc	2.000	2.000	2.000	1.204	12.454
100 year	170.90	39.47	867.87	5.660	6.362	6-FFc	2.000	2.000	2.000	1.383	12.563

Straight Culvert

Inlet Elevation (invert): 861.51 ft, Outlet Elevation (invert): 860.79 ft

Culvert Length: 83.00 ft, Culvert Slope: 0.0087

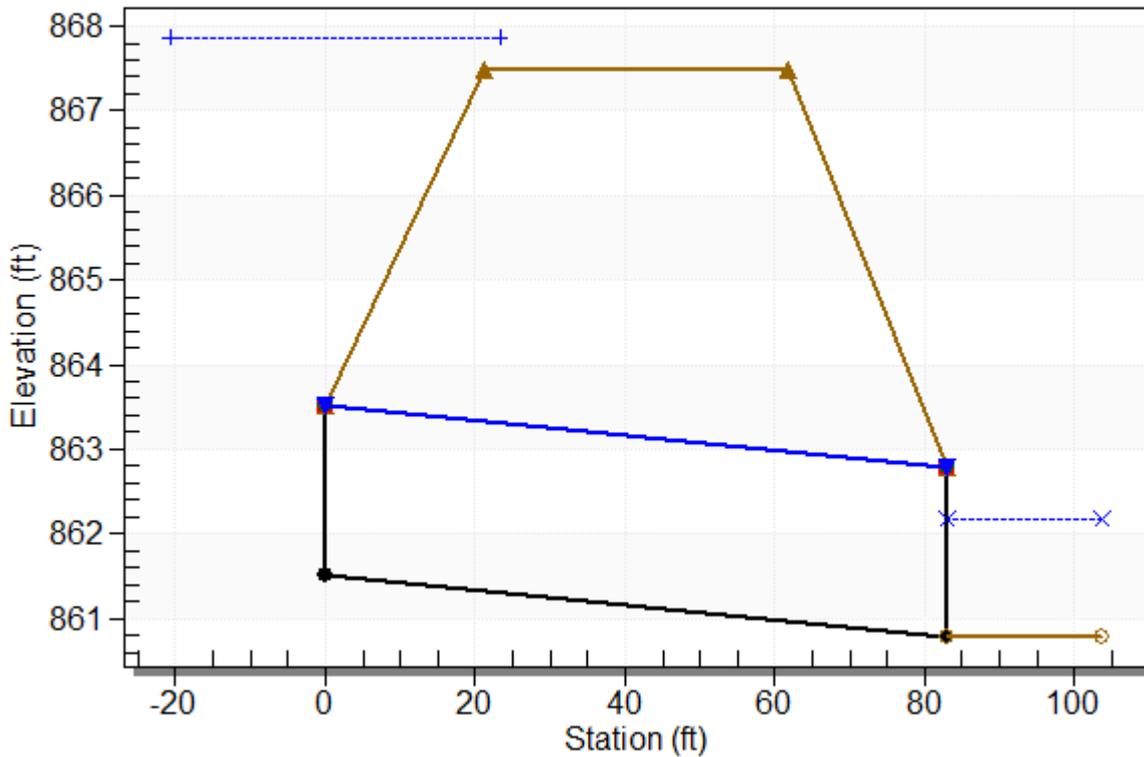
Culvert Performance Curve Plot: Culvert 1



Water Surface Profile Plot for Culvert: Culvert 1

Crossing - M-60, Design Discharge - 170.9 cfs

Culvert - Culvert 1, Culvert Discharge - 39.5 cfs



Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 861.51 ft

Outlet Station: 83.00 ft

Outlet Elevation: 860.79 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 2.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Beveled Edge (1.5:1)

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: M-60)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
25.12	861.31	0.52	11.24	8.11	3.14
40.96	861.46	0.67	12.95	10.52	3.24
59.51	861.61	0.82	14.39	12.78	3.32
94.20	861.82	1.03	16.32	16.13	3.42
128.36	861.99	1.20	17.73	18.79	3.49
170.90	862.17	1.38	19.13	21.58	3.55

Tailwater Channel Data - M-60

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 3.00 ft

Side Slope (H:V): 2.50 (1:1)

Channel Slope: 0.2500

Channel Manning's n: 0.0350

Channel Invert Elevation: 860.79 ft

Roadway Data for Crossing: M-60

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 178.04 ft

Crest Elevation: 867.48 ft

Roadway Surface: Paved

Roadway Top Width: 40.29 ft

Corey Lake Intercounty Drain – Preliminary Hydraulic Calculations

- Note – culverts will control actual Drain capacities. Therefore, actual existing and proposed capacities of the Drain are less than the simplified Manning’s calculations for open channel flow provided below.*

Existing Conditions

Open-Channel Flow

This calculator uses Chézy and Manning’s formula to calculate the wetted perimeter, hydraulic radius, flow area, Chézy coefficient and flow velocity.
For experimental values of Manning’s n factor, click [here](#)

Required Information

Enter the Slope: Enter the Channel Top Width (ft):

Enter the Channel Bottom Width (ft): Enter the Channel Height (ft):

Enter the Flow Depth (ft): Enter the n value:

Results

The wetted perimeter is ft

The flow area is ft²

The hydraulic radius is ft

The C value is

The flow is ft³/s

The flow is gal/min

The velocity is ft/s

Proposed Conditions (Sediment Removal per 1950 Alignment)

Open-Channel Flow

This calculator uses Chézy and Manning’s formula to calculate the wetted perimeter, hydraulic radius, flow area, Chézy coefficient and flow velocity.
For experimental values of Manning’s n factor, click [here](#)

Required Information

Enter the Slope: Enter the Channel Top Width (ft):

Enter the Channel Bottom Width (ft): Enter the Channel Height (ft):

Enter the Flow Depth (ft): Enter the n value:

Results

The wetted perimeter is ft

The flow area is ft²

The hydraulic radius is ft

The C value is

The flow is ft³/s

The flow is gal/min

The velocity is ft/s



Corey Lake Control Structure - Hydraulic Capacity based on Existing Conditions (Weir Crest Set 0.45-ft above Legal Lake Level)

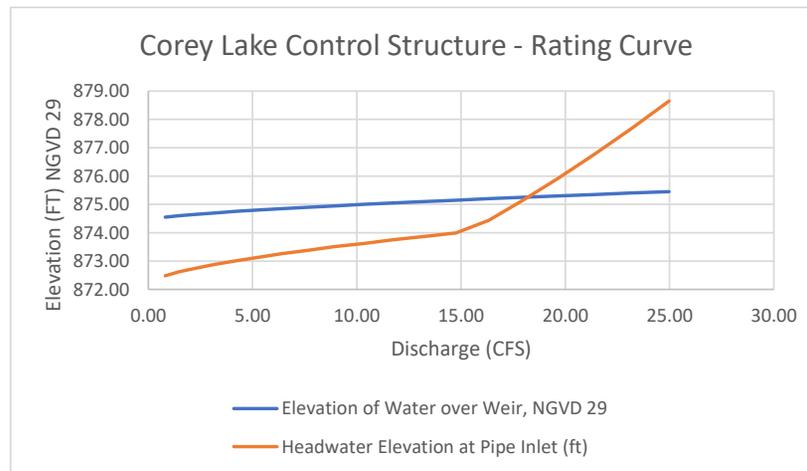
Sharp Crested Fully Contracted Weir Equation

$$Q^* = 3.33(L - 0.2H)(H)^{1.5}$$

L (ft) = 7.7

Weir set at 874.45

Water Height above Weir (ft) (H)	Elevation of Water over Weir, NGVD 29	Flow over Weir (cfs) (Q)	Headwater Elevation
0.10	874.55	0.81	872.48
0.15	874.60	1.48	872.62
0.20	874.65	2.28	872.75
0.25	874.70	3.18	872.88
0.30	874.75	4.18	873.01
0.35	874.80	5.26	873.13
0.40	874.85	6.42	873.26
0.45	874.90	7.65	873.38
0.50	874.95	8.95	873.51
0.55	875.00	10.31	873.62
0.60	875.05	11.73	873.75
0.65	875.10	13.21	873.87
0.70	875.15	14.74	873.99
0.75	875.20	16.33	874.44
0.80	875.25	17.97	875.15
0.85	875.30	19.65	875.92
0.90	875.35	21.38	876.76
0.95	875.40	23.16	877.67
1.00	875.45	24.98	878.65



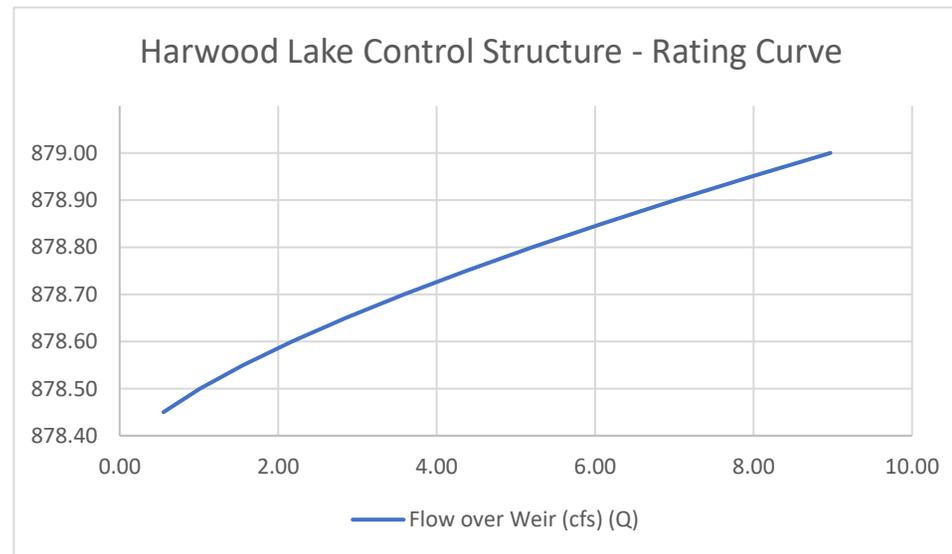
Harwood Lake Control Structure - Hydraulic Capacity based on Existing Conditions (Weir Crest Set 1.45-ft above Legal Lake Level)

Sharp Crested Fully Contracted Weir Equation

$$Q^* = 3.33(L - 0.2H)(H)^{1.5}$$

L (ft) = 5.27

Water Height above Weir (ft) (H)	Elevation of Water, NGVD29	Flow over Weir (cfs) (Q)
0.10	878.45	0.55
0.15	878.50	1.01
0.20	878.55	1.56
0.25	878.60	2.17
0.30	878.65	2.85
0.35	878.70	3.59
0.40	878.75	4.37
0.45	878.80	5.21
0.50	878.85	6.09
0.55	878.90	7.01
0.60	878.95	7.97
0.65	879.00	8.97



Appendix 3

Survey Details of Lake Control Structures

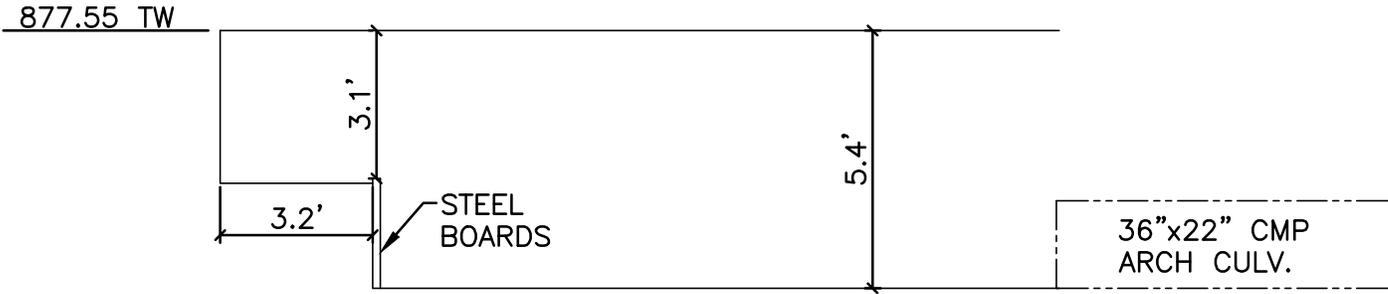


2121 3 Mile Rd.

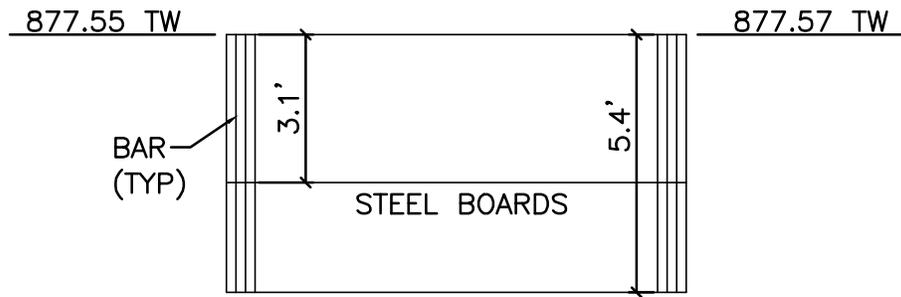
Walker, Michigan 49544

Phone: 616.301.7888

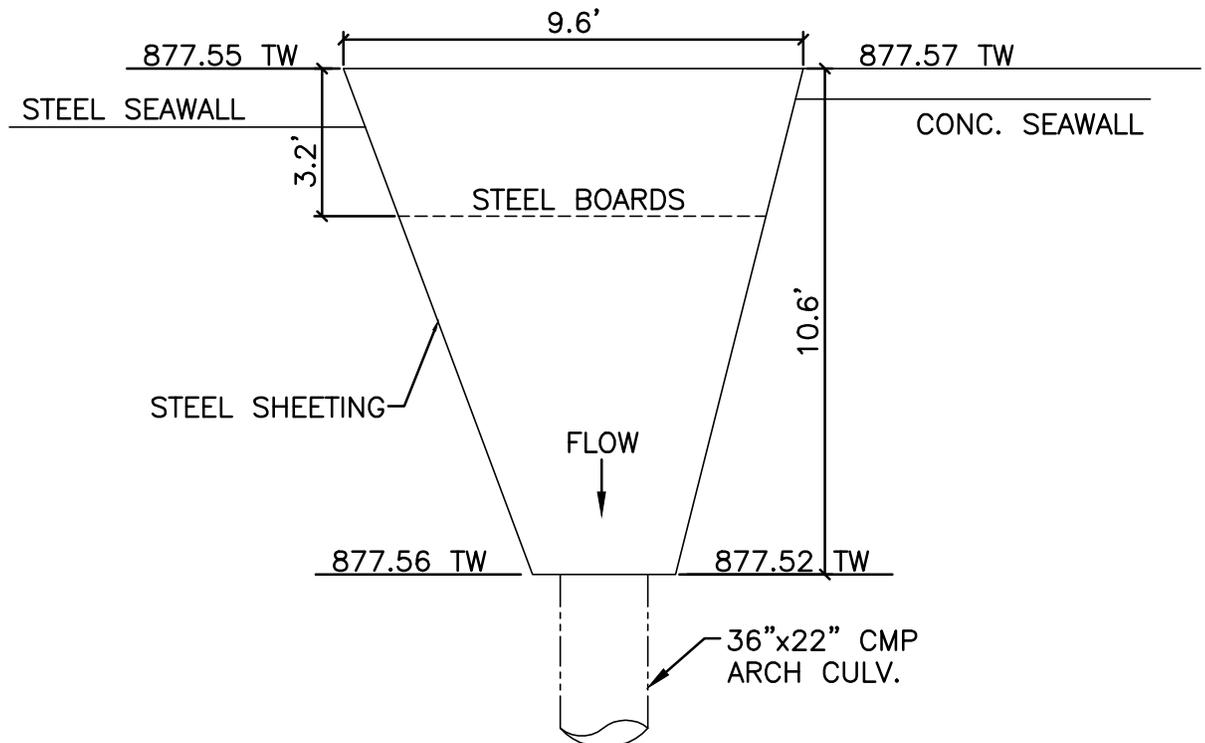
www.LREMI.com



SIDE VIEW



FRONT VIEW

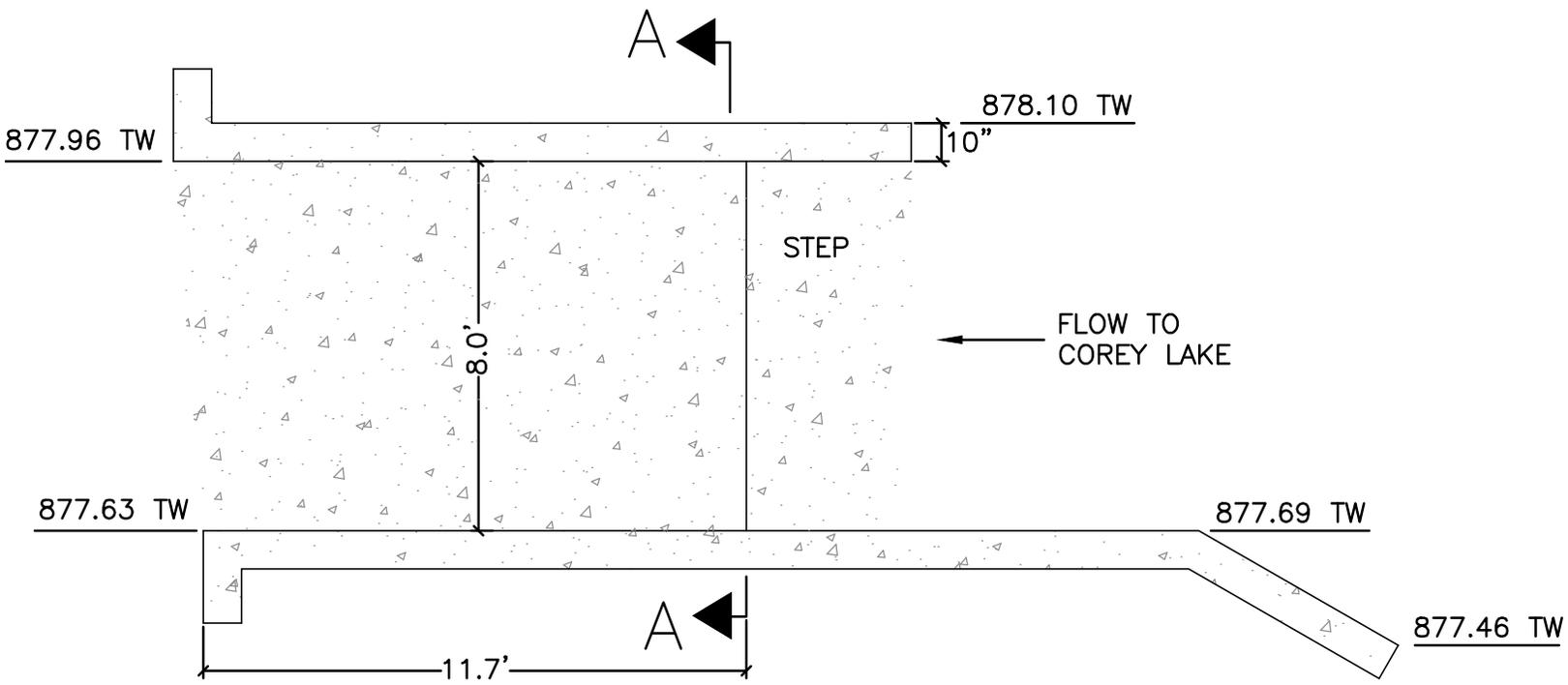


TOP VIEW

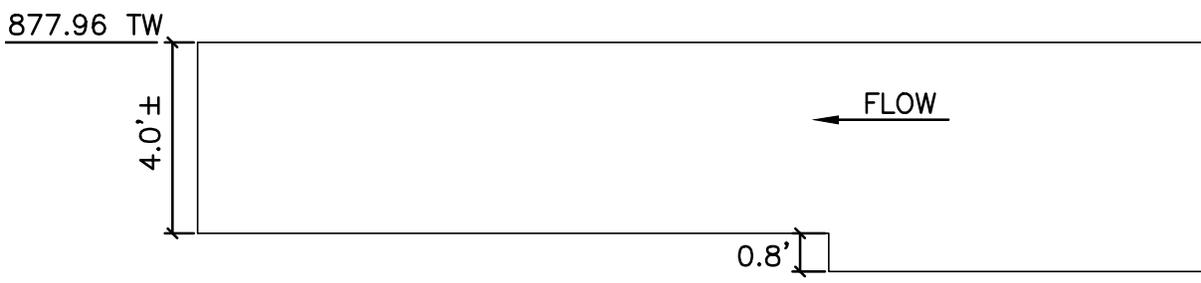
CONTROL STRUCTURE COREY LAKE

SCALE: 1"=4'

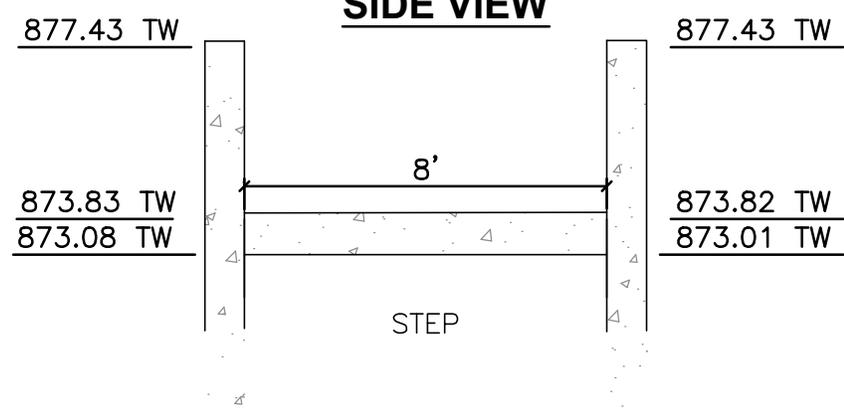
ELEVATIONS ARE BASED ON NGVD 29



TOP VIEW



SIDE VIEW

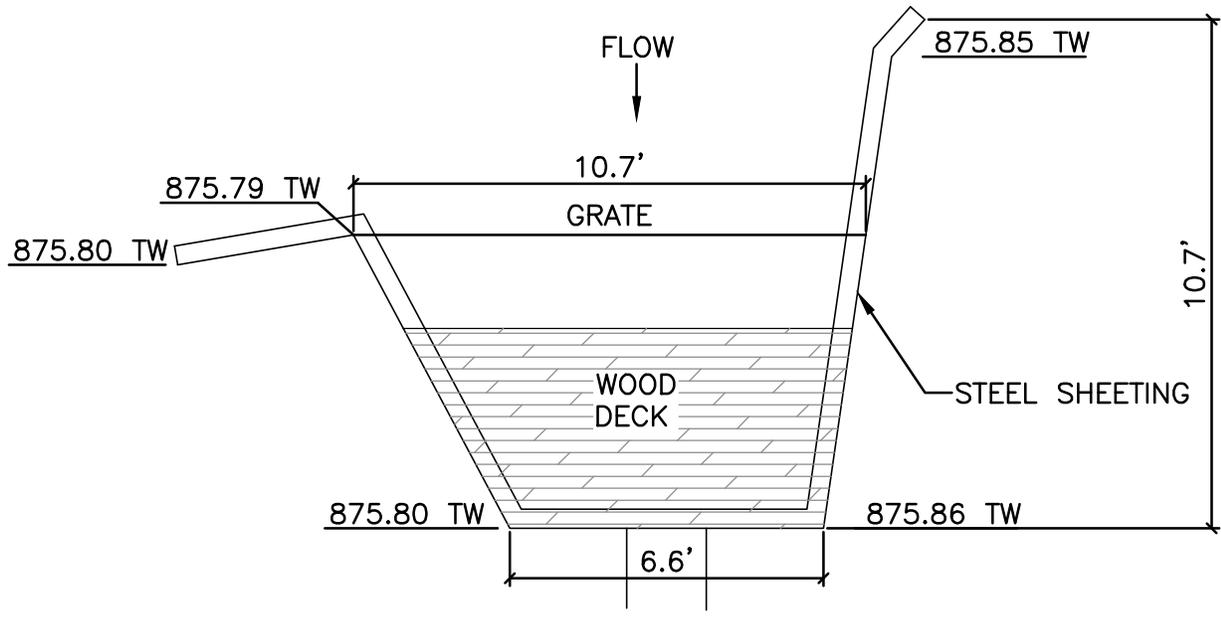


SECTION A-A

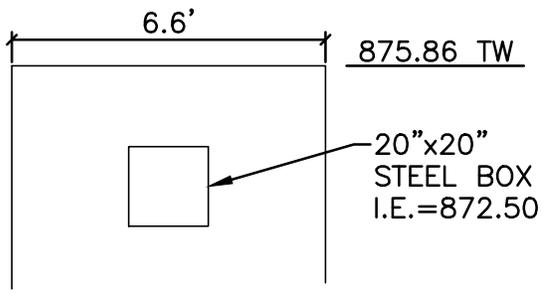
CONTROL STRUCTURE KAISER LAKE TO COREY LAKE

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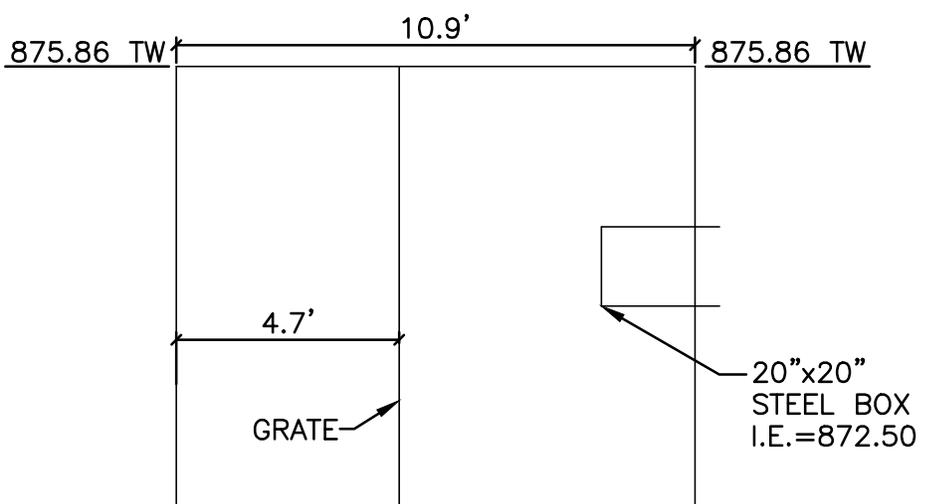
ELEVATIONS ARE BASED ON NGVD 29



TOP VIEW



FRONT VIEW

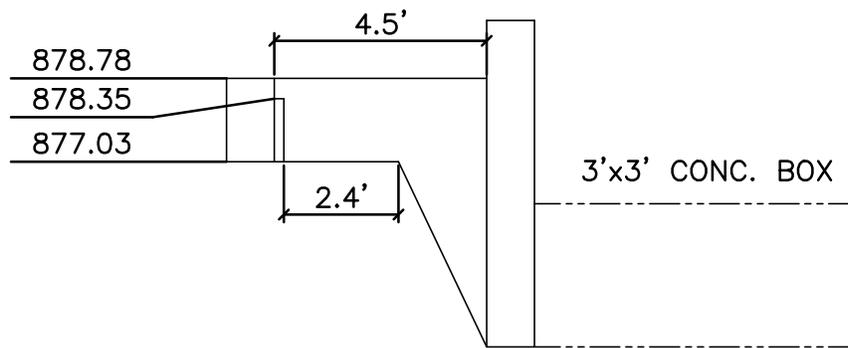
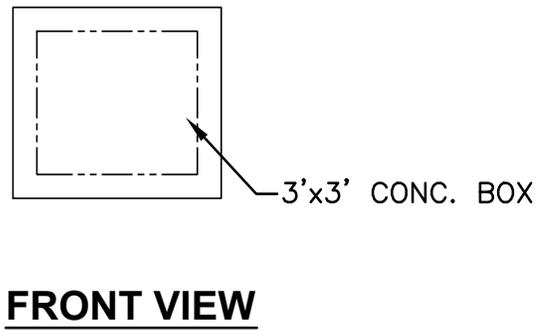
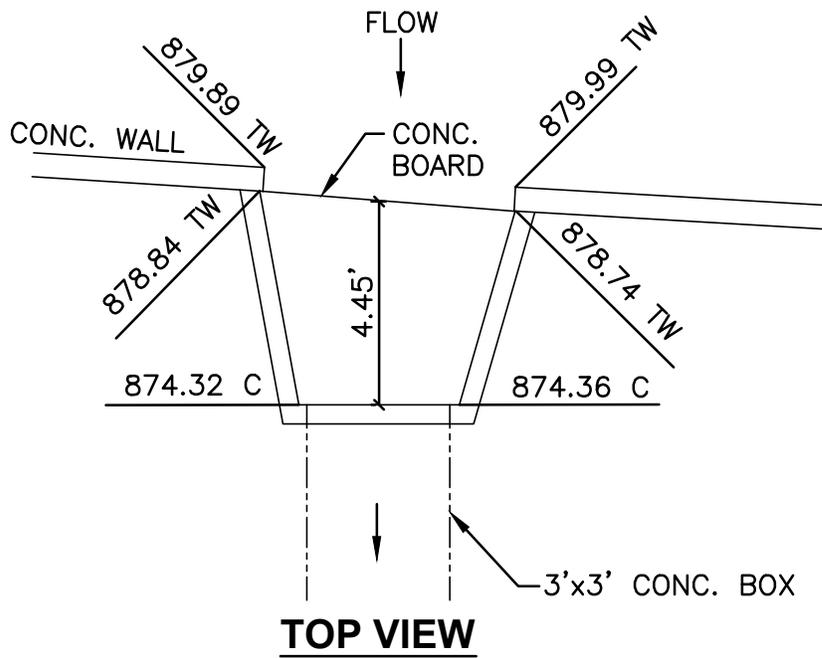


SIDE VIEW

CONTROL STRUCTURE CLEAR LAKE

SCALE: 1"=4'

ELEVATIONS ARE BASED ON NGVD 29



SIDE VIEW

CONTROL STRUCTURE HARWOOD LAKE

SCALE: 1"=4'

ELEVATIONS ARE BASED ON NGVD 29

Appendix 4

Historic Documents (Studies)



2121 3 Mile Rd.

Walker, Michigan 49544

Phone: 616.301.7888

www.LREMI.com

CORRY, KAISER, MUD AND CLEAR LAKES LEVEL CONTROL

St. Joseph County

Preliminary Engineering Investigation

July 1953

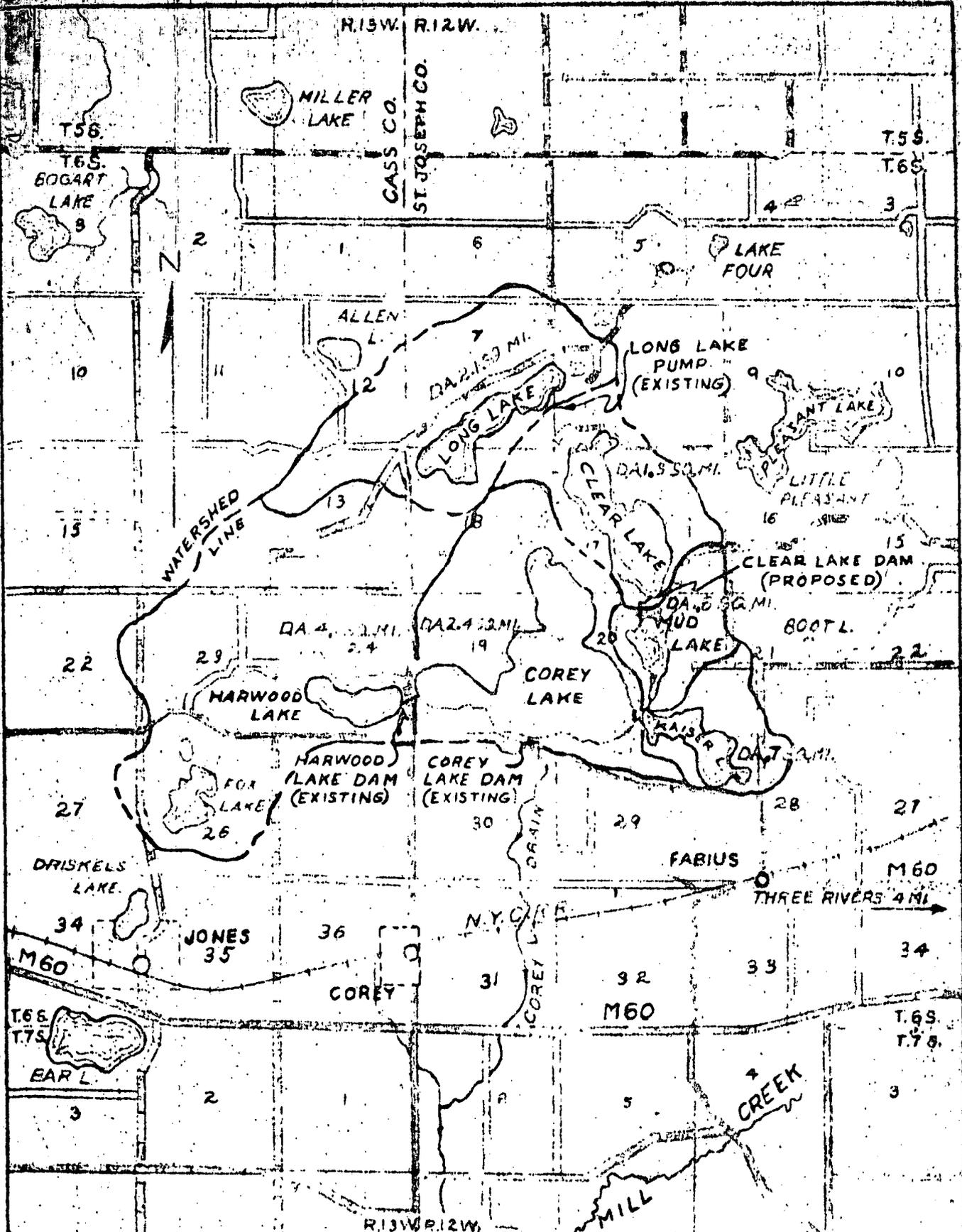
MICHIGAN DEPARTMENT OF CONSERVATION
ENGINEERING AND ARCHITECTURE
Division of General Operations

Otto H. Hall, In Charge
Registered Professional Engineer

Prepared by: Richard G. Foster, Hydraulic Engineer
Registered Professional Engineer

Approved by: *Hathaway J. Hanes*
Hathaway J. Hanes, Hydraulic Engineer
Registered Professional Engineer

Including Data and Graphs by
Water Resources Branch of the
United States Geological Survey



MICHIGAN DEPARTMENT OF CONSERVATION
 ENGINEERING & ARCHITECTURE SECTION
 LOCATION MAP - ST. JOSEPH COUNTY
 COREY, KAISER, MUD & CLEAR LAKES
 LEVEL CONTROL SCALE 1" = 1 MI.
 BY ESS FROM HIGHWAY MAP APRIL, 1953

COREY, KAISER, BAY AND CLEAR LAKES LEVEL CONTROL

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COREY, KAISER, MUD AND CLEAR
LAKES LEVEL CONTROL

I - INTRODUCTION

A legal level of elevation 873.45 was set for Corey Lake by the Honorable Theodore T. Jacobs, Circuit Court Judge, on January 25, 1932. There was no provision made for the maintenance of this level and consequently, the lake had risen to some 40 inches above this legally established level by July 1950. The result was the flooding of basements and other high water damage to property on Corey Lake.

The St. Joseph County Board of Supervisors on November 2, 1950, resolved to request the Department of Conservation to make an investigation of the Corey Lake problem. This resolution, as received, requested services which this office is not authorized to render; such as, acquisition of lands and rights-of-way.

The Board of Supervisors was informed of the limitations of Department investigations by John G. Hulison of the Geological Survey Division. Mr. Hulison informed them that the St. Joseph - Cass Inter-County Drain Board had in their possession, plans for a proposed Corey Lake Drain, prepared by T. A. Smith, Registered Engineer, Paw Paw, Michigan, and that these plans were available for use. He offered the assistance of department engineers in checking and analyzing these plans.

A meeting was held on November 29, 1950, to study the above mentioned plans and to make suggestions for their improvement. As a result of this meeting, T. A. Smith agreed to revise the plans. The drain was constructed from the revised plans and was opened on August 1, 1951, not as an inter-county drain, but as a private project financed by interested people on Corey Lake.

After the Corey Lake Drain was opened, interested parties on the adjoining lakes expressed concern over the effect the drain would have on other lakes in the vicinity. Especially interested were riparian owners on Kaiser Lake, since the main source of dry weather flow is from Corey Lake via the connecting channel between Kaiser the Corey Lakes. If the Corey Lake Dam were opened, excess flow (normally available as inflow to Kaiser Lake) would be discharged to the Corey Lake Drain and the St. Joseph River system.

A hearing for the establishment of a new legal level for Corey Lake was held on January 16, 1953, in the Circuit Court at St. Joseph County. Present at the hearing were several representatives from Corey and Kaiser Lakes and other interested parties as well as representatives of the Department of Conservation. As a result of the hearing, the Honorable Raymond W. Fox, Circuit Court Judge, requested the Department of Conservation to make an engineering study of Corey Lake and connecting lakes for the purpose of determining a new legal level for use in establishing a new legal level for Corey Lake.

A written request from Judge Fox, dated January 16, 1953, was received by the Geological Survey Division of the General Land Office, Department of the Interior, and subsequent surveys of the Corey Lake area were made by the Engineering and Architecture Section of the Department.

II - SCOPE

A. General

In response to the request of Circuit Judge Fox, the engineering section of the Conservation Department has in 1953, completed a brief field investigation of the physical conditions that can be expected to influence the levels of Corey Lake and the other lakes connected therewith.

Corey Lake is fed principally by surface flow from Harwood Lake which lies west of it. A natural channel, kept open by dredging, connects the east end of Corey Lake with Kaiser Lake and tends to equalize their levels. Proceeding north into the watershed, Mud Lake is connected to Kaiser Lake by a natural channel and Clear Lake discharges excess water to Mud Lake through a series of pipe culverts. Long Lake, farther to the north, has no natural connection, but a pump has been installed to discharge excess water from Long Lake to Clear Lake during intermittent periods of high water.

The entire watershed depends on the artificial "Corey Lake Drain" for an outlet. A control structure at the lake end of the drain controls Corey Lake levels and influences the levels of other lakes in the group, particularly Kaiser Lake.

A standard U. S. Geological Survey staff gage was installed on Corey Lake August 24, 1951, and intermittent records of lake stage are available since that date. Staff gages were installed on Kaiser, Mud, Clear and Harwood lakes in February 1953 and observations during spring and summer will be available at the time of the hearing which is scheduled for August 1953.

An established legal lake level, to be satisfactory, must meet the desires of the majority of riparian owners and preserve the natural resources of the state, with due consideration to public health and welfare. A stabilized lake level is considered most beneficial to fish and wildlife on any inland lake.

The Corey Lake Level Committee has compiled evidence which indicates that a lake level of elevation 874.5 (gage reading 4.50) is satisfactory to the majority of riparians on this lake. We are advised that this level will not adversely affect basements, low cottages, septic tanks and other shoreline installations.

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Legal counsel for the Kaiser Lake riparian owners has stated that the desire of his clients is to maintain Kaiser Lake at the same level as requested for Corey Lake. This would place the desired level for Kaiser Lake at elevation 874.5. It appears that the 6 owners on Kaiser Lake are willing to accept a legal level of elevation 874.5, but opinions differ as to the desirability of placing an obstruction in the Corey-Kaiser Channel. A number of small trees were found to be flooded at elevation 874.5, but the owner agreed that this was not of enough importance to make any change in the Kaiser Lake level as requested. Cottages, summer homes, and residences and any septic tanks connected therewith, and other shoreline installations are not adversely affected by a lake level of elevation 874.5 insofar as could be determined.

Kaiser Lake levels can be expected to recede during the summer months as a result of natural conditions beyond control, and therefore, storage of spring flows at as high a lake level as possible is desirable to partially compensate for these losses.

Mad Lake, which has no development, lies between Kaiser and Clear Lakes, and due to its location, must maintain a level between Clear and Kaiser Lake levels.

All available riparian owners on Clear Lake were contacted and the average of their desires places Clear Lake at a desired elevation of 874.8. Field data indicate that the majority of cottages and homes with their septic tanks and other shoreline installations will not be affected by this lake level.

There is, however, one basement floor at elevation 874.5, near Beach Profile #4, on the south end of Clear Lake. This floor has been raised by addition of a slab and a pump pump installed, and although the floor was damp at a lake level of 875.27, the situation was not serious. This owner did not wish to express a desired level at the time of our canvass of riparians.

Corey Lake riparians insist that the Corey-Kaiser Channel bottom be left as a natural barrier (elevation 874.2) against flow from Corey Lake to Kaiser Lake, except at times when Corey has excess water, or if this channel is excavated that a control weir be placed at a fixed crest elevation equal to the Corey Lake desired level of 874.5. Kaiser Lake riparians would like a boat canal between the lakes. No attempt has been made in this engineering investigation to establish the rights of either group.

Handwritten note:
 Corey
 Board of Supervisors

The design for Kaiser-Corey Channel suggested herein provides an equalizing channel with capacity to meet hydraulic requirements only and allow for passage of small boats. If a fixed crest weir is to be installed, the suggested location is at the new road proposed by the township supervisor.

A small inlet box, with stop log control, is suggested for the lakeward end of the Clear Lake outlet culvert to provide for retaining enough spring flood water to help hold the lake at or near the desired level during the dry summer periods.

Discharge of excess water from these lakes, to avoid excessively high levels, depends largely on the Corey Lake Drain. If this had not been completed previously, it would have added materially to the cost of improvements and control facilities necessary to cope with the problem of this group of lakes.

The Corey Lake Drain and Dam was designed to have a maximum capacity of about 20 second-foot, but imperfections in construction appear to have reduced the actual capacity. However, computations show that storage, on the mere than 1000 acres of lake area in the watershed, will absorb practically the entire runoff expected from a 25 year frequency storm.

Using available storage within reasonable limits, as outlined in Hydrology Section IV, and storm routing of flows results in a net outflow of 5 second-foot, and the Corey Lake Drain and Dam are adequate to discharge this amount and more by manipulation of the stop logs in Corey Lake Dam.

Necessary construction projects suggested herein are not extensive, as the existing facilities with minor changes are capable of maintaining desired levels on all the lakes, provided enough inflow is available to off-set natural losses resulting from evaporation, transpiration and seepage.

Operation of all control structures i.e., Corey Lake Dam, Clear Lake Dam (proposed) and Long Lake Pumping System, by one dependable individual responsible to the Board of Supervisors, is the key to maintaining the most beneficial levels on all lakes in this group.

Minor construction projects and careful operation of all control facilities will give satisfactory results.

II - SCOPE (Continued)

B. Field and Office Work

The field work has consisted of reconnaissance and surveys of the area, including the watershed or drainage area, existing inlets and outlets, beaches, low cottages and other shore installations, and general conditions which might affect the maintenance of a legal level for Corey, Kaiser, Mud and Clear Lakes.

Staff gages were installed on all four lakes and tied in to mean sea level datum for the purpose of obtaining lake stage records, and to provide for legal level establishment on mean sea level datum.

Available riparian owners on Clear Lake, were contacted and asked to express their individual desires as to a normal lake level. The majority of riparian owners on Corey Lake and Kaiser Lake had previously expressed desired levels for these lakes. There were no owners available on Mud Lake.

Beach profiles were surveyed on Clear and Mud Lakes to show the effect of various levels on shoreline installation and to serve as a guide to available storage in the lake basin.

Preliminary plans have been drafted, presenting a detailed area map, a plan and profile of the connecting channels, cross sections of the channels, and beach profiles. Special consideration has been given to control structures required for Clear Lake and for improvements to the interconnecting channel between Corey and Kaiser Lakes.

II - LOCATION AND DESCRIPTION

A. General

Corey, Kaiser, Mud and Clear Lakes occupy a total of 990 acres in St. Joseph County, T. 6 S., R. 12 W., with the extreme western end of Corey Lake at the Cass-St. Joseph County line. They are located about 6 miles due west of the City of Three Rivers and about 7 miles northwest of the Village of Constantine.

These four lakes, together with Harwood Lake in Cass County, constitute a chain of interconnected lakes (see location sketch preceding page one). Kaiser Lake is the lowest, except during periods of high water, with Clear and Mud Lakes emptying into it from the north, and Corey and Harwood Lakes flowing in from the west. There is no direct connection, but excess water can be and has been pumped from Long Lake to Clear Lake for outflow through the chain of lakes. The only outlet for discharging excess water out of the watershed is the Corey Lake Drain and Dam constructed in 1950.

The drainage area, contributing to this group of lakes, changes in size and scope as levels of the several lakes fluctuate. During the major portion of the year, Kaiser Lake is the lowest of the group and serves as a collecting reservoir for flows from two directions i.e., part of the inflow originates in the Harwood Lake watershed, is discharged from Harwood to Corey Lake where the Corey Lake watershed is added and finally finds its way to Kaiser Lake via a connecting channel between Kaiser and Corey Lakes; another part of the inflow to Kaiser Lake may start from the Long Lake watershed, whence it is pumped to Clear Lake, picks up the Clear Lake watershed, and is discharged to Mud Lake where that watershed is added, and is then discharged to Kaiser Lake through a connecting channel between Kaiser and Mud Lakes.

During certain periods of high runoff, Kaiser Lake may receive inflow from Long, Clear and Mud Lakes only, and discharge excess to Corey Lake. Under such conditions, excess flows are discharged from the Corey Lake Drain and Dam to Mill Creek about 3 miles south of the group of lakes.

The comparative drainage areas or watersheds are as follows: Kaiser Lake watershed 0.7 square miles, plus Corey Lake watershed 2.4 square miles, plus Harwood Lake watershed 2.0 square miles (an additional 2.1 square miles of indirect drainage area around Harwood Lake has been omitted because it does not affect peak flood flows) makes a total area from this direction of 5.1 square miles. Long Lake watershed (intermittent) 2.1 square miles, plus Clear Lake watershed 1.3 square miles, plus Mud Lake watershed 0.6 square miles gives a total of 4.0 square miles from the latter direction; and the aggregate total of the drainage areas is 9.1 square miles.

B. Corey Lake

Corey Lake, the largest of the four lakes has an area of 567 acres. It is highly developed along most of its shoreline and has very good bathing beaches. The only outlet to Corey Lake, except for a channel connecting it to Kaiser Lake, is an artificial outlet at the lake's southern end. This outlet was constructed in accordance with plans by T. A. Smith, dated February 14, 1951, and empties into Mill Creek, 3 miles south of the lake. The inlet is a small stream from Harwood Lake, entering Corey Lake from the west. The drainage area adjacent to Corey Lake is 2.4 square miles, while the total area, which includes intermittent drainage through the connecting lakes, is 9.1 square miles contributing direct drainage and 2.1 square miles from which drainage is indirect and does not affect peak runoff.

C. Kaiser Lake

Kaiser Lake with a surface area of 89 acres is a comparatively shallow lake with good beaches, and scattered shoreline development. Its watershed includes 0.7 square miles adjacent to the lake and the total watershed area may vary as outlined in previous paragraphs. The inlets are a small stream coming in from Mud Lake and the aforementioned connecting channel from Corey Lake. The latter serves as both inlet and outlet for Kaiser Lake depending on relative lake levels.

D. Mud Lake

Mud Lake, occupying 105 acres, is extremely shallow and has no resort development. The inlet from Clear Lake enters at the north, and the only outlet is the channel connecting it to Kaiser Lake. Its drainage area is 0.6 square miles, but it receives additional water from the Clear Lake and Long Lake drainage areas and thus its total drainage area is 4.0 square miles.

IV - AVAILABLE DATA

A. Desired Levels

1. Corey Lake

The Corey Lake Level Committee, in November 1952, presented to the St. Joseph County Board of Supervisors a petition for use of the establishment of a legal level for Corey Lake. The petition stated that the majority of riparian owners desired a level of 874.5 for Corey Lake.

2. Kaiser Lake

Riparian owners on Kaiser Lake were represented at a hearing for the establishment of a legal level for Corey Lake, held on January 16, 1953, in the Circuit Court at Centreville, St. Joseph County. At this hearing, the counsel for Kaiser Lake riparians indicated a desired lake elevation at the same level as was requested by owners on Corey Lake, or elevation 874.5.

3. Mud Lake

Desired levels were not taken for Mud Lake as there were no riparian owners available and there is very little, if any, development on the lake. However, as Mud Lake is extremely shallow, a level above elevation 874.0 would provide better fishing conditions and generally improve the lake.

4. Clear Lake

A canvass of all available riparian owners on Clear Lake was made on February 12 and 13, 1953, for the purpose of obtaining an expression of individual opinions as to the optimum lake level. These opinions made reference to the lake level as recorded on the U. S. Geological Survey staff gage at Clear Lake, on the dates mentioned above, and were expressed as number of feet or inches above or below the existing lake level. The average desire of the eleven owners contacted was elevation 874.83 and the median was 875.27 (7 of the 11 requested 875.27), the lowest request being elevation 873.27 and the highest elevation 875.27 showing a difference of opinion of 2 feet. A level near 875.0 appears to be a reasonable desired level and will be used for design purposes in this report.

5. Summary

In summation, the desired lake elevations in reference to mean sea level datum are as follows: Clear Lake, elevation 874.8; Mud Lake, at some level between the elevations of Clear and Kaiser Lakes; Kaiser Lake elevation 874.5; and Corey Lake, also 874.5. Elevations shown on the next page will be used in this report for purpose of designing control structures and connecting channels.

Lake	Coverage	Design Elev.	Source of Data
Corey	88 Owners	874.5	Corey Lake Committee
Kaiser	Not Known	874.5	By attorney for owners
Mud	General	875.0 or less	By Dept. of Conservation engineers
Clear	11 Owners	875.0	Consent of Owners

Kaiser Lake discharges water into Corey Lake only during periods of high runoff or when losses from Kaiser Lake are low. History of Kaiser Lake (from local people) indicates that losses, resulting from transpiration, evaporation, seepage and other causes, may exceed inflow from Mud Lake, while Corey Lake usually has an excess to be discharged as outflow either to Corey Lake drain or to Kaiser Lake. Therefore, during all periods, except spring break up, Kaiser Lake could receive inflow from both Mud Lake and Corey Lake. Reports of lake levels indicate that such a condition existed on July 4, 1953, with lake elevations as follows:

	Corey	Kaiser	Mud	Clear
Gage Zero	870.00	850.00	849.00	850.00
Gage Reading	<u>4.5</u>	<u>23.75</u>	<u>24.80</u>	<u>24.80</u>
Lake Elevation	874.5	873.75	873.80	874.80

Any gage reading added to the zero of the gage will give the elevation of the lake. Example: if the Corey Lake gage reads 4.50, then the elevation of the lake is $870.00 + 4.50$ or 874.50 (this level is the desired level of Corey Lake).

Any water surface elevation mentioned in this report may be converted to a gage reading by subtracting the zero elevation from it. For example, if the maximum water surface is elevation 875.1, the corresponding gage reading would be 875.1 minus 870.0 or 5.1 for Corey Lake.

Gage zero elevations for all the lakes in the group are shown in the foregoing tabulation.

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It is our understanding that the riparian owners on Kaiser have requested the same legal level as Corey Lake so they may have the benefit of excess water from Corey Lake rather than allowing it to be charged out the Corey Lake Drain.

From an engineering standpoint, this is not possible because there is flow of water there must be a slope or difference in water elevation between the two reservoirs as well as in the connecting channel. Therefore, it would be advisable to establish a level for Kaiser Lake slightly lower elevation than Corey Lake. The amount of difference will depend on whether the connection between the lakes is an open channel channel restricted by a fixed crest weir.

B. Hydrology

As only a few lake stage records are available for Corey Lake and no records for other lakes in the group, it has been necessary to estimate the frequency and magnitude of flood flows by a comparison with similar watersheds as follows:

Lake Name	County	Soil Type	Terrain	Active Inlet	Drain- age Area Sq. Mi.	Inflow 25 C.F.S. p Sq. Mi.
Van Anken	Van Buren	Silt Loam	Slightly Rolling	Yes	3.3	18
Wall	Ferry	Clay	Hilly	No.	6.3	25
Corey *	St. Joseph	Sand & Gravel	Hilly	Yes	11.2	20

* Corey Lake at outlet, including: Kaiser, Mad, Clear, Harwood and I Lakes. As a check apply Meyer's formula for peak runoff.

The "Minnesota Flood Flow Formula" as extracted from Adolph Meyer's "Elements of Hydrology" - $Q = 100 C_1 C_2 A^{0.6}$ when applied to the Corey Lake watershed, gives the following peak runoff:

$$C_1 = 1.0 \quad C_2 = .50 \quad A = 11.2$$

$$Q = 100 \times 1 \times .50 \times 4.25 = 213 \text{ c.f.s.}$$

$$213 \text{ c.f.s.} \div 11.2 \text{ square miles} = 19 \text{ c.f.s./sq. mi.}$$

As a result of the above computations and study of similar watersheds, a runoff rate of 20 c.f.s./sq. mile, of direct drainage area representing a storm runoff of about 25 year recurrence frequency will be used in this report for the purpose of design.

The following tabulation is a synopsis of results of computations made in determining the design outflow for each lake.

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STORM ROUTING OF 25 YEAR FREQUENCY FLOOD FLOWS

LAKE NAME	DRAINAGE AREA SQ. MI.	ELEV. BEFORE STORM	INFLOW		LAKE AREA ACRES	STORAGE		MAXIMUM ELEVATION	OUTFLOW	
			ACRE FEET	SEC. FT. DAYS		DEPTH FEET	ACRE FEET		SEC. FEET DAYS	DESIGN C.F.S.
LONG L.	2.1	887.0	252	126	203	1.1	223	888.1	15	5
CLEAR L.	1.3	875.0	185	92	229	0.8	184	875.8	* base flow	3
HARWOOD L.	2.0	878.9	240	120	91	1.0	91	879.9	75	25
COREY L.	2.4	874.5	438	219	567	0.6	340	875.1	49	16
MUD & KAISER L.	1.3	873.5	240	120	194	1.2	240	874.7	0	0

* In this case the storage was equal to the inflow. Therefore, the design outflow is equal to base flow which is estimated.

** The actual drainage area for Harwood Lake is 4.1 square miles, but 2.1 square miles of this was subtracted because drainage is indirect (seepage) and indirect drainage conditions will not affect a peak runoff.

*** Of this design outflow, 5 c.f.s. will be routed through the Corey Lake drain and 11 c.f.s. into Kaiser Lake.

The values for the different columns were attained as follows:

$$\text{Inflow (sec.ft.days)} = \text{Drainage area (sq.mi.)} \times \text{unit rate of runoff} \times \text{period (days plus inflow from adjacent drainage area)}$$

$$\text{Inflow (acre-ft.)} = \text{Inflow (sec.ft.days)} \times 2$$

$$\text{Storage} = \text{Inflow} - \text{Outflow}$$

$$\text{Storage Depth} = \frac{\text{Storage (acre ft.)}}{\text{Area of Lake (acres)}}$$

$$\text{Outflow (sec.ft.days)} = \frac{\text{Inflow (acre ft.)} - \text{Storage (acre ft.)}}{2}$$

$$\text{Design Outflow (c.f.s.)} = \frac{\text{Outflow (sec.ft.days)}}{\text{Period (days)}}$$

Assume a storm runoff of 5 day duration with 3 days maximum runoff.

Period = 3 days

Unit rate of runoff - 20 c.f.s./sq. mi.

From the preceding tabulation, it should be noted that:

1. The computed outflow from the Long Lake pump, 15 day-second-feet, will add 30 acre-feet to Clear Lake affecting its depth by 1 1/2 inches, on the average of once in 25 years, and in most years the effect of long lake pumping will not be noticeable.

2. The assumed maximum level for Clear Lake is at an elevation that may be above one or more basement floors, but it is our understanding that sump pumps have been installed so that serious damage can be avoided, and in view of the long term recurrence interval (25 years), it would seem that the condition can be tolerated.

During normal years, the maximum level of Clear Lake should not exceed elevation 875.3 because the suggested control structure provides for winter drawdown of the lake and for storage of part of the spring flood flows below the desired level of elevation 875.0. In April 1953, Clear Lake was found to be at elevation 875.28 and although the lowest basement floor (elevation 874.51) was damp, no flooding or serious damage resulted.

3. Control of Clear Lake, at or near elevation 875.00, may have a tendency to raise the general ground water level and help the low water condition on Kaiser Lake during dry seasons.

4. Mud and Kaiser lakes were treated as a single lake because they will probably fluctuate at nearly the same levels. Their drainage areas are similar in size and have somewhat the same characteristics, and they have a connecting channel which will tend to equalize their levels, during periods of low flow. Mud Lake will be slightly higher than Kaiser during periods of flood runoff when 3 to 5 second-feet of flow will be reaching Mud Lake from Clear Lake, and a portion of which can be expected to flow into Kaiser Lake.

5. The pattern and behavior of underground seepage in this lake area is not known and lake stage records are of too short duration to serve as a basis for predictions of expected losses from these lakes, particularly Kaiser Lake. It is hoped that by retaining as much as possible of the spring flows in the lake reservoirs and ground water reservoirs, more satisfactory summer levels may be maintained on all of the lakes.

6. Kaiser Lake was assumed to be at elevation 873.5, prior to spring runoff, based on information compiled from local residents and other people familiar with the behavior of Kaiser Lake during late summer, fall and winter in past years. In the event that this storage is not available in Kaiser Lake, storm flows could be discharged through the Corey Lake Drain and dam by removal of additional stop logs to increase the waterway opening.

7. The distribution of discharge, 5 c.f.s. out of Corey Lake Drain and Dam, and 11 c.f.s. into Kaiser Lake under the assumption made for developing the design outflow of 16 c.f.s. (25 year frequency) shown in the table, may vary according to antecedent conditions. However, capacity of Corey Lake Drain and Dam is such that these discharges could be reversed, i.e., 11 c.f.s. discharged out of Corey Lake Drain and Dam, in fact, this figure could be increased to 15 c.f.s. if the occasion demanded.

8. The natural bottom in the Corey-Kaiser Channel (elevation 874.2), 25 feet west of the existing bridge, has in the past acted as a control which allows Kaiser Lake to drop below the level of Corey Lake and assumed lake levels are based on those existing conditions, and in this design, a 25 year storm runoff was applied to the watershed and storm routed through the various lakes and channels.

9. Excavation of a deeper and wider channel, between Corey and Kaiser Lakes, will tend to equalize their levels during all periods of the year, while installation of a control weir in the connecting channel can be expected to maintain these lakes at different levels depending on the direction and volume of inflow, i.e., from Harwood Lake or from Clear and Mud Lakes. Installation of a control weir with crest elevation at the proposed legal level of 874.5 will, according to the history of these lakes, result in lower summer levels for Kaiser Lake than for Corey Lake.

10. A summation of the picture amounts to this:

a. A variation in lake levels between spring high and summer low is to be expected on any and all lakes, in this group, or in the state.

b. Natural conditions just will not permit holding one lake within a few hundredths of a foot above or below an established level.

c. In dry years, it would seem feasible to share the available supply of inflow equitably among all the lakes in the group; namely, Clear, Mud, Kaiser and Corey Lakes. Extremely dry conditions might result in Corey Lake dropping below an established level, but the other lakes would also be proportionately low and conversely during periods of high runoff, all the lakes can be expected to be proportionately high.

d. It would be folly to attempt to predict what levels will occur on these lakes in the future, but it should be possible to maintain generally satisfactory levels if the whole group of lakes is considered in the operational procedures for the several control units and connecting channels.

e. On the basis of above outlined procedures, it is believed the lake levels more satisfactory to all would result if no control structures were built in the channel between Kaiser and Corey Lakes. Also, that levels would tend to balance automatically, requiring less operational control of Corey outlet dam, especially during extremely dry periods when Corey Lake may drop below the established legal level.

f. An equalization and satisfactory distribution of inflow can be influenced appreciably, particularly during dry seasons, if one person is responsible for operation of all control structures in the group of lakes.

C. Existing Channel Capacities

The existing connecting channel capacities were computed for the purpose of determining the ability of the existing channels to handle the maximum discharges, which are expected to occur at the maximum lake stages. Below is a tabulation of the results of these computations.

<u>Name</u>	<u>Design Capacity</u> <u>C.F.S.</u>	<u>Existing Capacity</u> <u>C.F.S.</u>
Clear Lake to Mid Lake	3	3.5
Harwood Lake to Corey Lake	25	42
Corey Lake to Kaiser Lake	*** 11	12
Corey Lake Drain and Dam	5	* 5
** Mid - Kaiser	<u>0 0</u>	<u>0 0</u>

* The existing Corey Lake Drain and Dam will pass 5 c.f.s. with the top of the stop logs at elevation 874.7 and Corey Lake at elevation 875.1 (maximum lake elevation), but will pass 15 c.f.s. if all the stop logs are removed.

** In addition to the channels itemized above, there is also a connecting channel between Kaiser and Mid Lakes, which by observation, has sufficient capacity to accommodate any flows expected at maximum lake stage.

*** Based on 10 foot control weir under a head of 0.6 feet.

The Corey Lake Drain was designed by T. A. Smith to discharge a maximum of 20 c.f.s., but imperfections in construction appear to have reduced its actual capacity. Since completion it has, however, proved adequate to maintain Corey Lake within a few tenths of a foot of the desired level, and computations indicate that it will meet expected flow requirements.

REMEDIAL MEASURES

A. Corey Lake Drain

Since the opening of the Corey Lake Drain, there has been little fluctuation in the level of Corey Lake indicating the ability of the drain to maintain the desired level of 874.5, but with the opening of the drain, water that could be used to raise the level of Kaiser and Mud Lakes has been allowed to pass down the drain. To accomplish the divergence of this flow into Kaiser Lake, an additional stop log should be added to the Corey Lake Drain outlet structure, bringing its crest to elevation 874.7, or by leaving crest at 874.5 if Kaiser Lake level is established at 0.2 foot lower (elevation 874.3).

B. Corey-Kaiser Channel

Channel improvements will be required to provide hydraulic capacity in the channel from Corey to Kaiser Lakes to equalize their levels. If it is decided that a control structure is needed between Corey and Kaiser Lakes, the control structure should have a fixed crest of 0.2 feet lower than the crest at Corey Lake Drain, and the channel should be cleaned out to provide for flow of water between Corey and Kaiser Lakes, and to facilitate the passage of boats between the lakes.

C. Kaiser-Mud Channel

Addition of excess water from Corey Lake will relieve to some extent the low water conditions which have existed on Mud and Kaiser Lakes, however, the latter lakes may be expected to recede to a level of about elevation 873.5, in the late summer and autumn due to losses from evaporation, transpiration and seepage. The existing loose rock dam between Kaiser and Mud Lakes should be removed to provide an equalizing channel between these two lakes.

D. Clear Lake Outlet

The existing outlet from Clear Lake has sufficient capacity to pass the expected flows, but provision should be made for the storage of water for dry seasons by the addition of a control structure at the upstream end of the existing corrugated metal pipe culverts.

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The Clear Lake control structure should consist of a drop in lot with a spillway length of 3.0 feet, a fixed crest at elevation 874.5 and equipped with stop logs to an elevation of 875.5. This will provide for storage of a portion of spring flows to compensate for receding lake levels during dry seasons.

Stop logs can be adjusted to a crest as low as 874.5 to allow one-half foot of storage for spring flood flows before the lake reaches the desired level of 875.0, thus avoiding excessive spring highs. Under moderate flow, the crest can be raised so that several inches of storage above the desired level will be available to compensate for inflow deficiencies during summer months.

The lowest basement floor was only damp at lake elevation 875.27 and no serious damage occurred, so it appears feasible to accept the average desired level of elevation 875.0 as a normal level for the lake.

B. Control of Lake Levels

It appears advisable for one person to operate the several control structures in a manner that will be most beneficial to all the lakes, under the varying conditions of inflow that will most certainly occur. It is suggested that this person operate under the direction of the St. Joseph Board of Supervisors.

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DATA RELATIVE TO LAKES IN THE COREY LAKE AREA

LAKE NAME	LEGAL ELEV.	LEGAL LEVEL EST.	DESIRED LEVEL	DR. AREA SQ. MILES	LAKE AREA ACRES	OUTLET		PUBLIC ACCESS
						DESCRIPTION	CAPACITY C.F.S.	
Long L.	887.0	5-16-52	887.00	2.1	203	Pumping system to Clear Lake.	7	No
Clear L.	None	-	875.00	1.3	229	C.M.P.'s to Mud Lake	3	Yes, Public Fishing Site
Mud L.	None	-	874.00 +	0.6	105	Channel between Mud and Kaiser Lakes, or Kaiser Corey Channel		No
Kaiser L.	None	-	874.5	0.7	89	Channel between Mud and Kaiser Lakes.		Yes, Boat Livery
Harwood L.	877.00	1932	877.00	4.1	91	Channel to Corey L. with Control Structure	42	No
Corey L.	873.45	1-25-32	874.5	2.4	567	Corey L. Drain Channel to Kaiser L. Existing Proposed	15 Varies* 11	Yes, Boat Livery

* The waterway area has been changed by repeated cleanout and refilling.

DEPT. OF CONSERVATION
Engr. & Arch. Section
Drawn by WCR 4/1/53
Checked by KRJ 4/2/53

SUMMARY OF CONDITIONS

1. On January 19, 1953, the Geological Survey Division of the Conservation Department received from the Honorable Raymond W. Fox, Circuit Judge, a request for an engineering investigation of Corey Lake and connecting lakes for the purpose of obtaining data for use in establishing a legal level for Corey Lake, and to determine the feasibility of establishing legal levels for the connecting lakes.

2. A legal level of elevation 873.45 had previously been set for Corey Lake on January 25, 1932, but no provision for maintenance had been made and consequently, the lake rose some 40 inches above this level with resulting high water damage to property on Corey Lake.

3. The lakes influencing the Corey Lake problem are: Corey, Kaiser, Mud, Clear, Long and Harvard. Available data on each are shown on the table preceding this page.

4. Long Lake has no natural connection with the other lakes in the group, but a pumping system has been installed to remove excess water when the lake rises above the legal level of elevation 887.0.

If Long Lake enters the spring season at the legal level, it may raise as much as 1.1 feet once in 25 years, however, this condition can be improved by anticipating snow melt and high runoff, and pumping the lake down prior to arrival of flood flows to provide some storage below the legal level. This will lower the maximum elevation of Long Lake during high runoff periods.

It should prove practical to allow Long Lake to store some water above the legal level, so that pumping to Clear Lake can be adjusted to a period when it will not cause undesirable levels on Clear Lake.

5. The culverts that have been installed as an outlet for Clear Lake are limited as to capacity, but will probably be capable of maintaining the lake level within desirable limits in the majority of years, if a small control structure is constructed at Clear Lake.

6. One cottage owner (near Clear Lake outlet and Beach Profile No. 1) who has a basement floor at elevation 874.5 did not express a desired level for Clear Lake.

7. The natural channel between Mid Lake and Kaiser Lake has sufficient capacity to pass expected flood flows if minor improvements are made.

8. Lake stage records are not available, but it is our understanding that Kaiser Lake has a natural tendency to show excessive drops during the summer months, probably due to evaporation, transpiration and perhaps underground seepage. This condition may be improved to some degree by the recent installation of culverts providing some flow from Clear Lake via Mid Lake into Kaiser Lake.

9. It appears that Corey Lake receives enough inflow to maintain a rather stable level throughout the year and has during most periods discharged some excess water to the Corey Lake Drain.

10. It is the desire of the Kaiser Lake riparians to be allowed the benefit of any available flow from Corey Lake, and a channel capable of passing small boats has been requested by some Kaiser Lake riparian owners.

11. Some Corey Lake riparian owners have stipulated that a fixed culvert barrier be placed in the Corey-Kaiser Channel to provide for flow from Corey Lake to Kaiser Lake only at times when Corey Lake is higher than the proposed new level of elevation 874.5. Such a barrier would interrupt boat passage through the connecting channel and Kaiser Lake riparians may be entitled to such navigation privileges. A decision on this point should be made by the Court and does not fall within the scope of this engineering investigation.

12. The existing road bridge on the Corey-Kaiser Channel is in poor condition and extensive improvements will be required to provide enough roadway area to match the improved channel as proposed. No information is available as to whether this bridge will be removed or continued in place after the road is relocated.

13. The Township Supervisor plans to request the relocation of the bridge which crosses the Corey-Kaiser Channel, and plans include a different bridge, the parts of which are said to be available from the County Board of Commissioners. We are advised that this bridge will have a span of ten feet and this will provide adequate waterway opening if footing and underpinning elevations meet minimum specifications.

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RECOMMENDATIONS

1. An equalizing channel of adequate capacity will be required between Corey and Kaiser Lakes to discharge flood flows from the watershed above this point to the only outlet, Corey Lake Drain and Dam. A weir or barrier in this channel is not required from the standpoint of hydraulic function.
2. Excavate a channel with a 4.0' bottom width and 2 to 1 side slopes, from Corey Lake (Station 81 + 60) to the proposed bridge (Station 85 + 90) a distance of 430 feet, the bottom should be at elevation 871.5, a minimum of 3 feet below the desired lake elevation of 874.5. Place spoil from this channel on the banks, between Station 84 + 00 and the proposed road bridge, forming a berm with a minimum elevation of 876.0 as shown on plans.
3. The existing bridge at the county road presents a problem in the excavation of this channel, as its abutments may be undermined, which could result in failure of the bridge. This bridge should be removed if no longer needed, but in the event that its continued use is considered necessary, the proposed channel could be narrowed through the bridge and the bridge abutments protected by extension of footings with sheet piling and concrete.
4. Excavate a channel 140 feet long from the proposed bridge (Station 85 + 90) to Kaiser Lake (Station 37 + 30) with a 4.0 foot bottom, 2 to 1 side slopes and a bottom elevation of 871.5.
5. In the event that it appears to the Court that a control weir should be placed between Corey and Kaiser Lakes (to reserve all the low summer flow from the Corey Lake drainage area for Corey Lake only) such a control structure can be built of concrete or steel sheet piling in conjunction with the proposed new bridge on the relocated road which will cross the Corey-Kaiser Lake Channel.
6. Design of such a control structure for Kaiser Lake is based on the probable construction of a bridge at the proposed road relocation between Corey and Kaiser Lakes, with the assumption that the bridge will have concrete abutment walls, a span of 10 feet, and will have an underclearance not lower than elevation 878.0.

7. In the event that it is required, construct a weir 10 feet long, between the upstream ends of the abutments of the above mentioned bridge, with a fixed crest at elevation 874.3 or two-tenths of a foot below the new proposed Corey Lake legal level.

8. Adjust the stop logs in the Corey Lake Drain control structure to bring the crest elevation to the new legal level each year after major spring runoff has passed.

9. On Clear Lake at the upstream end of the existing corrugated metal pipe culverts, which serve as an outlet from Clear Lake to Mad Lake, construct a concrete drop inlet control structure with a spillway low of 3.0 feet, a fixed crest at elevation 874.5 and with provision for stop logs to an elevation of 875.5.

10. Remove the existing loose rock dam between Kaiser and Mad Lakes to provide for an equalizing channel with a maximum bottom elevation of 872.5.

11. It is definitely recommended that legal levels be established for Corey, Kaiser and Clear Lakes, in accordance with the provisions of Act 194, Public Acts 1939, in order to avoid future litigation by individuals. Some fluctuation of these lake levels may be expected during spring runoff and dry seasons each year.

12. The absence of development on Mad Lake would seem to justify allowing it to fluctuate naturally, serving as a connecting channel and reservoir between Clear and Kaiser Lakes, and no legal level is suggested for this lake at present.

13. Funds should be provided in the original assessment for maintenance and operation of all control structures and for periodic cleaning of connecting channels to insure proper hydraulic operation of the entire lake system.

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One person should be designated by, and made responsible to, the Joseph County Board of Supervisors as operator of all control structures, including the Long Lake pumping system, Clear Lake control structure and Corey Lake Drain and Dam, so that flows can be controlled to the mutual benefit of all lakes i.e.: Corey, Kaiser, Mad, Clear and Long Lakes.

15. Provision should be made for the permanent installation of a staff gage and for observations and records of lake levels on each lake, to serve as a guide to maintenance of the legal levels if and when these levels are established. It is further recommended that the Board of Supervisors keep these records of lake levels in their files.

16. This report and plans N 78 A-1 are of preliminary nature, intended to aid the Court in establishing legal lake levels. Final designs, cost estimates, plan and specifications, and field supervision for construction should be carried out under the direction of a Registered Professional Engineer.

Ralph Vogel

I. SUMMARY

The purpose of this study is to determine the existing lake level of Long Lake and its surrounding lakes and to evaluate alternatives to lower Long Lake to its legal lake level. Our investigation has shown that Long Lake is approximately 1.5 feet above its legal level of 887.0 feet. Clear Lake is approximately 0.2 feet above its legal level which would be very normal for this time of year. Corey Lake is approximately 0.6 feet above its legal level. Since Corey Lake has outlets both to Kaiser Lake to the east and the Corey Lake Drain to the south, it would appear that the outlets are being regulated to maintain the lake at this elevated level. Harwood Lake is approximately 1.9 feet above its legal level and is being regulated at that level by means of the outlet structure between Harwood and Corey Lakes. Mud Lake has no legal level but is presently about 2.0 feet below Clear Lake which outlets to it. Kaiser Lake is approximately 1.3 feet below its legal level. Kaiser Lake is 1.4 feet below Corey Lake which drains to it and 1.8 feet below Clear Lake which can drain to Kaiser Lake through Mud Lake. At this time though, Mud Lake is 0.4 feet below Kaiser Lake.

Thirteen alternatives were evaluated to lower Long Lake and to allow the lake level on Long Lake to be regulated to maintain its legal level. These alternatives started with pumping to Clear Lake in a manner similar to the system used in the early 1950's and included pumping to all other lakes and swamp areas in the general vicinity. In addition gravity flow options outletting from the west end of Long Lake were also considered. These gravity alternatives included flow to Corey Lake, Howard Lake, Spatterdock Lake and swamp areas. Potential environmental effects were considered for all options along with a consideration for which options would be most socially acceptable to all interested parties in the general vicinity.

It is our opinion and recommendation that the gravity flow alternative to the swamp area north of Harwood Lake, with overflow to Harwood Lake, is the best option when all factors are considered. This option entails constructing an outflow structure on the west end of Long Lake to regulate the flow and then running pipe from Long Lake to the swamp area north of Bald Hill Road. This swamp area would be connected by pipe to the large swamp area south of Bald Hill Road and north of Harwood Lake with a final segment of pipe connecting the swamp area with Harwood Lake. Careful consideration must be given during design to regulating the level of water in the swamp areas so as not to further flood them or drain them significantly.

The construction costs of this option are more than some of the pumping options but there are no operating costs for power or labor which will escalate with inflation over time. The gravity flow

situation also eliminates potential conflicts and controversy in the future each time an attempt is made to turn the pumps on. From an environmental standpoint, with the inconclusive data available on area lakes, this option has the least negative environmental impacts on surrounding water quality. From a social acceptance standpoint, the least number of people other than those on Long Lake are affected by this option than by the other options.

The preliminary estimated construction cost for this recommended option is \$190,000. Assuming that the project would be financed through a bond issue with an interest rate of 10% repayable over 30 years, the yearly cost is just over \$20,000. This relates to a yearly cost of from \$70 to \$90 for each property owner in the drainage district, depending on the number of parcels of property in the drainage district.

II. BACKGROUND

Long Lake is generally located in northwestern Fabius Township in the most western part of St. Joseph County. The extreme west end of Long Lake is located in Newberg Township, Cass County with the centerline of County Line Road south of Long Lake being the approximate dividing line between the two counties. Long Lake is the most northern of a cluster of six lakes in the immediate area. Long Lake has no natural inlet or outlet and its legal level is the highest of any lake in the area. Long Lake's current water surface elevation is 10 feet higher than any other lake in this area. The general location of lakes in the area is shown on Figure 1.

The land surrounding Long Lake is generally forest and farm land other than the homes and cottages on the lake shore. The land to the west, north and east consists for the most part, of steep slopes directly adjacent to the lake. The land to the south, southwest, and some areas along the north are low. Approximately half the homes and cottages surrounding the lake are built on low land very close to the lake. Long Lake has documented high water problems which go back to the late 1940's and early 1950's. In May of 1952 Long Lake was almost 5 feet above its legal level. Late in 1952 a pump station and piping was installed to pump the extra water from Long Lake over the 90 foot high hill to the south to Clear Lake. This system was legally established as a county drain. This pumping system worked effectively at the time to lower the water level. Once Long Lake was back down to its legal level the pump and piping were basically abandoned. The pump, pump house and much of the pipe still exists today, but has deteriorated beyond a point of repair. Table 1 presents the historical data we have been able to gather together for the lakes in the area.

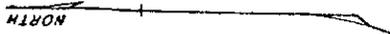


FIGURE 1

KAISER LAKE
AND
NEARBY LAKES,
FABIUS TOWNSHIP,
ST. JOSEPH COUNTY,
MICHIGAN.

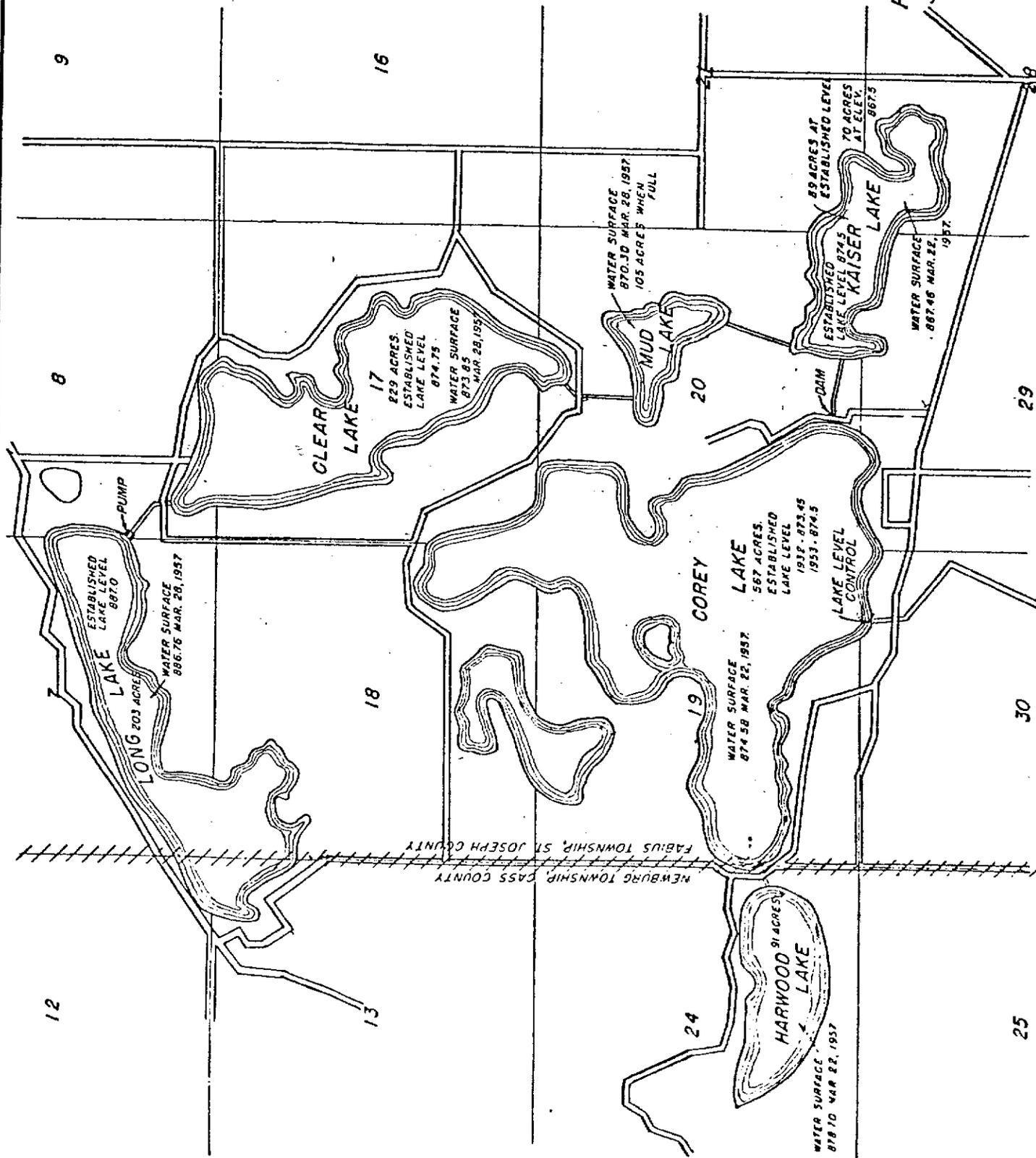


TABLE 1

LAKE LEVELS

	1981 LEGAL	1914 U.S.G.S.*	1944-49 U.S.G.S.	1950 JULY	1951 AUGUST	1951 OCTOBER	1952 MAY	1952 MAY M.D.O.C.**	1953 APRIL M.D.O.C.	1957 MARCH	1969 U.S.G.S.	1970 MAY	1975 SEPTEMBER	1981 JANUARY
LONG LAKE	887.00	888	887			891.80	891.56		886.76	887	888.25			888.49
CLEAR LAKE	874.75	875		876.78	877.39	877.68	875.90		875.28	873.85	874		874.62	874.95
COREY LAKE	874.00	875		876.78					874.81	874.58	873		874.21	874.58
HARWOOD LAKE	877.00			878.83					878.80	878.70				878.90
KAISER LAKE	874.50	875		876.78					873.95	867.46			872.70	873.21
MUD LAKE		872		876.78	876.66				874.04	870.30	875		872.79	872.80

* UNITED STATES GEOLOGICAL SURVEY

** MICHIGAN DEPARTMENT OF CONSERVATION

Lake levels fluctuate on a natural cycle associated with rainfall. The records indicate that the lake level did not significantly until the late 1960's and early 1970's. An attempt was made at that time to lower the lake level, but no action was taken, the lake is rising again at this time.

High water levels present two basic problems. The first and most significant relates to septic tanks around the lake. Sewage treatment around the lake is most predominately by septic tank. Many of these systems were built during low water periods and as systems to serve cottages. As the water rises the septic tanks and tile fields become inundated and raw sewage can flow almost directly to the lake. If this occurs to a great number of systems a serious health problem can develop and the nutrients in the sewage overload what the lake can handle with the water quality being lowered and the lake begins to die.

III. ALTERNATIVES

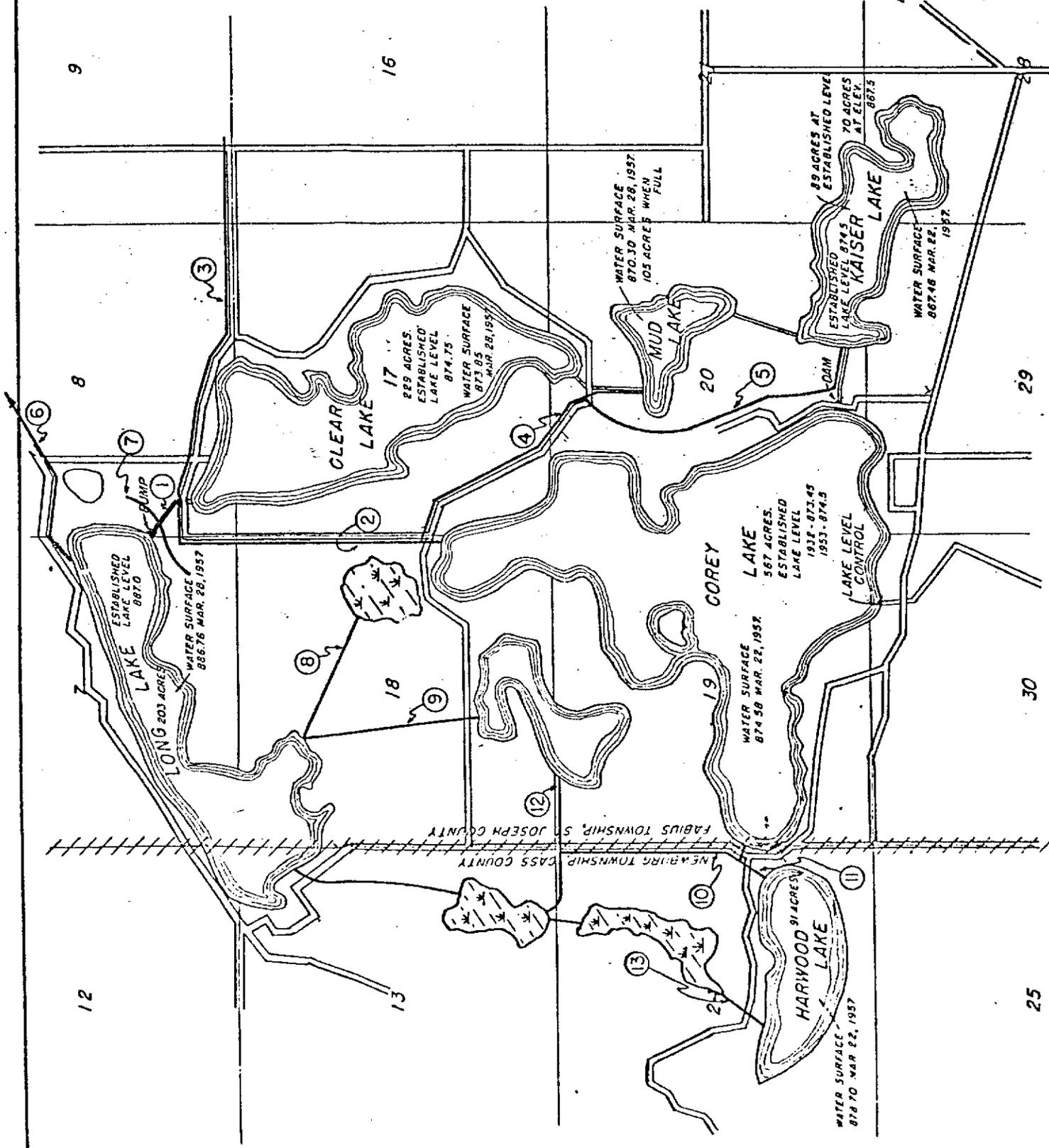
Thirteen alternatives were developed as possible methods of lowering Long Lake. Once the alternatives were developed they were evaluated based upon construction cost, operating cost, land and easement costs, design and study costs, potential environmental impact, and social acceptance. The alternatives considered are shown on Figure 2 and as follows:

1. Pump to Clear Lake similar to the set-up used in the early 1950's.
2. Pump to Corey Lake using the same initial route as in 1, but then following the road right-of-way to Corey Lake.
3. Pump to Pleasant Lake using the same initial route as in 1, but then proceeding east over to Reed Road and along Reed Road to Pleasant Lake.
4. Pump to Mud Lake - This involves continuing piping from #2 to Corey Lake along Coon Hollow Road to Mud Lake.
5. Pump to Kaiser Lake - Continue piping from #4 along Schaefer Brothers Road to Kaiser Lake.
6. Pump to Lake Four - Establish a pumping station on the northern side of Long Lake and pump along Lucas Road to Hoffman Road, east along Hoffman and then north to Lake Four.



FIGURE 2

KAISER LAKE AND NEARBY LAKES, FABIUS TOWNSHIP, ST. JOSEPH COUNTY, MICHIGAN.



7. Pump onto the high ground above Clear Lake and discharge onto the ground through gated pipe at a rate low enough to allow the water to soak into the ground and not run over the ground causing erosion.
8. Pump to the swamp north of Corey Lake - This could be done from the same location pumping station used with #1 or a pumping station on the southwest part of the lake.
9. Pump to Spatterdock Lake with a pumping station on the southwest part of Long Lake.
10. Gravity flow to Corey Lake in an enclosed drain through low areas west of County Line Road to the swamp north of Bald Hill Road and then along County Line Road to the west end of Corey Lake.
11. Gravity flow to Harwood Lake - Same route as #10 except build the outfall to the east end of Harwood Lake.
12. Gravity flow to Spatterdock Lake - Same initial route as #10 and #11 but then east to Spatterdock Lake.
13. Gravity flow to the swamp north of Harwood Lake - Same initial route as other three gravity alternatives, but then into the swamp south of Bald Hill Road and finally an overflow pipe into Harwood Lake.

IV. EVALUATION

Each alternative was evaluated for cost, potential environmental impact and social acceptance. From a cost standpoint, design costs, land and construction costs were all considered as initial construction costs. For comparison purposes construction costs are also shown as yearly costs for bond repayment assuming the construction will be financed over a 30 year bond issue at 10% interest. Yearly operating costs for power and labor were then added to yearly construction costs to determine total yearly costs. For simplicity it is assumed that power for pumping and labor costs remain constant over time which of course will not be true. Finally, an average yearly per benefit cost is determined by dividing the total annual cost by the number of benefitted around the Lake. I have assumed that there are 225 parcels until a final determination is made. For alternatives which require pumping, the yearly operation and maintenance (O&M) costs are estimated at \$2,000, \$1,000 for power and \$1,000 for labor. Gravity alternatives have no yearly O&M costs and O&M costs for option Number 7 are estimated at \$3,000.

Transparency of the lake

TABLE 2

Secchi Disc (ft)

	Long Lake			Clear Lake			Corey Lake			Pleasant Lake		
	<u>1974</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>
early	3.9	13.0	9.0	11.0	10.0	7	9.0	10.0	8.5	17.0	11.5	11.0
<u>July</u>	7.0	12.0	12.0	13.0	11.0	8		9.5	11.5	10.0	12.0	8.0
late	5.0	12.0	11.0	10.0	13.0	10	12.0	8.0	11.5	9.0	14.0	8.0
early	5.5	11.0	10.0	10.0	13.0	12.5	11.0	10.0	9.5	16.0	18.0	8.0
<u>Aug.</u>	3.0	11.0	11.0	6.5	11.5	11.0	11.0	11.5	9.0	16.0	16.0	6.0
late	4.0	12.0	13.0	11.5	12.0	9.5	10.0	9.5	9.0	16.5	16.0	6.0
early	3.5	13.0	13.0	12.0	12.0	8.5	11.0	16.0	9.0	14.0	16.0	7.0
<u>Sept.</u>	2.5	13.5	13.0	13.0	12.5	8.0	11.5	9.5	8.0	14.0	15.5	7.0
late	4.0	13.0	12.0	13.0	12.0	10.0	11.0	14.0	8.0	13.0	15.0	7.0
early	6.0	11.0	13.0	12.0	13.0	9.5	11.0	14.0	9.0	13.0	14.0	6.0
<u>Oct.</u>	3.0	12.0	12.0	11.0	10.0	13.0	11.0	14.0	9.0	13.0	14.0	6.0
late	3.0	11.5	11.5	11.0	10.0	12.0	11.0	9.5	8.5	12.5	13.0	6.0
early	5.0	13.0	12.0	13.0	12.0	13.0	11.0	9.5	9.5	12.5	13.0	6.0
<u>Oct.</u>	6.0	11.0	13.0	12.0	10.0	13.0	11.0	11.0	12.0	12.0	12.0	6.0
late	9.0	13.0	12.0	11.0	10.0	13.0	11.0	11.0	12.0	12.0	12.0	6.0

Chlorophyll a (µg/l)

Transparency of end of July -

early	25.8	1.1	2.2	3.02	4.02	0.87	1.1	4.2	2.8
<u>July</u>	11.16	3.4	2.2	2.56	4.02	0.71	1.1	2.4	2.0
late	19.5	3.7	0.65	3.25	1.65	2.0	1.1	2.6	2.5
early	18.13	4.3	1.6	3.72	1.95	2.0	1.6	2.6	2.5
<u>Aug.</u>	75.32	2.2	1.6	3.25	1.71	1.2	1.2	2.6	2.6
late	53.0	4.6	0.48	4.42	1.71	2.3	2.3	3.3	2.3
early	72.06	2.5	3.1	3.95	1.89	1.6	1.6	3.9	2.3
<u>Sept.</u>	97.64	3.6	3.1	3.25	2.24	2.83	2.83	3.9	2.3
late	61.37	4.1	3.1	4.65	2.24	2.83	2.83	3.9	2.3
early	26.50	4.1	3.1	5.11	2.36	2.83	2.83	3.9	2.3
<u>Oct.</u>	91.13	4.1	3.1	3.95	2.36	2.83	2.83	3.9	2.3
late	100.4	4.1	3.1	3.95	2.36	2.83	2.83	3.9	2.3
early	97.6	4.1	3.1	3.95	2.36	2.83	2.83	3.9	2.3
<u>Oct.</u>	74.4	4.1	3.1	3.95	2.36	2.83	2.83	3.9	2.3
late	23.7	4.1	3.1	3.95	2.36	2.83	2.83	3.9	2.3

2. Pump to Corey Lake:

Initial Construction Cost	\$189,000
Yearly Construction Cost	\$ 20,000
Yearly O&M	\$ 2,000
Total Yearly Cost	\$ 22,000
Average Cost/Parcel/Year	\$ 98

This solution is environmentally the same as pumping to Clear Lake and would not be highly accepted.

3. Pump to Pleasant Lake:

Initial Construction Cost	\$219,000
Yearly Construction Cost	\$ 23,200
Yearly O&M	\$ 2,000
Total Yearly Cost	\$ 25,200
Average Cost/Parcel/Year	\$ 112

This solution is environmentally similar to pumping to Clear or Corey Lake, however it appears that Pleasant Lake is not in the same sub basin of the St. Joseph River as the other lakes. This is not necessarily a negative an impact but it should be considered. It is not likely that pumping to Pleasant Lake would be any more acceptable than pumping to Clear or Corey.

6. Pump to Lake Four

Initial Construction Cost	\$209,000
Yearly Construction Cost	\$ 22,200
Yearly O&M	\$ 2,000
Total Yearly Cost	\$ 24,200
Average Cost/Parcel/Year	\$ 108

No information is available on Lake Four, however the overall size of the Twin Lake system suggests shallow water with possible substantial submergent and emergent vegetation. Impact to these lakes is likely to be minimal. Lake Four has no inlet or outlet and is scarcely populated. This may be an acceptable solution.

7. Pump to High Ground Above Clear Lake:

Initial Construction Cost	\$135,000
Yearly Construction Cost	\$ 14,300
Yearly O&M	\$ 3,000
Total Yearly Cost	\$ 17,300
Average Cost/Parcel/Year	\$ 77

This alternative is likely to cause erosion of the steep banks on the north side of Clear Lake and possibly silt deposition in the northern bay of Clear Lake if the pumping and discharge is not very carefully controlled. This alternative is unacceptable because of potential negative impacts if not properly supervised.

8. Pump to the Swamp North of Corey Lake:

Initial Construction Cost	\$155,000
Yearly Construction Cost	\$ 16,400
Yearly O&M	\$ 2,000
Total Yearly Cost	\$ 18,400
Average Cost/Parcel/Year	\$ 82

This alternative is feasible from an environmental standpoint. The marsh area north of Corey Lake is large. A properly placed discharge would allow an extensive area for nutrient uptake by plants before discharge waters reached Corey Lake.

This solution may still not be acceptable to the Corey Lake landowners because of the close relationship of the swamp and lake.

* 9. Pump to Spatterdock Lake:

Initial Construction Cost	170,000
Yearly Construction Cost	\$120,000
Yearly O&M	\$ 18,000
Total Yearly Cost	\$ 2,000
Average Cost/Parcel/Year	\$ 20,000
	\$ 89

No water quality data is available for this lake. Given its small size and extensive emergent vegetation, Spatterdock Lake would seem a promising site for Long Lake water discharge.

Because Spatterdock Lake is not directly connected to Corey Lake and has no residents this may be an acceptable solution.

10. Gravity Flow to Corey Lake:

Initial Construction Cost	\$182,000
Yearly Construction Cost	\$ 19,300
Yearly O&M	-0-
Total Yearly Cost	\$ 19,300
Average Cost/Parcel/Year	\$ 86

This alternative is likely to cause some adverse environmental impact to Corey Lake, especially at the inlet point. Greatest impact is likely during initial draw down of Long Lake. Lesser impacts are likely during subsequent years when lower flow is expected.

Although the lack of O&M makes this an attractive solution, the potential impact on Corey Lake makes it undesirable.

* * * 13. Gravity Flow to the Swamp North of Harwood Lake:

Initial Construction Cost	\$190,000
Yearly Construction Cost	\$ 20,300
Yearly O&M	-0-
Total Yearly Cost	\$ 20,300
Average Cost/Parcel/Year	\$ 90

This alternative is likely to have minimal adverse environmental impacts. These areas are large and swampy with extensive submerged, emergent and floating vegetation. Greatest impact could be felt in the initial stage of the project with lesser impacts in subsequent years.

Extensive nutrient uptake would occur before discharge to Harwood Lake. Lake level changes in Harwood and Corey Lakes would not be noticeable. Water quality changes should also not be noticeable. This should be an acceptable solution.

V. CONCLUSIONS AND RECOMMENDATIONS

Long Lake is presently 1.5 feet above its legal lake level of 887.0 feet (USGS). The Regional Water Quality Report listed Long Lake as a moderately shallow, naturally eutrophic lake with moderate to good water quality for this type of lake. Available test data indicates that the water quality in Long Lake may be less than some of the other surrounding lakes. The only definitive statement that can be made about the water quality is that it is unknown. Because of this, potential negative environmental impacts must be considered when transferring water from Long Lake to another lake.

Review of the costs of each proposed alternative indicates pumping to Clear Lake is the least expensive and pumping to Pleasant Lake is the most expensive. Acceptable environmental solutions include pumping to Lake Four, pumping to the swamp north of Corey Lake, pumping to Spatterdock Lake and gravity flow to the swamp north of Harwood Lake. The two solutions which appear most acceptable are pumping to Spatterdock Lake and gravity flow to the swamp north of Harwood Lake.

It is our recommendation that gravity flow to the swamp north of Harwood Lake is the best solution. The alternative should provide acceptable renovation of the Long Lake water if it is of poor quality, not increase the levels of other lakes, not require power or labor to operate and should be acceptable to a great majority of people in the area. The cost is only \$25 per year more expensive than the least expensive solution.

Conversation with the drain referee in the State Department of Agriculture has confirmed that the proposed solution would be considered a new drain, not a relocated drain and that all appropriate procedures for a new inter-county drain would have to be followed to establish this as a drain prior to construction. The drainage district would not change substantially, if at all, from the existing district for the existing drain.

We would also recommend that all lakes in the area participate in DNR's self-help program for lakes. DNR has indicated that they are likely to sample all lakes in the area at some point this summer. This will provide some more meaningful data on the lakes for comparison. But it will still only be one sample and of limited value. It would be helpful if the Lake Associations in the area established committees to monitor water quality of their own lakes and meet once or twice a year to coordinate sampling times and exchange data. We would be glad to sit down with the Lake Associations and discuss sampling techniques and locations in coordination with DNR.

We would further recommend that the final design of the selected solution include an environmental assessment of that proposed solution and an environmental assessment and detailed costs of the next most acceptable solution.

CLEAR, COREY, LONG AND PLEASANT LAKES
ST. JOSEPH COUNTY, MICHIGAN

CLEAR LAKE

Clear Lake is a moderately shallow, naturally eutrophic lake which has been residentially developed. This lake has two basins and a large area of shallow water with extensive submerged macrophyte growth.

The two sets of Landsat data indicate that Clear Lake is a marginal problem lake with periodic algal blooms. The 1973 data show dominant blue-green algae throughout most of the lake with a particularly heavy concentration in the eastern basin. The 1976 data show little blue-green algal concentration, but do indicate heavy macrophyte growth and discoloration in much of the eastern basin, the nature of which is unknown. It is possible that this is a green algal signature that emulated a macrophyte coloration. There was substantial clear water in the two deep basins in 1976 although much of that shows a discoloration.

In summary, Clear Lake appears to be culturally eutrophic but not yet extremely so. Wastewater management should be undertaken in this lake to prevent further water quality degradation. Further residential development without wastewater treatment should be discouraged.

Since this is a naturally eutrophic lake, wastewater management can be expected to slow further degradation of water quality, but management will not eliminate problems with macrophytes and the removal of these rooted plants without reduction in nutrient loading should be done with caution. This lake does not rank

among the most severe problem areas of the Region, but management efforts should be aided and encouraged, especially in view of the active interest of the people here. Actions to reduce surface sources of nutrient loading in this lake should be encouraged.

COREY LAKE

Corey Lake is a natural deep, cold water lake considered to be among the most productive trout lakes in the Region. Based on the available data it probably is classified as mesotrophic, but large segments are eutrophic and perhaps the entire lake falls in this category now. The lake is residentially developed and appears to be suffering cultural eutrophication, at least in some segments.

Harwood Lake from which Corey Lake gains water shows a strong algal dominance in both sets of Lambert data. It appears that this is a source of substantial nutrient loading and should be examined in more detail. The 1973 data show algal dominance throughout most of the residentially developed portions of the lake. Even in very shallow water where substantial macrophyte growth is indicated by the "Lake Inventory Map", such as the extreme north portions, the dominant feature is blue-green algae. Only in the west-central and central portions of the lake is the water quality good. Even in these areas there is evidence of some organic discoloration, the nature of which is unknown.

The 1976 data show more extensive macrophyte growth in most shallow water areas as was expected due to the later date (July vs. June). These data show improvement in water quality in the extreme southwest basin probably due to reduced flow from Harwood Lake and increased macrophyte growth in this basin. The extreme

north of Corey Lake also shows increased macrophyte growth, but no associated improvement in water clarity. The strong dominant algal signal persists here as it does along the shoreline of most of the residentially developed parts. Most of the remainder of Corey Lake is dominated by a signal which in shallow water appears to be a filliform aquatic macrophyte class (narrow leaf rooted plants). This is clearly not the case in the deep portions and therefore is not completely understood. Spectrographically this signal is most like a green algae and indeed may be, but we cannot be certain. Disregarding the nature of this feature it is clear that it is organic and that Corey Lake has little surface area of high water quality.

Based on these data Corey Lake is a marginal problem with specific areas requiring detailed evaluation and management. These are: 1) the southwest basin and Harwood Lake inlet; 2) the west-central and south shores; and 3) the north basin, particularly the east shore.

This is a lake with active public interest and while it is not among the most severe problem areas now, there is much to suggest that it soon may be. Every effort should be made to manage the nutrient loading in this lake to recover and preserve what is naturally one of the top quality lakes in southern Michigan.

LONG LAKE

Long Lake is moderately shallow, naturally eutrophic lake which is residentially developed. It has extensive areas of macrophyte growth and two distinct basins.

Based on the two sets of Landsat data this lake has moderately good water quality with some evidence of problems in the

east basin on the south side. Since this is the area of steepest slope, it may indicate nutrient discharge in an area of limited macrophyte growth.

The 1973 data shows good water quality in the west basin with some algal concentrations between the two basins. A heavy blue-green algal signal is seen in the eastern basin in the deep water side. In 1976 the water quality appeared somewhat better with more extensive macrophyte growth in all areas of the lake. The water quality of the west basin still appears good, but there is some persistent algal evidence in the east basin.

In summary, the water quality of Long Lake is moderate to good for a developed, naturally eutrophic situation. The presence of extensive macrophyte growth probably is the factor which prevents increased algal problems. In the east basin where steep slope limits macrophyte growth evidence of algal dominance appears. This lake appears to be a marginal problem area at this time, requiring preventative management. Additional development should be carefully considered. The landowners should be encouraged to reduce surface drainage nutrient loading. More detailed analysis of the east basin should be undertaken.

PLEASANT LAKE

Pleasant Lake is a naturally eutrophic lake of moderate depth which is residentially developed and suffers from cultural eutrophication. There are two distinct basins in this lake with large areas of shallow water between the basins and along the extreme north and east portions of the lake.

Both sets of Landsat data indicate strong algal dominance throughout the entire east basin. This feature includes both deep and shallow water. Domination is so complete that it is

difficult to tell whether submerged macrophytes grow here or not. There is evidence of submerged aquatics in the shallow water between the basins with limited effect on water clarity. The west basin is dominated by blue-green algae in the 1973 data and appears much like the deep portion of Corey Lake in 1976.

Pleasant Lake appears to have the poorest water quality of this group of lakes and should be considered a problem area. The data indicate that water quality is somewhat poorer in the east basin, but the signal is so extensive that no clear indication of possible sources is apparent.

The strong algal dominance indicates a cultural eutrophication problem and further residential development on this lake should be done with caution. More detailed evaluation of the problem sources appears necessary and wastewater management and nutrient loading control should be initiated.

TABLE 1

LANDSAT SATELLITE IMAGERY

KEY TO SYMBOLS

1973 <u>Symbols</u>	1976 <u>Symbols</u>	<u>Class</u>	<u>Key</u>
M	I	Water-9	Clear Water
Absent*	H	Water-8	Diatoms, Desmids, Discoloration
X + O**	G	Water-7	Submerged Narrow-leafed Aquatics (unknown**) ^{plus}
T	F	Water-6	Blue-Green Algae
L	E	Water-5	Zooplankton
I	D	Water-4	Blue-Green Algae
Absent	C	Water-3	Broad-leafed Submerged Aquatics & Detritus
/	B	Water-2	Green Algae
=	A	Water-1	Loam Silt
.	-	Wetlands-3	Broad-leafed Emergent - Water Lilies
Absent	=	Wetlands-2	Narrow-leafed Emergent - Grasses
-	/	Wetlands-1	Swampland - Trees and Brush
=	M	Marl	Marl
	*	Clouds	Clouds

* The organization by water class is based on the 1976 data, therefore, where a corresponding class does not appear in 1973 the word absent appears.

**Two separable spectral classes are included in water class 7 because of our inability to precisely distinguish among the dominant features indicated in the two classes. One of them corresponds to water class 3; elements of water class 8 also appear, in the form of tannin discoloration.

PLEASANT LAKE

ASCII art for Pleasant Lake, top left section.

LMM
LMCCC
-XTT/

ASCII art for Long Lake, bottom left section.

LONG LAKE

CLEAR LAKE

ASCII art for Clear Lake, middle section.

JUNE 9, 1973

M - Clear Water

COREY LAKE

Large ASCII art for Corey Lake, bottom right section.

Survey Drawings



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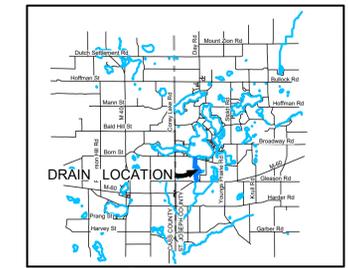
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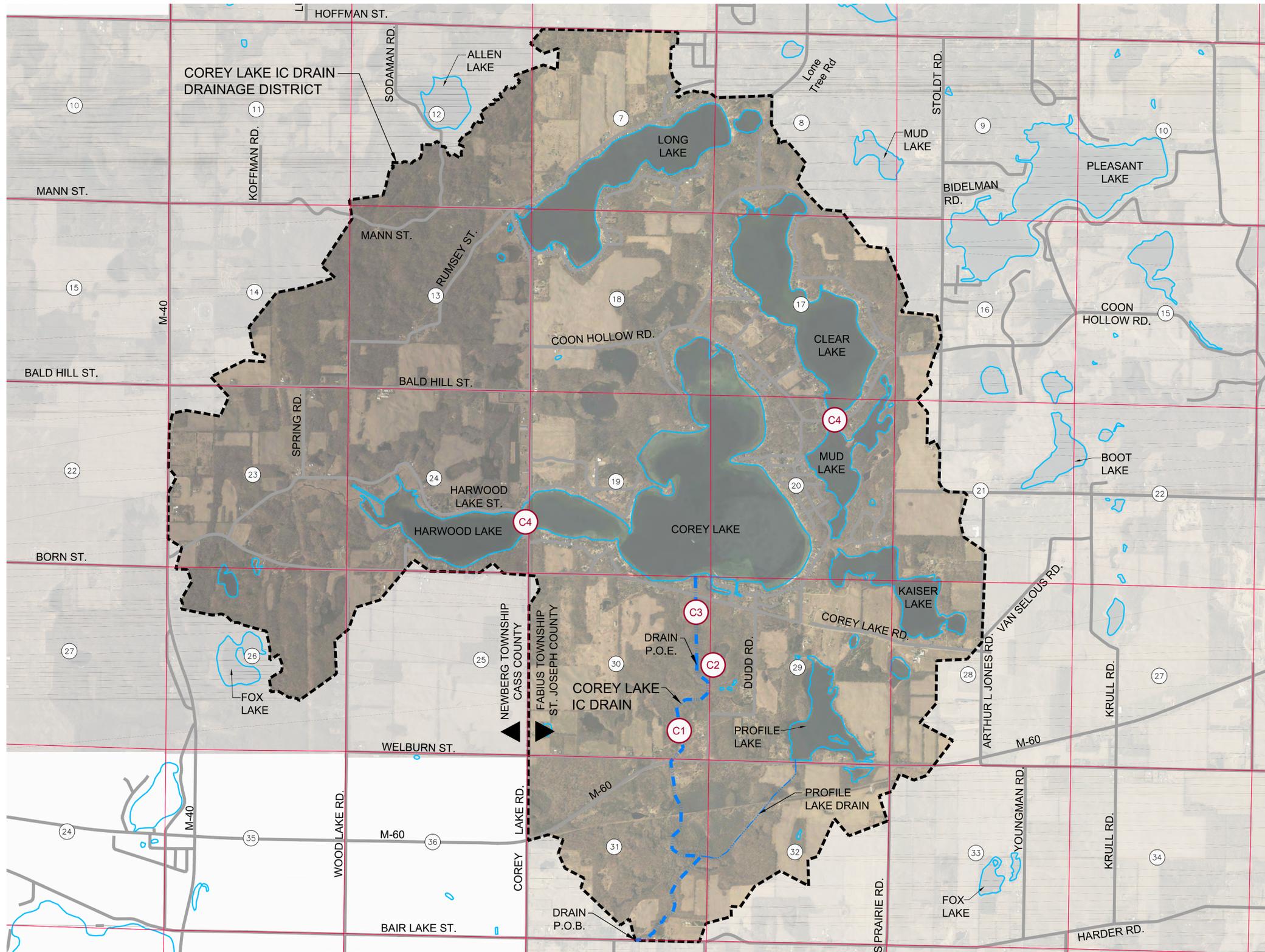
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T6S R13W
NEWBERG TOWNSHIP, CASS COUNTY

SECTIONS 7-8, 16-21 & 28-33
T6S R12W
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- MUD LAKE
 - C4 - PLAN & PROFILE**
(STA. 0+00 - 3+50) COREY LAKE
- KAISER LAKE

DISTRICT INFORMATION:

DRAIN DISTRICT AREA:	
CASS COUNTY:	2,590.9 ACRES (30%)
ST. JOSEPH COUNTY:	5,973.0 ACRES (70%)
TOTALS	8,563.9 ACRES

LEGEND

- ENCLOSED CHANNEL DRAIN
- OPEN CHANNEL DRAIN
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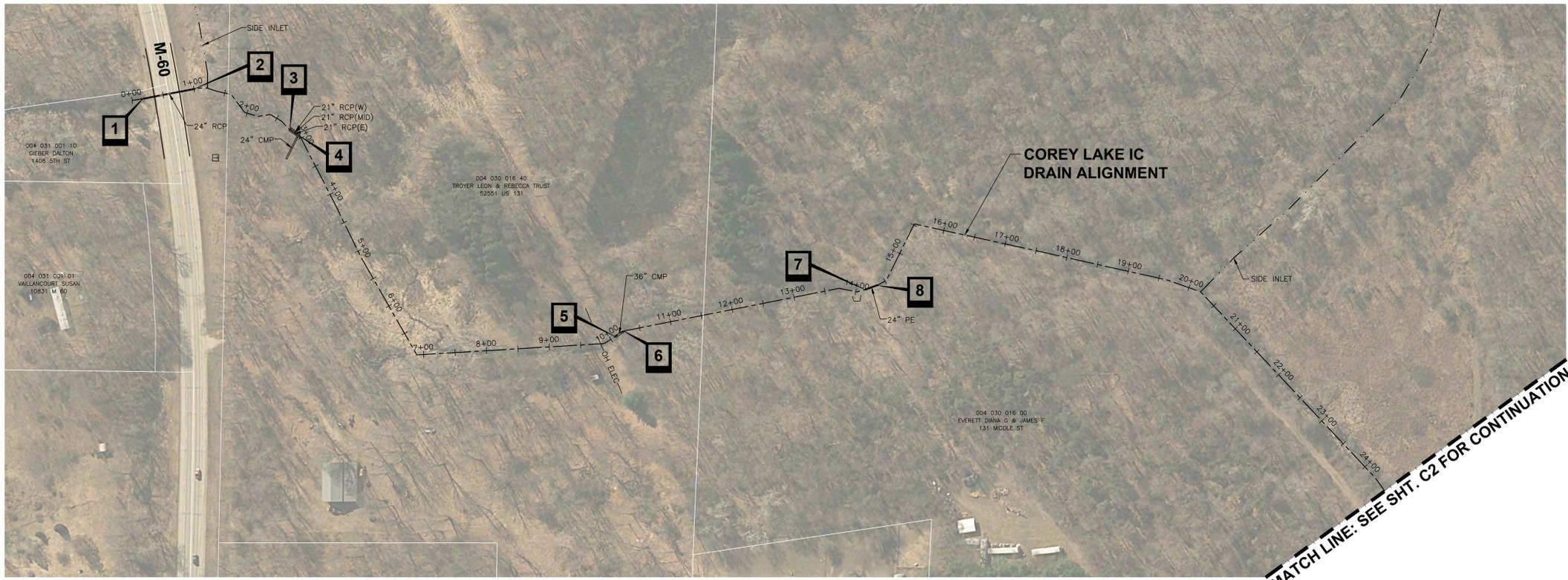
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COREY LAKE INTERCOUNTY DRAIN
CASS AND ST. JOSEPH COUNTIES, MICHIGAN

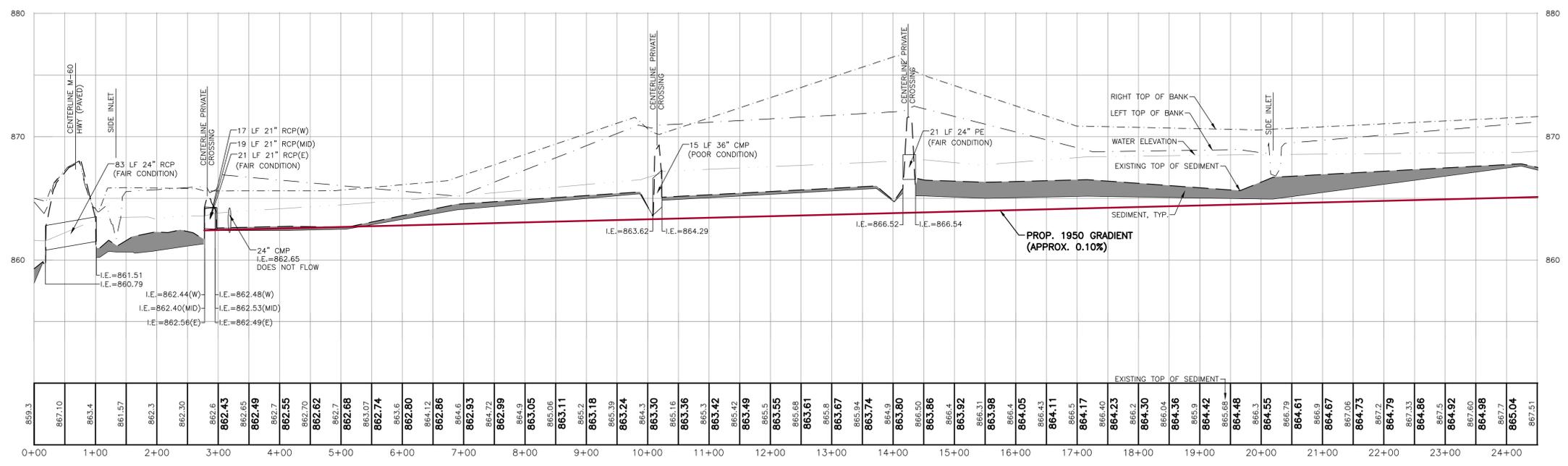
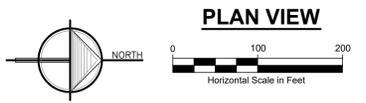
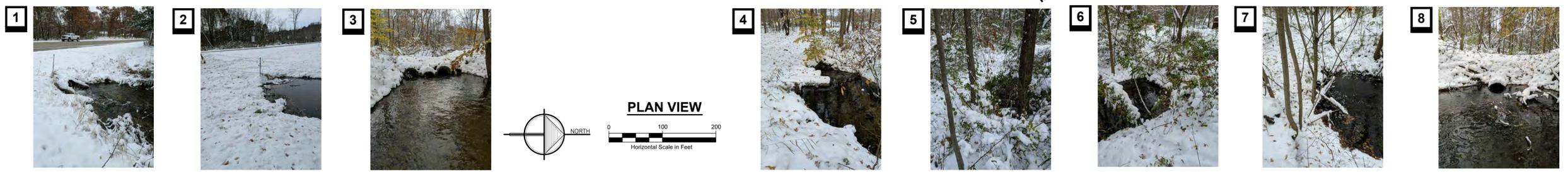
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DESIGNED BY: DJF	11/2019
DRAFTED BY: RAG	11/2019
CAOCC-DJF	11/2019

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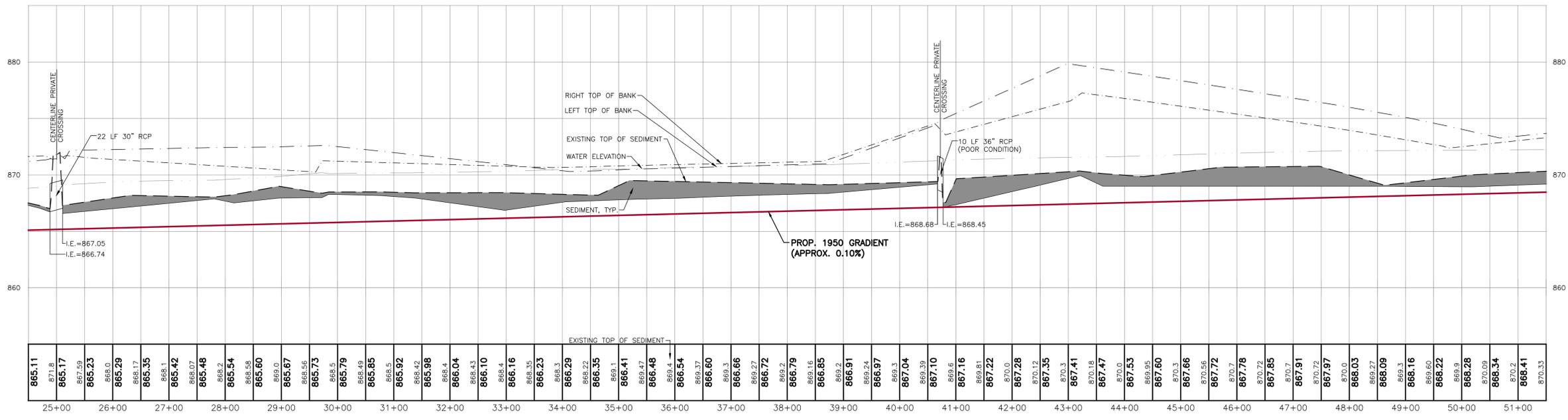
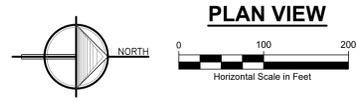
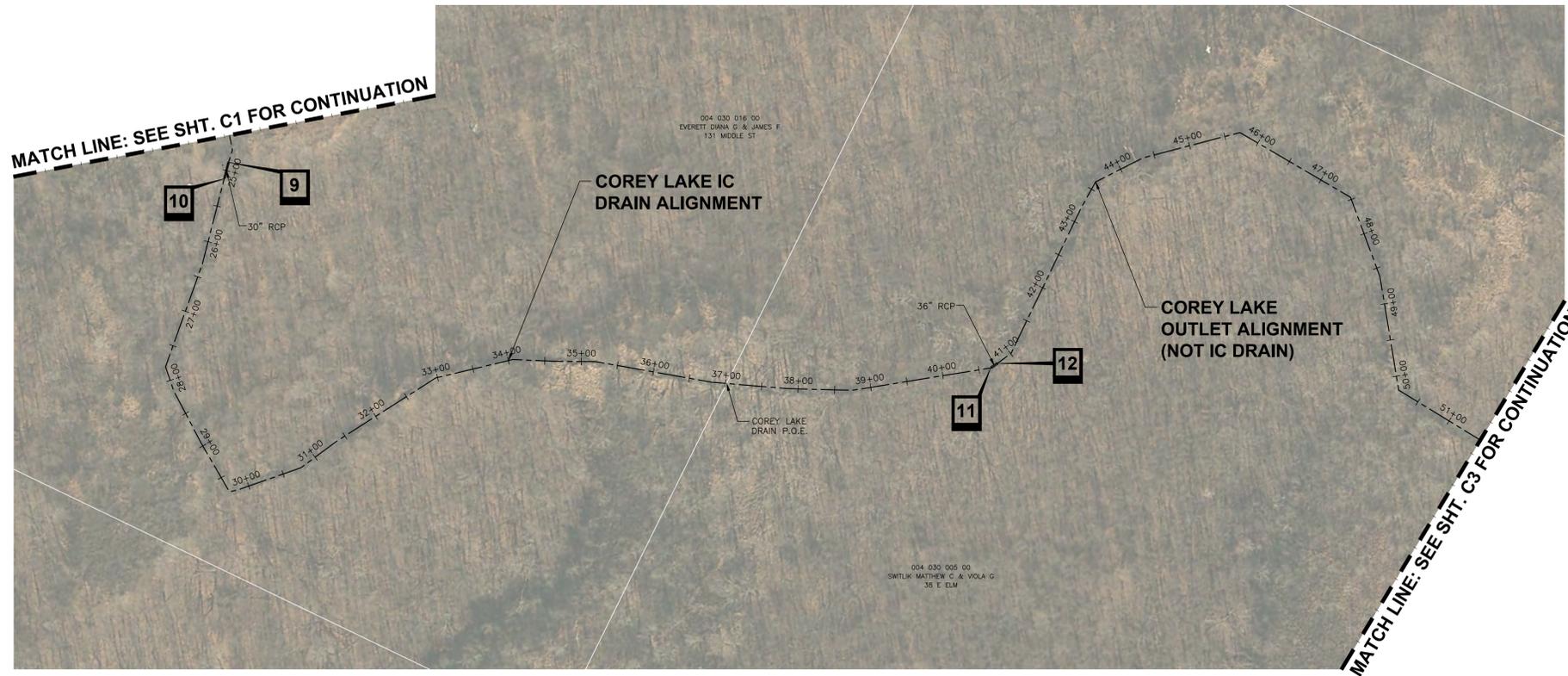
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	11/2019	DRAFTED BY: DJF	11/2019
		CHECKED BY: RAG	11/2019
		CADC/DJF	11/2019

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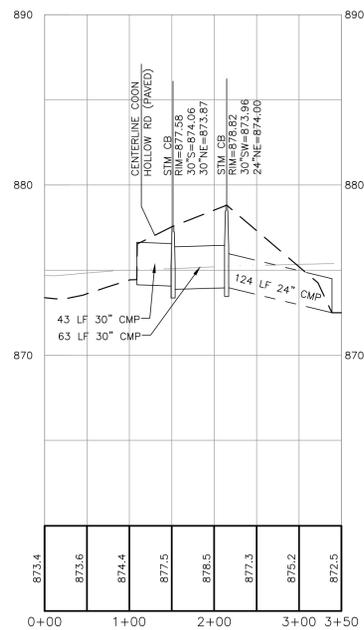
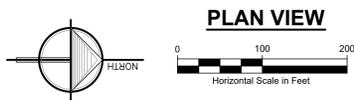
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CASS AND ST. JOSEPH COUNTIES, MICHIGAN

PROJECT NUMBER:	19-078
SURVEYED BY:	CPV-ADK
DESIGNED BY:	DJF
DRAFTED BY:	RAG
CAD/CHECK:	DJF

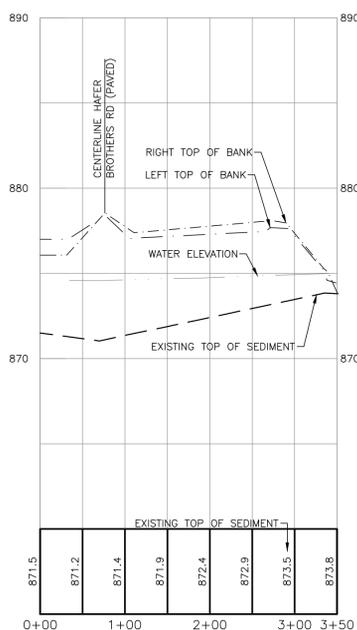
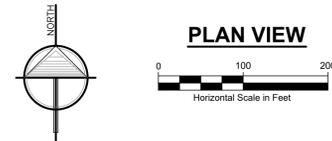
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CACD-DJF	11/2019

SHEET NAME:
PLAN & PROFILE
 STA: 51+50 - 68+00

SHEET NUMBER:
C4

11/27/2019 10:58 AM C:\Users\jag\OneDrive\Documents\Projects\19-078\19-078.dwg - User: jag, Plot Date: 11/27/2019