Duncan Lake Intercounty Drain

Engineering Report

Prepared for:

Duncan Lake Intercounty Drain Drainage Board

September 22, 2022

FINAL

LRE ENGINEERS & SURVEYORS

2121 3 Mile Rd. NW
Walker, MI 49544
Ph: 616-301-7888
www.LREMI.com

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INTRODUCTION

Purpose of Study

Petitions from freeholders of land, Thornapple Township, and the Barry County Board of Road Commissioners (BCBRC) were received by the Duncan Lake Intercounty Drain Drainage Board (Board) in 2021. A Hearing of Practicability was held on December 7, 2021 at which time the petition for maintenance / improvements to the Drain was determined practicable by the Board. The petition from the BCBRC was primarily in response to chronic flooding / roadway overtopping of 108th Street. Landowners voiced concerns over flashy hydrology that spike water levels in Duncan Lake during rainfall events and cause flooding of adjacent properties. In addition, several residents expressed concern over water quality within the lake, in part due to poor land management practices within the District.

Land & Resource Engineering (LRE) was retained by the Board on January 6, 2022 to conduct an engineering study in preparation for the Hearing of Necessity. The purpose of our study is to investigate flooding issues, identify impairments / deficiencies in the current drainage system and evaluate feasible alternatives to better regulate water levels within Duncan Lake. The findings and recommendations of our engineering study are presented in this report.

Watershed Description

The Duncan Lake Intercounty Drain Drainage District (District) encompasses 11,539.4 acres within Gaines and Caledonia Townships in Kent County, Leighton Township in Allegan County, and Thornapple Township in Barry as shown on the **Cover Sheet** of the **Survey Drawings**. The District was updated in 2020 and the breakdown of drainage area by county is as follows:

- Allegan County: 2,485.7 Acres (21.54%)
- Barry County: 4,240.1 Acres (36.75%)
- Kent County: 4,813.6 Acres (41.71%)


Typical Land Use

The watershed includes two lakes in-line with the Duncan Lake Intercounty Drain (Drain). Hanna Lake is located in Section 26 of Gaines Township, Kent County and encompasses more than 14 acres. Duncan Lake is located in Sections 5, 6 and 7 of Thornapple Township, Barry County and encompasses roughly 130 acres. More than 90% of the total drainage area, primarily from Kent and

Allegan Counties, discharges into Duncan Lake. Combined, these two lakes make up only 1.25% of the total watershed.

Land use within the watershed has not changed significantly in the past 25-years and consists primarily of agriculture and larger homesteads. Denser residential developments are located around Duncan Lake and Hanna Lake. Soils within the District are primarily composed of "somewhat well-draining" sandy loams with "B" and "C" hydrologic soil group classifications.

Route and Course

The Drain is approximately 6.6 miles long (including the portion that flows through Duncan Lake). The upstream terminus of the Drain is located along the southeast corner of Hanna Lake near the center of Section 26, Gaines Township, Kent County. The Drain flows approximately 4 miles southeasterly through Kent County before discharging into Duncan Lake near the border with Barry County. The Drain continues from the outlet on the east side of Duncan Lake southeasterly through Barry County to the legally established downstream terminus at Cherry Valley Road. The watercourse continues southeasterly until it meets the Thornapple River, just east of M-37.

The Duncan Lake Intercounty Drain was established in 1897. The most recent petition project along the Drain was completed in 1996. The intent of the project was to improve conveyance downstream of Duncan Lake, thereby, reducing peak water levels and the extent of flooding around the lake. The project consisted of open channel excavation from Duncan Lake to Cherry Valley Road as well as replacement of the culvert at Duncan Lake Road.

Drain Downstream Duncan Lake

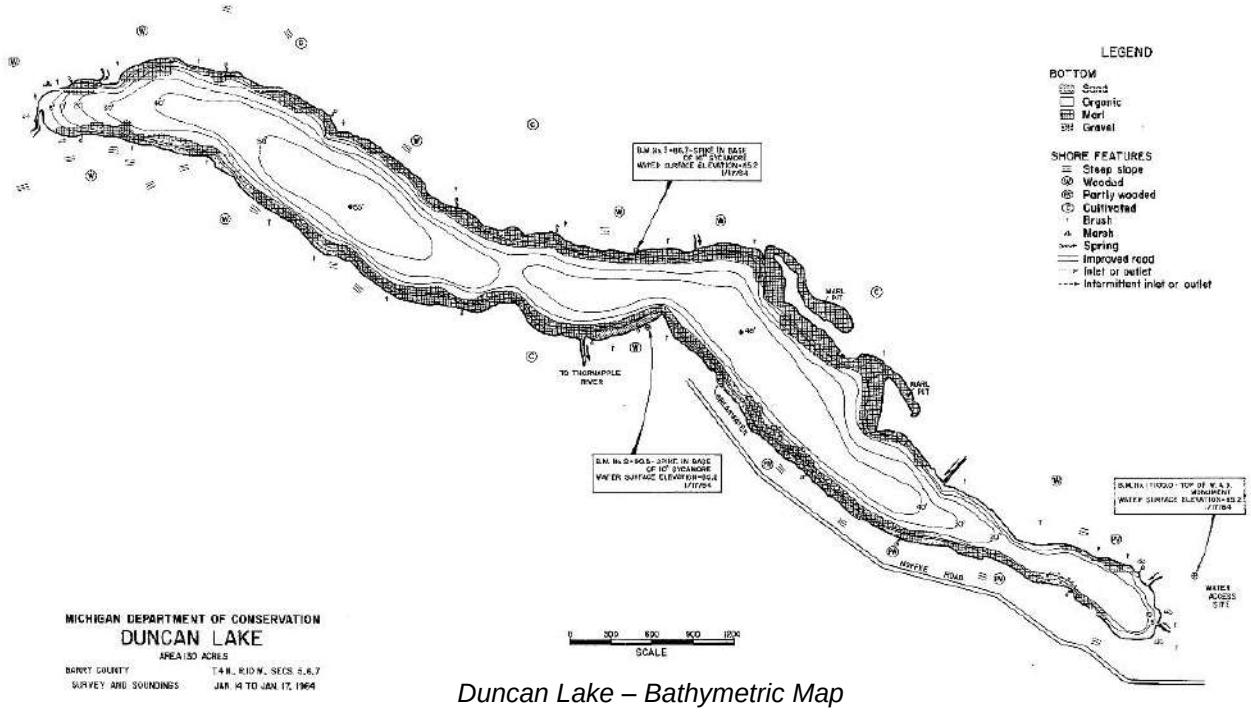
The 1995 construction drawings specificed a 12-ft bottom width (downstream of Duncan Lake) with 2:1 (H:V) side slopes. The width required for construction as documented in the 1917 pettion proceedings is 100-ft. The history of proceedings (including establishment and petiton projects) is summarized in the legal opinion by Clark Hill provided in **Appendix 1**.

Duncan Lake


Duncan Lake

Duncan Lake encompasses roughly 130 acres within Sections 5-7 of Thornapple Township, Barry County. The maximum water depth as indicated by the historic Michigan Department of Conservation (Natural Resources) map is approximately 55-feet.

The lake does not have an established legal lake level. The minimum water surface elevation is essentially governed by the Drain outlet channel and corrugated steel pipe arch culvert under Noffke Drive (invert elevation of 763.52-ft NAVD 88). The contributing watershed is more than 80 times the surface area of Duncan Lake, resulting in extreme water level fluctuations during heavy rainfall events. According to public testimony and confirmed by our hydrologic and hydraulic analysis, water levels in Duncan Lake can rise between 5 and 10-feet during major storm events. While flooding of homes has not been reported, nuisance flooding of sea walls, yards, docks and boat house structures and sheds near the water have been reported.



Duncan Lake – Bathymetric Map

FIELD RECONNAISSANCE

LRE conducted a field reconnaissance, including topographic survey, of the Drain during the winter/spring 2022. **Survey Drawings** with photographs of the Drain between 108th Street and the downstream terminus (Cherry Valley Road) are enclosed.

Duncan Lake Intercounty Drain

In general, the Drain is highly channelized with a trapezoidal cross section and depths varying from 5 to 10-ft. The channel bottom is as wide as 12-ft in some areas; however, many parts of the upstream reach in Kent County have developed a smaller low flow channel. Cobble and gravel were noted along portions of the substrate indicative of a relatively steep slope. The water course downstream of Cherry Valley Road exhibits the characteristics of a natural stream with meandering pattern, riffle-pool profile, dense riparian corridor and fairly well-connected floodplain.

Low Flow Channel – Upstream Duncan Lake

The Drain is relatively flat from 108th Street to Duncan Lake with approximately 1-foot of sediment buildup in the channel bottom near 108th Street. The downstream invert elevation of the 108th Street 154" x 100" CMP arch culvert (763.8-ft NAVD 88) is essentially the same as the upstream invert elevation of the Noffke Drive 138" x 96" CMP arch culvert (763.52-ft NAVD 88). As a result backwater from Duncan Lake during storm events creates a tailwater effect on the culvert at 108th Street. The low point in the 108th Street is located approximately 300-ft west of the Drain and has an elevation of 770.26-ft NAVD 88.

Drain Downstream Duncan Lake

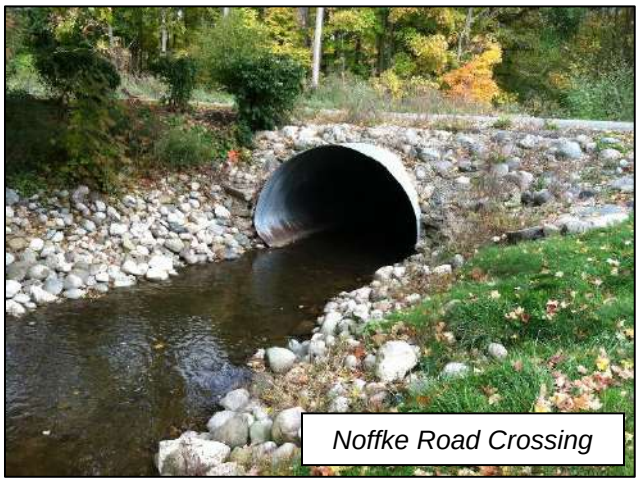
The Noffke Drive culvert essentially acts as the water level control structure for Duncan Lake. The gradient of the Drain between Noffke Drive and Duncan Lake Road is approximately 0.1% and aside from some minor sediment buildup near Duncan Lake Road, the Drain is relatively clean and open.

The gradient of the channel increases to approximately 0.15% downstream of Duncan Lake Road. The riparian corridor becomes more wooded and the channel takes on more natural stream characteristics downstream toward Cherry Valley Road. Several log jams and areas of bank erosion are present between Cherry Valley Road (Sta. 0+00) and Sta. 16+00; however, these are too far downstream to have an impact on water levels in Duncan Lake. A beaver dam was also noted near Sta. 42+00.

A detailed condition inventory of Drain crossings was conducted by ENG in March 2014 (note some culvert diameter sizes do not exactly match LRE measurements). A copy of the "*existing conditions and drain analysis*" as summarized in ENG's Report to the Board dated December 2014 (updated December 2015) is provided in **Appendix 2**.

Duncan Lake

Under normal base-flow conditions, the water surface elevation of Duncan Lake is approximately 764-ft NAVD 88. As previously mentioned, the upstream invert of the Noffke Drive culvert (763.52-ft NAVD 88) effectively serves as the water control structure for the lake.



Noffke Road Crossing

The Michigan Department of Environment Great Lakes and Energy (EGLE) estimates the 100-year floodplain elevation of Duncan Lake to be 770.4-ft NGVD 29. LRE estimates the 100-year peak water surface elevation may be as high as 772.32-ft NAVD 88.

Duncan Lake – East Shoreline

The majority of homes around Duncan Lake are well above the 100-year floodplain. However, there are numerous docks, shore-stations, sheds and landscaping that are located within flood-prone areas. LRE recorded the minimum building opening (MBO) of the most low-lying residences along the east side of the lake (Noffke Drive), which are located above the EGLE 100-year floodplain but below LRE's estimate. Floodplain limits as well as critical survey elevations around Duncan Lake are provided in **Figure 1**.

Preliminary Ecological Assessment

LRE contracted SES to perform a preliminary ecological assessment of Duncan Lake based on available information. SES obtained data and/or reports from the Cooperative Lakes Management Program, PLM Lake and Land Management Corporation, and the Michigan Department of Natural Resources. A summary of available data for Duncan Lake is provided below.

The Cooperative Lakes Management Program, a volunteer-based data program for Michigan lakes, provided a report indicating that Duncan Lake is slightly eutrophic based upon the Trophic Status Index. Eutrophic lakes are nutrient-enriched, highly productive, turbid and typically host an abundance of aquatic vegetation. Because the lake serves as a receiving water for the Duncan Lake Intercounty Drain, this condition would be expected to be exacerbated since the lake collects runoff from the upstream watershed.

Duncan Lake – looking north near outlet

PLM Lake and Land Management Corporation (PLM) conducted water quality monitoring bi-annually (spring and fall) from 2017-2021. The sampling included Secchi disk depth, conductivity, total dissolved solids, pH, alkalinity, total phosphorus and nitrates. Secchi disk readings, which are a measure of water clarity, indicate that the lake is, indeed, quite turbid, with visibility never exceeding five feet during sampling events. Total phosphorus concentrations were excessive during many of the sampling events. Nitrogen concentration was excessive during all sampling events.

E. coli concentration was sampled by PLM on four dates: August 16, 2017; July 15, 2019; July 13, 2020 and; July 9, 2021. Each of the four sampling results indicated that the lake was meeting the Water Quality Standards (WQS) for partial and total body contact recreation on those particular dates and the lake was safe for swimming. Because *E. coli* concentrations can vary widely by season and weather patterns, a more robust sampling design would be required to determine if the lake consistently meets WQS.

PLM also conducted herbicide treatments of the lake for nuisance aquatic vegetation, including filamentous and planktonic algae, curly-leaf pondweed, Eurasian watermilfoil and lily pads. Curly-leaf pondweed and Eurasian watermilfoil are considered to be highly invasive. According to the Midwest Invasive Species Information Network (MISIN), giant reed grass (*Phragmites*), another invasive plant, has also been reported near the lake.

Little information exists to describe the fishery of Duncan Lake. In 1977, Michigan Department of Natural Resources (MDNR) caught bluegill, pumpkinseed, yellow perch, black crappie, largemouth bass, northern pike, bullhead, white sucker, redhorse, common carp, green sunfish, and golden shiner. Ten years later, in 1987, MDNR conducted a one-night electrofishing survey. The catch was dominated by bluegill, largemouth bass and pumpkinseed sunfish, in descending order. Black crappie, yellow perch, northern pike, common carp, suckers and a variety of minnows and shiners were also present in the catch. Common carp are considered to be an invasive species. At that time, the biologist noted that "*The fish collected appeared to be very healthy. All fish except bass were growing at or above state average rates. Bass are slower growing, especially older fish. The lake has a well-balanced fish population and supports a popular fishery. No management is recommended at this time. This lake has a problem with non-point pollution, primarily agricultural and farmlot runoff. It experiences excessive weed and algae growth, and the residents routinely treat for weeds. These problems apparently have not affected the fish population too much to date; however, the fishery should be monitored closely in the future".* DNR suggests that the lake has been known for agricultural runoff (animal waste), numerous fish kills, and a long history of aquatic herbicide treatments.

Duncan Lake – Looking West

HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic and hydraulic analysis was performed to study existing conditions as well as evaluate improvement alternatives. Our analysis focused specifically on the hydraulic capacity (roadway overtopping) at the 108th Street crossing as well as spikes in water levels in Duncan Lake during storm events. Data from our hydrologic and hydraulic analysis are provided in **Appendix 3**.

The Duncan Lake watershed was broken down into 3 sub-catchments for hydrologic analysis purposes. Peak discharges at critical design locations 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 provided by EGLE Hydrologic Studies and Dam Safety Unit. Peak discharges for various locations along the Drain are presented in **Table 1**, it's worth noting that some of the drainage areas estimated by EGLE are slightly higher than those delineated by LRE.

Table 1. Peak Discharges along the Duncan Lake Intercounty Drain

Location	**Drainage Area** (Miles^2)	**Peak Discharge Rate** (cfs)					
		Return Period and 24-Hour Precipitation Depth					
		2-Year	**5-Year**	**10-Year**	**25-Year**	**50-Year**	**100-Year**
		2.55 inches	3.15 inches	3.72 inches	4.59 inches	5.34 inches	6.16 inches
108th Street	7.7	160	260	350	470	600	700
Duncan Lake Outlet	17.1	190	320	430	600	700	850
Cherry Valley Road	18.9	250	390	500	650	750	900

cfs-cubic feet per second

A hydrologic model was developed using HydroCAD computer software to analyze the hydrology of the watershed and its impact on water levels in Duncan Lake for a variety of rainfall durations and frequencies. Peak discharges and hydrographs provided by EGLE were used to calibrate the HydroCAD model. Hydraulic rating curves for both existing and proposed channel conditions, downstream of Duncan Lake, were input into the HydroCAD model. The pond and flood-routing capabilities of the HydroCAD software allowed us to evaluate the effectiveness of various improvement alternatives, including detention/retention and improved downstream conveyance.

A GeoHECRAS© hydraulic model of the Drain was developed from 108th Street to the downstream terminus at Cherry Valley Road using a combination of GIS data and survey data collected by LRE. The hydraulic model was used to analyze the existing hydraulic capacity of the Drain and evaluate the effectiveness of various hydraulic improvements along the Drain in reducing the potential for flooding around Duncan Lake and overtopping of 108th Street.

Existing Conditions

The focus of LRE's hydrologic and hydraulic analysis was to determine the existing hydraulic capacity of 108th Street crossing as well as how Duncan Lake reacts (in terms of water surface elevation) to various storm event intensities and determine whether any of the residences around Duncan Lake may be susceptible to flooding. Below is a brief summary of existing conditions.

108th Street: The Drain crossing at 108th Street consists of a 154" x 100" CMP arch culvert. The upstream invert elevation of 108th Street culvert is 764-ft NAVD 88 and the low point in the 108th Street is located approximately 300-ft west of the Drain and has an elevation of 770.26-ft NAVD 88. The crossing is affected by backwater from Duncan Lake, which creates a tailwater condition. The 108th Street is capable of conveying the 2-year storm; however, higher peak discharges will cause overtopping of the roadway. Another key item to note is that peak water surface elevations in Duncan Lake are higher than the low-point in 108th Street during storm events greater than the 25-year return frequency. The peak water surface elevation at 108th Street and Duncan Lake for the 2, 10 and 100-year, 24-hour storm events are provided below in **Table 2** (elevations above the low-point in 108th Street are highlighted in gray).

Duncan Lake: Under normal base-flow conditions, the water surface elevation of Duncan Lake is approximately 764-ft NAVD 88. The contributing watershed is more than 80 times the surface area of Duncan Lake, resulting in extreme water level fluctuations during heavy rainfall events. Results from our hydrologic and hydraulic analysis indicate that water levels in the lake rise from 2 to 8-ft in response to 24-hour storm events ranging from the 2-year (50%) to 100-year (1% return frequency).

EGLE estimates the 100-year floodplain elevation of Duncan Lake to be 770.4-ft NGVD 29, which is slightly lower than LRE's model results. Based on USGS LiDAR data all the homes around Duncan Lake appear to be above the EGLE 100-year floodplain. However, at least two homes on the east side of the lake have MBOs below the 100-year floodplain elevation calculated by LRE. Floodplain limits as well as critical survey elevations (including low-lying MBOs) around Duncan Lake are provided in **Figure 1**.

Table 2. Peak Water Surface Elevations – Existing Conditions

Location	**Drainage Area** (Miles^2)	**Peak Water Surface Elevation** (feet NAVD 88)		
		Return Period and 24-Hour Precipitation Depth		
		2-Year	**10-Year**	**100-Year**
		2.55 inches	3.72 inches	6.16 inches
108th Street	7.7	768.87	770.89	773.78
Duncan Lake	17.1	766.28	768.49	772.32

Note: gray shading indicates water surface overtops 108th Street

Proposed Conditions

LRE utilized the HydroCAD and GeoHECRAS© models to evaluate potential hydraulic conveyance and detention storage alternatives to alleviate roadway overtopping at 108th Street and reduce peak water surface elevations in Duncan Lake. Below is a brief summary of proposed conditions.

108th Street: The existing 154" x 100" CMP arch culvert at 108th Street is larger than both the Noffke Drive and Duncan Lake Road culverts along the outlet channel, downstream of Duncan Lake. The primary reason for overtopping at 108th Street is due to the low elevation of the roadway versus an inadequacy in hydraulic capacity of the crossing itself.

A 10-year level of flood protection (point at which water would overtop the roadway) can be achieved for 108th Street if the minimum elevation in the roadway is raised from 770.26-ft to 772-ft NAVD 88 and the downstream improvements along the Drain as identified in Alternative 1 (described subsequently) are implemented. Raising the roadway in this instance will increase the upstream energy grade line but not actual water surface elevations in part because the existing low point in the roadway is approximately 2-ft below the crown of the culvert.

It is our understanding that the Barry County Road Commission (BCRC) would like to provide sufficient hydraulic capacity to convey the 100-year peak discharge without overtopping 108th Street or raising upstream water levels. This can only be achieved by increasing the crossing size (either by replacing the crossing entirely with a larger span or adding one or more culverts) in addition to raising the road. For analysis purposes, LRE also analyzed the impact of raising the minimum road elevation to 772.5 ft NAVD 88 and adding an auxiliary 100"x154" CMPA culvert, which would increase the total span of the crossing to greater than 20-ft, thereby, making it eligible for future critical bridge funding. Under this scenario, hydraulic improvements downstream of Duncan Lake would also be required (to reduce the backwater impact of Duncan Lake) in order to provide a 100-year level of flood protection at 108th Street. A summary of the existing versus proposed conveyance capacity at 108th Street both with downstream improvements along the Drain as identified in Alternative 1 are provided in **Table 3.**

Table 3. Peak Water Surface Elevations at 108th Street – Existing vs. Proposed

108th Street Crossing	**Drainage Area** (Miles^2)	**Peak Water Surface Elevation** (feet NAVD 88)		
		Return Period and 24-Hour Precipitation Depth		
		2-Year	**10-Year**	**100-Year**
		2.55 inches	3.72 inches	6.16 inches
Existing	7.7	768.87	770.89	773.78
Proposed	7.7	768.87	770.55	772.5 +/-

Note: gray shading indicates water surface overtops 108th Street

Duncan Lake: Potential measures to reduce spikes in the water surface elevation of Duncan Lake and ensure that all homes around the lake have MBOs above the 100-year floodplain include increasing the hydraulic capacity of the downstream Drain as well as creating additional regional detention / retention upstream of the lake. Four alternatives were evaluated in detail, the hydrologic and hydraulic results of which are summarized below. A comparative summary of the effectiveness of each alternative in terms of reducing the peak water surface elevation in Duncan Lake for the 2, 10 and 100-year, 24-hour storm events are provided in **Table 4.**

Alternative 1: Survey data indicates that the gradient of the Drain increases downstream of Duncan Lake Road. Conveyance improvements focus on an aggressive clean-out of the Drain, lowering the channel bottom by as much as 2-ft from the lake outlet to approximately 250 linear feet downstream of Duncan Lake Road. In addition, the culverts at Noffke Drive and Duncan Lake Road would be upsized to increase hydraulic capacity. In order to maintain normal water levels in Duncan Lake, a water control structure (weir) will likely need to be constructed at the lake outlet.

Conveyance improvements alone have the potential to reduce peak water surface elevations in Duncan Lake by up to 1.5-ft. This drop in peak water surface elevations would be significant enough to ensure that all homes around Duncan Lake have MBOs above the 100-year floodplain elevation based on both EGLE estimates and LRE modeling.

Water Control Structure - Example

Alternative 2: Alternative 2 centers on determining the extent of additional upstream storage volume required to achieve the same level of peak water surface reductions in Duncan Lake as Alternative 1. Model results indicate that approximately 695 acre-feet (more than 1.1 million cubic yards) of additional detention / retention storage would be required to equal the water surface reductions provided by Alternative 1.

Alternative 3: A combination of both downstream conveyance (Alternative 1) as well as upstream regional detention / retention (Alternative 2) was analyzed to determine the impact on reducing peak water surface elevations within Duncan Lake. Alternative 3 would reduce peak water surface elevations in Duncan Lake by up to 2.7-ft.

Alternative 4: The contributing drainage area to Duncan Lake is more than 80 times the surface area of lake, resulting in extreme water level fluctuations during heavy rainfall events. The goal of Alternative 4 is to reduce the proposed 100-year peak water surface elevation in the lake to the existing 2-year peak water surface elevation, which would require approximately 2,430 acre-feet (almost 4 million cubic yards) of additional storage volume.

Table 4. Peak Water Surface Elevations in Duncan Lake for Various Alternatives

Alternative Scenario	**Volume of Add. Detention Storage**	**Peak Water Surface Elevation** (feet NAVD 88) Return Period and 24-Hour Precipitation Depth		
		2-Year 2.55 inches	**10-Year** 3.72 inches	**100-Year** 6.16 inches
Existing Conditions	0	766.28	768.49	772.32
Alternative 1	0	765.33	767.34	770.86
Alternative 2	695 ac-ft	765.92	767.58	770.85
Alternative 3	695 ac-ft	765.19	766.74	769.62
Alternative 4	2,430 ac-ft	764.24	764.85	766.19

Neither outlet alternative should adversely impact downstream properties since the contributing drainage area / discharge from Duncan Lake will not be increased. Rather the proposed hydraulic improvements will lower the bottom elevation of the outlet channel, which will convey the same amount of discharge but at a lower elevation relative to the water surface of Duncan Lake.

EVALUATION OF ALTERNATIVES

Numerous alternatives were considered to reduce the potential for roadway overtopping at 108th Street as well as attenuate water level fluctuations in Duncan Lake. These alternatives were evaluated to appropriate levels of detail, which included detention/retention storage, increased conveyance and diversion or combinations thereof. Following is a breakdown of the alternatives evaluated by LRE:

Do Nothing

The 108th Street crossing of the Drain is currently capable of conveying peak discharges resulting from storm events less than the 5-year (20% return frequency) without causing roadway overtopping. Water surfaces within Duncan Lake may rise as much as 8-ft during the 100-year (1% return frequency) storm event. Home MBOs appear to be below the estimated EGLE 100-year floodplain elevation; however, at least two homes have MBOs below the peak 100-year water surface elevation calculated by LRE. The “do nothing” alternative may be acceptable if property owners within the District determine that the current water surface fluctuations in Duncan Lake are acceptable and the BCBRC considers the conveyance capacity of the 108th Street crossing to be adequate, or the proposed improvements are too costly to implement.

Diversion

While not evaluated in detail, it’s worth nothing that LRE investigated several alternatives to divert / re-route stormwater drainage around Duncan Lake. Potential diversion alignments included re-routing the Drain east along 108th Street and then south along Duncan Lake Road as well as diverting drainage from the Wilson Intercounty Drain along the south side of the lake to the Finkbeiner Drain. The biggest issue for either of these solutions is lack of grade to convey the drainage over a longer route. The 108th Street diversion would be more than a mile long, require an excessively large diameter pipe or box culvert and require cut depths greater than 20-ft. The Wilson Intercounty Drain diversion would require crossing a sub-watershed divide, extensive deepening of the Finkbeiner Drain and pose significant wetland impacts. Given the lack of grade (feasibility to provide an engineering solution), substantial cost (estimated to be in excess of $5 million dollars) and potential disturbance to environmentally sensitive areas (wetlands), diversion of the Drain is not a viable solution.

Alternative 1 – Conveyance Improvements

Alternative 1 seeks to optimize the hydraulic capacity of the Drain downstream of Duncan Lake to reduce peak water surface elevations in Duncan Lake by up to 1.5-ft and ensure that all homes around the lake have an MBO above the 100-year floodplain. In addition,

the conveyance capacity of the crossing at 108th Street will be increased and the low-point in the road will be raised by more than 2-ft to provide a 100-year level of flood protection (point at which water overtops the roadway). A schematic map of the proposed maintenance and improvements associated with Alternative 1 is provided in **Figure 2**. Below is a summary of the major items of work.

Upstream – 2 Stage Channel Construction: Approximately 9,125 linear feet of channel maintenance including woody debris management and sediment removal is necessary upstream of 100th Street in Section 25 of Gaines Township, Kent County. LRE recommends constructing a 2-stage channel where feasible to provide additional floodplain storage to help attenuate downstream flows.

Increase Hydraulic Capacity and Raise 108th Street: Currently, roadway overtopping at 108th Street occurs during storms greater than the 2-year event. Increasing the hydraulic capacity of the crossing (for estimating purposes an additional 100”x154”CMPA culvert with invert set at the bankfull stage was assumed) combined with raising the elevation of the road by more than 2-ft will prevent overtopping during storm events up to the 100-year return frequency.

Water Control Structure: Some form of water control structure (weir, rock grade control, etc.) will likely need to be installed to maintain the lake level at the normal elevation. The control structure should be designed so as not to limit peak discharges from the lake, which will continue to be controlled by the culvert at Noffke Drive. In addition, the structure should be designed to maintain aquatic species passage.

Downstream – Open Channel Excavation: Approximately 4,415 linear feet of open channel excavation is proposed from Duncan Lake to 250-ft downstream of Duncan Lake Road. The proposed outlet channel elevation at Duncan Lake would be lowered almost 2-ft to an elevation of approximately 762-ft NAVD 88 and the channel bottom graded to a slope of just under 0.1%.

Culvert Replacement: The culverts at Noffke Drive and Duncan Lake Road will need to be lowered and should be upsized to optimize the hydraulic capacity of the Drain. The recommended culvert size at Noffke Drive is 15’ x 8’ concrete box (or similar) and at Duncan Lake Road is 15’ x 10’ concrete box (or similar).

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 1 is approximately $1,500,000.00. A detailed project cost breakdown is provided in **Appendix 4**.

Alternative 2 – Equivalent Detention

Alternative 2 seeks to provide the same effect as Alternative 1 (reduce peak water surface elevations in Duncan Lake by up to 1.5-ft) through the creation of additional upstream detention / retention. In addition, the low-point in 108th Street will be raised almost 2-ft to provide a 10-year level of flood protection (point at which water overtops the roadway). Approximately 695 acre-feet (more than 1.1 million cubic yards) of additional detention / retention storage would be required to equal the water surface reductions provided by Alternative 1. A schematic map showing the required amount of stormwater storage area over 1-ft depth relative to the surface area of Duncan Lake is provided in **Figure 3**.

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 2 is approximately $10 million dollars.

Alternative 3 – Combination of Alternatives 1 & 2

Alternative 3 consists of the conveyance improvements associated with Alternative 1 and the additional storage volume associate with Alternative 2. Alternative 3 would reduce peak water surface elevations in Duncan Lake by up to 2.7-ft. A schematic map showing the proposed scope of work associated with Alternative 3 is provided in **Figure 4**.

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 3 is approximately $11 million dollars.

Alternative 4 – Maximum Detention

The District has several large “low areas” and wetlands (including Hana Lake) upstream of Duncan Lake that help attenuate flow, provide storm water storage and act as natural water filters. Large portions of the District are in agricultural production. After reviewing the Michigan Wetland Map Viewer, it is evident there were more wetlands prior to settlement by the presence of hydric (wetland) soils.

The goal of Alternative 4 is to convert large tracts of agricultural lands back to wetland / stormwater storage areas to reduce the proposed 100-year peak water surface elevation in Duncan Lake to the existing 2-year peak water surface elevation. Implementing Alternative 4 would require approximately 2,430 acre-feet (almost 4 million cubic yards) of additional storage volume, which likely is not feasible. A schematic map of Alternative 4 showing the required amount of stormwater storage area over 1-ft depth relative to the surface area of Duncan Lake is provided in **Figure 5**.

Estimated Project Cost: The preliminary estimate of probable cost to implement the improvements associated with Alternative 4 is approximately $40 million dollars.

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 1 as the most cost-effective solution to provide a 100-year level of flood protection for 108th Street and reduce peak water surface elevations in Duncan Lake so as to ensure that all surrounding lake homes have an MBO above the 100-year floodplain. Opportunities to provide additional stormwater detention within the District should be considered as opportunities arise so long as they are cost-effective. Implementation of the recommended scope of improvements to the Drain, as presented in this report, requires consideration of the following:

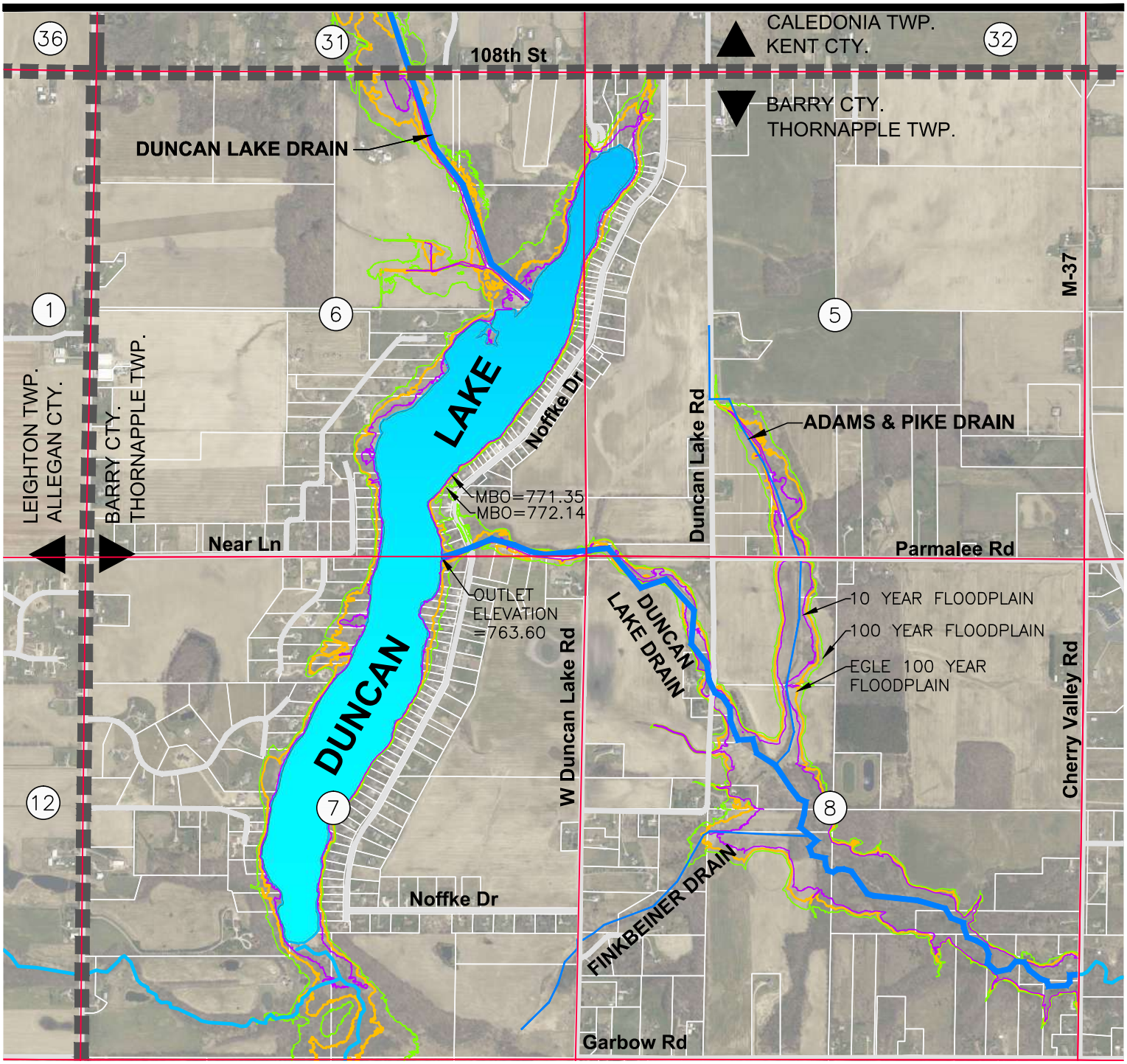
Easement Acquisition: The existing 100-feet wide drainage easeement should be sufficient for proposed maintenance and improvement activities along the Drain.

Permitting: Certain components of the project, including water control structure in Duncan Lake and any deepening of the historic channel bottom may require permits from EGLE 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). EGLE may require a functional lift to improve the stream system and/or wetlands. In addition, considerations for impacts to aquatic life, fisheries, and water quality may also need to be considered.

Drainage District Revisions: The District was updated in 2020 and the proposed project should not alter the District. Therefore, the District should remain as shown on the **Cover Sheet** of the **Survey Drawings**.

Final Design and Construction: If the petition is found necessary, LRE will work with the Board to define the project scope and schedule, complete the final design and prepare contract documents for bidding and construction.

Figures



NOTE

10 YEAR FLOODPLAIN = 768.49 (NAVD 88)
100 YEAR FLOODPLAIN = 772.32 (NAVD 88)
EGLE 100 YEAR FLOODPLAIN = 770.40 (NGVD 29)

NORTH

0 1500 3000

Horizontal Scale in Feet

LRE ENGINEERS & SURVEYORS

2121 3 Mile Rd. NW
Walker, MI 49544
Ph: 616-301-7888
www.LREMI.com

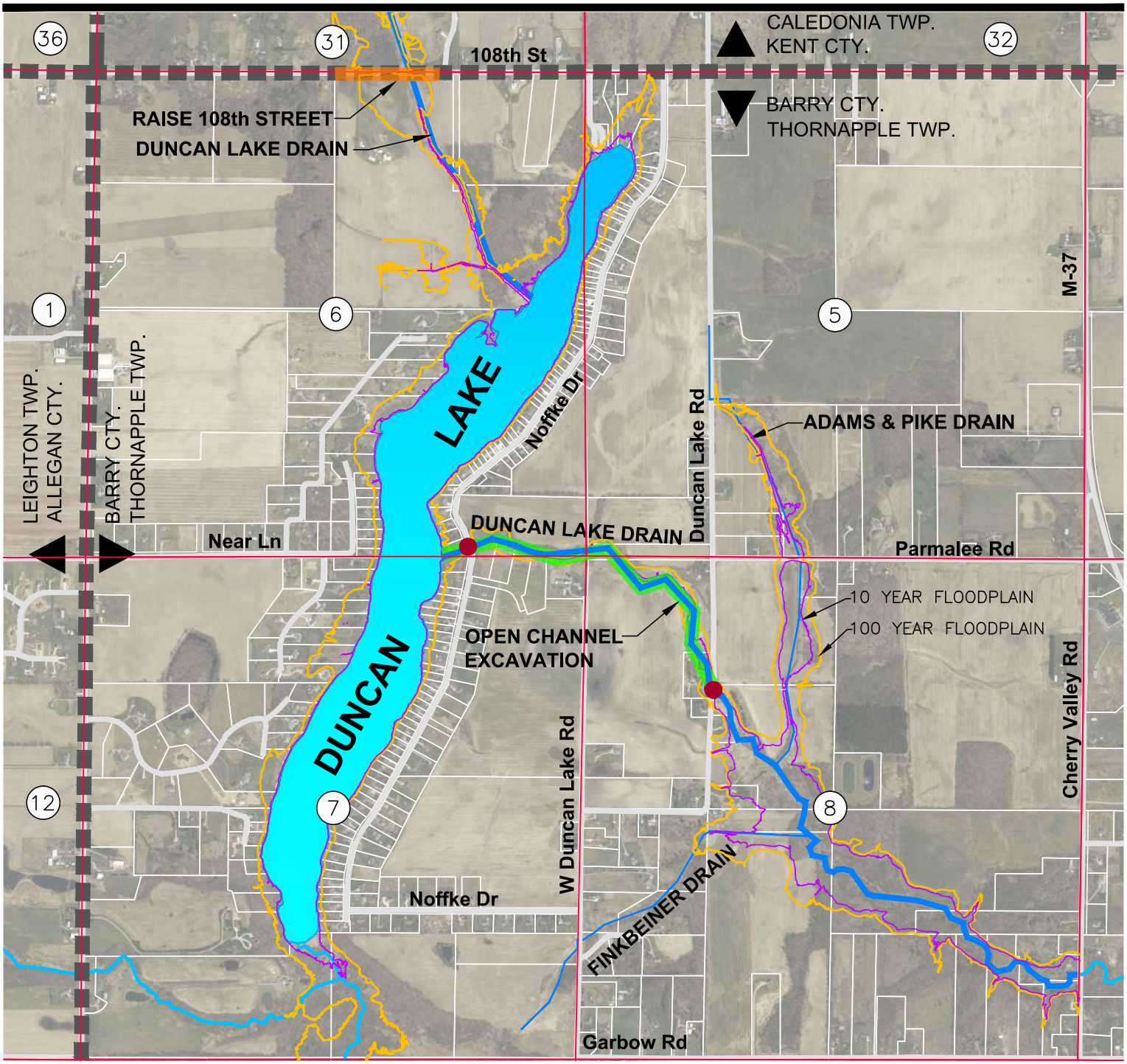
EXISTING CONDITIONS

DATE: JULY 26, 2022

PROJECT: 22-008

FIGURE 1

Jul 25, 2022 – 4:39pm H:\Projects\22-008 Duncan Lake ICD\LD\Exhibit – Alternatives.dwg, XREFs:
By: Z840



LEGEND

- PROPOSED RAISE ROAD
- PROPOSED OPEN CHANNEL EXCAVATION
- DUNCAN LAKE ICD OPEN CHANNEL
- PROPOSED CULVERT REPLACEMENT

NORTH

0 1500 3000

Horizontal Scale in Feet

NOTE

10 YEAR FLOODPLAIN
= 767.34 (NAVD 88)
100 YEAR FLOODPLAIN
= 770.86 (NAVD 88)

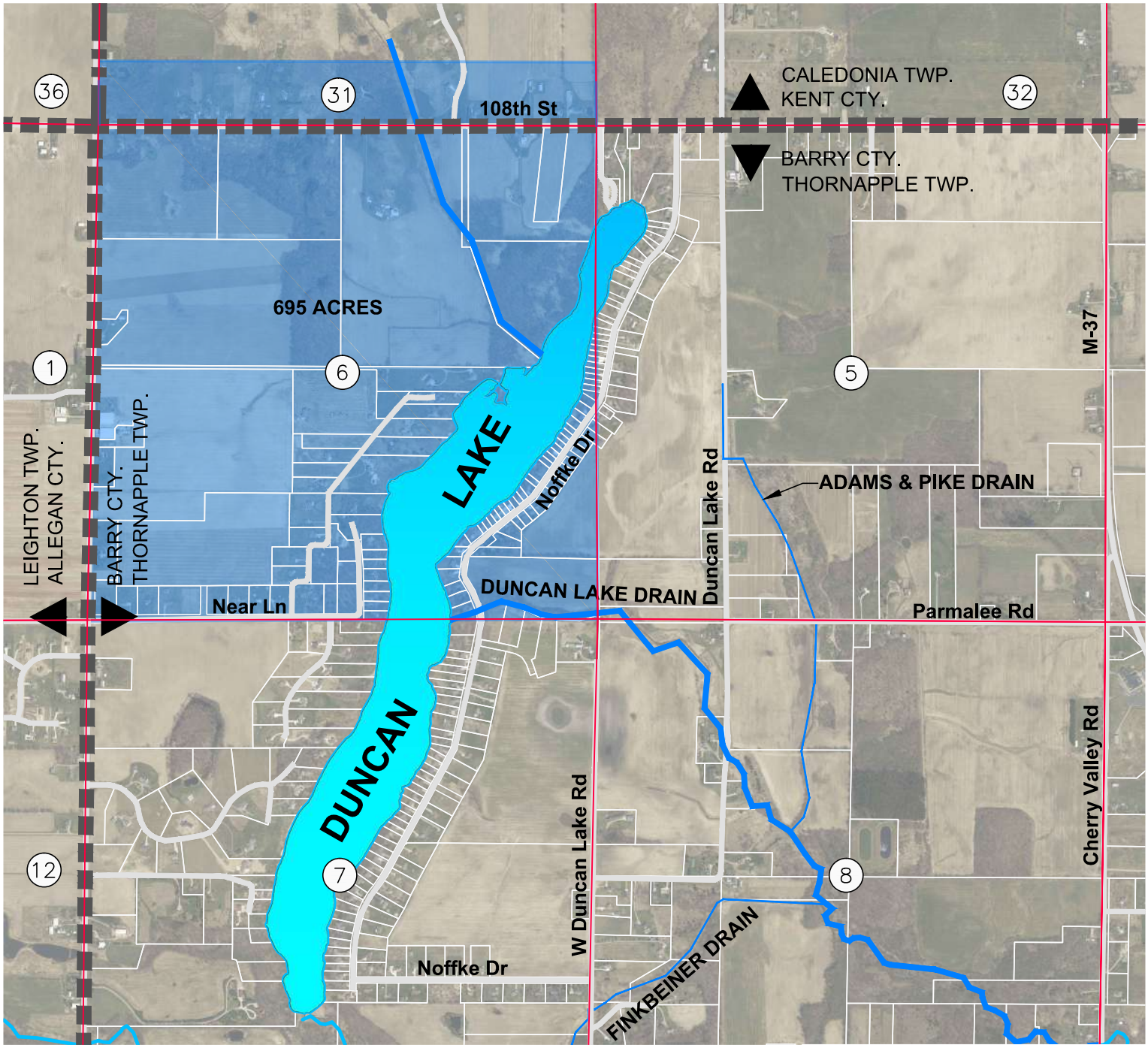
LRE ENGINEERS & SURVEYORS
2121 3 Mile Rd. NW
Walker, MI 49544
Ph: 616-301-7888
www.LREMI.com

ALTERNATIVE 1

DATE: JULY 26, 2022
PROJECT: 22-008

FIGURE 2

Jul 25, 2022 – 4:40pm H:\Projects\22-008 Duncan Lake ICD\LD\Exhibit – Alternatives.dwg, XREFs:
By: Z840



LEGEND

- REQUIRED AREA OF DETENTION AT 1-FOOT DEPTH TO LOWER 100-YR LAKE LEVEL BY 1.5 FEET+/-.

NORTH

0 1500 3000

Horizontal Scale in Feet

LRE ENGINEERS & SURVEYORS

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Ph: 616-301-7888
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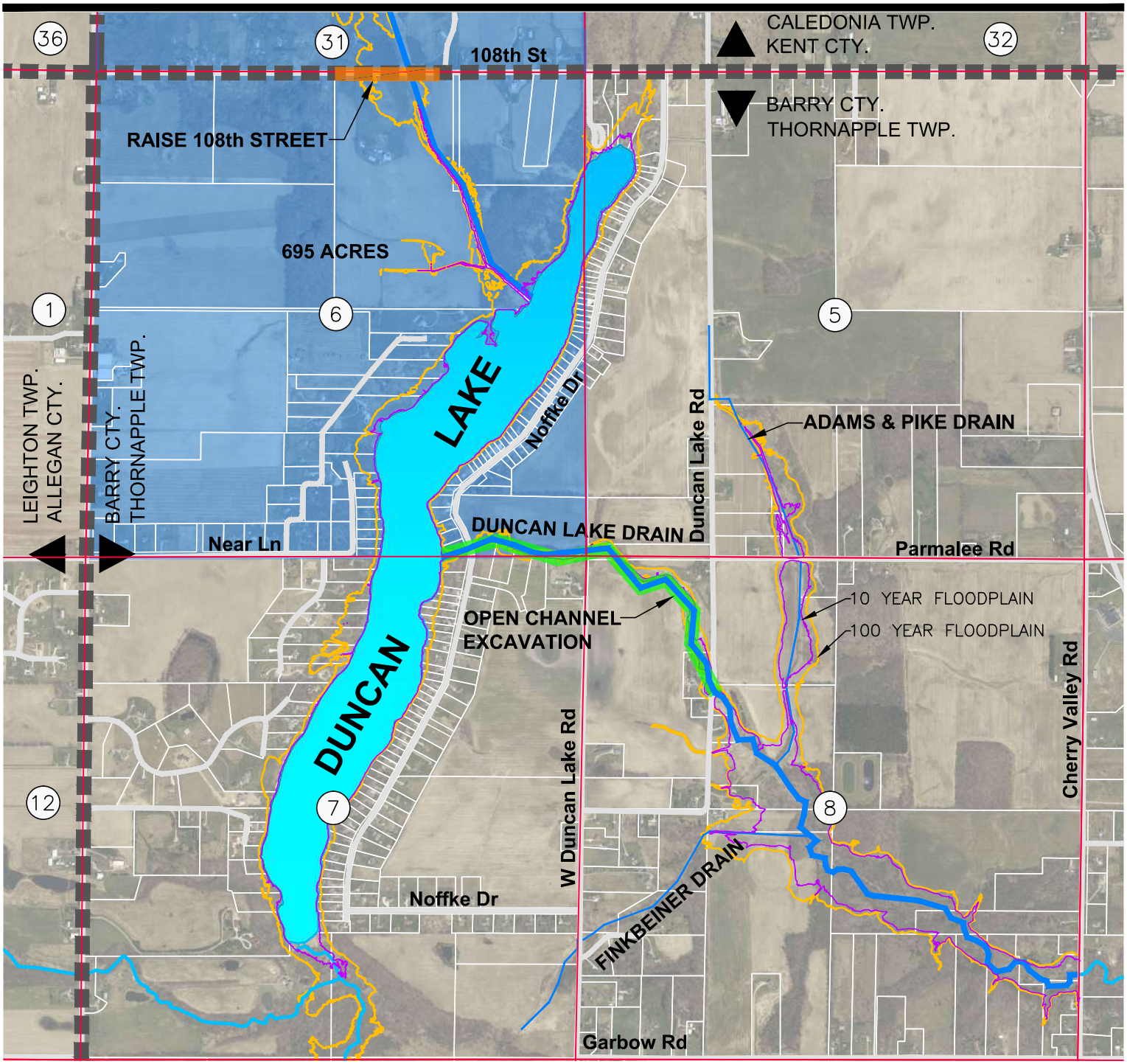
ALTERNATIVE 2

DATE: JULY 26, 2022

PROJECT: 22-008

FIGURE 3

Jul 25, 2022 – 4:40pm H:\Projects\22-008 Duncan Lake ICD\LD\Exhibit – Alternatives.dwg, XREFs:
By: Z840



LEGEND

- PROPOSED RAISE ROAD
- PROPOSED OPEN CHANNEL EXCAVATION
- DUNCAN LAKE ICD OPEN CHANNEL
- PROPOSED CULVERT REPLACEMENT
- REQUIRED AREA OF DETENTION AT 1-FOOT DEPTH TO LOWER 100-YR LAKE LEVEL BY 1.5 FEET+/-.

NORTH

0 1500 3000

Horizontal Scale in Feet

LRE ENGINEERS & SURVEYORS

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Walker, MI 49544
Ph: 616-301-7888
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NOTE

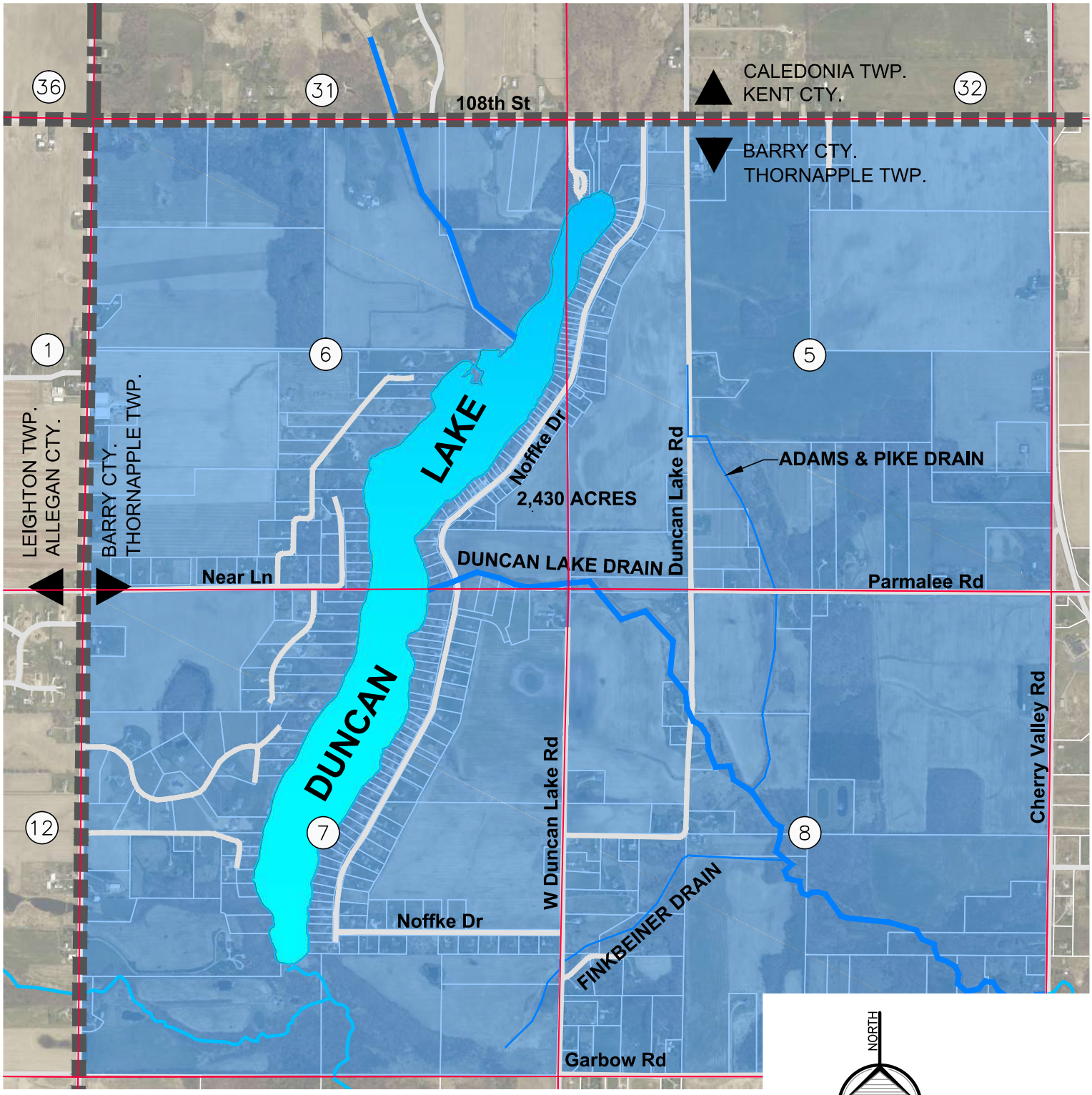
10 YEAR FLOODPLAIN = 766.74 (NAVD 88)
100 YEAR FLOODPLAIN = 769.62 (NAVD 88)

ALTERNATIVE 3

DATE: JULY 26, 2022
PROJECT: 22-008

FIGURE 4

Jul 25, 2022 – 4:40pm H:\Projects\22-008 Duncan Lake ICD\LD\Exhibit – Alternatives.dwg, XREFs:
By: Z840



LEGEND

- REQUIRED AREA OF DETENTION AT 1-FOOT DEPTH TO LOWER 100-YR LAKE LEVEL BY 6 FEET+/-.

NORTH

0 1500 3000

Horizontal Scale in Feet

LRE ENGINEERS & SURVEYORS

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ALTERNATIVE 4

DATE: JULY 26, 2022

PROJECT: 22-008

FIGURE 5

Jul 25, 2022 – 4:40pm H:\Projects\22-008 Duncan Lake ICD\LD\Exhibit – Alternatives.dwg, XREFs:
By: Z840

Appendix 1

Clark Hill PLC Legal Opinion (February 26, 2019)

CLARK HILL

LEGAL OPINION

DUNCAN LAKE INTERCOUNTY DRAIN

TO: Duncan Lake Intercounty Drain Drainage Board

FROM: Clark Hill PLC

DATE: February 26, 2019

SUBJECT: Duncan Lake Intercounty Drain

Establishment of Drain
Year: 1897
Chapter: 6

Municipalities
Allegan County: *Leighton Township*
Barry County: Thornapple Township
Kent County: Caledonia Township, Gaines Township

Jurisdiction of Drain
☐ Drain Commissioner
☒ Drainage Board
☐ Other: _____

Petitioned Proceedings

Date/Type: 1896-1897 Establishment Proceedings
Application to Locate and Establish a Drain dated August 1, 1896 (filed with Kent County; refers to Barry and Kent Counties
First Order of Determination dated October 10, 1896 (signed by Barry and Kent Counties)
Final Order of Determination dated January 7, 1897 (signed by Barry and Kent Counties)
Apportionment of Benefits

Date/Type: 1899-1900 Establishment Proceedings – Duncan Lake Extension Drain (Kent County only)
Application to Locate and Establish a Drain dated August 8, 1899
First Order of Determination dated October 12, 1899
Final Order of Determination dated July 12, 1900

Date/Type: 1908 Maintenance and Improvement Proceedings
Petition for maintenance and improvement dated August 1, 1908 (filed with Barry and Kent Counties)
Final Order of Determination dated November 15, 1908 (signed by Barry and Kent Counties)
Apportionment of Benefits

Date/Type: 1916 Maintenance and Improvement Proceedings
Petition for maintenance and improvement dated June 21, 1916 (filed with Kent County; refers to Barry and Kent Counties)
Order of Necessity dated July 10, 1916 (signed by Barry and Kent Counties)
No Further Records

Date/Type: 1917 Establishment Proceedings
Application to Locate and Establish a Drain dated March 15, 1917 (filed with Barry County; refers to Barry and Kent Counties)
Opinion of Drain Commissioners dated April 5, 1917 (signed by Barry and Kent Counties)
Order of Necessity dated April 26, 1917 (signed by Barry and Kent Counties)
First Order of Determination dated May 18, 1917 (signed by Barry and Kent Counties)
Releases of Right of Way
Final Order of Determination dated August 6, 1917 (signed by Barry and Kent Counties)
Notice of Letting dated August 8, 1917
Apportionment Between Counties dated August 8, 1917 (Barry County – 42.5%; Kent County – 57.5%)
Apportionment of Benefits
Special Assessment Roll

Date/Type: 1917-1918 Maintenance and Improvement Proceedings – Duncan Lake Extension Drain
Application to Locate and Establish a Drain dated August 7, 1917 (filed with Kent County; refers to Barry and Kent Counties)
Order of Necessity dated October 3, 1917 (signed by Barry and Kent Counties)
First Order of Determination dated December 17, 1917 (signed by Barry and Kent Counties)
Final Order of Determination dated February 21, 1918 (signed by Barry and Kent Counties; refers to cleaning out, deepening and widening)

Date/Type: 1943-1944 Maintenance and Improvement Proceedings
Petition for maintenance and improvement dated June 2, 1943 (filed with Kent County; refers to Barry and Kent Counties)
Order of Practicableness dated July 6, 1943 (signed by Drainage Board)
Order of Necessity dated January 27, 1944 (signed by Drainage Board)
First Order of Determination dated January 27, 1944 (Barry County – 14%; Kent County – 86%; signed by Drainage Board Chair)
Final Order of Determination dated February 1, 1944 (signed by Drainage Board Chair)
Notice of Letting and Day of Review dated February 4, 1944
Intercounty Contract After Letting dated March 1, 1944
Special Assessment Roll

Date/Type: 1968-1971 Maintenance and Improvement Proceedings
Petition for maintenance and improvement dated May 27, 1968 (filed with Kent County; refers to Barry and Kent Counties)
Petition for maintenance and improvement dated September 10, 1968 (filed with Kent County; refers to Barry and Kent Counties)
Order of Practicableness dated May 9, 1969 (signed by Drainage Board)
Order of Necessity dated January 21, 1970 (signed by Drainage Board)
First Order of Determination dated January 27, 1970 (Allegan County – 3%; Barry County 1%; Kent County – 96%; signed by Drainage Board Chair)
Final Order of Determination dated January 27, 1970 (signed by Drainage Board Chair)
Notice of Letting and Day of Review dated February 10, 1970
Notice of Letting and Day of Review dated March 17, 1970
Intercounty Contract After Letting dated April 17, 1970
Intercounty Contract After Letting dated August 25, 1971
Special Assessment Rolls

Date/Type: 1991-1992 Maintenance and Improvement Proceedings – NOT PRACTICABLE
Petition for maintenance and improvement dated April 22, 1991 (filed with Barry County, refers to Allegan, Barry and Kent Counties)
Order of NO Practicability dated June 30, 1992 (signed by Drainage Board)

Date/Type: 1993-1996 Maintenance and Improvement Proceedings
Petition for maintenance and improvement dated September 13, 1993 (filed with Barry County, refers to Allegan, Barry and Kent Counties)
Order of Practicability dated July 26, 1994 (signed by Drainage Board)
Order of Necessity dated September 6, 1995 (signed by Drainage Board)
First Order of Determination dated November 1, 1995 (Allegan County – 9%; Barry County – 66%; Kent County – 25%; signed by Drainage Board Chair)
Recorded Releases of Right of Way (Barry County)
Notice of Letting and Day of Review dated July 23, 1996
Contract After Letting dated September 12, 1996

<u>Miscellaneous Proceedings</u>

Date/Type: 1999 Drainage Board Meeting
Meeting minutes dated April 27, 1999 reflect approval of maintenance apportionments (Kent County – 52%; Barry County – 38%; Allegan County – 10%)

Date/Type: 2015 Drainage District Boundary Revisions – Allegan County
Notice for Day of Review of Drainage District Boundaries dated September 9, 2015

Date/Type: 2016 Drainage District Boundary Revisions – Allegan County
Notice for Day of Review of Drainage District Boundaries dated September 14, 2016

Date/Type: 2017 Drainage District Boundary Revisions – Kent County
Order Appointing Special County Drain Commissioner dated February 14, 2017
Order Describing and Establishing the Revised Drainage District Boundaries dated May 22, 2017 (signed by Joe Bush, Special Drain Commissioner for Kent County)

Status of Drain

☒ Under the Jurisdiction of the Duncan Lake Intercounty Drain Drainage Board
☐ Abandoned
☐ Relinquished

Comments

1. The Duncan Lake Intercounty Drain is a legally established intercounty drain under the jurisdiction of the Duncan Lake Intercounty Drain Drainage Board, consisting of the Allegan County Drain Commissioner, Barry County Drain Commissioner, Kent County Drain Commissioner and the Director of the Michigan Department of Agriculture and Rural Development.

2. Although established as a separate county drain, the "Duncan Lake Extension Drain" was subsequently combined with the Duncan Lake Intercounty Drain. Accordingly, there is no "Duncan Lake Extension Drain" as it is part of the Duncan Lake Intercounty Drain.

3. Based on a review of the records, there was no Final Order of Determination issued for the 1993-1996 petitioned project. It is recommended the Drainage Board issue a Final Order of Determination for this project to clarify the established route and course of the Duncan Lake Intercounty Drain.

4. Affidavits relating to the existence of historical releases of right of way should be recorded with the Register of Deeds.

Appendix 2

"Existing Conditions and Drain Analysis" ENG Report (December 2015)

4.0 EXISTING CONDITIONS AND DRAIN ANALYSIS

The drain was inspected in March of 2014 and the following pictures were taken. Survey data was gathered on both upstream and downstream

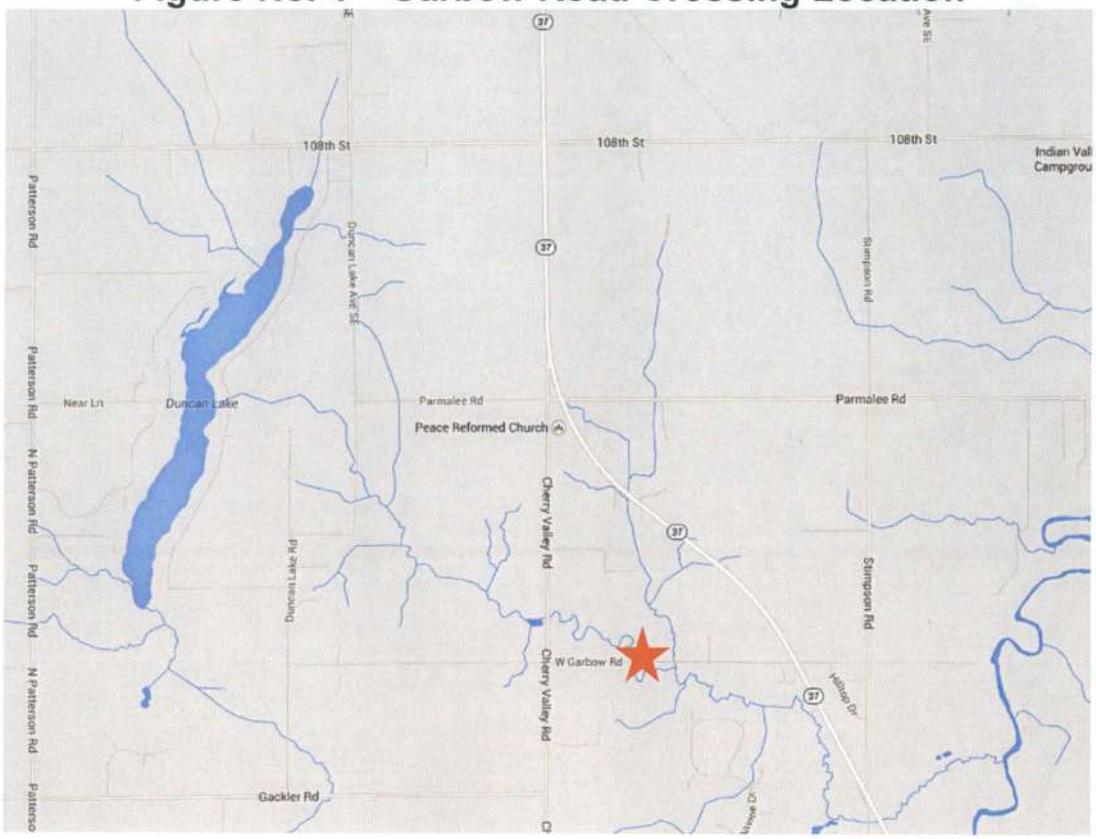
Drain Crossing Summary

LOCATION	DESCRIPTION	ELEVATIONS	PIC #	COMMENTS
STA ± 8+46 Duncan Lake Intercounty Drain Portion downstream of Main Drain Barry County	Garbow Rd. 2 - 82" Steel Culverts 1 - 88" Steel Culvert	82" Steel INV (S) = 741.22 82" Steel INV (N) = 741.51 82" Steel INV (S) = 741.23 82" Steel INV (N) = 741.49 88" Steel INV (S) = 740.68 88" Steel INV (N) = 740.83	1 & 2	• 3 separate culverts • Middle and west culverts in good condition and flowing freely • East culvert has roughly 12" sediment build up • Trees have fallen across downstream end on crossing
STA ± 48+75 Duncan Lake Intercounty Drain Main Drain POB Barry County	Cherry Valley Rd. 9' X 16' Box Culvert	9' X 16' Box INV (E) = 750.57 9' X 16' Box INV (W) = 750.52	3 & 4	• Concrete bridge crossing • Good Condition
STA ± 106+25 Duncan Lake Intercounty Drain Main Drain Barry County	N. Duncan Lake Rd. 8' X 12' CSP Culvert	8' X 12' CSP INV (E) = 759.33 8' X 12' CSP INV (W) = 759.25	5 & 6	• Elliptical culvert, looks slightly distorted from possible settling • Good condition • Little to no sediment bottom • Evidence of some erosion in NW corner
STA ± 143+61 Duncan Lake Intercounty Drain Main Drain Barry County	Noffke Dr. 7.5' X 11.5' CSP Culvert	7.5' X 11.5' CSP INV (E) = 763.12 7.5' X 11.5' CSP INV (W) = 763.84	7 & 8	• Shape is a slightly distorted, even though it is elliptical • Good condition • Little to no sediment in bottom • Rusting of bottom 1/5 of pipe from waterline down
STA ± 206+37 Duncan Lake Intercounty Drain Main Drain Barry County / Kent County	108th St. 8.5' X 13' CSP Culvert	8.5' X 13' CSP INV (S) = 763.62 8.5' X 13' CSP INV (N) = 764.00	9 & 10	• Arch culvert with tapered ends • Good condition • Approx. 8 inches of sediment
STA ± 268+89 Duncan Lake Intercounty Drain Main Drain Kent County	100th St. SE 9' X 12.5' CSP Culvert	9' X 12.5' CSP INV (S) = 768.38 9' X 12.5' CSP INV (N) = 768.53	11 & 12	• Elliptical culvert • Good condition • Approx. 12 inches of sediment
STA ± 271+90 Duncan Lake Intercounty Drain Main Drain Kent County	Patterson Ave. SE 8' X 12' Box Culvert	8' X 12' Box INV (E) = 768.03 8' X 12' Box INV (W) = 768.54	13 & 14	• Concrete Box Culvert • Very good condition
STA ± 360+49 Duncan Lake Intercounty Drain Main Drain Kent County	E. Paris Ave. SE 5' X 9' RCP Culvert	5' X 9' RCP INV (E) = 787.22 5' X 9' RCP INV (W) = 787.69	15 & 16	• Elliptical concrete culvert • Good condition • Approx. 6 inches of sediment
STA ± 380+16 Duncan Lake Intercounty Drain Main Drain Kent County	Meadow Valley 66" CSP Culvert	66" CSP INV (E) = 789.13 66" CSP INV (W) = 789.58	17 & 18	• CSP circular culvert with landscape blocks • Good condition • Little to no accumulated sediment
STA ± 417+11 Duncan Lake Intercounty Drain Main Drain Kent County	Hannah Lake Ave. 5' X 7.5' RCP Culvert	5' X 7.5' RCP INV (E) = 797.84 5' X 7.5' RCP INV (W) = 797.84	19 & 20	• Elliptical concrete culvert • Fair condition • Debris in upstream end of pipe

Garbow Road crossing

The Garbow Road crossing consists of three separate large steel culverts, two 82-inch and one 88-inch. The western two culverts are flowing freely while the eastern culvert has accumulated approximately 12-inches of sediment.

Figure No. 4 – Garbow Road Crossing Location



Picture No. 1

Picture No. 1 shows the southern end of the three steel culverts under Garbow Road. Dead trees have fallen across this outlet end of the eastern culvert.

Picture No. 2

Picture No. 2 shows the upstream north end of the three steel culverts. The culvert on the far right of the picture (east culvert) has accumulated approximately 12 inches of sediment.

Garbow Rd. to Cherry Valley Rd.

General pictures between Garbow Rd. and Cherry Valley Rd.



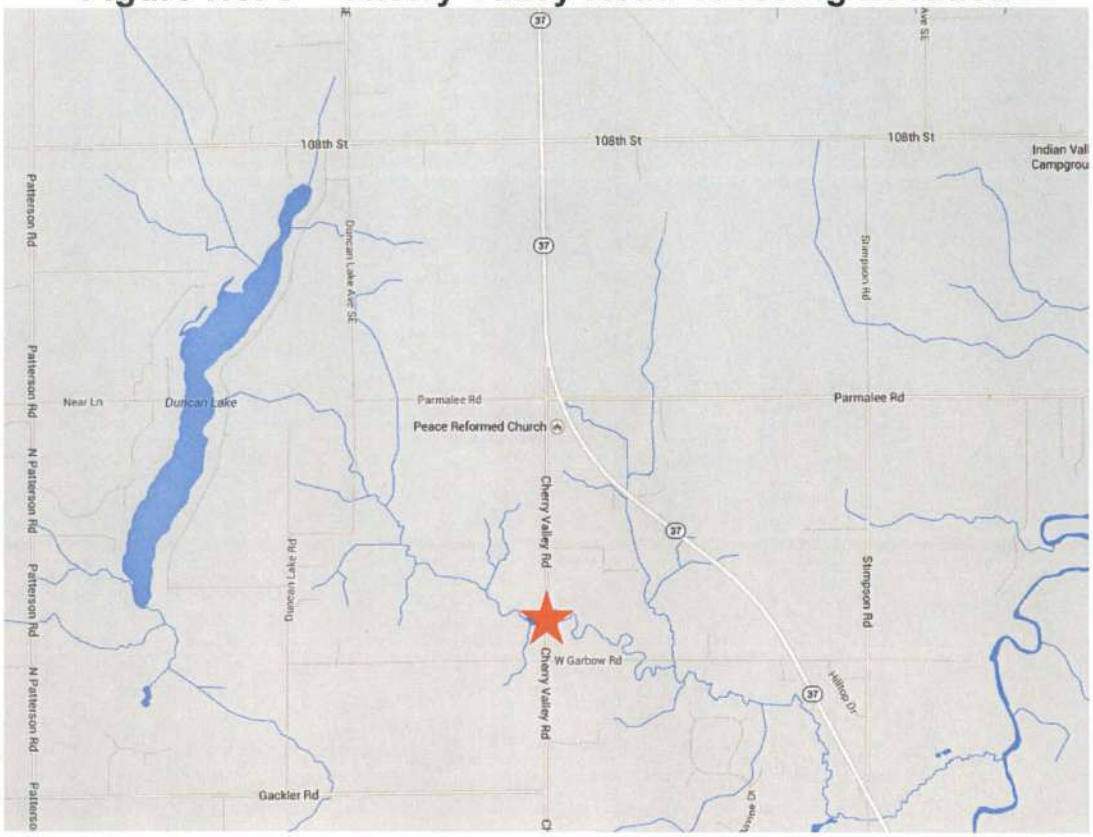




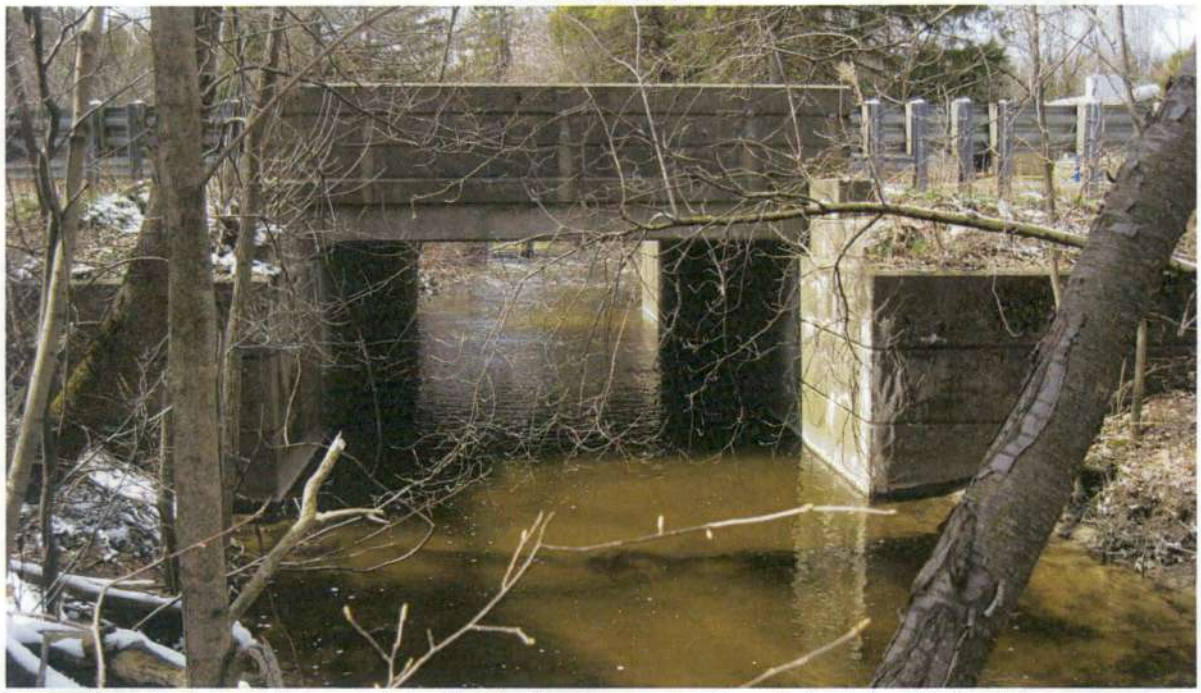

Cherry Valley Road crossing

The Cherry Valley Road crossing is a 9-foot tall by 16-foot wide concrete box culvert in good condition. There were no noticeable signs of structural damage at the time of inspection.

Figure No. 5 – Cherry Valley Road Crossing Location

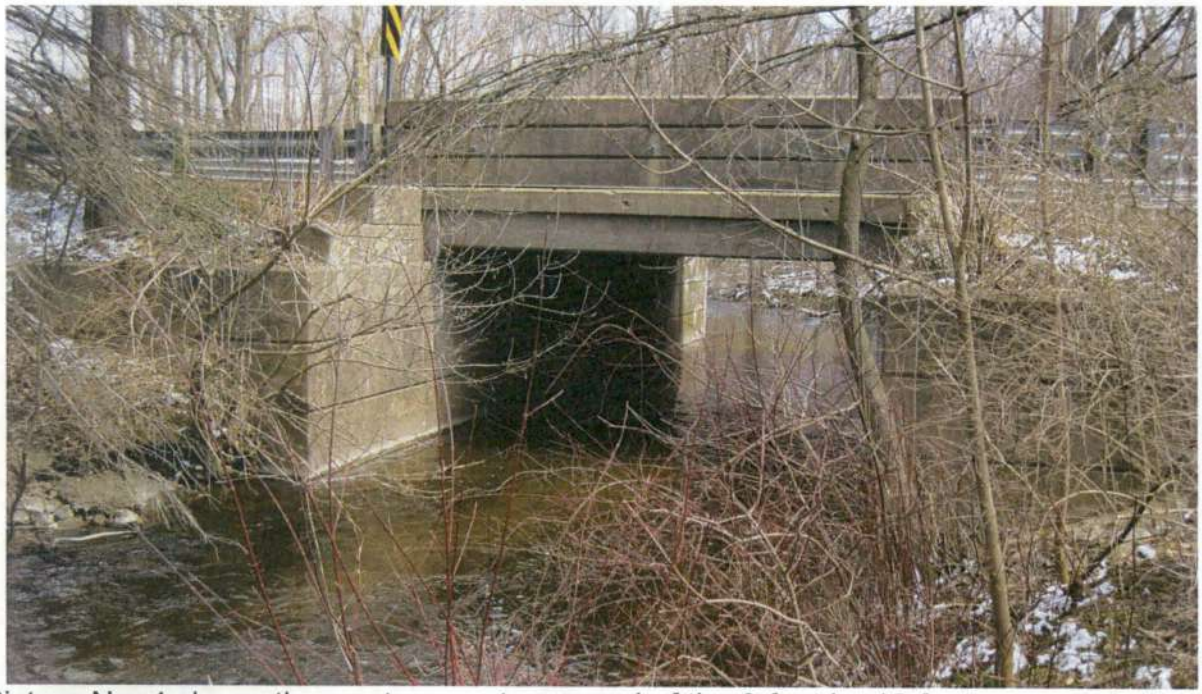


Picture No. 3



Picture No. 3 shows the eastern downstream end of the 9-foot by 16-foot concrete bridge structure over Cherry Valley Road. Picture is looking towards the west.

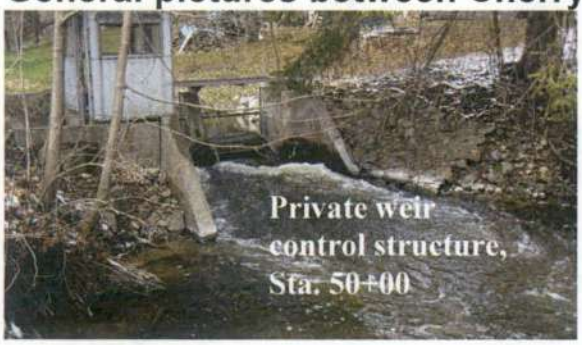
Picture No. 4

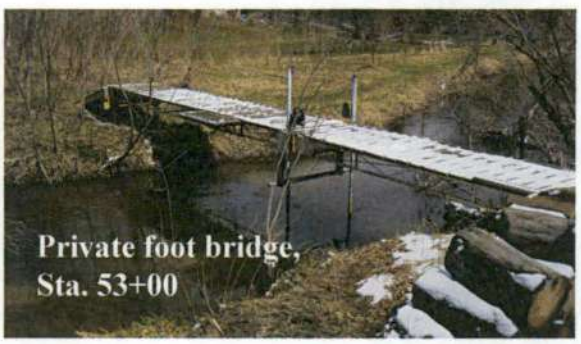


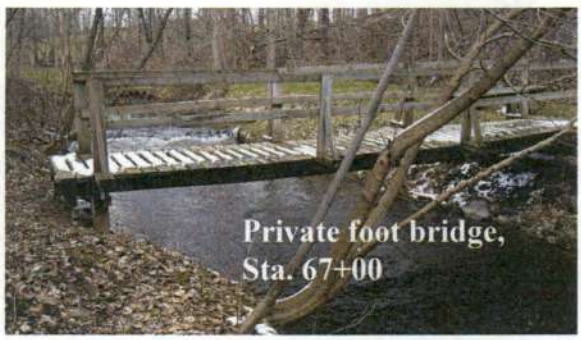
Picture No. 4 shows the western upstream end of the 9-foot by 16-foot concrete bridge under Cherry Valley Road. Picture is looking towards the east.

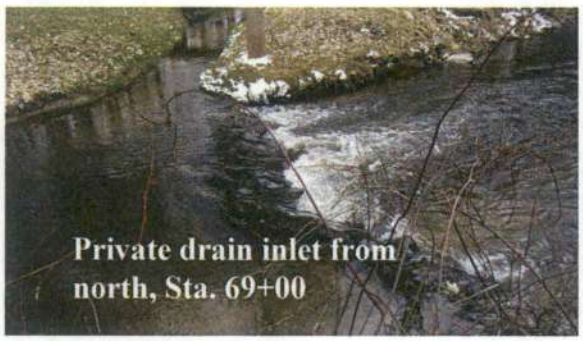
Cherry Valley Rd. to Duncan Lake Rd.

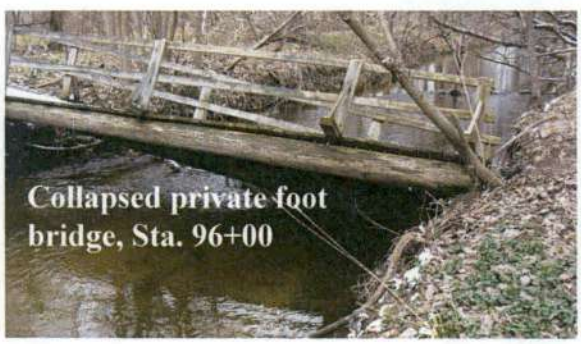
General pictures between Cherry Valley Rd. and Duncan Lake Rd.






Private foot bridge,
Sta. 67+00

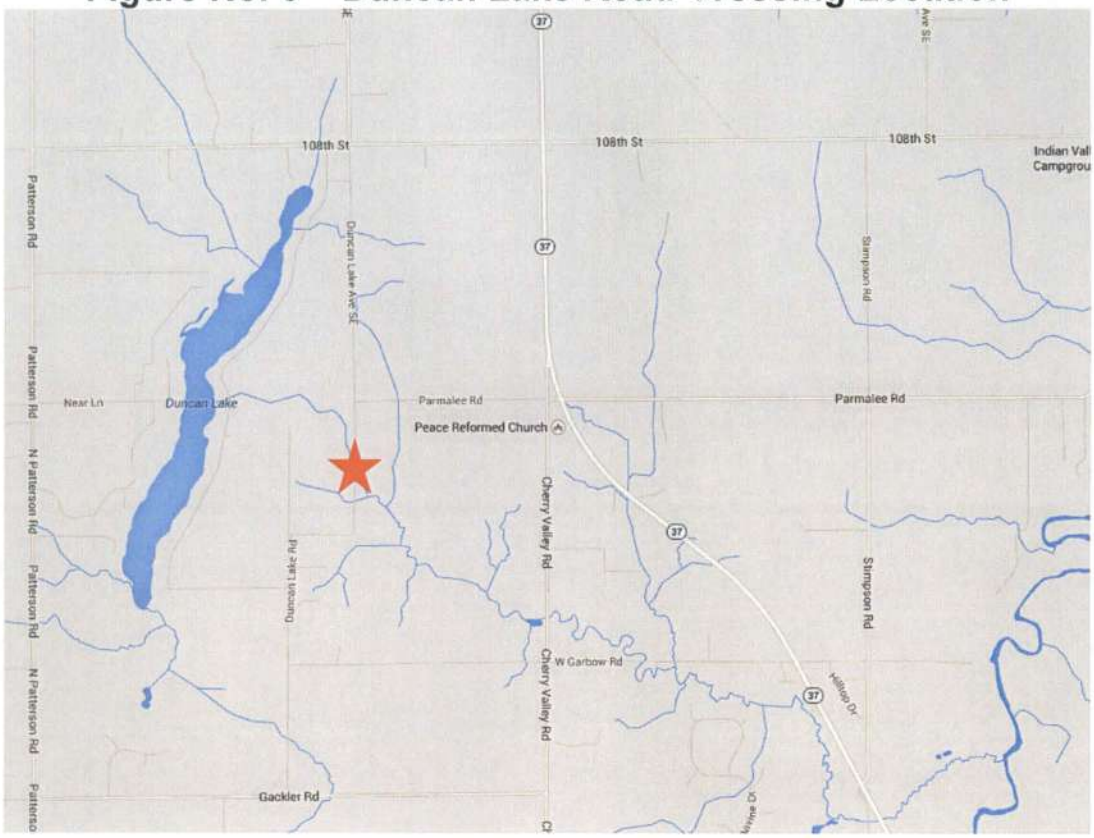

Private drain inlet from
north, Sta. 69+00


Collapsed private foot
bridge, Sta. 96+00

Duncan Lake Road crossing

An 8-foot tall by 12-foot wide elliptical corrugated steel pipe (CSP) crosses under Duncan Lake Road. This culvert appeared slightly distorted due to possible settlement over time. Overall, it is in good condition with little to no sediment although there are signs of possible erosion near the downstream end.

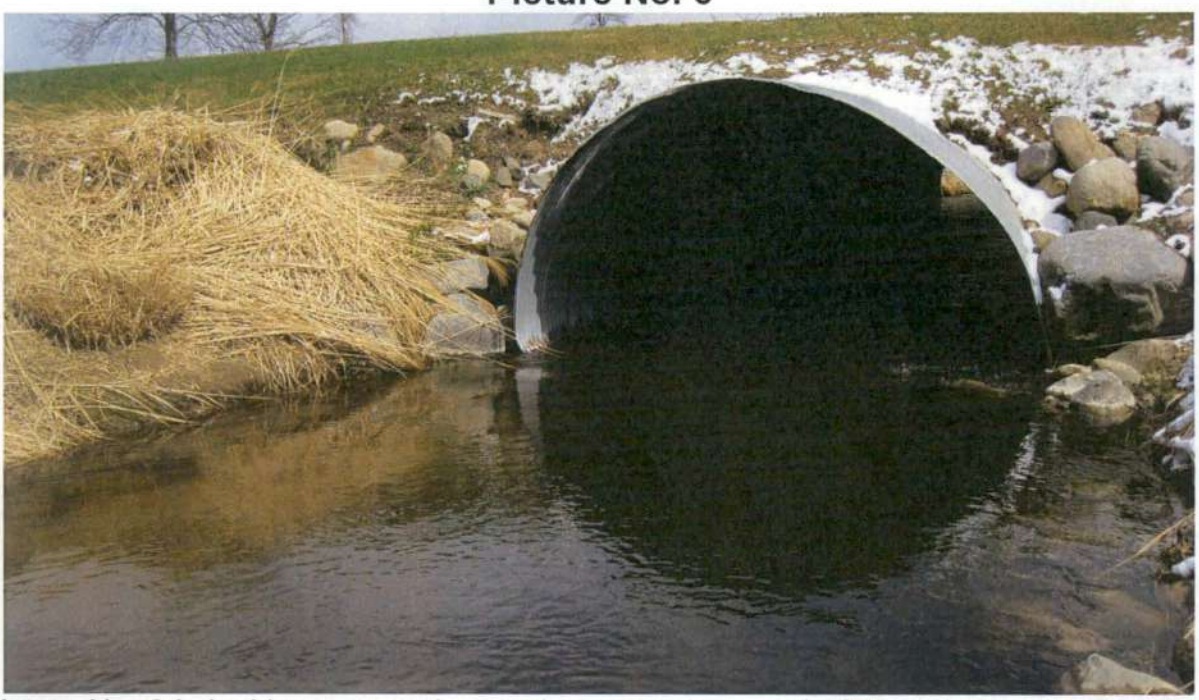
Figure No. 6 – Duncan Lake Road Crossing Location



Picture No. 5

Picture No. 5 is looking west at the downstream end of the 8-foot by 12-foot CSP culvert. Signs of erosion can be seen to the north of the outlet end.

Picture No. 6



Picture No. 6 is looking east at the southern upstream end of the 8-foot by 12-foot CSP culvert under Duncan Lake Road.

Duncan Lake Rd. to Noffke Rd.

General pictures from Duncan Lake Rd. to Noffke Rd. & Duncan Lake



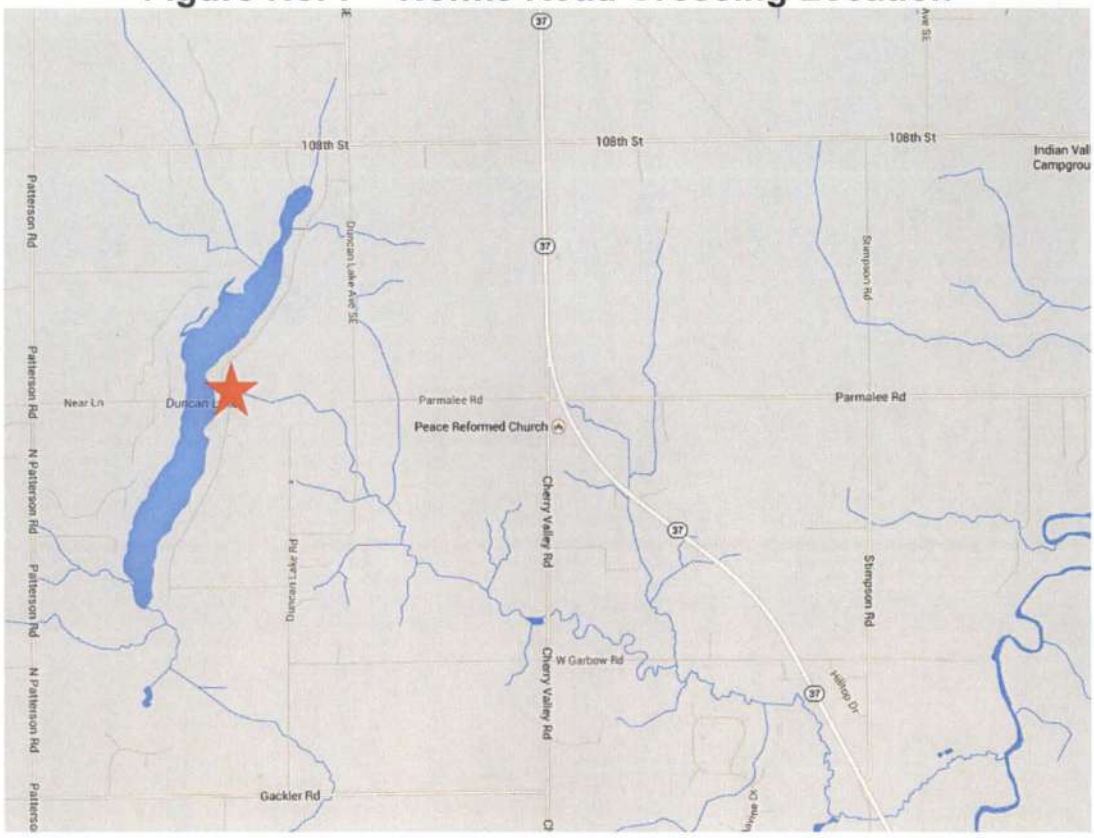





Noffke Road crossing

The Noffke Road crossing consists of a 7.5-foot tall by 11.5-foot wide elliptical CSP culvert. There is rusting below the waterline, approximately the bottom 1/5 of the pipe but no sediment was observed within the culvert.

Figure No. 7 – Noffke Road Crossing Location



Picture No. 7

Picture No. 7 is looking at the east downstream end of the 7.5-foot by 11.5-foot elliptical CSP culvert crossing under Noffke Road. Picture is taken looking towards the west.

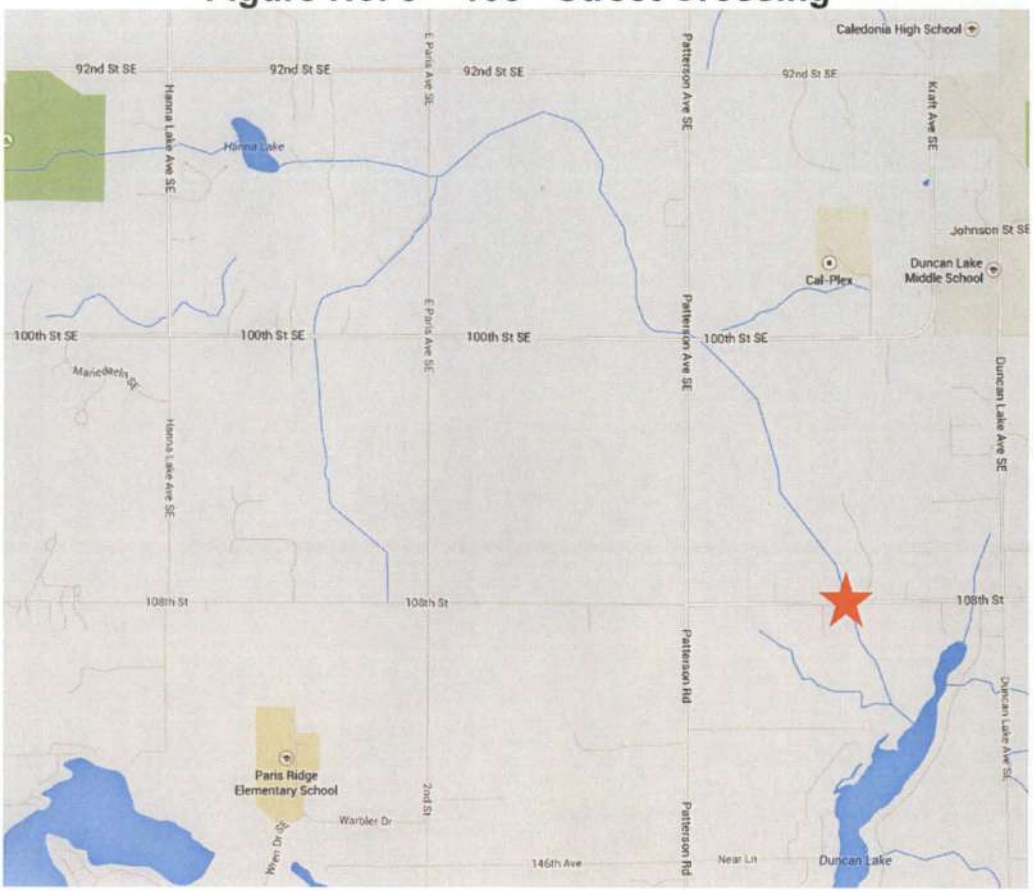
Picture No. 8

Picture No. 8 is the western upstream end of the 7.5-foot by 11.5 foot elliptical CSP culvert. There is slight distortion near the springline of the pipe. Picture is taken looking towards the northeast.

108th Street crossing

The 108th Street crossing is an 8.5-foot tall by 13-foot wide elliptical CSP culvert that is in good condition. At the time of inspection, approximately 8-inches of sediment were built up within the culvert.

Figure No. 8 – 108th Street Crossing



Picture No. 9

Picture No. 9 shows the southern downstream end of the 8.5-foot by 13-foot arch CSP culvert crossing under 108th Street. Picture is taken looking northwesterly.

Picture No. 10

Picture No. 10 shows the northern upstream end of the 8.5-foot by 13-foot arch CSP culvert crossing 108th Street.

Duncan Lake to 108th Street

General pictures from Duncan Lake to 108th Street

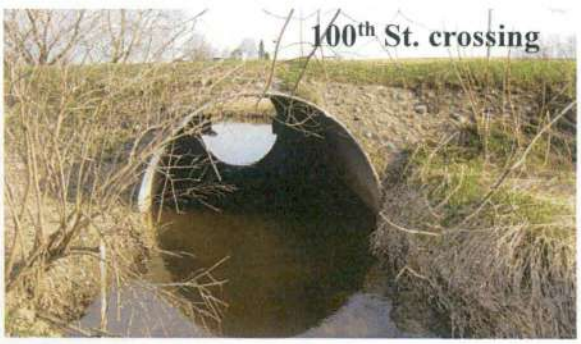


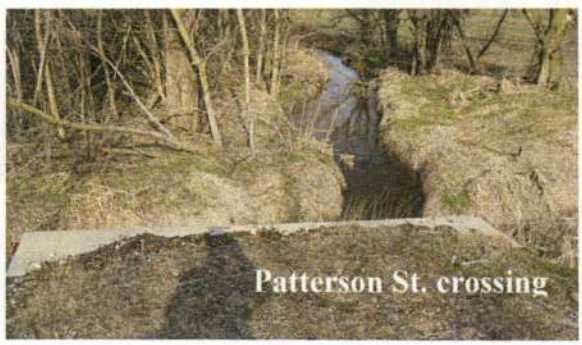





108th Street crossing to 100th Street & Patterson Ave. crossing

General pictures from 108th Street crossing to 100th Street & Patterson Ave. crossings

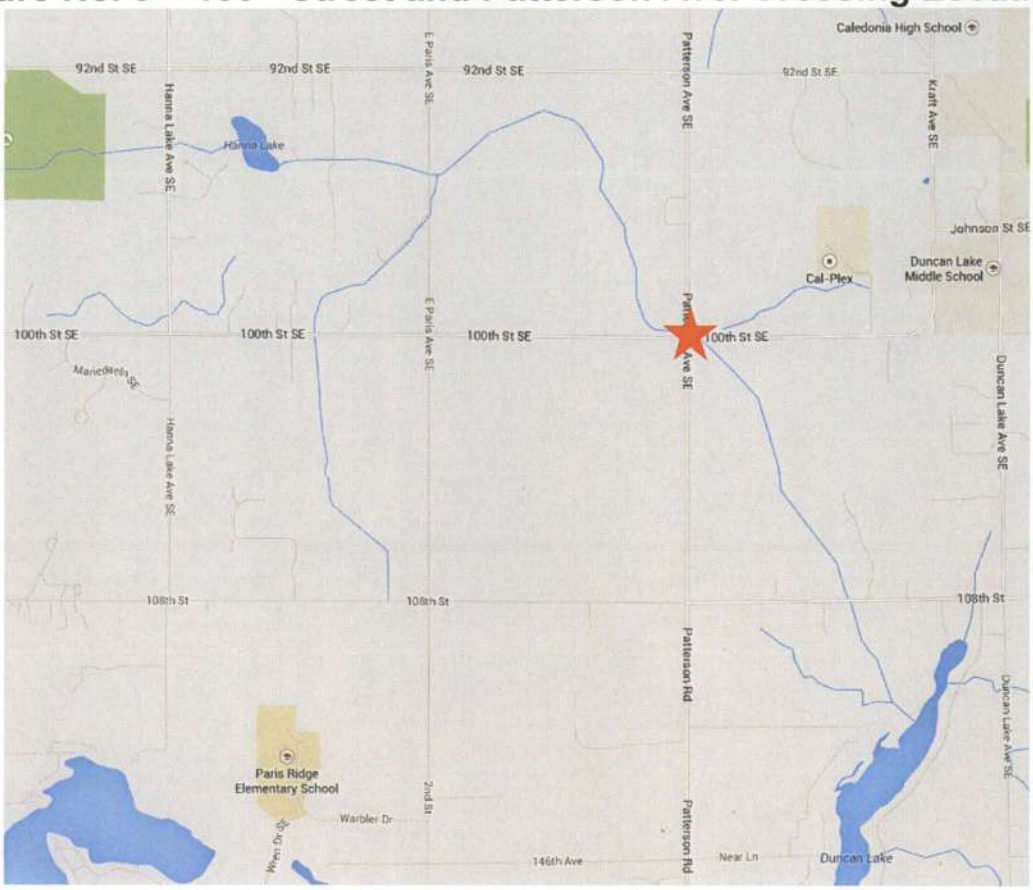




100th Street crossing

The 100th Street crossing consists of a 9-foot tall by 12.5-foot wide CSP culvert that is in good condition. There is approximately 12 inches of sediment build up within the culvert.

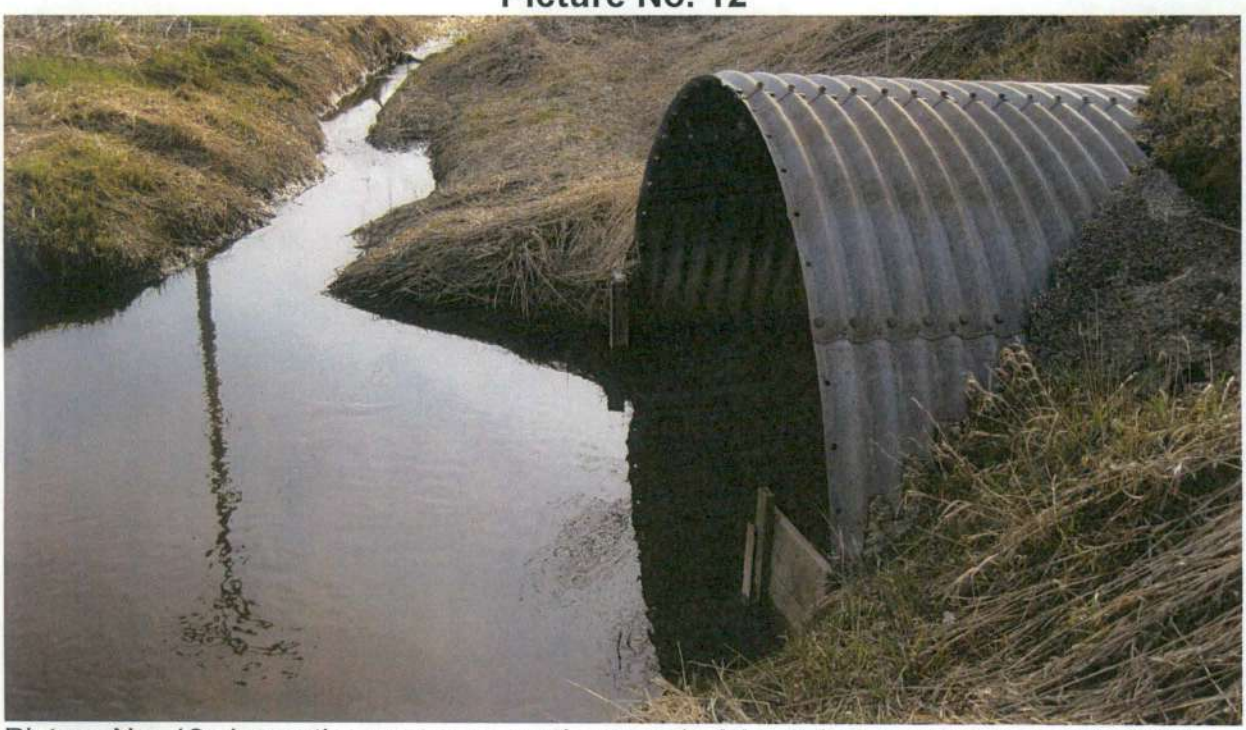
Figure No. 9 – 100th Street and Patterson Ave. Crossing Locations



Picture No. 11

Picture No. 12 shows the southern downstream end of the 9-foot by 12.5-foot arch CSP culvert crossing under 100th Street.

Picture No. 12



Picture No. 12 shows the upstream northern end of the 9-foot by 12.5-foot arch CSP culvert crossing under 100th Street.

Patterson Ave crossing

The Patterson Ave crossing is an 8-foot tall by 12-foot wide concrete box culvert that is in great condition. No structural damage or severe cracking was present at the time of inspection and structure was clear of debris.

Picture No. 13

Picture No. 13 shows the eastern downstream end of the 8-foot by 12 foot concrete box culvert crossing under Patterson Ave.

Picture No. 14

Picture No. 14 shows the western upstream end of the 8-foot by 12-foot concrete box culvert crossing under Patterson Ave.

Patterson Street crossing to East Paris Ave Crossing

General pictures from Patterson Street Crossing to East Paris Ave Crossing



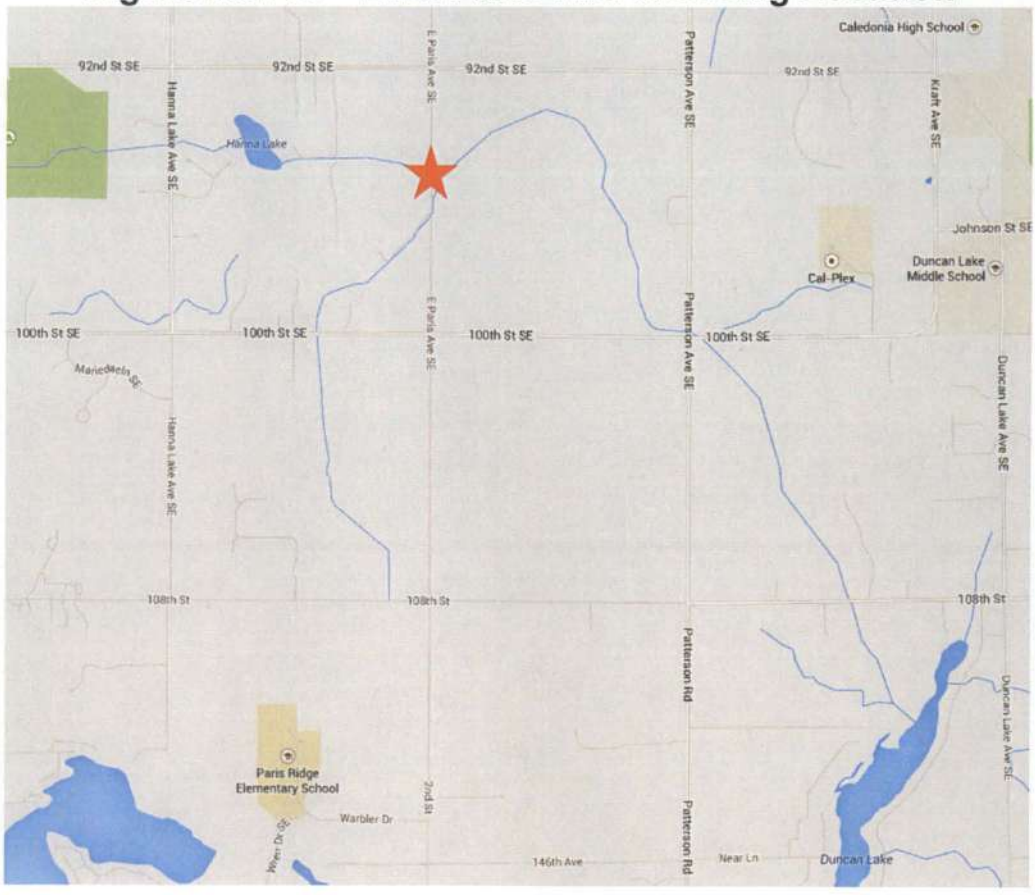





East Paris Ave crossing

East Paris Ave crossing consists of a 5-foot tall by 9-foot wide elliptical reinforced concrete pipe (RCP). This crossing is in good condition, although there is approximately 6 inches of built up sediment within the culvert.

Figure No. 10 – East Paris Ave Crossing Location



Picture No. 15

Picture No. 15 shows the downstream eastern end of the 5-foot by 9-foot elliptical RCP culvert crossing under East Paris Ave. Picture is taken looking southwest.

Picture No. 16

Picture No. 16 shows the upstream western end of the 5-foot by 9-foot elliptical RCP culvert crossing under East Paris Ave.

East Paris Ave crossing to Meadow Valley crossing

General pictures from East Paris Ave crossing to Meadow Valley crossing

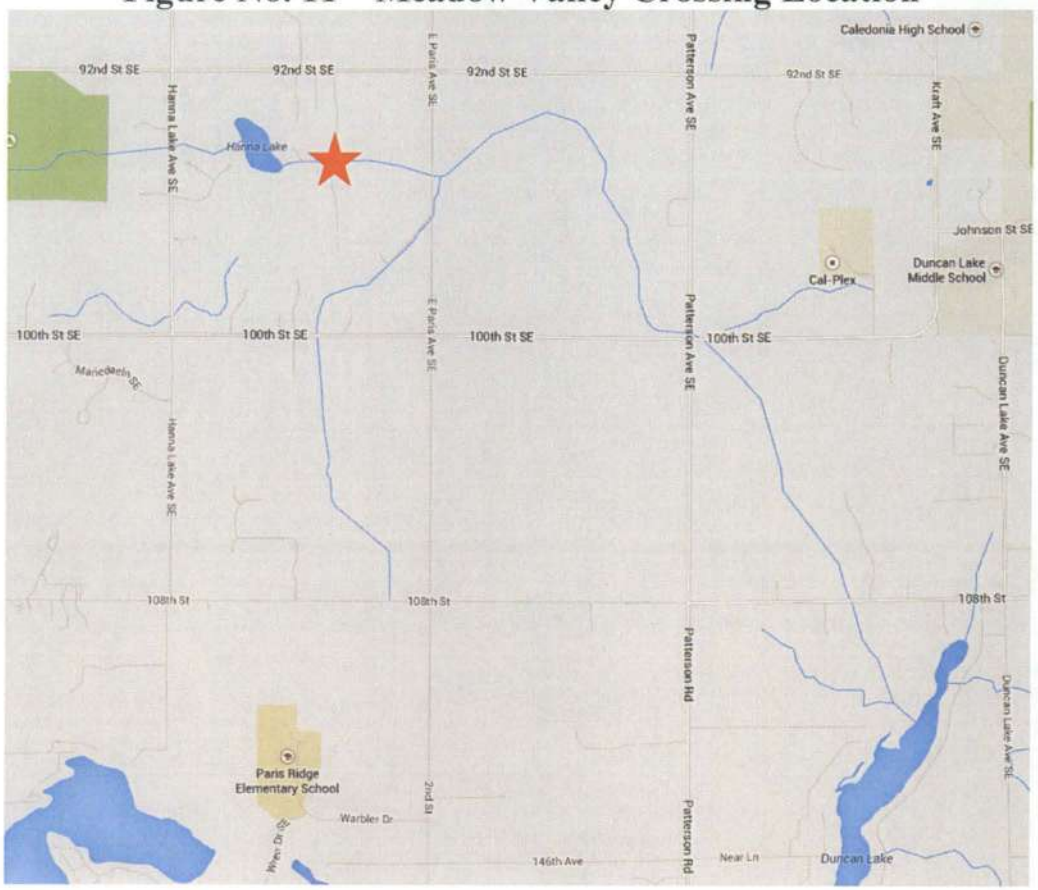





Meadow Valley Crossing

The Meadow Valley crossing consists of a 66-inch CSP circular culvert that has been landscaped around with brick and landscape blocks. This culvert is in good condition and is free of any significant sediment build up.

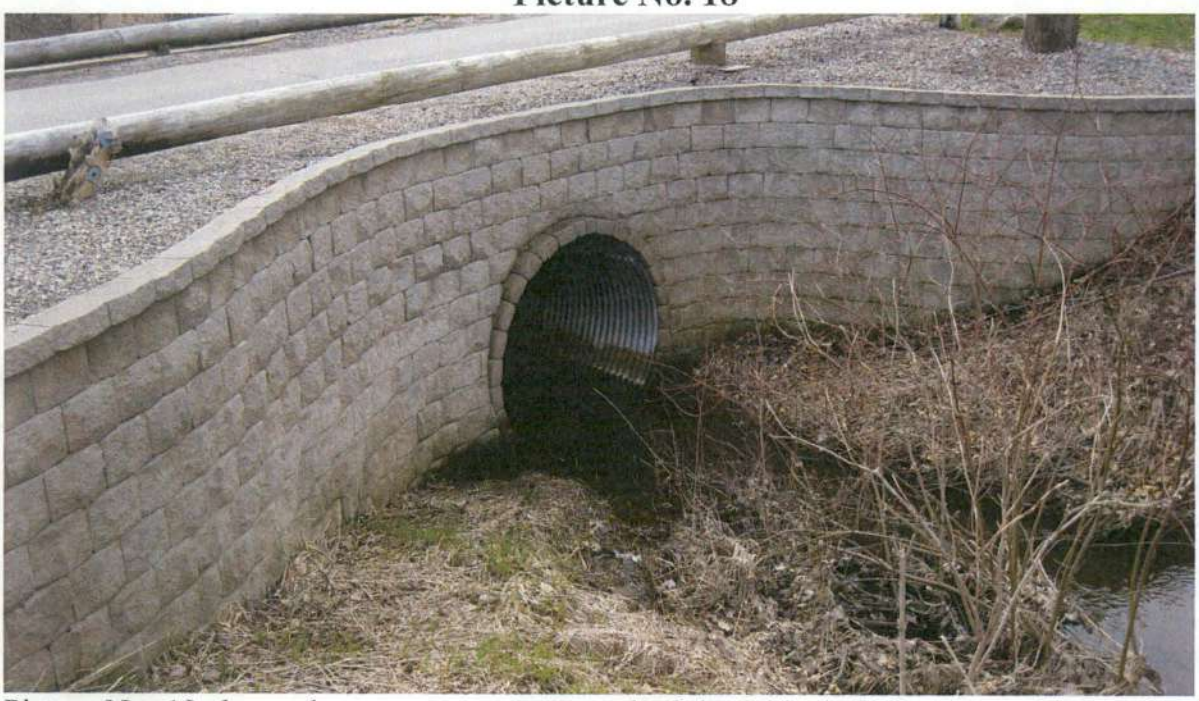
Figure No. 11 – Meadow Valley Crossing Location



Picture No. 17

Picture No. 17 shows the eastern downstream end of the 66-inch CSP culvert under Meadow Valley. Picture is taken looking northwest.

Picture No. 18



Picture No. 18 shows the western upstream end of the 66-inch CSP culvert. Picture is taken looking southeast.

Meadow Valley crossing to Hannah Lake

General pictures from Meadow Valley crossing to Hanna Lake

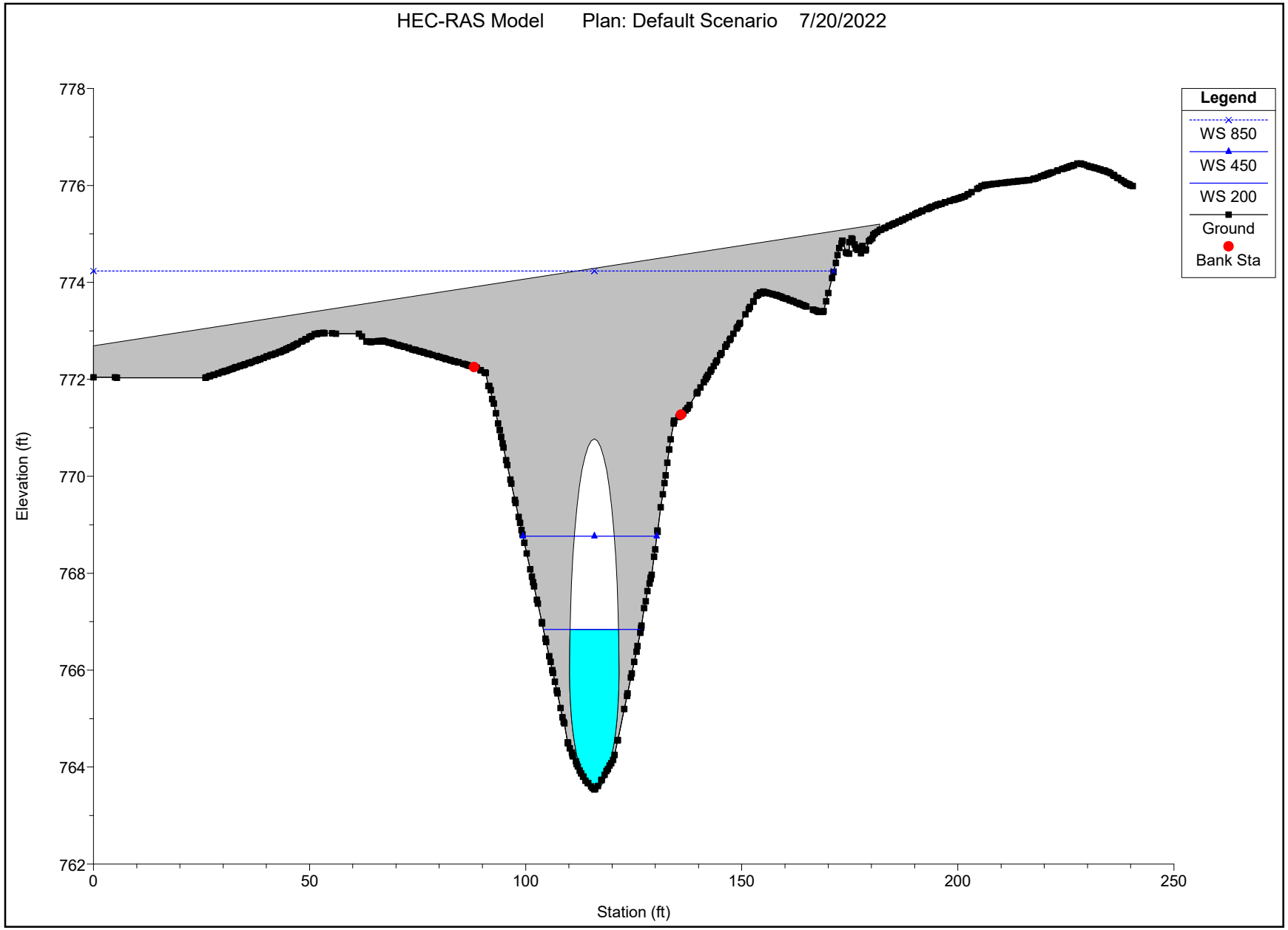


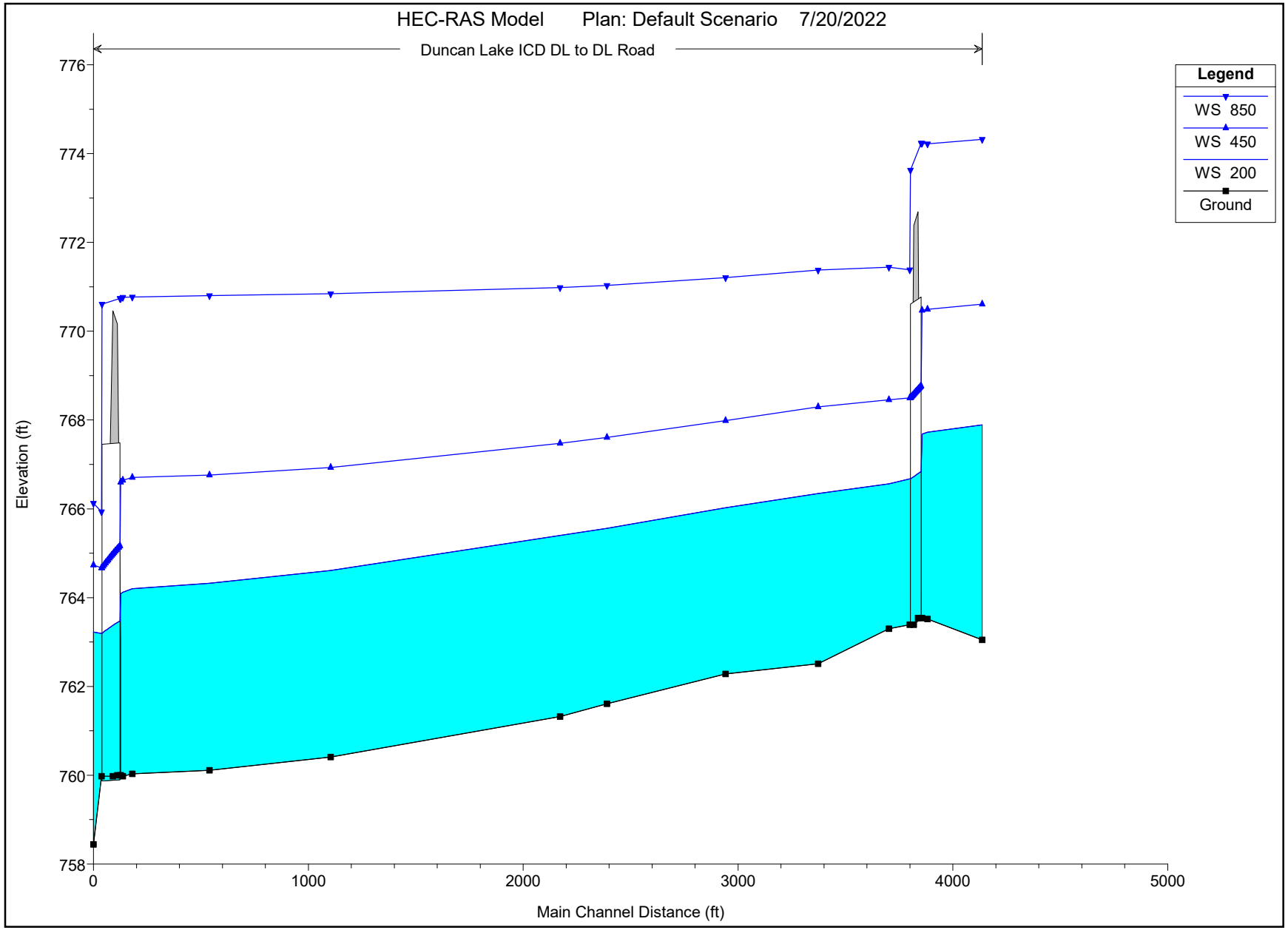





Appendix 3

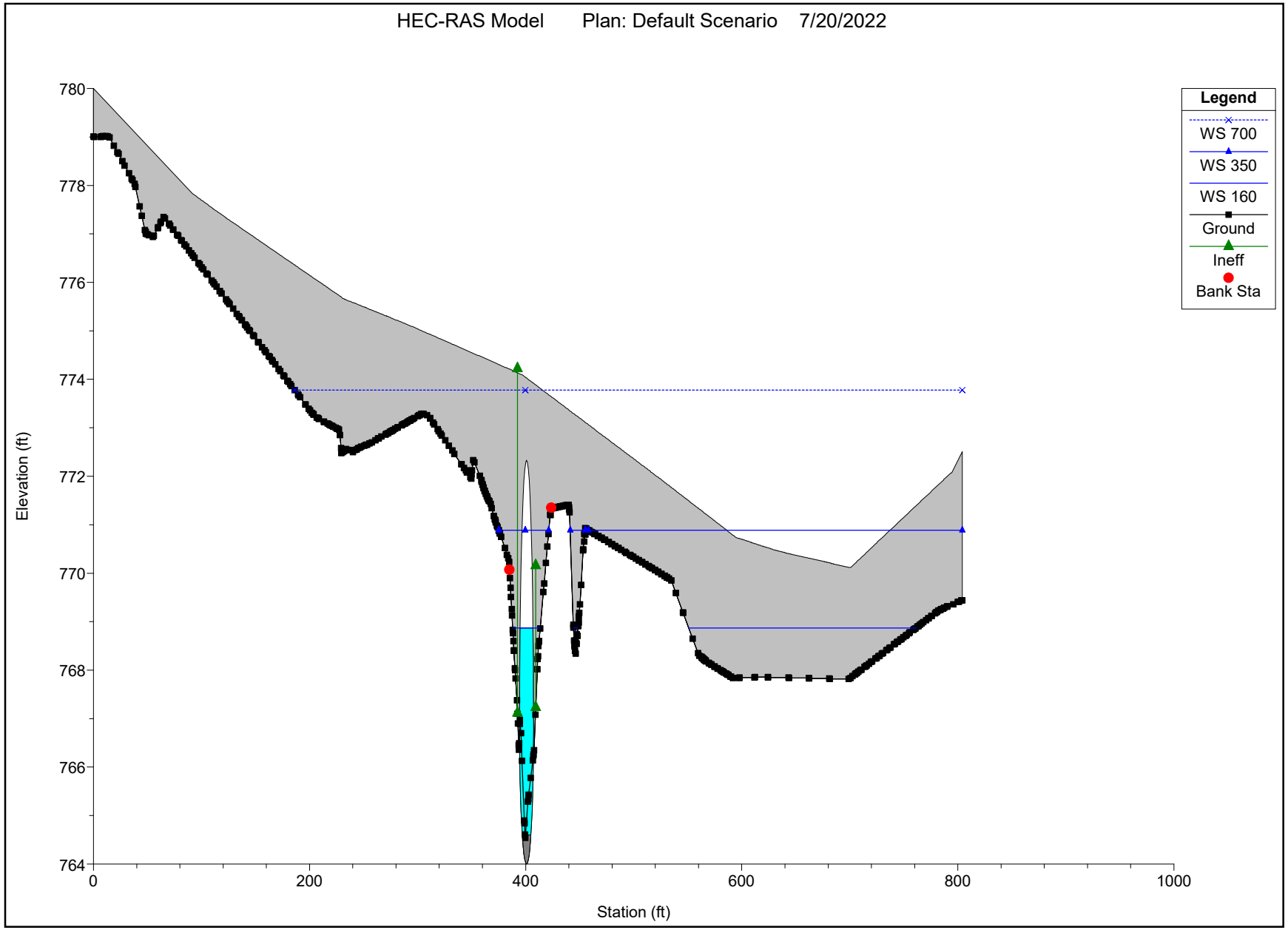
Hydrologic & Hydraulic Calculations

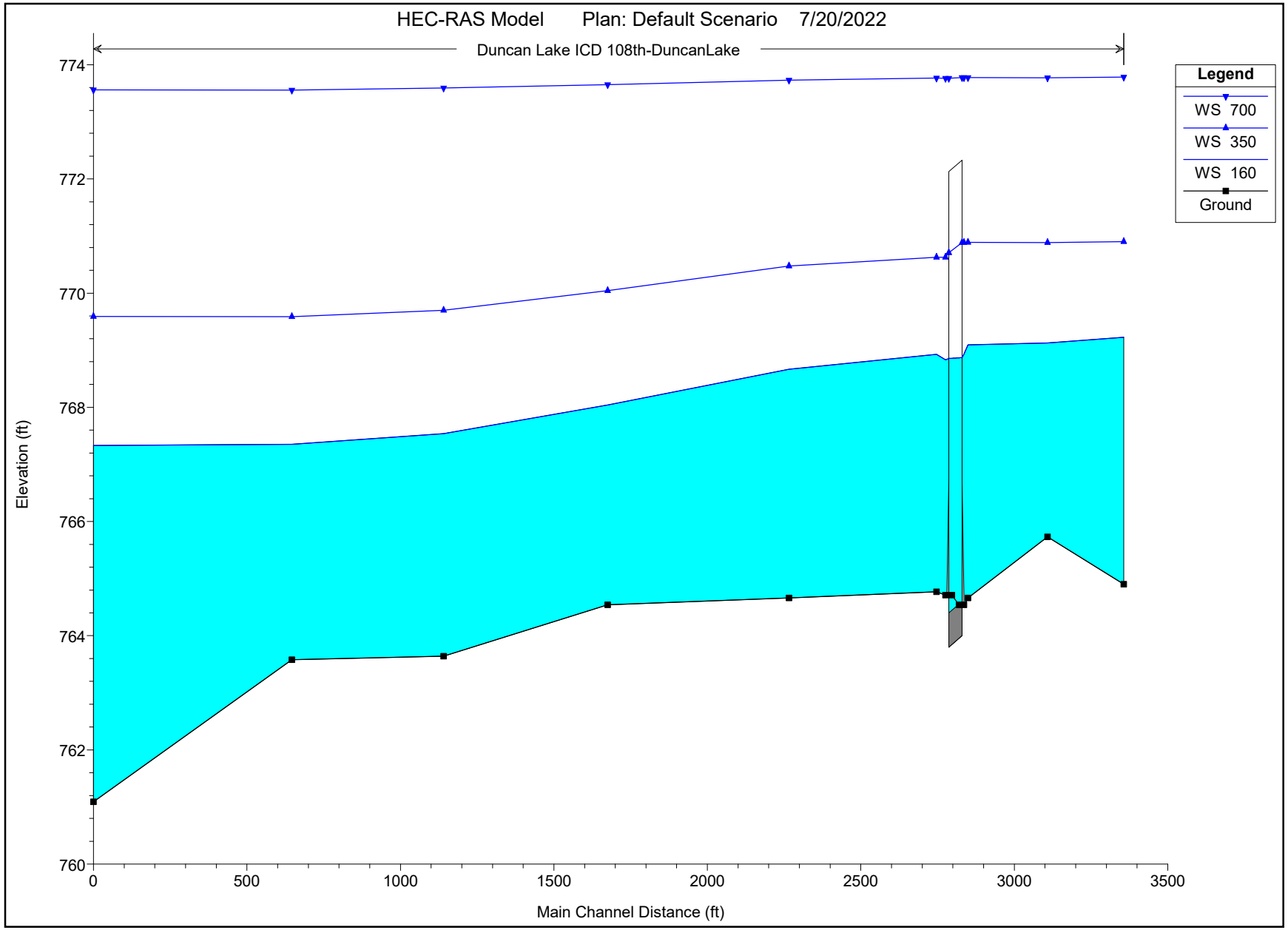

HEC-RAS Model Plan: Default Scenario 7/20/2022
Legend
WS 850
WS 450
WS 200
Ground
Bank Sta
Elevation (ft)
778
776
774
772
770
768
766
764
762
0
50
100
150
200
250
Station (ft)


HEC-RAS Model Plan: Default Scenario 7/20/2022
Duncan Lake ICD DL to DL Road
Legend
WS 850
WS 450
WS 200
Ground
Elevation (ft)
776
774
772
770
768
766
764
762
760
758
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

HEC-RAS Plan: Default Scenario River: Duncan Lake ICD Reach: DL to DL Road

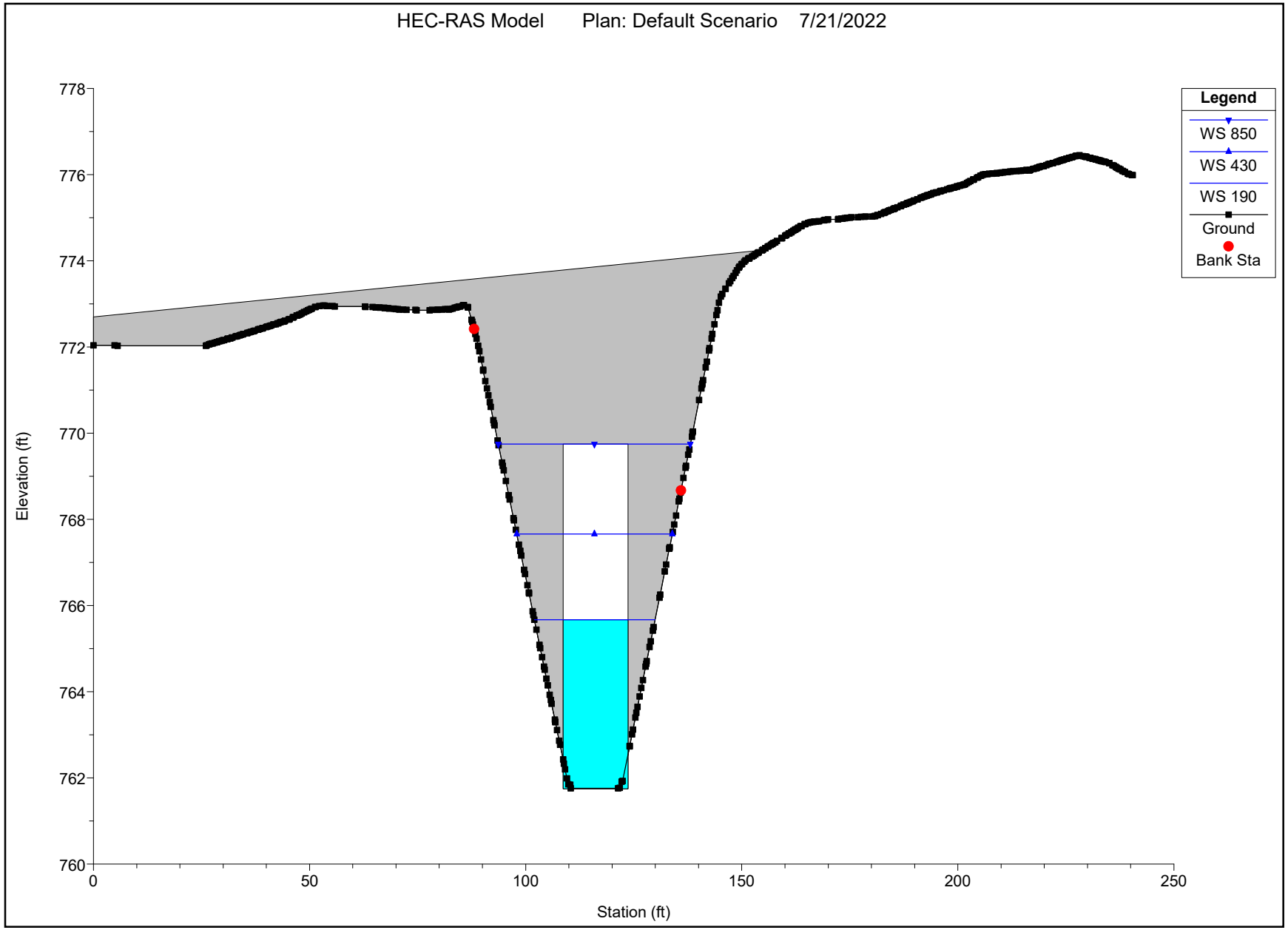
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DL to DL Road	5136	190	190.00	763.05	767.89		767.91	0.000109	1.08	176.69	51.91	0.10
DL to DL Road	5136	430	430.00	763.05	770.99		771.00	0.000052	1.06	558.73	241.58	0.08
DL to DL Road	5136	850	850.00	763.05	774.47		774.48	0.000021	0.91	1399.37	241.58	0.05
DL to DL Road	4881	190	190.00	763.52	767.73		767.84	0.000979	2.68	70.97	26.50	0.29
DL to DL Road	4881	430	430.00	763.52	770.88		770.97	0.000421	2.42	177.41	41.16	0.20
DL to DL Road	4881	850	850.00	763.52	774.36		774.46	0.000216	2.49	391.63	107.12	0.16
DL to DL Road	4856	190	190.00	763.54	767.68	765.90	767.81	0.001163	2.84	66.90	26.32	0.31
DL to DL Road	4856	430	430.00	763.54	770.86	767.06	770.96	0.000453	2.50	171.82	39.55	0.21
DL to DL Road	4856	850	850.00	763.54	774.38	768.40	774.44	0.000172	2.13	553.78	171.75	0.14
DL to DL Road	4826		Culvert									
DL to DL Road	4799	190	190.00	763.39	766.67		766.98	0.003491	4.46	42.61	18.90	0.52
DL to DL Road	4799	430	430.00	763.39	768.73		769.10	0.002421	4.89	87.96	25.18	0.46
DL to DL Road	4799	850	850.00	763.39	771.54		771.85	0.001275	4.54	234.66	122.63	0.36
DL to DL Road	4702	190	190.00	763.30	766.56		766.72	0.001578	3.18	59.80	24.94	0.36
DL to DL Road	4702	430	430.00	763.30	768.70		768.90	0.001114	3.55	121.36	33.15	0.32
DL to DL Road	4702	850	850.00	763.30	771.61		771.72	0.000440	3.03	396.04	134.11	0.22
DL to DL Road	4373	190	190.00	762.51	766.34		766.41	0.000537	2.08	91.54	32.52	0.22
DL to DL Road	4373	430	430.00	762.51	768.55		768.65	0.000444	2.50	172.70	41.26	0.21
DL to DL Road	4373	850	850.00	762.51	771.54		771.61	0.000205	2.40	509.43	161.87	0.16
DL to DL Road	3942	190	190.00	762.28	766.02		766.12	0.000810	2.55	74.49	25.48	0.26
DL to DL Road	3942	430	430.00	762.28	768.25		768.40	0.000732	3.14	137.08	32.96	0.26
DL to DL Road	3942	850	850.00	762.28	771.36		771.49	0.000387	3.03	362.63	130.55	0.20
DL to DL Road	3390	190	190.00	761.61	765.56		765.66	0.000863	2.55	74.39	27.37	0.27
DL to DL Road	3390	430	430.00	761.61	767.88		768.01	0.000659	2.91	147.93	36.02	0.25
DL to DL Road	3390	850	850.00	761.61	771.18		771.30	0.000306	2.84	373.64	128.50	0.19
DL to DL Road	3172	190	190.00	761.32	765.40		765.49	0.000711	2.38	79.82	28.06	0.25
DL to DL Road	3172	430	430.00	761.32	767.76		767.87	0.000576	2.74	156.91	37.66	0.24
DL to DL Road	3172	850	850.00	761.32	771.13		771.23	0.000263	2.60	408.13	127.62	0.17
DL to DL Road	2104	190	190.00	760.41	764.61		764.71	0.000751	2.51	76.92	30.66	0.26
DL to DL Road	2104	430	430.00	760.41	767.25		767.35	0.000420	2.65	203.29	80.29	0.21
DL to DL Road	2104	850	850.00	760.41	770.99		771.03	0.000116	1.97	678.32	154.99	0.12
DL to DL Road	1540	190	190.00	760.11	764.32		764.39	0.000414	2.08	93.23	29.89	0.20
DL to DL Road	1540	430	430.00	760.11	767.10		767.17	0.000225	2.27	266.85	110.13	0.16
DL to DL Road	1540	850	850.00	760.11	770.95		770.98	0.000073	1.79	798.42	159.39	0.10
DL to DL Road	1180	190	190.00	760.03	764.20		764.25	0.000353	1.81	109.24	46.25	0.18
DL to DL Road	1180	430	430.00	760.03	767.04		767.09	0.000160	1.88	279.31	71.23	0.14
DL to DL Road	1180	850	850.00	760.03	770.91		770.95	0.000079	1.84	713.28	156.60	0.10
DL to DL Road	1137	190	190.00	759.98	764.12		764.22	0.000856	2.54	74.75	27.37	0.27
DL to DL Road	1137	430	430.00	759.98	766.99		767.08	0.000415	2.42	190.23	66.64	0.20
DL to DL Road	1137	850	850.00	759.98	770.91		770.95	0.000104	1.86	663.15	145.33	0.11
DL to DL Road	1127	190	190.00	760.00	764.09	762.15	764.21	0.001048	2.82	67.38	24.28	0.30
DL to DL Road	1127	430	430.00	760.00	766.95	763.33	767.07	0.000570	2.83	156.67	47.76	0.24
DL to DL Road	1127	850	850.00	760.00	770.88	764.74	770.94	0.000161	2.24	555.59	148.24	0.14
DL to DL Road	1081		Culvert									
DL to DL Road	1038	190	190.00	759.98	763.20		763.42	0.002379	3.77	50.54	22.91	0.44
DL to DL Road	1038	430	430.00	759.98	764.84		765.17	0.001799	4.71	103.32	41.09	0.42
DL to DL Road	1038	850	850.00	759.98	765.99	764.62	766.63	0.002609	6.73	175.20	106.27	0.53
DL to DL Road	1000	190	190.00	758.44	763.22	761.25	763.33	0.000917	2.64	74.82	33.00	0.28
DL to DL Road	1000	430	430.00	758.44	764.91	762.48	765.08	0.000918	3.38	141.90	46.23	0.30
DL to DL Road	1000	850	850.00	758.44	766.24	763.79	766.44	0.000917	4.09	331.45	167.50	0.31

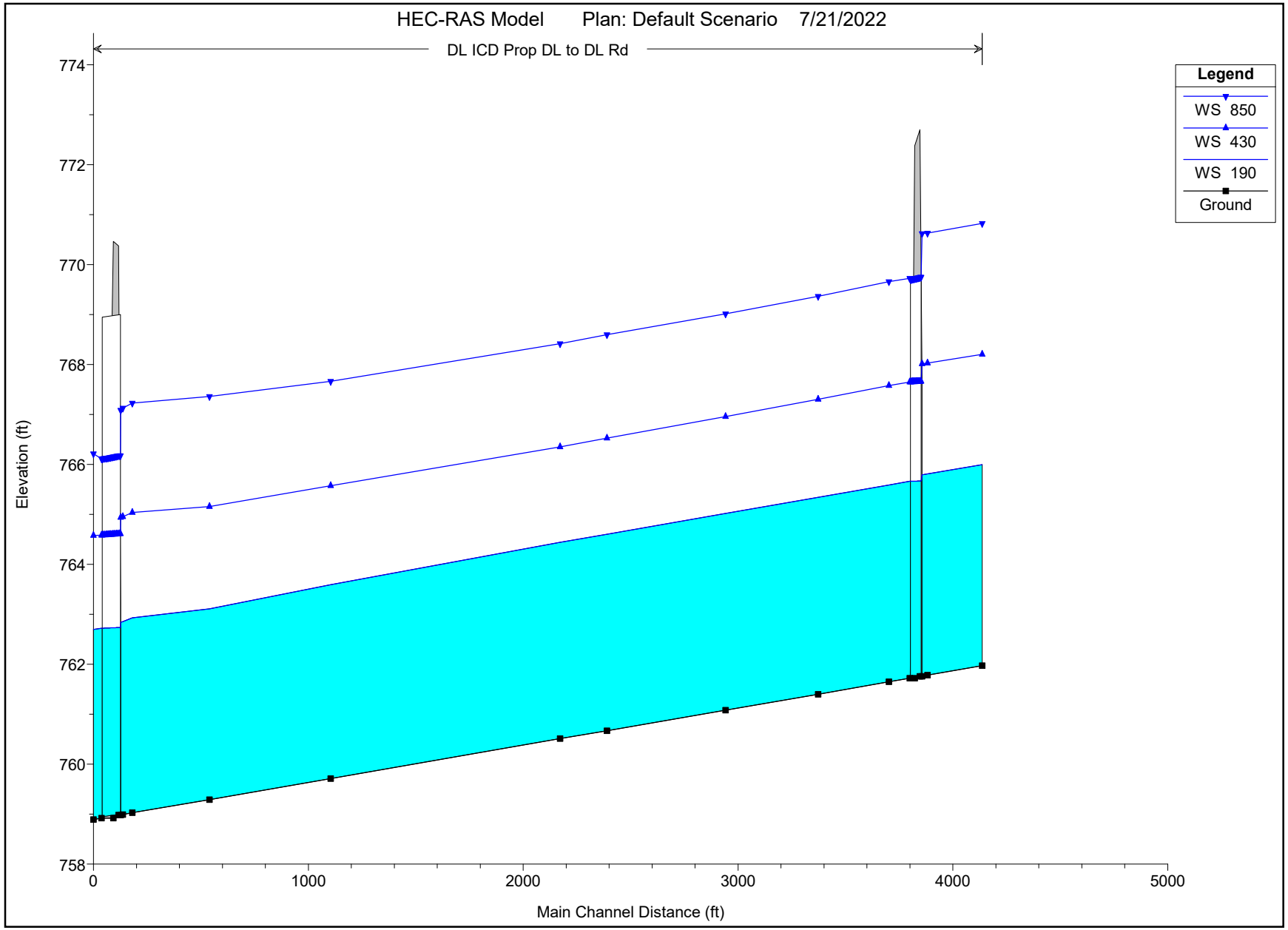

HEC-RAS Model Plan: Default Scenario 7/20/2022
Legend
WS 700
WS 350
WS 160
Ground
Ineff
Bank Sta
Elevation (ft)
780
778
776
774
772
770
768
766
764
0
200
400
600
800
1000
Station (ft)


HEC-RAS Model Plan: Default Scenario 7/20/2022
Duncan Lake ICD 108th-DuncanLake
Legend
WS 700
WS 350
WS 160
Ground
Elevation (ft)
774
772
770
768
766
764
762
760
0
500
1000
1500
2000
2500
3000
3500
Main Channel Distance (ft)

HEC-RAS Plan: Default Scenario River: Duncan Lake ICD Reach: 108th-DuncanLake

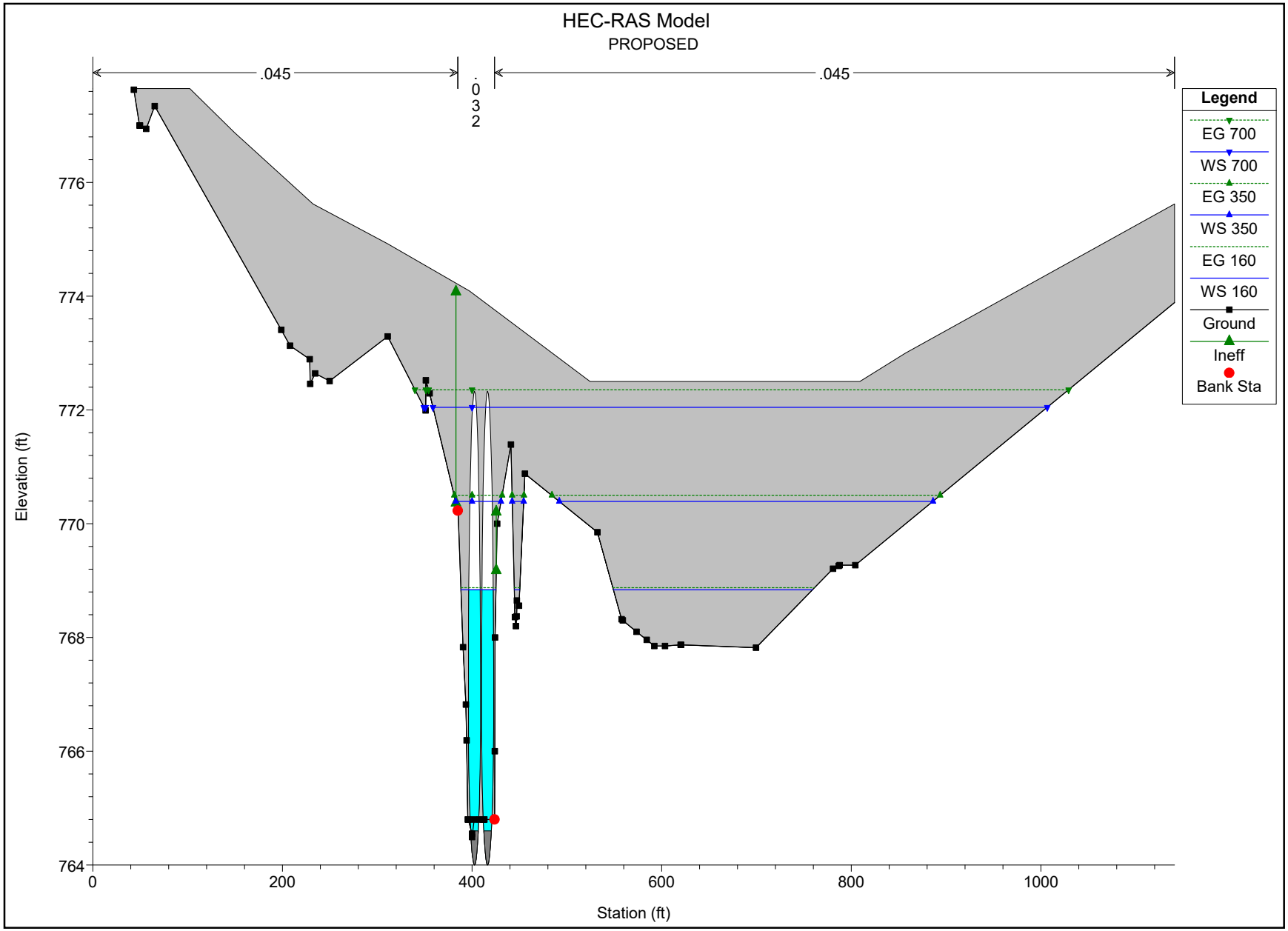
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
108th-DuncanLake	13382	160	160.00	764.90	769.23		769.35	0.001114	2.80	57.10	22.04	0.30
108th-DuncanLake	13382	350	350.00	764.90	770.90		771.04	0.000879	3.17	148.75	92.49	0.28
108th-DuncanLake	13382	700	700.00	764.90	773.78		773.82	0.000171	1.93	605.53	200.00	0.14
108th-DuncanLake	13134	160	160.00	765.73	769.13		769.17	0.000410	1.72	111.12	87.93	0.19
108th-DuncanLake	13134	350	350.00	765.73	770.89		770.91	0.000200	1.55	311.84	123.52	0.14
108th-DuncanLake	13134	700	700.00	765.73	773.77		773.79	0.000065	1.26	827.82	200.00	0.09
108th-DuncanLake	12875	160	160.00	764.66	769.09		769.10	0.000135	1.02	308.30	328.99	0.11
108th-DuncanLake	12875	350	350.00	764.66	770.89		770.89	0.000029	0.61	994.33	411.75	0.05
108th-DuncanLake	12875	700	700.00	764.66	773.78		773.78	0.000009	0.47	2269.45	513.92	0.03
108th-DuncanLake	12861	160	160.00	764.54	768.93	767.31	769.09	0.001145	3.12	51.29	245.28	0.32
108th-DuncanLake	12861	350	350.00	764.54	770.89	768.28	770.89	0.000047	0.71	853.83	406.56	0.07
108th-DuncanLake	12861	700	700.00	764.54	773.78	769.66	773.78	0.000012	0.52	2034.70	617.86	0.04
108th-DuncanLake	12838		Culvert									
108th-DuncanLake	12801	160	160.00	764.71	768.83	767.08	768.99	0.001112	3.16	50.67	331.00	0.32
108th-DuncanLake	12801	350	350.00	764.71	770.63	768.15	770.63	0.000036	0.74	941.81	422.81	0.06
108th-DuncanLake	12801	700	700.00	764.71	773.77	769.59	773.77	0.000009	0.53	2205.97	679.42	0.03
108th-DuncanLake	12772	160	160.00	764.77	768.93		768.94	0.000154	0.93	323.04	337.47	0.11
108th-DuncanLake	12772	350	350.00	764.77	770.63		770.63	0.000032	0.61	1011.93	519.95	0.06
108th-DuncanLake	12772	700	700.00	764.77	773.77		773.77	0.000006	0.40	2976.03	699.01	0.03
108th-DuncanLake	12291	160	160.00	764.66	768.67		768.77	0.001140	2.52	63.62	29.86	0.30
108th-DuncanLake	12291	350	350.00	764.66	770.48		770.58	0.000735	2.62	158.17	115.13	0.26
108th-DuncanLake	12291	700	700.00	764.66	773.73		773.76	0.000105	1.56	688.12	200.00	0.11
108th-DuncanLake	11701	160	160.00	764.54	768.04		768.13	0.001000	2.42	66.09	28.32	0.28
108th-DuncanLake	11701	350	350.00	764.54	770.04		770.16	0.000695	2.67	131.65	52.92	0.25
108th-DuncanLake	11701	700	700.00	764.54	773.65		773.69	0.000134	1.77	574.77	197.00	0.12
108th-DuncanLake	11166	160	160.00	763.64	767.54		767.64	0.000865	2.50	64.07	24.09	0.27
108th-DuncanLake	11166	350	350.00	763.64	769.70		769.81	0.000609	2.69	153.73	86.77	0.24
108th-DuncanLake	11166	700	700.00	763.64	773.59		773.62	0.000102	1.56	666.75	200.00	0.11
108th-DuncanLake	10672	160	160.00	763.58	767.35		767.38	0.000295	1.47	108.92	42.50	0.16
108th-DuncanLake	10672	350	350.00	763.58	769.59		769.63	0.000195	1.63	214.72	51.69	0.14
108th-DuncanLake	10672	700	700.00	763.58	773.56		773.58	0.000062	1.32	660.91	134.84	0.09
108th-DuncanLake	10026	160	160.00	761.09	767.33	763.53	767.33	0.000027	0.60	413.94	200.00	0.05
108th-DuncanLake	10026	350	350.00	761.09	769.59	764.37	769.59	0.000016	0.63	865.95	200.00	0.04
108th-DuncanLake	10026	700	700.00	761.09	773.56	764.90	773.56	0.000009	0.63	1659.94	200.00	0.03


HEC-RAS Model Plan: Default Scenario 7/21/2022
Legend
WS 850
WS 430
WS 190
Ground
Bank Sta
Elevation (ft)
Station (ft)
778
776
774
772
770
768
766
764
762
760
0
50
100
150
200
250

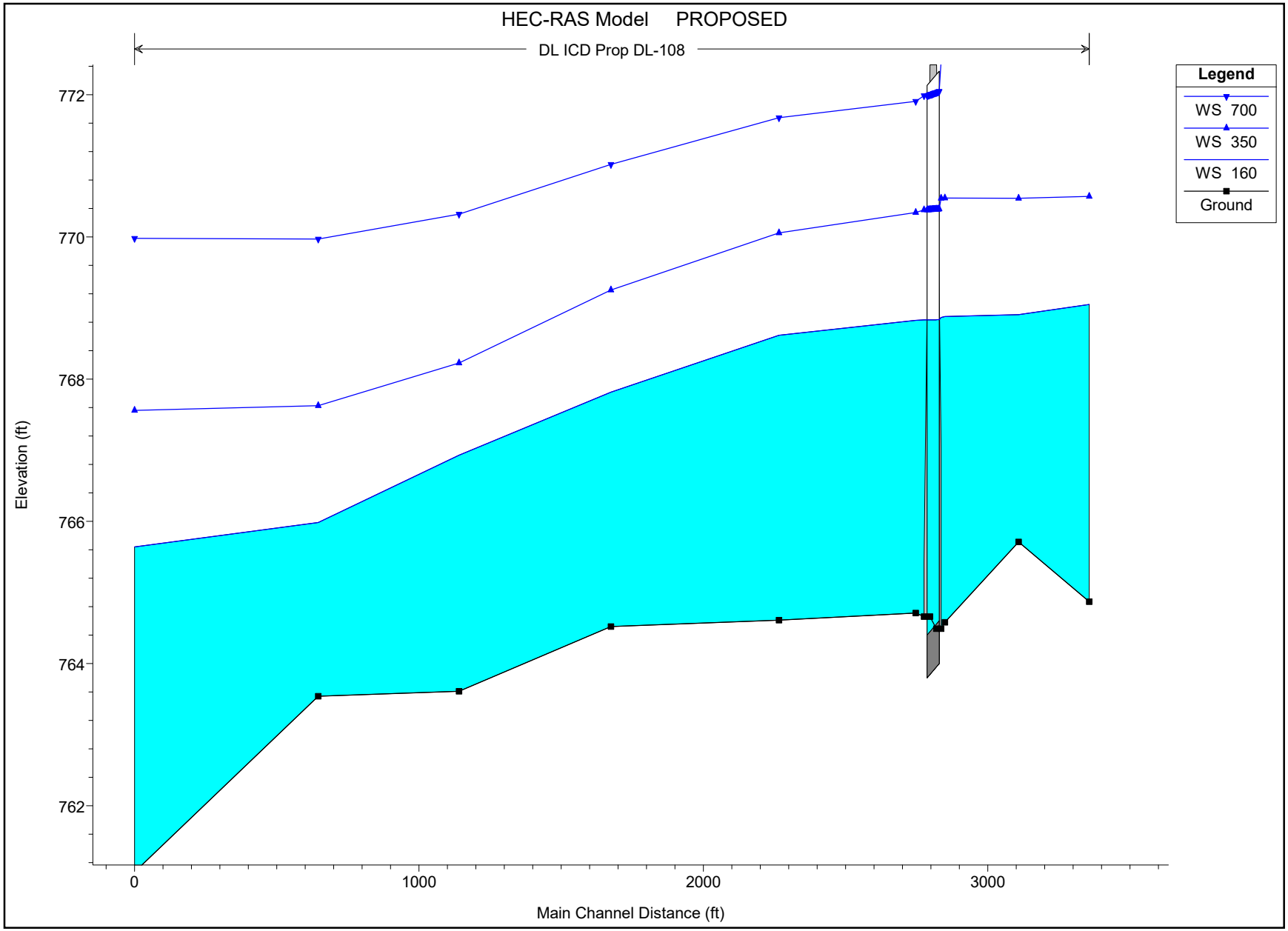

HEC-RAS Model Plan: Default Scenario 7/21/2022
DL ICD Prop DL to DL Rd
Legend
WS 850
WS 430
WS 190
Ground
Elevation (ft)
774
772
770
768
766
764
762
760
758
0
1000
2000
3000
4000
5000
Main Channel Distance (ft)

HEC-RAS Plan: Default Scenario River: DL ICD Prop Reach: DL to DL Rd

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DL to DL Rd	5136	190	190.00	761.97	766.00		766.06	0.000579	1.99	95.33	38.43	0.22
DL to DL Rd	5136	430	430.00	761.97	768.20		768.28	0.000416	2.23	192.66	50.77	0.20
DL to DL Rd	5136	850	850.00	761.97	770.82		770.89	0.000240	2.23	518.90	241.58	0.16
DL to DL Rd	4881	190	190.00	761.78	765.81		765.90	0.000687	2.35	80.74	28.12	0.24
DL to DL Rd	4881	430	430.00	761.78	768.03		768.15	0.000603	2.81	152.96	37.00	0.24
DL to DL Rd	4881	850	850.00	761.78	770.63		770.80	0.000507	3.31	262.78	47.41	0.24
DL to DL Rd	4856	190	190.00	761.76	765.79	763.53	765.88	0.000670	2.33	81.65	28.43	0.24
DL to DL Rd	4856	430	430.00	761.76	768.01	764.63	768.13	0.000596	2.78	154.75	37.41	0.24
DL to DL Rd	4856	850	850.00	761.76	770.62	765.96	770.78	0.000499	3.23	266.06	47.96	0.23
DL to DL Rd	4823		Culvert									
DL to DL Rd	4799	190	190.00	761.72	765.66		765.75	0.000746	2.43	78.34	27.77	0.25
DL to DL Rd	4799	430	430.00	761.72	767.65		767.80	0.000724	3.05	141.45	35.71	0.27
DL to DL Rd	4799	850	850.00	761.72	769.73		769.96	0.000742	3.90	224.25	44.03	0.28
DL to DL Rd	4702	190	190.00	761.65	765.59		765.68	0.000747	2.43	78.24	27.75	0.25
DL to DL Rd	4702	430	430.00	761.65	767.58		767.72	0.000734	3.04	141.42	35.72	0.27
DL to DL Rd	4702	850	850.00	761.65	769.66		769.89	0.000724	3.86	237.75	79.11	0.28
DL to DL Rd	4373	190	190.00	761.40	765.34		765.43	0.000751	2.47	77.02	26.35	0.25
DL to DL Rd	4373	430	430.00	761.40	767.30		767.46	0.000868	3.20	134.58	32.83	0.28
DL to DL Rd	4373	850	850.00	761.40	769.36		769.61	0.000961	4.01	222.04	80.95	0.31
DL to DL Rd	3942	190	190.00	761.08	765.02		765.11	0.000751	2.43	78.11	27.73	0.26
DL to DL Rd	3942	430	430.00	761.08	766.96		767.11	0.000767	3.09	139.44	35.49	0.27
DL to DL Rd	3942	850	850.00	761.08	769.01		769.25	0.000727	3.95	234.29	72.14	0.28
DL to DL Rd	3390	190	190.00	760.67	764.60		764.69	0.000752	2.43	78.06	27.72	0.26
DL to DL Rd	3390	430	430.00	760.67	766.52		766.67	0.000796	3.10	138.75	35.42	0.28
DL to DL Rd	3390	850	850.00	760.67	768.60		768.83	0.000790	3.89	220.75	43.72	0.29
DL to DL Rd	3172	190	190.00	760.51	764.44		764.53	0.000755	2.44	77.97	27.72	0.26
DL to DL Rd	3172	430	430.00	760.51	766.35		766.50	0.000805	3.11	138.22	35.37	0.28
DL to DL Rd	3172	850	850.00	760.51	768.42		768.65	0.000866	3.87	219.94	43.63	0.30
DL to DL Rd	2104	190	190.00	759.71	763.59		763.69	0.000824	2.52	75.52	27.62	0.27
DL to DL Rd	2104	430	430.00	759.71	765.57		765.72	0.000669	3.11	149.71	45.31	0.26
DL to DL Rd	2104	850	850.00	759.71	767.66		767.87	0.000615	3.85	290.71	101.26	0.27
DL to DL Rd	1540	190	190.00	759.29	763.11		763.21	0.000857	2.63	72.29	24.98	0.27
DL to DL Rd	1540	430	430.00	759.29	765.16		765.32	0.000725	3.33	143.19	51.88	0.27
DL to DL Rd	1540	850	850.00	759.29	767.36		767.54	0.000539	3.70	337.15	114.51	0.25
DL to DL Rd	1180	190	190.00	759.03	762.93		762.99	0.000428	1.92	99.78	36.74	0.20
DL to DL Rd	1180	430	430.00	759.03	765.04		765.13	0.000335	2.44	192.43	51.06	0.19
DL to DL Rd	1180	850	850.00	759.03	767.23		767.37	0.000350	3.17	317.72	65.86	0.21
DL to DL Rd	1137	190	190.00	758.99	762.85		762.96	0.000924	2.61	72.80	27.13	0.28
DL to DL Rd	1137	430	430.00	758.99	764.95		765.10	0.000767	3.11	140.35	37.58	0.27
DL to DL Rd	1137	850	850.00	758.99	767.13		767.34	0.000720	3.76	243.72	68.12	0.28
DL to DL Rd	1127	190	190.00	758.98	762.84	760.85	762.95	0.000929	2.63	72.11	26.63	0.28
DL to DL Rd	1127	430	430.00	758.98	764.94	761.98	765.09	0.000764	3.19	136.96	35.23	0.27
DL to DL Rd	1127	850	850.00	758.98	767.09	763.34	767.33	0.000799	4.01	223.00	47.71	0.29
DL to DL Rd	1083		Culvert									
DL to DL Rd	1038	190	190.00	758.92	762.72		762.83	0.000758	2.67	73.76	27.02	0.26
DL to DL Rd	1038	430	430.00	758.92	764.58		764.78	0.000767	3.65	131.48	35.25	0.29
DL to DL Rd	1038	850	850.00	758.92	766.11		766.49	0.001096	5.20	221.90	118.06	0.36
DL to DL Rd	1000	190	190.00	758.89	762.70	760.66	762.80	0.000777	2.60	75.51	29.34	0.26
DL to DL Rd	1000	430	430.00	758.89	764.58	761.74	764.74	0.000778	3.32	144.46	43.16	0.28
DL to DL Rd	1000	850	850.00	758.89	766.21	763.16	766.40	0.000777	3.92	342.48	165.32	0.29



1 in Horiz. = 150 ft 1 in Vert. = 2.5 ft



1 in Horiz. = 500 ft 1 in Vert. = 2 ft

HEC-RAS Plan: DL-DL Road River: DL ICD Prop Reach: DL-108

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
DL-108	13382	160	160.00	764.87	769.05		769.18	0.001215	2.93	54.70	20.37	0.31
DL-108	13382	350	350.00	764.87	770.57		770.76	0.001190	3.63	122.86	73.47	0.33
DL-108	13382	700	700.00	764.87	772.52		772.62	0.000577	3.07	361.77	178.71	0.24
DL-108	13134	160	160.00	765.71	768.91		768.97	0.000552	1.92	93.82	71.66	0.22
DL-108	13134	350	350.00	765.71	770.54		770.58	0.000297	1.82	268.18	122.27	0.17
DL-108	13134	700	700.00	765.71	772.49		772.53	0.000172	1.77	573.04	183.06	0.14
DL-108	12875	160	160.00	764.58	768.88		768.90	0.000118	1.07	270.64	292.14	0.10
DL-108	12875	350	350.00	764.58	770.55		770.55	0.000037	0.74	960.44	508.01	0.06
DL-108	12875	700	700.00	764.58	772.50		772.51	0.000018	0.62	2123.80	687.72	0.04
DL-108	12861	160	160.00	764.49	768.87	765.76	768.89	0.000139	1.25	129.12	254.96	0.12
DL-108	12861	350	350.00	764.49	770.55	766.44	770.55	0.000038	0.80	899.26	481.08	0.06
DL-108	12861	700	700.00	764.49	772.50	767.41	772.51	0.000019	0.71	2037.18	706.01	0.05
DL-108	12838		Culvert									
DL-108	12801	160	160.00	764.66	768.83	765.77	768.85	0.000112	1.03	183.67	352.30	0.10
DL-108	12801	350	350.00	764.66	770.38	766.39	770.38	0.000027	0.62	1063.05	466.55	0.05
DL-108	12801	700	700.00	764.66	771.99	767.22	771.99	0.000021	0.68	1855.99	687.92	0.05
DL-108	12772	160	160.00	764.71	768.83		768.84	0.000092	1.00	160.63	346.32	0.10
DL-108	12772	350	350.00	764.71	770.34		770.38	0.000143	1.48	237.15	490.16	0.12
DL-108	12772	700	700.00	764.71	771.91		771.98	0.000209	2.17	322.68	698.31	0.16
DL-108	12291	160	160.00	764.61	768.62		768.72	0.001256	2.60	61.54	29.53	0.32
DL-108	12291	350	350.00	764.61	770.06		770.21	0.001222	3.16	112.75	74.32	0.33
DL-108	12291	700	700.00	764.61	771.68		771.81	0.000736	3.16	294.95	116.44	0.27
DL-108	11701	160	160.00	764.52	767.82		767.93	0.001429	2.74	58.45	27.26	0.33
DL-108	11701	350	350.00	764.52	769.25		769.44	0.001408	3.44	101.88	33.23	0.35
DL-108	11701	700	700.00	764.52	771.02		771.25	0.001192	3.95	216.27	115.17	0.34
DL-108	11166	160	160.00	763.61	766.93		767.09	0.001726	3.19	50.14	22.07	0.37
DL-108	11166	350	350.00	763.61	768.23		768.52	0.002113	4.29	81.59	26.41	0.43
DL-108	11166	700	700.00	763.61	770.32		770.57	0.001355	4.25	213.94	98.83	0.36
DL-108	10672	160	160.00	763.54	765.98		766.11	0.002229	2.89	55.35	36.04	0.41
DL-108	10672	350	350.00	763.54	767.63		767.76	0.001039	2.89	120.96	43.82	0.31
DL-108	10672	700	700.00	763.54	769.97		770.11	0.000603	2.98	234.84	53.23	0.25
DL-108	10026	160	160.00	761.07	765.64	763.53	765.67	0.000302	1.45	153.89	113.44	0.16
DL-108	10026	350	350.00	761.07	767.56	764.37	767.57	0.000098	1.19	460.72	200.00	0.10
DL-108	10026	700	700.00	761.07	769.98	765.51	769.99	0.000050	1.14	944.72	200.00	0.08

Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 0.66" for 2-yr event
Inflow = 329.34 cfs @ 18.98 hrs, Volume= 561.021 af
Outflow = 86.16 cfs @ 42.09 hrs, Volume= 379.641 af, Atten= 74%, Lag= 1,386.3 min
Primary = 86.16 cfs @ 42.09 hrs, Volume= 379.641 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 766.28' @ 42.09 hrs Surf.Area= 148.203 ac Storage= 3,973.000 af (368.212 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,539.4 min (3,226.3 - 1,686.9)

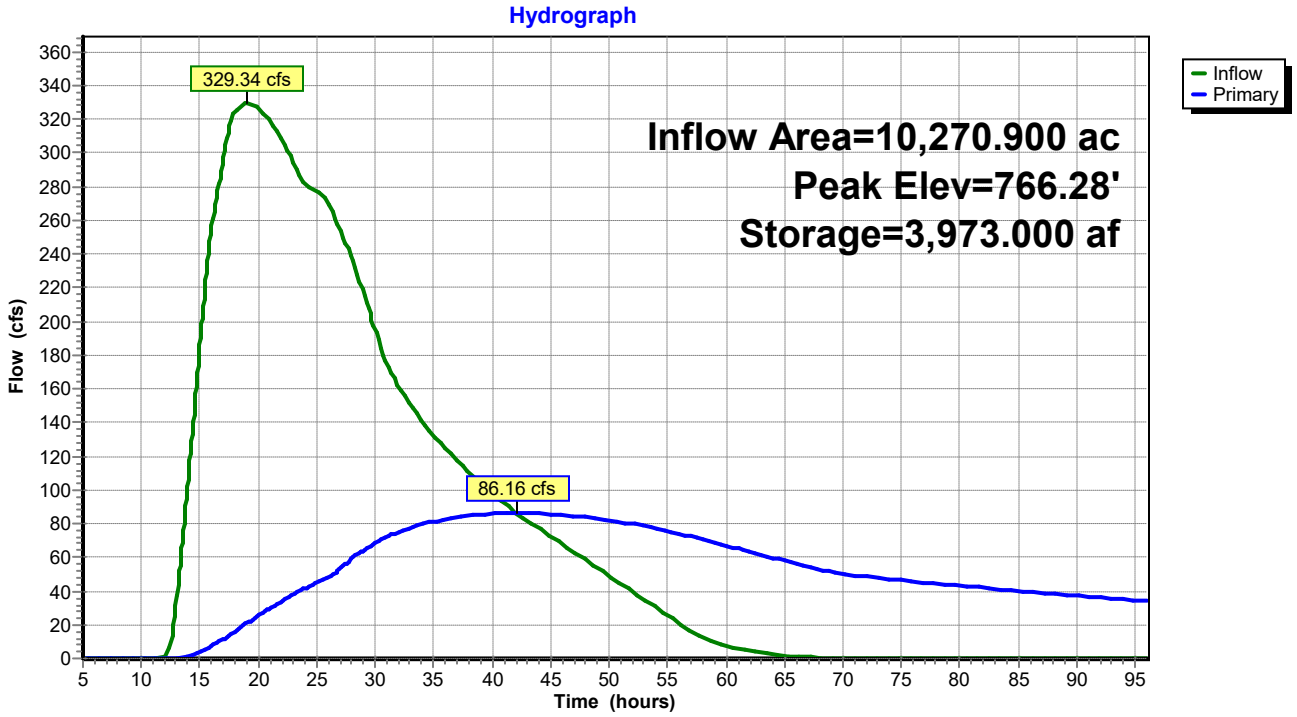
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,503.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	169.500	169.750	4,576.250
771.00	281.000	225.250	4,801.500
772.00	355.400	318.200	5,119.700
773.00	412.800	384.100	5,503.800

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=86.16 cfs @ 42.09 hrs HW=766.28' (Free Discharge)
1=Special & User-Defined (Custom Controls 86.16 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 1.42" for 10-yr event
Inflow = 723.08 cfs @ 18.74 hrs, Volume= 1,216.379 af
Outflow = 235.52 cfs @ 38.31 hrs, Volume= 942.674 af, Atten= 67%, Lag= 1,174.2 min
Primary = 235.52 cfs @ 38.31 hrs, Volume= 942.674 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 768.49' @ 38.31 hrs Surf.Area= 165.911 ac Storage= 4,320.655 af (715.867 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,358.5 min (3,034.2 - 1,675.8)

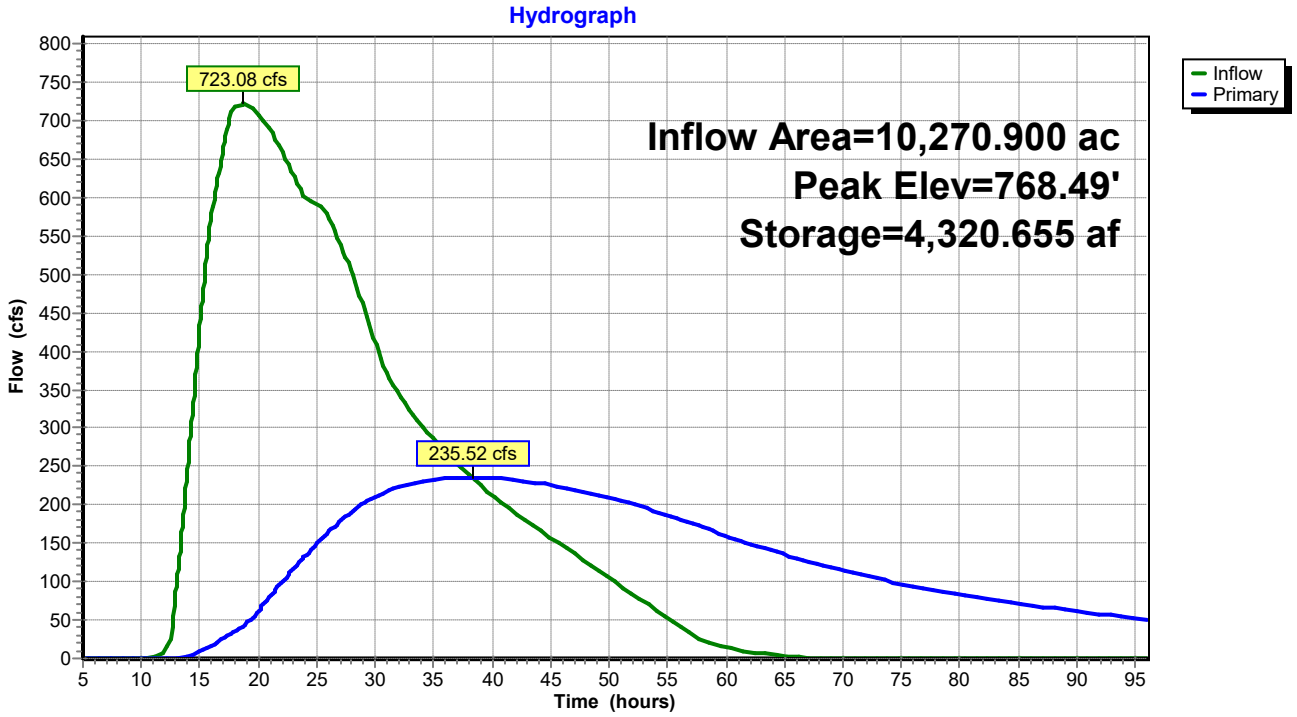
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,503.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	169.500	169.750	4,576.250
771.00	281.000	225.250	4,801.500
772.00	355.400	318.200	5,119.700
773.00	412.800	384.100	5,503.800

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=235.52 cfs @ 38.31 hrs HW=768.49' (Free Discharge)
1=Special & User-Defined (Custom Controls 235.52 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 3.36" for 100-yr event
Inflow = 1,722.10 cfs @ 17.76 hrs, Volume= 2,874.517 af
Outflow = 537.20 cfs @ 38.90 hrs, Volume= 2,412.223 af, Atten= 69%, Lag= 1,267.9 min
Primary = 537.20 cfs @ 38.90 hrs, Volume= 2,412.223 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 772.32' @ 38.90 hrs Surf.Area= 373.698 ac Storage= 5,235.908 af (1,631.120 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,373.1 min (3,035.5 - 1,662.4)

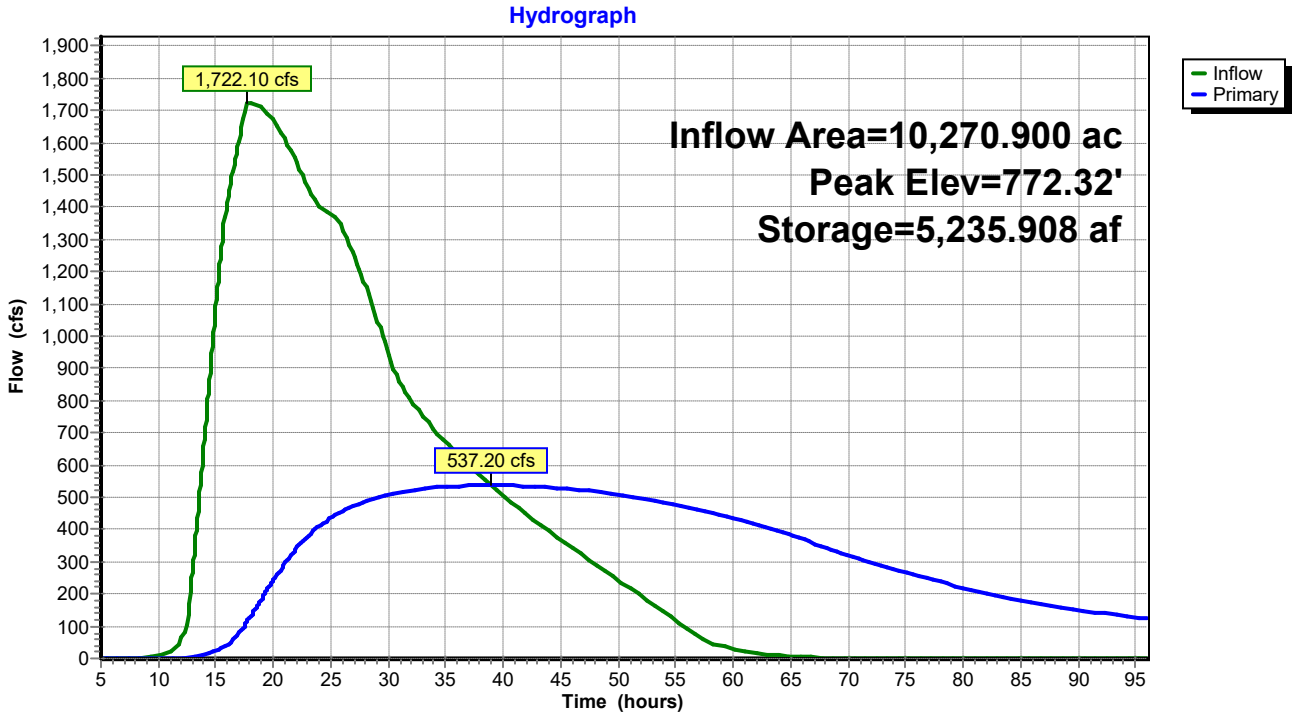
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,503.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	169.500	169.750	4,576.250
771.00	281.000	225.250	4,801.500
772.00	355.400	318.200	5,119.700
773.00	412.800	384.100	5,503.800

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=537.20 cfs @ 38.90 hrs HW=772.32' (Free Discharge)
1=Special & User-Defined (Custom Controls 537.20 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 0.66" for 2-yr event
Inflow = 329.34 cfs @ 18.98 hrs, Volume= 561.021 af
Outflow = 137.57 cfs @ 34.34 hrs, Volume= 596.247 af, Atten= 58%, Lag= 921.7 min
Primary = 137.57 cfs @ 34.34 hrs, Volume= 596.247 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 765.33' @ 34.34 hrs Surf.Area= 140.648 ac Storage= 3,836.623 af (231.835 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,113.5 min (2,800.4 - 1,686.9)

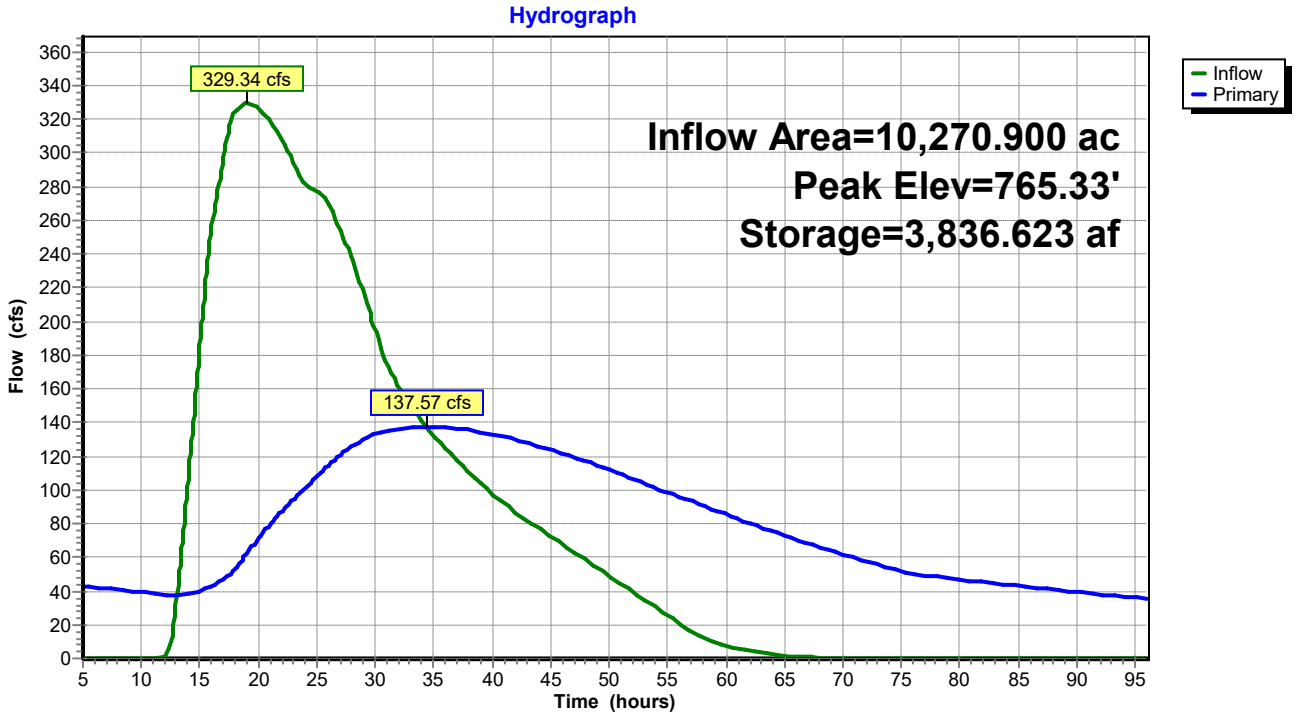
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,533.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	199.500	184.750	4,591.250
771.00	281.000	240.250	4,831.500
772.00	355.400	318.200	5,149.700
773.00	412.800	384.100	5,533.800

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=137.57 cfs @ 34.34 hrs HW=765.33' (Free Discharge)
↑**1=Special & User-Defined** (Custom Controls 137.57 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 1.42" for 10-yr event
Inflow = 723.08 cfs @ 18.74 hrs, Volume= 1,216.379 af
Outflow = 324.93 cfs @ 32.88 hrs, Volume= 1,195.522 af, Atten= 55%, Lag= 848.4 min
Primary = 324.93 cfs @ 32.88 hrs, Volume= 1,195.522 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 767.34' @ 32.88 hrs Surf.Area= 156.742 ac Storage= 4,135.756 af (530.968 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,053.2 min (2,729.0 - 1,675.8)

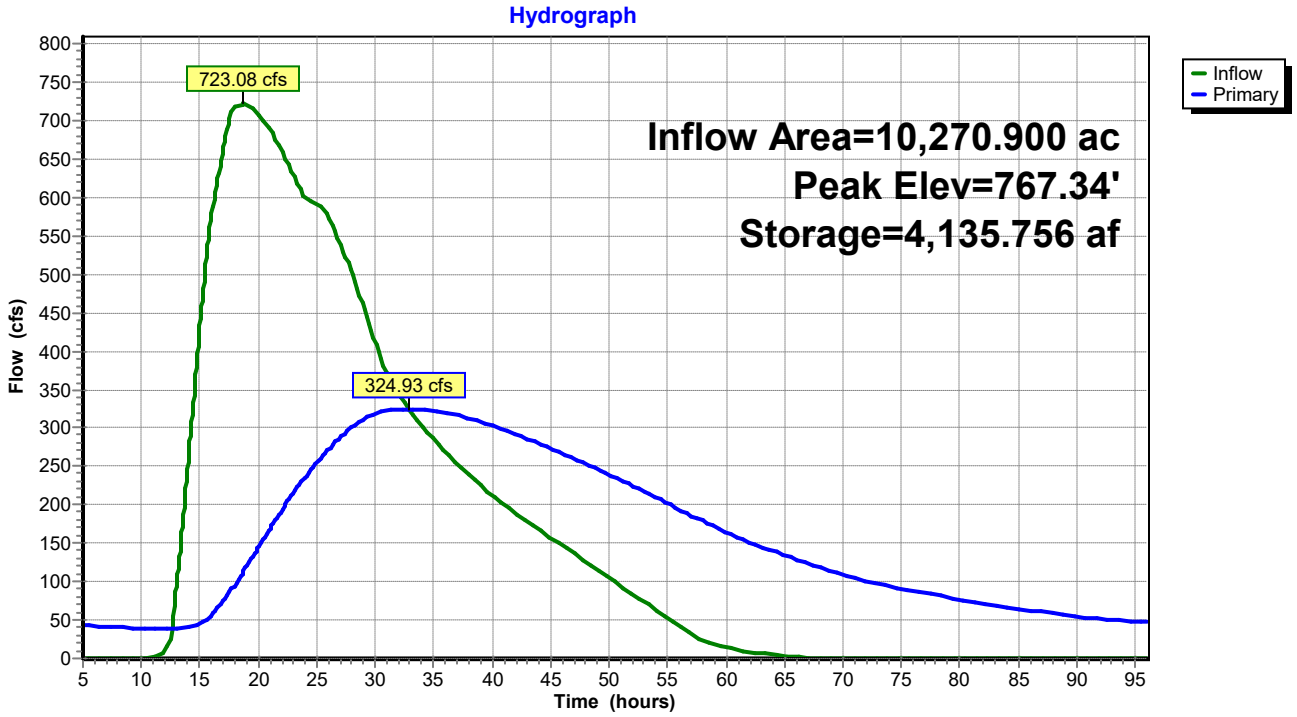
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,533.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	199.500	184.750	4,591.250
771.00	281.000	240.250	4,831.500
772.00	355.400	318.200	5,149.700
773.00	412.800	384.100	5,533.800

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=324.93 cfs @ 32.88 hrs HW=767.34' (Free Discharge)
↑**1=Special & User-Defined** (Custom Controls 324.93 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 3.36" for 100-yr event
Inflow = 1,722.10 cfs @ 17.76 hrs, Volume= 2,874.517 af
Outflow = 856.47 cfs @ 31.00 hrs, Volume= 2,789.296 af, Atten= 50%, Lag= 794.1 min
Primary = 856.47 cfs @ 31.00 hrs, Volume= 2,789.296 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 770.86' @ 31.00 hrs Surf.Area= 269.703 ac Storage= 4,793.333 af (1,188.545 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 927.2 min (2,589.7 - 1,662.4)

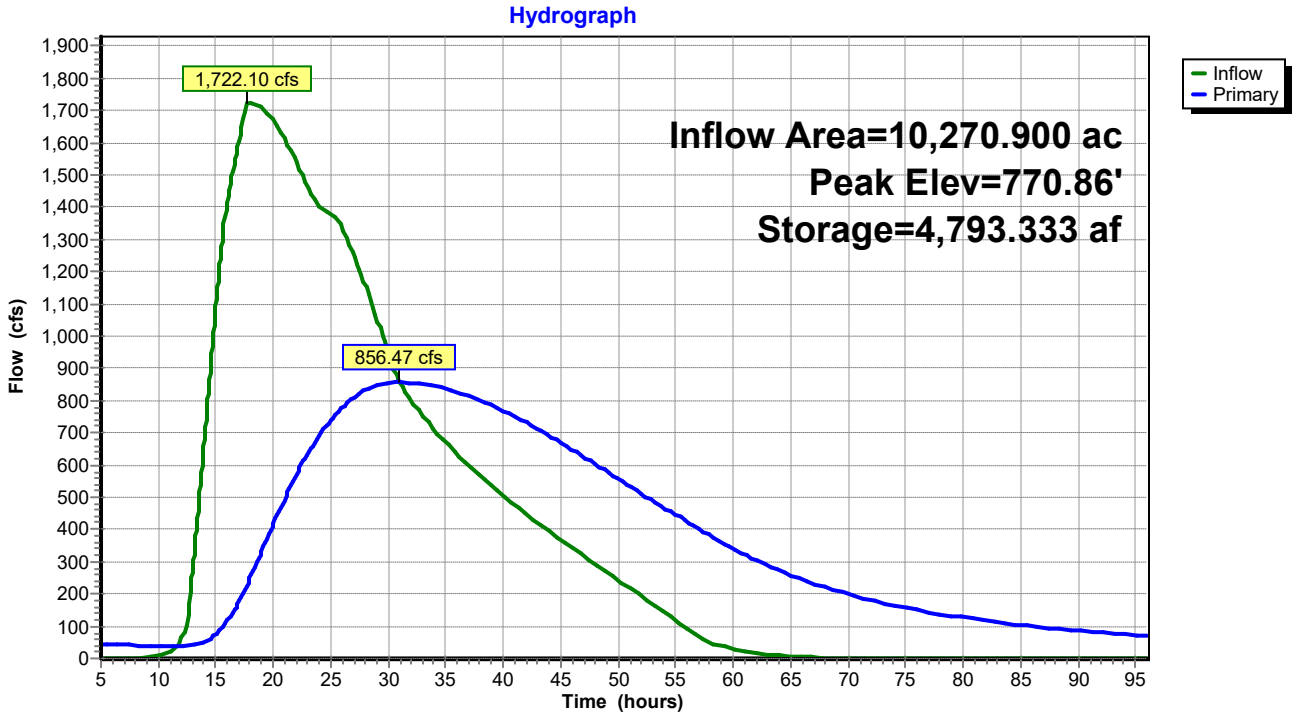
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,533.800 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
769.00	170.000	750.000	4,406.500
770.00	199.500	184.750	4,591.250
771.00	281.000	240.250	4,831.500
772.00	355.400	318.200	5,149.700
773.00	412.800	384.100	5,533.800

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=856.47 cfs @ 31.00 hrs HW=770.86' (Free Discharge)
↑**1=Special & User-Defined** (Custom Controls 856.47 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 0.66" for 2-yr event
Inflow = 329.34 cfs @ 18.98 hrs, Volume= 561.021 af
Outflow = 67.00 cfs @ 46.16 hrs, Volume= 333.830 af, Atten= 80%, Lag= 1,630.5 min
Primary = 67.00 cfs @ 46.16 hrs, Volume= 333.830 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 129.600 ac Storage= 77.580 af
Peak Elev= 765.92' @ 46.16 hrs Surf.Area= 243.282 ac Storage= 474.979 af (397.399 af above start)

Plug-Flow detention time= 2,669.9 min calculated for 256.250 af (46% of inflow)
Center-of-Mass det. time= 1,669.4 min (3,356.3 - 1,686.9)

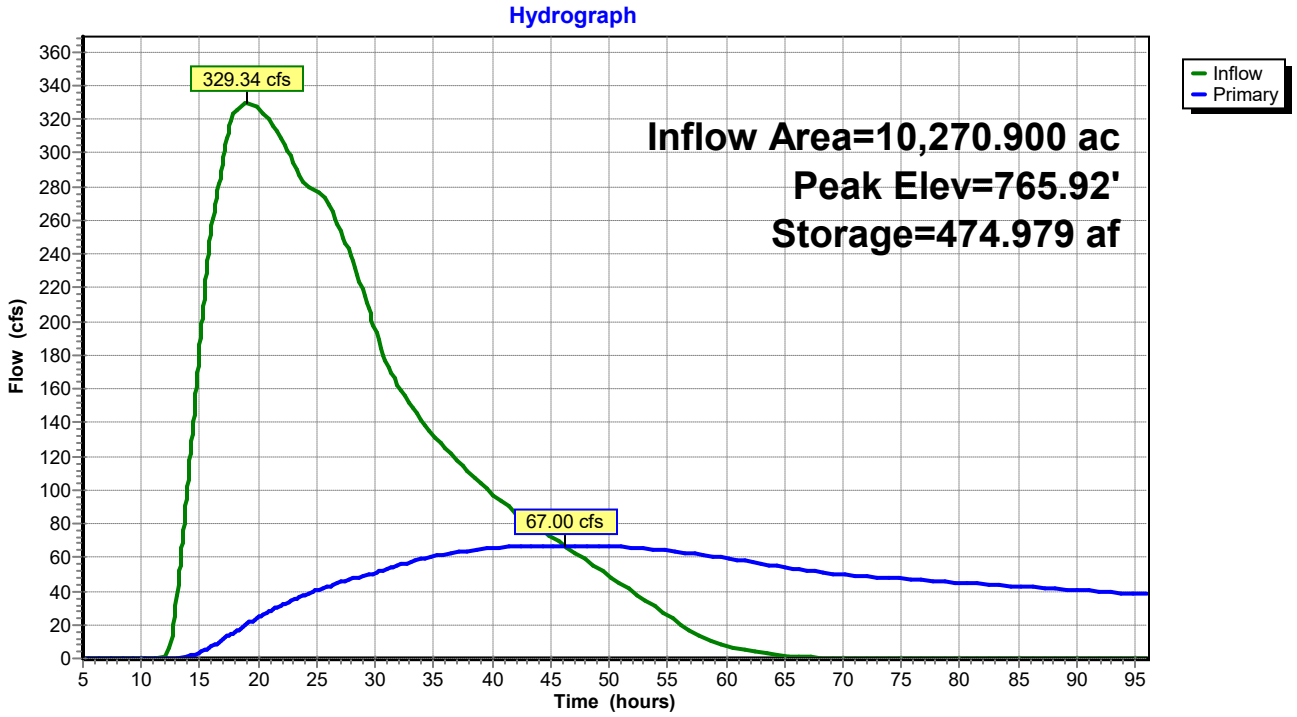
Volume	Invert	Avail.Storage	Storage Description
#1	763.00'	2,014.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
763.00	129.000	0.000	0.000
764.00	130.000	129.500	129.500
765.00	175.000	152.500	282.000
766.00	249.000	212.000	494.000
767.00	255.000	252.000	746.000
768.00	300.000	277.500	1,023.500
769.00	325.000	312.500	1,336.000
770.00	340.000	332.500	1,668.500
771.00	351.000	345.500	2,014.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=67.00 cfs @ 46.16 hrs HW=765.92' (Free Discharge)
1=Special & User-Defined (Custom Controls 67.00 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 1.42" for 10-yr event
Inflow = 723.08 cfs @ 18.74 hrs, Volume= 1,216.379 af
Outflow = 167.94 cfs @ 43.98 hrs, Volume= 793.945 af, Atten= 77%, Lag= 1,514.7 min
Primary = 167.94 cfs @ 43.98 hrs, Volume= 793.945 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 129.600 ac Storage= 77.580 af
Peak Elev= 767.58' @ 43.98 hrs Surf.Area= 281.150 ac Storage= 901.784 af (824.204 af above start)

Plug-Flow detention time= 2,227.5 min calculated for 716.365 af (59% of inflow)
Center-of-Mass det. time= 1,601.6 min (3,277.4 - 1,675.8)

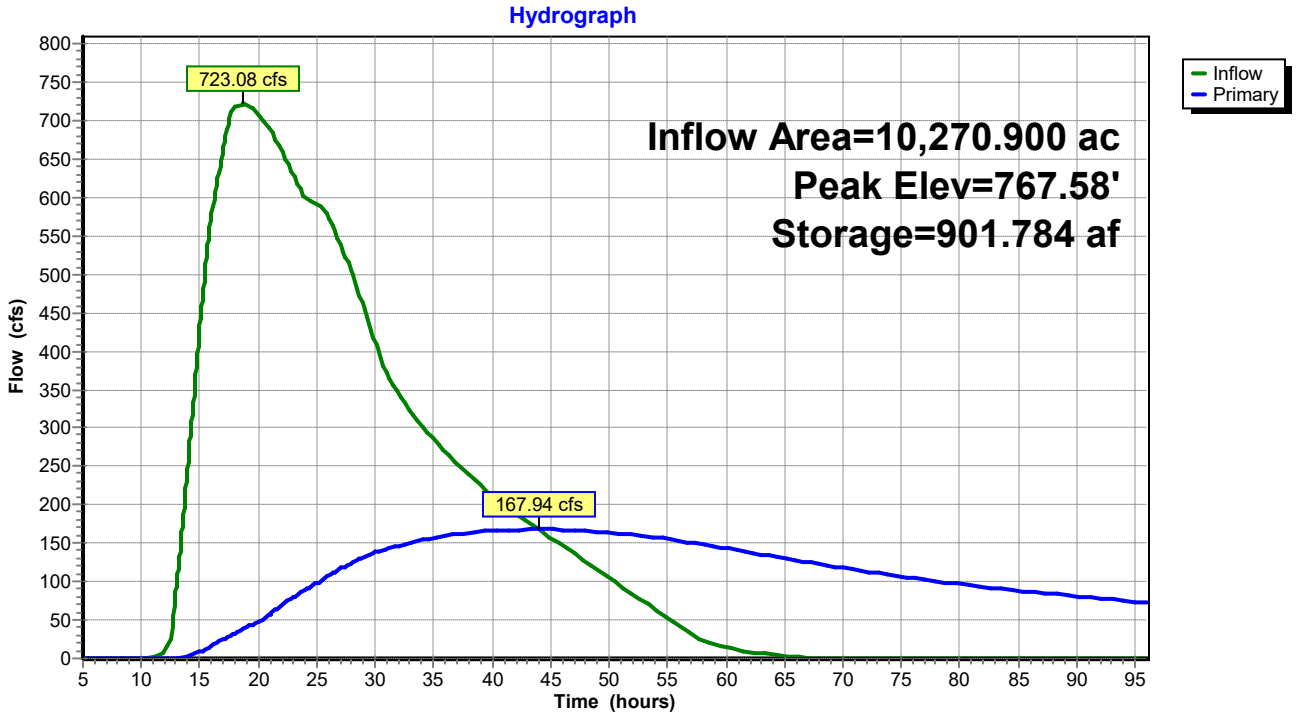
Volume	Invert	Avail.Storage	Storage Description
#1	763.00'	2,014.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
763.00	129.000	0.000	0.000
764.00	130.000	129.500	129.500
765.00	175.000	152.500	282.000
766.00	249.000	212.000	494.000
767.00	255.000	252.000	746.000
768.00	300.000	277.500	1,023.500
769.00	325.000	312.500	1,336.000
770.00	340.000	332.500	1,668.500
771.00	351.000	345.500	2,014.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=167.94 cfs @ 43.98 hrs HW=767.58' (Free Discharge)
1=Special & User-Defined (Custom Controls 167.94 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 3.36" for 100-yr event
Inflow = 1,722.10 cfs @ 17.76 hrs, Volume= 2,874.517 af
Outflow = 420.19 cfs @ 43.04 hrs, Volume= 2,019.872 af, Atten= 76%, Lag= 1,516.4 min
Primary = 420.19 cfs @ 43.04 hrs, Volume= 2,019.872 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 129.600 ac Storage= 77.580 af
Peak Elev= 770.85' @ 43.04 hrs Surf.Area= 349.340 ac Storage= 1,961.149 af (1,883.569 af above start)

Plug-Flow detention time= 2,026.5 min calculated for 1,942.292 af (68% of inflow)
Center-of-Mass det. time= 1,583.8 min (3,246.2 - 1,662.4)

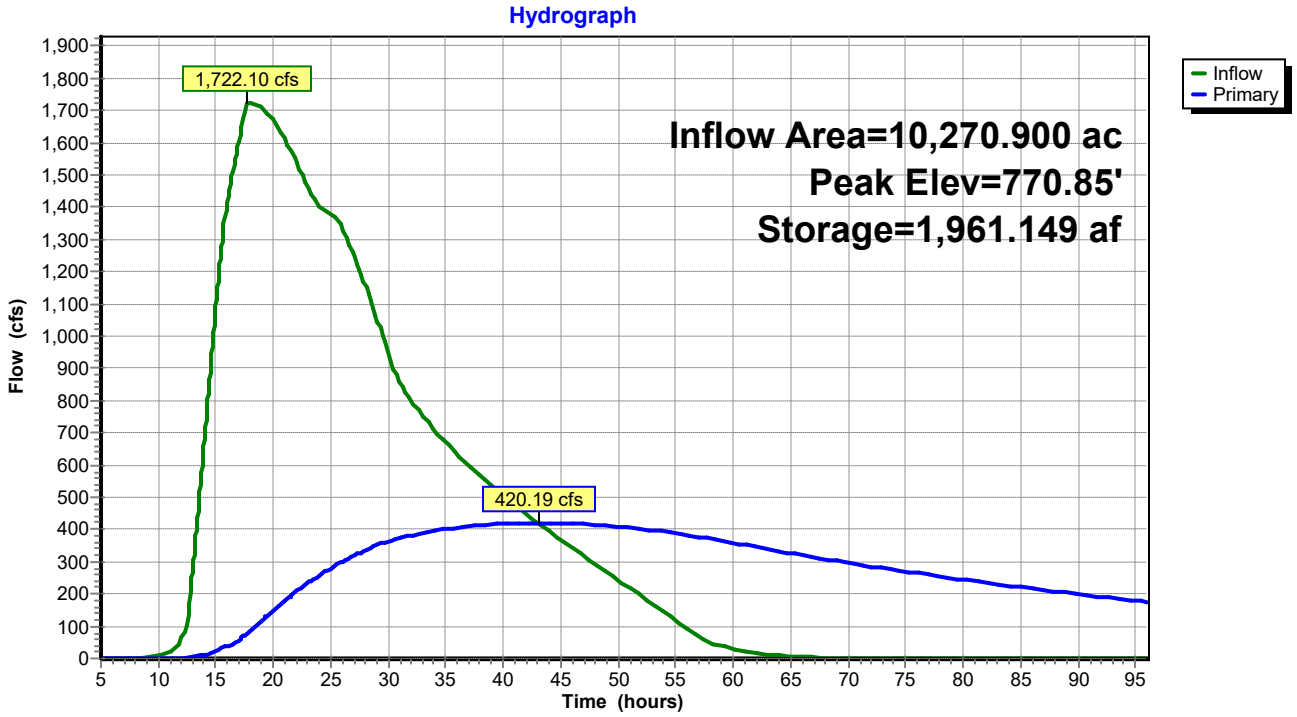
Volume	Invert	Avail.Storage	Storage Description
#1	763.00'	2,014.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
763.00	129.000	0.000	0.000
764.00	130.000	129.500	129.500
765.00	175.000	152.500	282.000
766.00	249.000	212.000	494.000
767.00	255.000	252.000	746.000
768.00	300.000	277.500	1,023.500
769.00	325.000	312.500	1,336.000
770.00	340.000	332.500	1,668.500
771.00	351.000	345.500	2,014.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=420.19 cfs @ 43.04 hrs HW=770.85' (Free Discharge)
1=Special & User-Defined (Custom Controls 420.19 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 0.66" for 2-yr event
Inflow = 329.34 cfs @ 18.98 hrs, Volume= 561.021 af
Outflow = 127.74 cfs @ 35.57 hrs, Volume= 589.946 af, Atten= 61%, Lag= 995.4 min
Primary = 127.74 cfs @ 35.57 hrs, Volume= 589.946 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 765.19' @ 35.57 hrs Surf.Area= 189.024 ac Storage= 3,843.495 af (238.707 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,156.3 min (2,843.2 - 1,686.9)

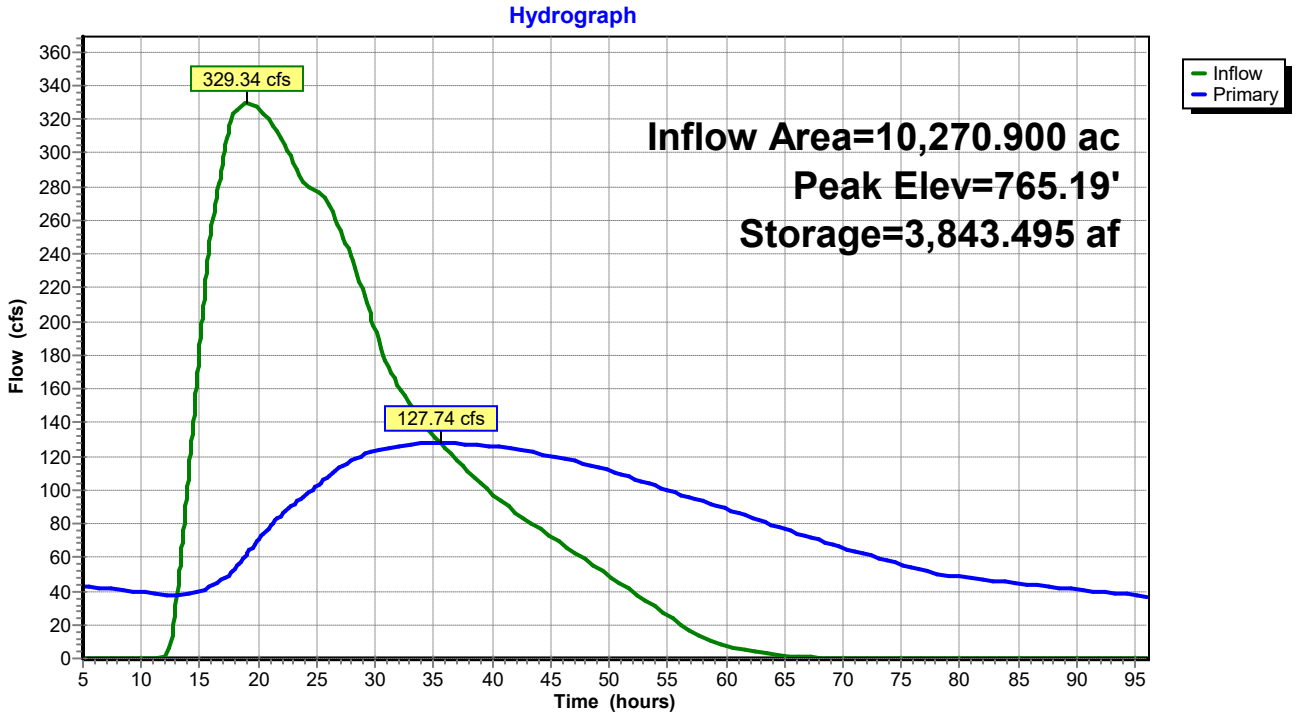
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,890.900 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
765.00	175.000	152.500	3,809.000
766.00	249.000	212.000	4,021.000
767.00	255.000	252.000	4,273.000
768.00	300.000	277.500	4,550.500
769.00	325.000	312.500	4,863.000
770.00	340.000	332.500	5,195.500
772.00	355.400	695.400	5,890.900

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=127.74 cfs @ 35.57 hrs HW=765.19' (Free Discharge)
↑—**1=Special & User-Defined** (Custom Controls 127.74 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 1.42" for 10-yr event
Inflow = 723.08 cfs @ 18.74 hrs, Volume= 1,216.379 af
Outflow = 259.97 cfs @ 36.61 hrs, Volume= 1,152.904 af, Atten= 64%, Lag= 1,072.3 min
Primary = 259.97 cfs @ 36.61 hrs, Volume= 1,152.904 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 766.74' @ 36.61 hrs Surf.Area= 253.414 ac Storage= 4,205.810 af (601.022 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,246.0 min (2,921.8 - 1,675.8)

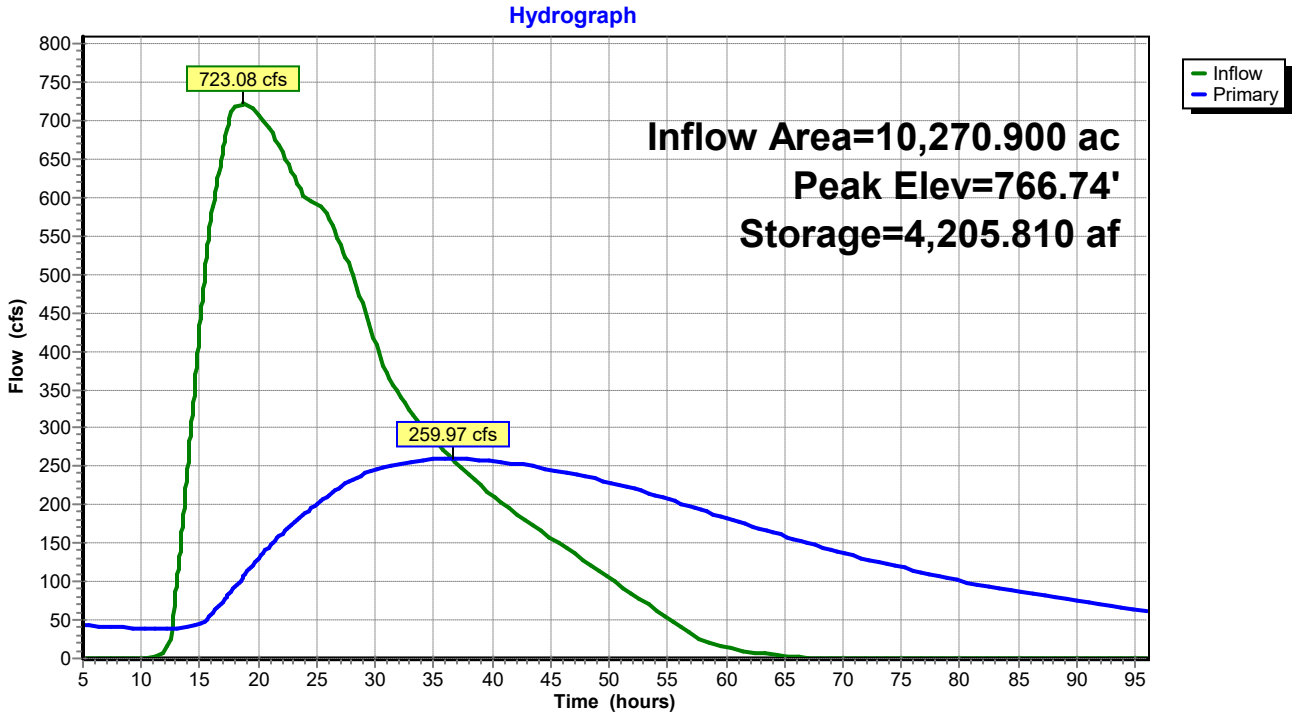
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,890.900 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
765.00	175.000	152.500	3,809.000
766.00	249.000	212.000	4,021.000
767.00	255.000	252.000	4,273.000
768.00	300.000	277.500	4,550.500
769.00	325.000	312.500	4,863.000
770.00	340.000	332.500	5,195.500
772.00	355.400	695.400	5,890.900

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=259.97 cfs @ 36.61 hrs HW=766.74' (Free Discharge)
↑—**1=Special & User-Defined** (Custom Controls 259.97 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 3.36" for 100-yr event
Inflow = 1,722.10 cfs @ 17.76 hrs, Volume= 2,874.517 af
Outflow = 639.56 cfs @ 35.84 hrs, Volume= 2,622.213 af, Atten= 63%, Lag= 1,084.8 min
Primary = 639.56 cfs @ 35.84 hrs, Volume= 2,622.213 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 128.560 ac Storage= 3,604.788 af
Peak Elev= 769.62' @ 35.84 hrs Surf.Area= 334.261 ac Storage= 5,066.509 af (1,461.721 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,245.8 min (2,908.2 - 1,662.4)

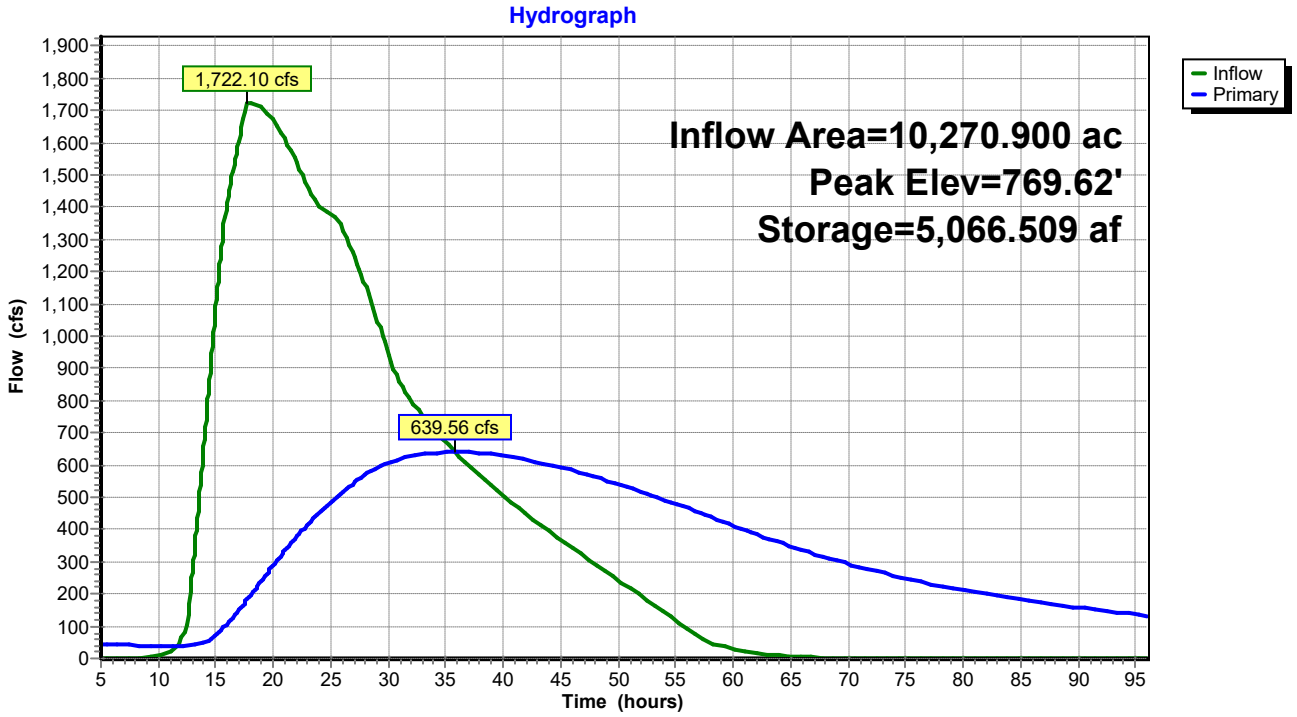
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	5,890.900 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
764.00	130.000	605.000	3,656.500
765.00	175.000	152.500	3,809.000
766.00	249.000	212.000	4,021.000
767.00	255.000	252.000	4,273.000
768.00	300.000	277.500	4,550.500
769.00	325.000	312.500	4,863.000
770.00	340.000	332.500	5,195.500
772.00	355.400	695.400	5,890.900

Device	Routing	Invert	Outlet Devices
#1	Primary	761.99'	**Special & User-Defined** Elev. (feet) 761.99 763.87 764.79 765.51 766.00 766.11 766.64 767.12 767.30 767.56 767.97 768.20 768.35 768.73 769.06 769.38 769.68 769.98 770.26 770.54 770.82 771.14 771.75 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=639.56 cfs @ 35.84 hrs HW=769.62' (Free Discharge)
↑—**1=Special & User-Defined** (Custom Controls 639.56 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 0.66" for 2-yr event
Inflow = 329.34 cfs @ 18.98 hrs, Volume= 561.021 af
Outflow = 15.97 cfs @ 57.03 hrs, Volume= 90.881 af, Atten= 95%, Lag= 2,283.0 min
Primary = 15.97 cfs @ 57.03 hrs, Volume= 90.881 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 576.600 ac Storage= 3,745.180 af
Peak Elev= 764.24' @ 57.03 hrs Surf.Area= 929.418 ac Storage= 4,253.706 af (508.526 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,904.6 min (3,591.5 - 1,686.9)

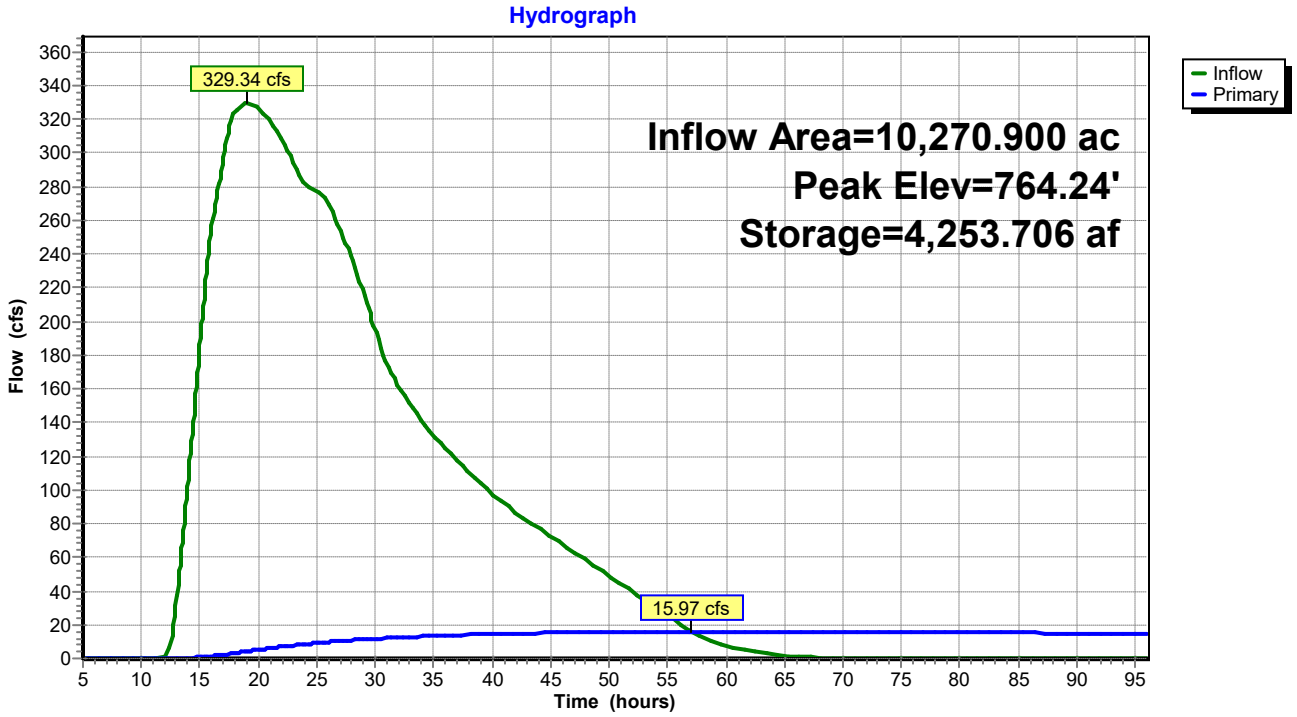
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	23,953.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
763.00	129.000	482.000	3,533.500
764.00	875.000	502.000	4,035.500
765.00	1,100.000	987.500	5,023.000
766.00	1,200.000	1,150.000	6,173.000
767.00	1,300.000	1,250.000	7,423.000
768.00	750.000	1,025.000	8,448.000
769.00	700.000	725.000	9,173.000
770.00	430.000	565.000	9,738.000
771.00	3,000.000	1,715.000	11,453.000
772.00	4,000.000	3,500.000	14,953.000
774.00	5,000.000	9,000.000	23,953.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=15.97 cfs @ 57.03 hrs HW=764.24' (Free Discharge)
↑—**1=Special & User-Defined** (Custom Controls 15.97 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 1.42" for 10-yr event
Inflow = 723.08 cfs @ 18.74 hrs, Volume= 1,216.379 af
Outflow = 31.21 cfs @ 57.02 hrs, Volume= 178.277 af, Atten= 96%, Lag= 2,296.7 min
Primary = 31.21 cfs @ 57.02 hrs, Volume= 178.277 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 576.600 ac Storage= 3,745.180 af
Peak Elev= 764.85' @ 57.02 hrs Surf.Area= 1,067.324 ac Storage= 4,865.621 af (1,120.441 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,914.3 min (3,590.0 - 1,675.8)

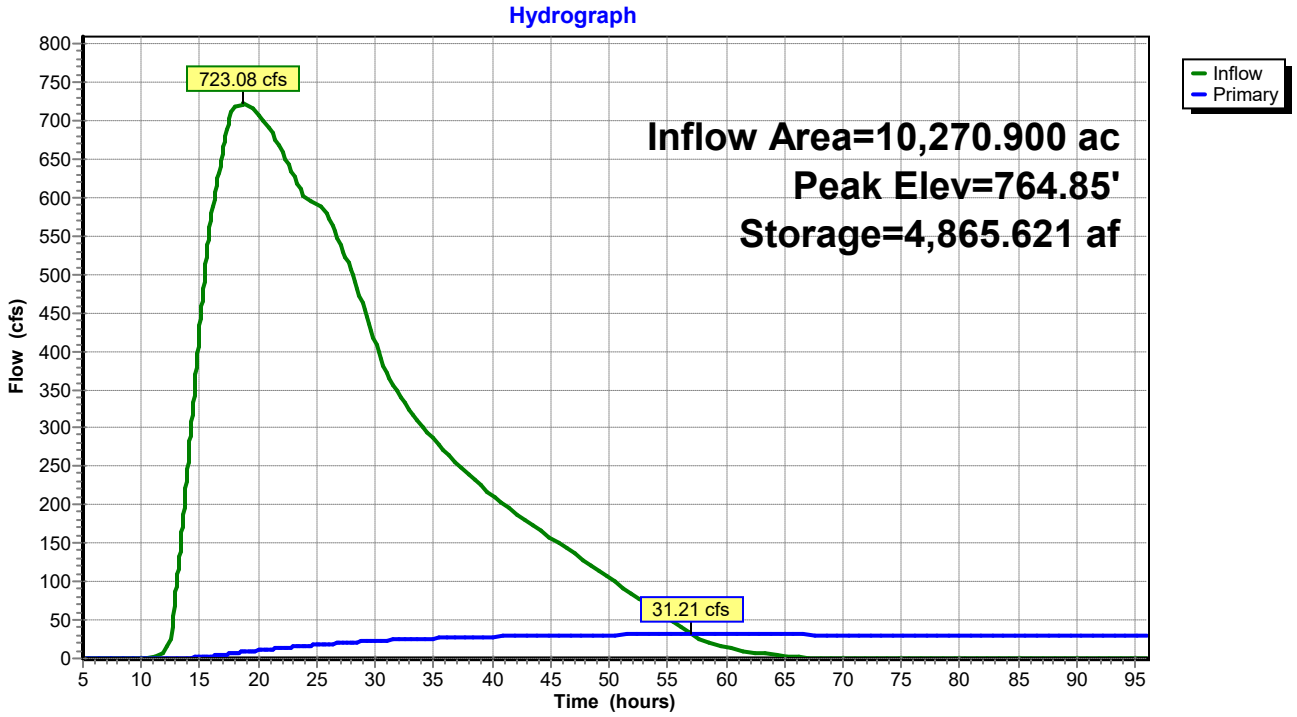
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	23,953.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
763.00	129.000	482.000	3,533.500
764.00	875.000	502.000	4,035.500
765.00	1,100.000	987.500	5,023.000
766.00	1,200.000	1,150.000	6,173.000
767.00	1,300.000	1,250.000	7,423.000
768.00	750.000	1,025.000	8,448.000
769.00	700.000	725.000	9,173.000
770.00	430.000	565.000	9,738.000
771.00	3,000.000	1,715.000	11,453.000
772.00	4,000.000	3,500.000	14,953.000
774.00	5,000.000	9,000.000	23,953.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=31.21 cfs @ 57.02 hrs HW=764.85' (Free Discharge)
↑—**1=Special & User-Defined** (Custom Controls 31.21 cfs)

Pond 5P: Duncan Lake



Summary for Pond 5P: Duncan Lake

Inflow Area = 10,270.900 ac, 1.77% Impervious, Inflow Depth = 3.36" for 100-yr event
Inflow = 1,722.10 cfs @ 17.76 hrs, Volume= 2,874.517 af
Outflow = 81.71 cfs @ 56.38 hrs, Volume= 441.285 af, Atten= 95%, Lag= 2,316.6 min
Primary = 81.71 cfs @ 56.38 hrs, Volume= 441.285 af

Routing by Stor-Ind method, Time Span= 5.00-96.00 hrs, dt= 0.05 hrs
Starting Elev= 763.60' Surf.Area= 576.600 ac Storage= 3,745.180 af
Peak Elev= 766.19' @ 56.38 hrs Surf.Area= 1,219.342 ac Storage= 6,406.979 af (2,661.799 af above start)

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= 1,972.8 min (3,635.2 - 1,662.4)

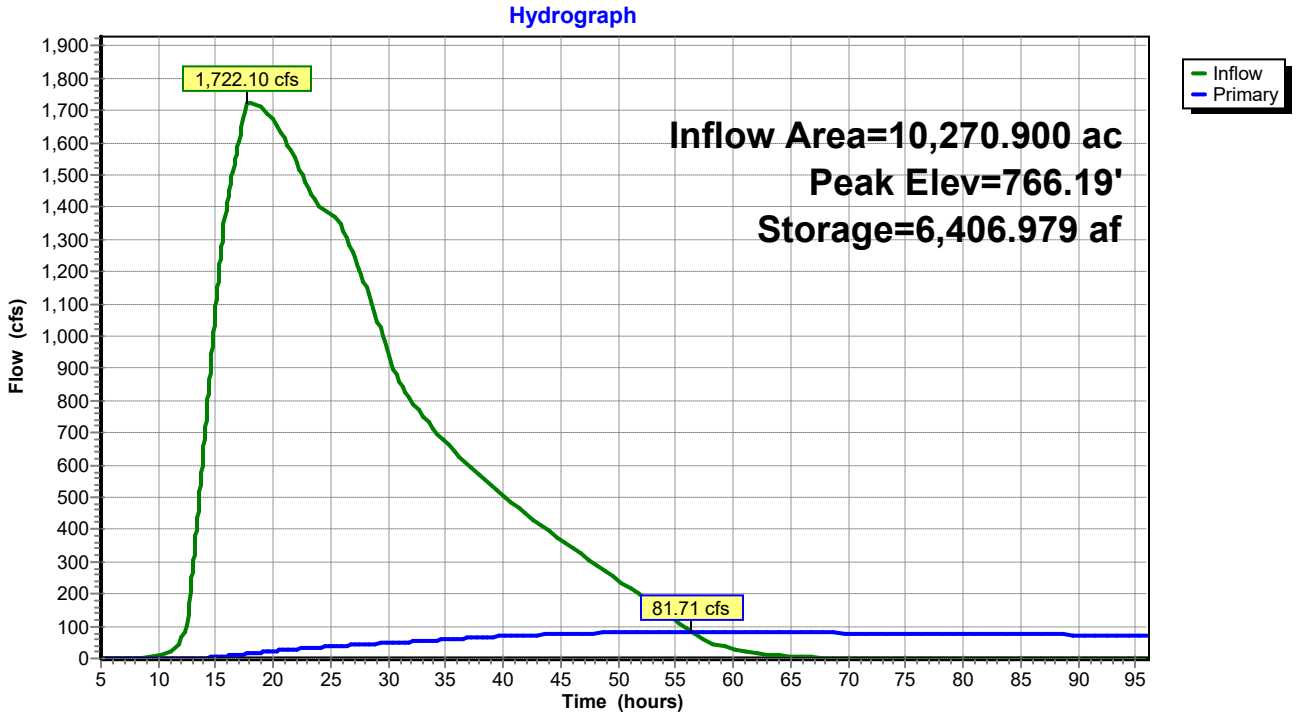
Volume	Invert	Avail.Storage	Storage Description
#1	714.00'	23,953.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
714.00	10.700	0.000	0.000
724.00	44.900	278.000	278.000
734.00	66.000	554.500	832.500
744.00	84.400	752.000	1,584.500
754.00	102.000	932.000	2,516.500
759.00	112.000	535.000	3,051.500
763.00	129.000	482.000	3,533.500
764.00	875.000	502.000	4,035.500
765.00	1,100.000	987.500	5,023.000
766.00	1,200.000	1,150.000	6,173.000
767.00	1,300.000	1,250.000	7,423.000
768.00	750.000	1,025.000	8,448.000
769.00	700.000	725.000	9,173.000
770.00	430.000	565.000	9,738.000
771.00	3,000.000	1,715.000	11,453.000
772.00	4,000.000	3,500.000	14,953.000
774.00	5,000.000	9,000.000	23,953.000

Device	Routing	Invert	Outlet Devices
#1	Primary	763.60'	**Special & User-Defined** Elev. (feet) 763.60 765.61 766.53 767.33 767.89 768.02 768.68 769.33 769.59 769.97 770.60 770.97 771.22 771.85 772.48 773.12 773.56 773.87 774.14 774.31 774.46 774.59 774.82 Disch. (cfs) 0.000 50.000 100.000 150.000 190.000 200.000 250.000 300.000 320.000 350.000 400.000 430.000 450.000 500.000 550.000 600.000 650.000 700.000 750.000 800.000 850.000 900.000 1,000.000

Primary OutFlow Max=81.71 cfs @ 56.38 hrs HW=766.19' (Free Discharge)
1=Special & User-Defined (Custom Controls 81.71 cfs)

Pond 5P: Duncan Lake



Appendix 4

Preliminary Estimates of Project Cost

DUNCAN LAKE INTERCOUNTY DRAIN
ALTERNATIVE 1 - PRELIMINARY ESTIMATE OF PROJECT COST
Prepared By: Land & Resource Engineering 9/20/2022

ENGINEERS & SURVEYORS

Alternative 1: Project Scope

- Open Channel Excavation from Duncan Lake to Duncan Lake Road
- Replacement of Noffke Rd
- Replacement of Duncan Lake Road
- Raise 108th Street & Install Additional 154"x 100" CMPA Culvert
- Construct 2-Stage Channel Upstream of 100th Street

No.	Item Description	Quantity	Unit	Unit Cost	Total Cost
1	Mobilization	1	LS	$ 75,000.00	$ 75,000.00
2	Traffic Control	1	LS	$ 25,000.00	$ 25,000.00
3	Water Control Structure	1	LS	$ 100,000.00	$ 100,000.00
4	Open Channel Excavation (DS of Duncan Lake)	4415	LF	$ 20.00	$ 88,300.00
5	Open Channel Excavation (2-Stage, US of 100th St)	9125	LF	$ 20.00	$ 182,500.00
6	Noffke Drive X-ING 15'x8' RCP Box	60	LF	$ 2,250.00	$ 135,000.00
7	Duncan Lake Road X-ING 15'x10' RCP Box	84	LF	$ 2,500.00	$ 210,000.00
8	108th Street X-ING 154"x100" CMPA Culvert	60	LF	$ 1,250.00	$ 75,000.00
9	Riprap End Treatment	250	SY	$ 100.00	$ 25,000.00
10	Raise & Pave 108th Street	1	LS	$ 35,000.00	$ 35,000.00
11	Road Restoration	2	EA	$ 10,000.00	$ 20,000.00
12	Open Channel Seeding	13540	LF	$ 5.00	$ 67,700.00
13	Miscellaneous Restoration / BMPs	1	LS	$ 20,000.00	$ 20,000.00

Sub-Total	$ 1,058,500.00
Engineering Study	$ 42,995.00
Estimated Engineering (Design & Construction)	$ 100,000.00
Permitting	$ 100,000.00
15% +/- Contingency	$ 198,505.00
***Preliminary Estimate of Project Cost**	**$ 1,500,000.00**

**Note - Does not include Legal, Easement Acquisition, Mitigation, Administrative or Financing Costs.*

Survey Drawings

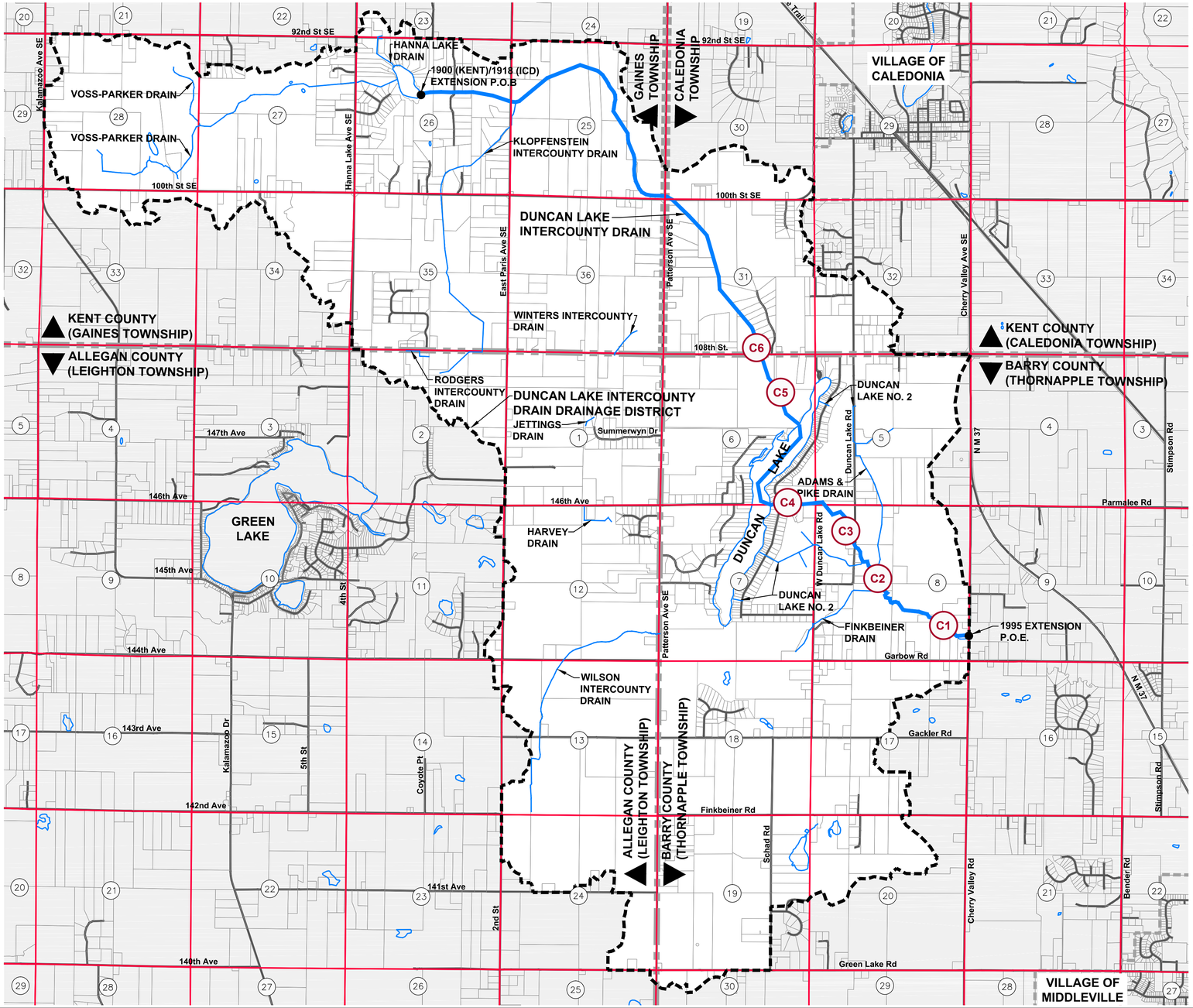
Duncan Lake Intercounty Drain

SECTIONS 23-28, 33-36, T05N R11W
GAINES TOWNSHIP &

SECTIONS 30-32, T05N R10W
CALEDONIA TOWNSHIP, KENT COUNTY

SECTIONS 1, 2, 11-14, 24, 25, T04N R11W
LEIGHTON TOWNSHIP, ALLEGAN COUNTY

SECTIONS 5-8, 17-20, 30, T04N R10W
THORNAPPLE TOWNSHIP, BARRY COUNTY



INDEX OF SHEETS

LEGEND

- ENCLOSED CHANNEL DRAIN
- OPEN CHANNEL DRAIN
- DRAINAGE DISTRICT BOUNDARY
- SECTION LINE
- TOWNSHIP LINE
- ROADS
- PROPERTY LINES
- # SECTION NUMBERS
- C1 SHEET NUMBERS

DRAIN INFORMATION:

DISTRICT AREA:	
KENT COUNTY:	4,813.6 ACRES
ALLEGAN COUNTY:	2,485.7 ACRES
BARRY COUNTY:	4,240.1 ACRES
TOTAL:	11,539.4 ACRES
DRAIN LENGTH	34,854 FT (6.6 MILES) (PER GIS)

SOILS INFORMATION

PER USDA WEB SOIL SURVEY SITE SOILS CONSIST OF:

BARRY COUNTY

5B	Ithaca Loam, 0-4% slopes
6D	Boyer Loamy Sand, 12-18% slopes
6E	Boyer Loamy Sand, 18-40% slopes
7A	Brady Sandy Loam, 0-3% slopes
9B	Capac Loam, Lake Michigan Lobe, 0-4% slopes
13	Colwood Loam
15	Edwards Muck, 0-1% slopes
16	Udorthents and Udipsamments, 0-6% slopes
18	Glendora Loamy Fine Sand
20B	Tekenink Fine Sandy Loam, 1-6% slopes
20C	Tekenink Fine Sandy Loam, 6-12% slopes
20D	Tekenink Fine Sandy Loam, 12-18% slopes
21	Houghton Muck, 0-1% slopes
22C	Kalamazoo Loam, 6-12% slopes
22D	Kalamazoo Loam, 12-18% Slopes
23	Lenawee Silty Clay Loam
24B	Filer Loam, 2-6% slopes
24C	Filer Loam, 6-12% slopes
24D	Filer Loam, 12-18% slopes
24E	Filer loam, 18-35% slopes
25	Histosols and Aquents, ponded
26B	Matherton Loam, Loamy substratum, 0-4% slopes
29C	Onekama Loam, Saginaw Lobe, 6-12% slopes
29D	Perrinton Loam 12-18% slopes
29E	Perrinton Loam, 18-40% slopes
31C	Oshtemo Sandy Loam, 6-12% slopes
32	Palms Muck, 0-1% slopes
33	Parkhill Loam, Non Dense Till Subsoil, 0-2% slopes
36	Sebewa Loam, Loamy Substratum
37B	Selfridge Loamy Sand, 0-4% slopes
39	Sloan Loam, Sandy Substratum
40B	Sprinks Loamy Sand, 0-6% slopes
40C	Sprinks Loamy Sand, 6-12% slopes
47B	Perrinton Loam, Saginaw Lobe, 2-6% slopes
51B	Marlette Fine Sandy Loam, 2-6% slopes
55	Algansee Loamy Fine Sand
56A	Thetford Loamy Sand, 0-3% slopes
58B	Coloma-Boyer Loamy Sands, 0-6% slopes
58D	Coloma-Boyer Loamy Sands, 12-18% slopes
59A	Brems Sand, 0-3% slopes
67B	Marlette-Oshtemo Complex, 0-6% slopes
67C	Marlette-Oshtemo Complex, 6-12% slopes
67D	Marlette-Oshtemo Complex, 12-18% slopes
W	Water

KENT COUNTY

6	GLENDORA LOAMY SAND
11C	OWOSSO-MARLETTE SANDY LOAMS, 6-12% SLOPES
20	HOUGHTON MUCK, 0-1% SLOPES
23A	THETFORD LOAMY SAND, 0-3% SLOPES
26	ADRIAN MUCK, 0-1% SLOPES
30C	SPINKS LOAMY SAND, 6-12% SLOPES
36B	FILER LOAM, 2-6% SLOPES
36C	FILER LOAM, 6-12% SLOPES
44	EDWARDS MUCK, 0-1% SLOPES
48B	METEA LOAMY SAND, 2-6% SLOPES
83B	MARLETTE LOAM, 2-6 % SLOPES

NORTH

0 2000 4000
Horizontal Scale in Feet

3 WORKING DAYS
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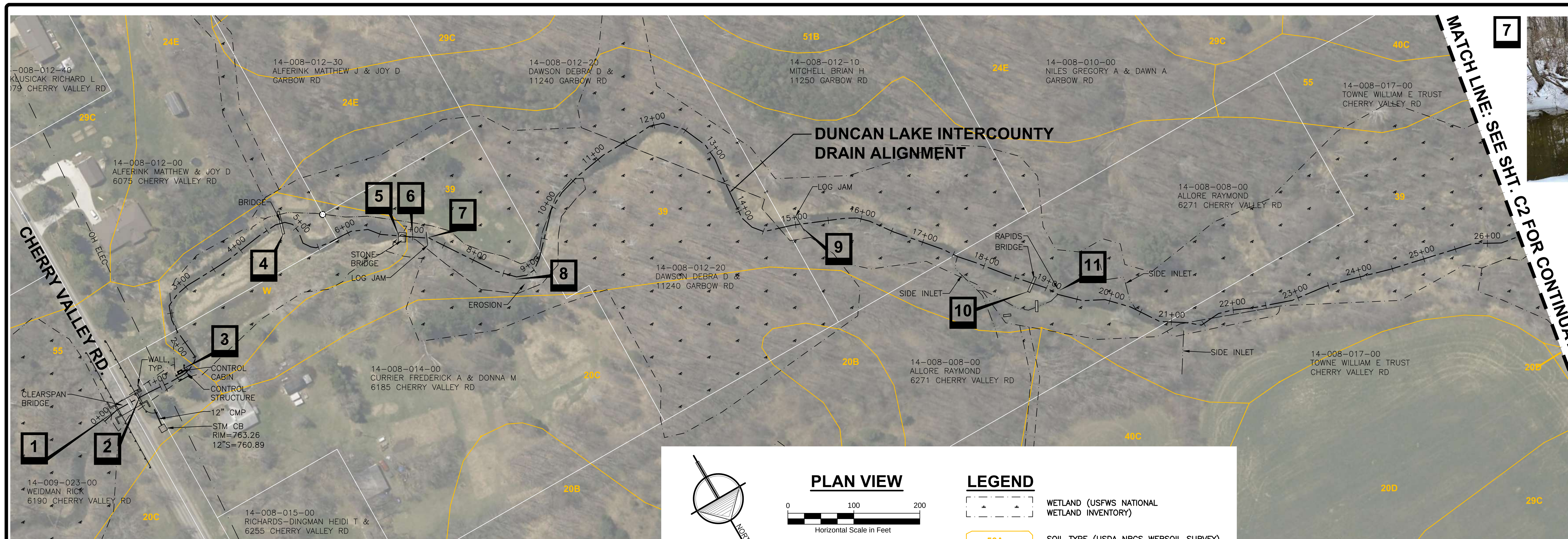
REVISIONS:		
NO.	ISSUED FOR	DATE
1.	PRELIMINARY REVIEW	2/25/2022

CLIENT:
PROJECT: DUNCAN LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT BOARD
DUNCAN LAKE INTERCOUNTY DRAIN
KENT, ALLEGAN & BARRY COUNTY, MICHIGAN

PROJECT NUMBER: 22-008

SURVEYED BY: CVF, ADK	02/2022
DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
CHCK:	03/2022

SHEET NAME: COVER SHEET
SHEET NUMBER: CS



PLAN VIEW

0 100 200
Horizontal Scale in Feet

LEGEND

WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A SOIL TYPE (USDA NRCS WEBSOIL SURVEY)

1

2

3

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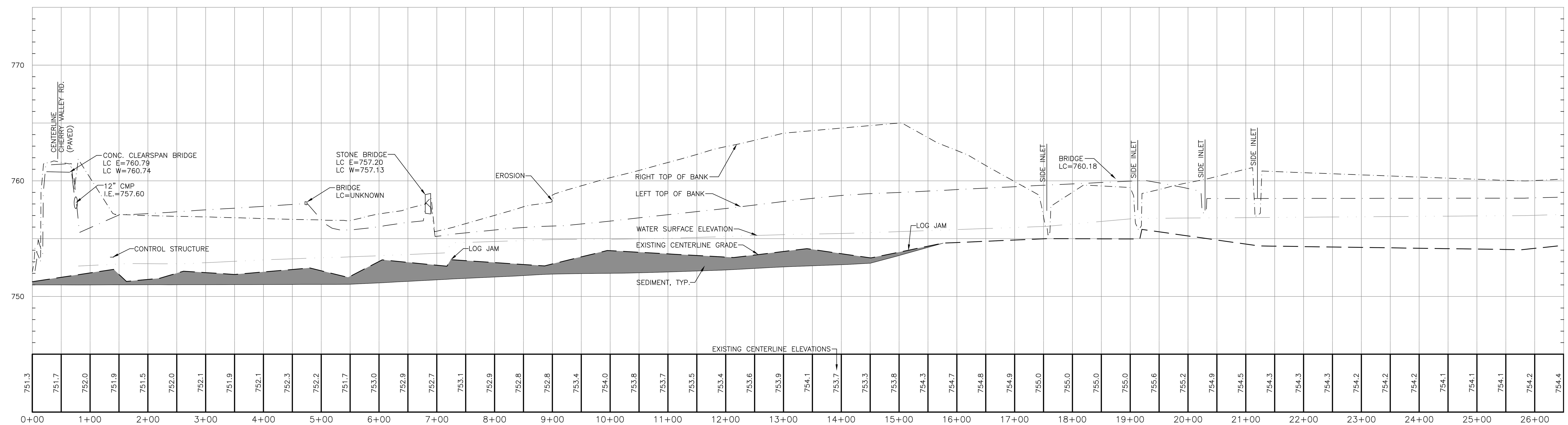

CENTERLINE PROFILE

SCALE: HORIZONTAL: 1" = 100'
VERTICAL: 1" = 5'

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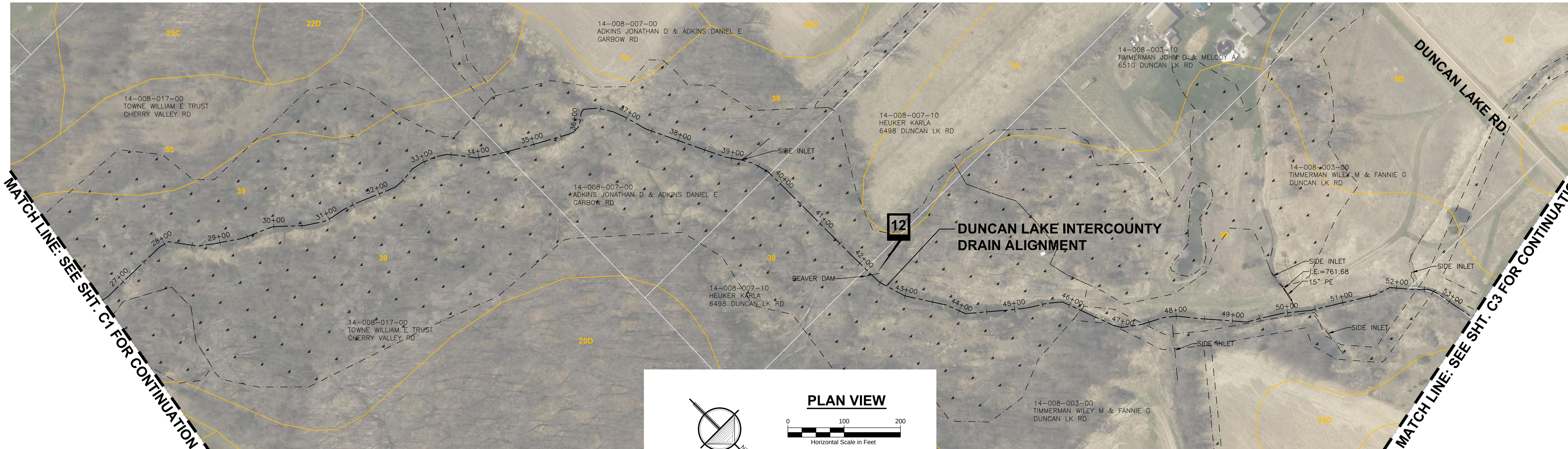
CLIENT: DUNCAN LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT BOARD

PROJECT: DUNCAN LAKE INTERCOUNTY DRAIN
KENT, ALLEGAN & BARRY COUNTY, MICHIGAN

PROJECT NUMBER: 22-008	DATE
SURVEYED BY: CVF, ADK	02/2022
DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
QA/QC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 0+00 - 26+50

SHEET NUMBER
C1



PLAN VIEW

0 100 200
Horizontal Scale in Feet

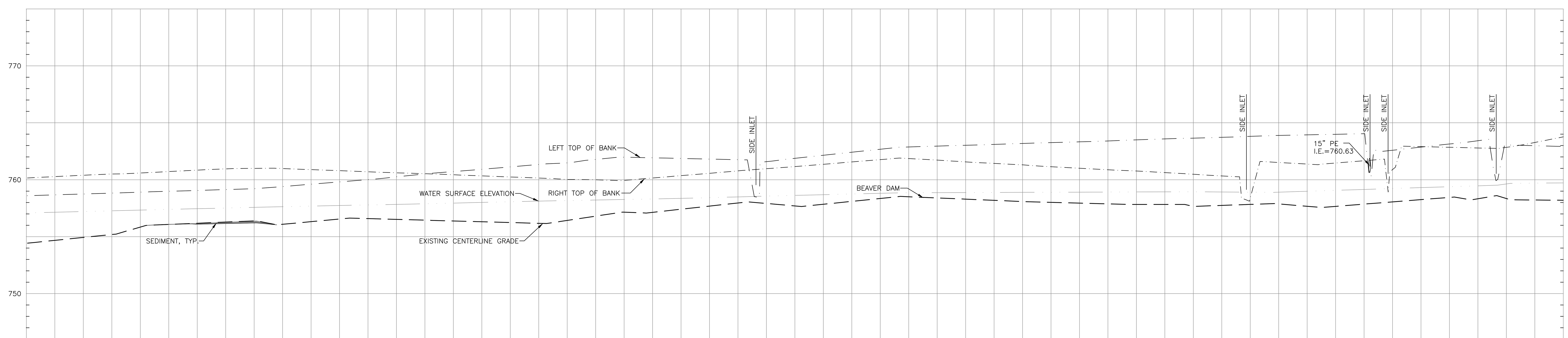
NORTH

12

LEGEND

WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A SOIL TYPE (USDA NRCS WEBSOIL SURVEY)



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27+00 28+00 29+00 30+00 31+00 32+00 33+00 34+00 35+00 36+00 37+00 38+00 39+00 40+00 41+00 42+00 43+00 44+00 45+00 46+00 47+00 48+00 49+00 50+00 51+00 52+00 53+00

CENTERLINE PROFILE

SCALE: HORIZONTAL: 1" = 100'
VERTICAL: 1" = 5'

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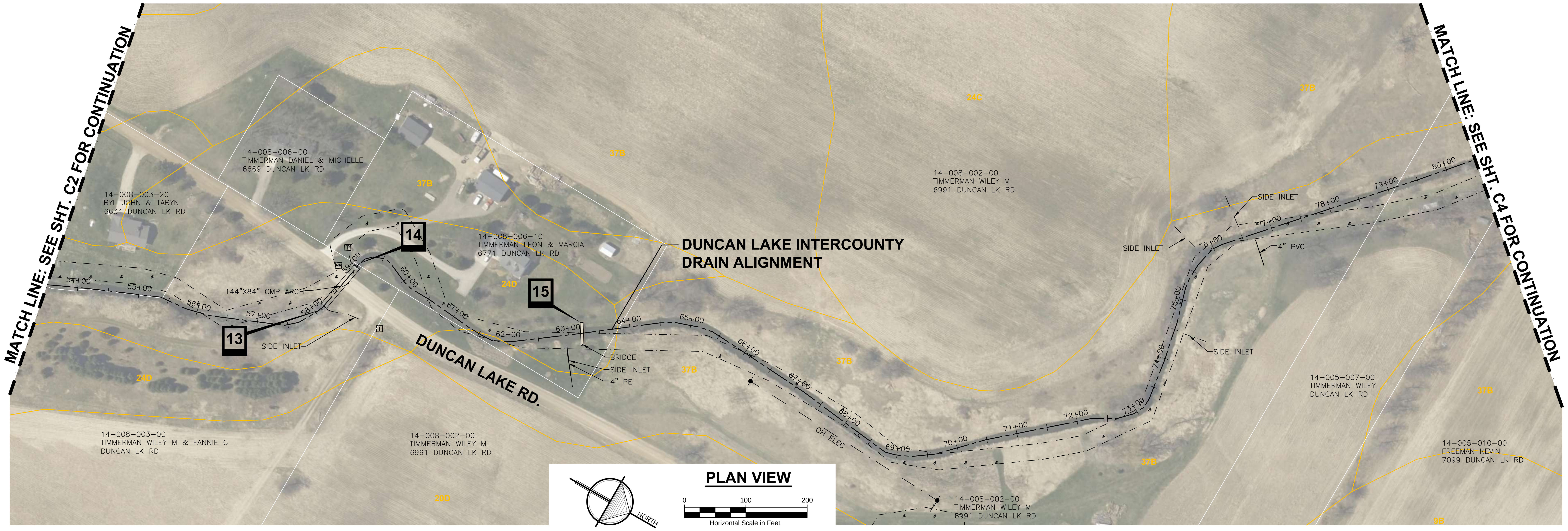
KENT, ALLEGAN & BARRY COUNTY, MICHIGAN

PROJECT NUMBER: 22-008	DATE
SURVEYED BY: CVF, ADK	02/2022
DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
QA/QC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 26+50 - 53+50

SHEET NUMBER
C2



LEGEND

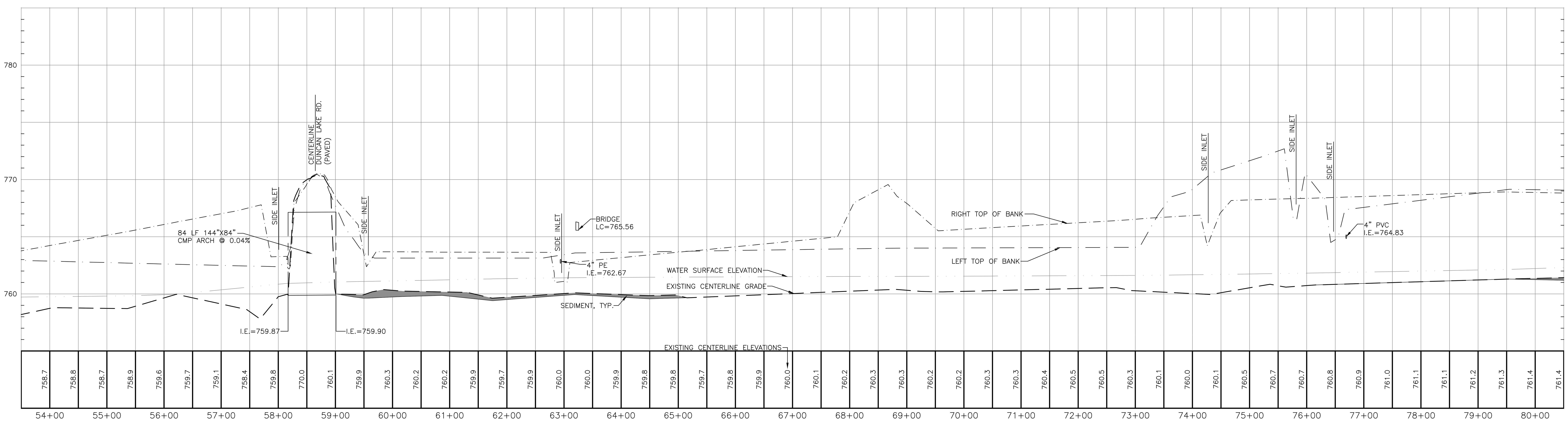
WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A SOIL TYPE (USDA NRCS WEBSOIL SURVEY)

13

14

15



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DRAFTED BY: LGG	02/2022
QAQC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 53+50 - 80+50

SHEET NUMBER
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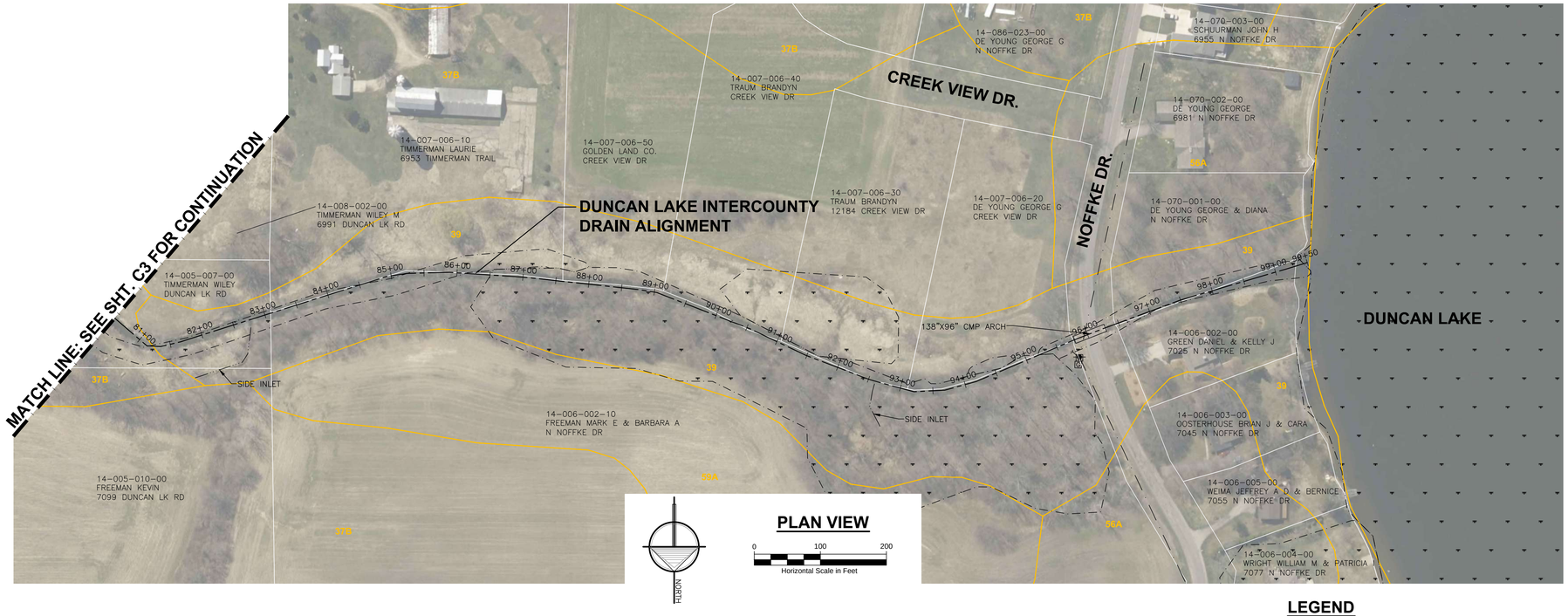


PLAN VIEW

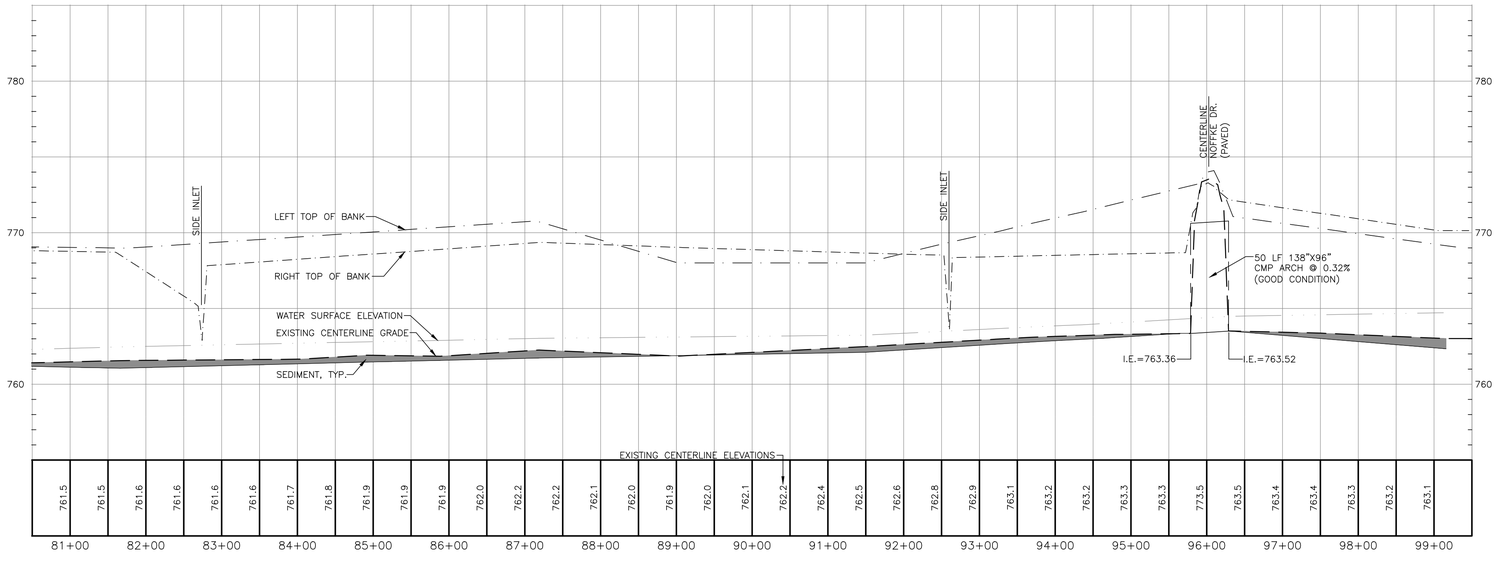
0 100 200

Horizontal Scale in Feet

LEGEND

WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A — SOIL TYPE (USDA NRCS WEBSOIL SURVEY)



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DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
CK/QC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 80+50 - 99+50

SHEET NUMBER
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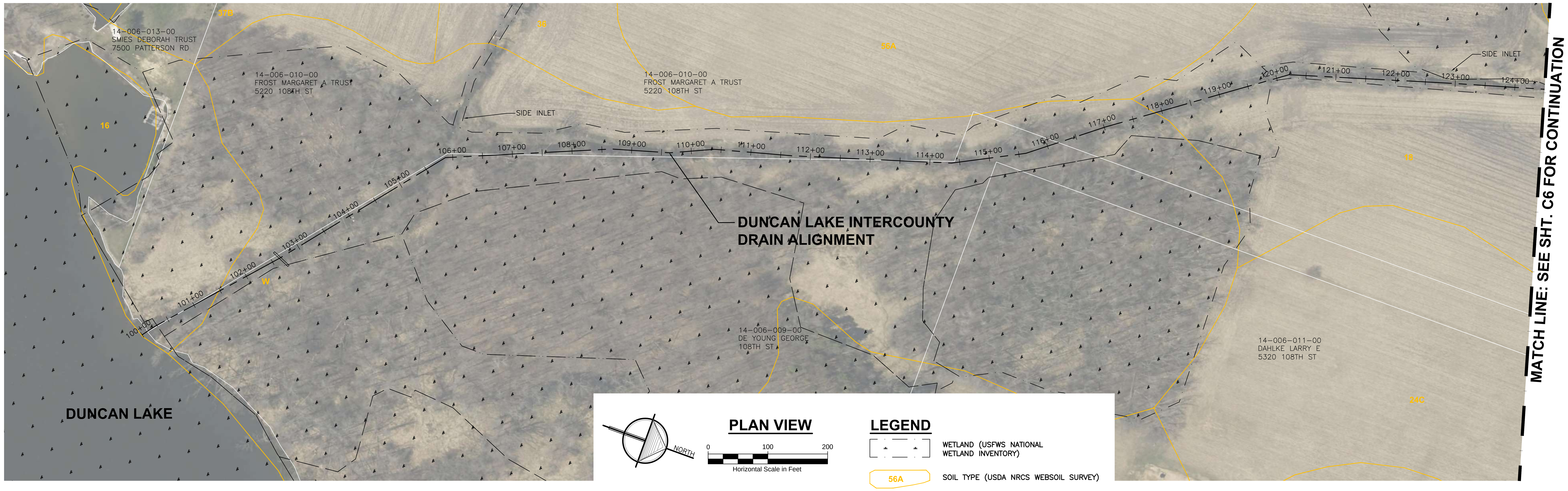


PLAN VIEW

NORTH

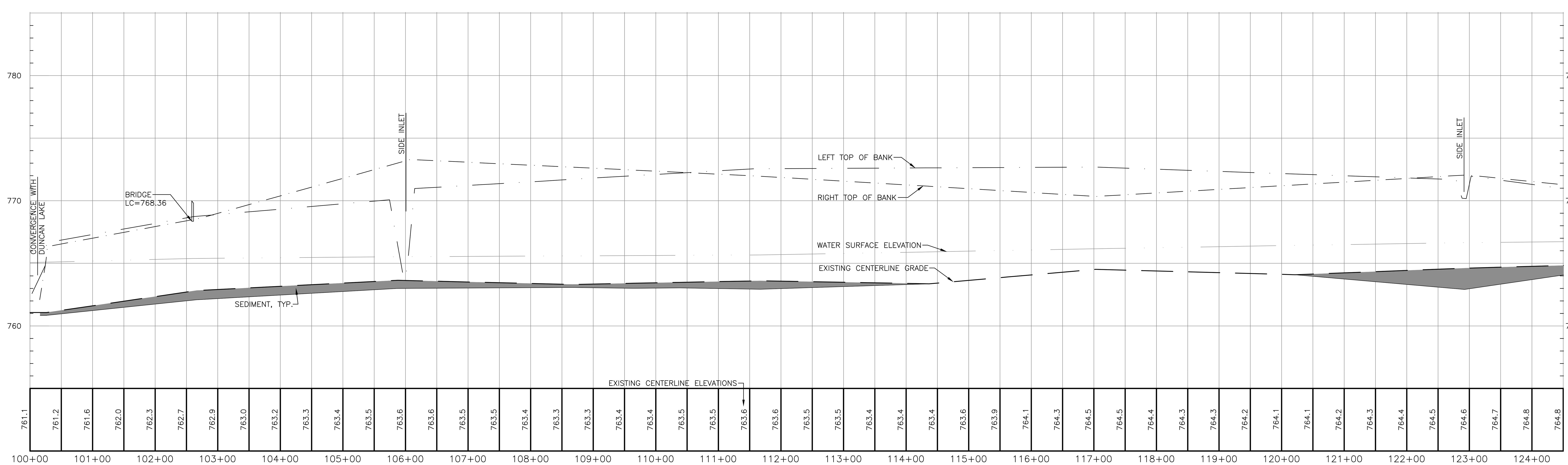
0 100 200

Horizontal Scale in Feet

LEGEND

WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A SOIL TYPE (USDA NRCS WEBSOIL SURVEY)



CENTERLINE PROFILE

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DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
QAQC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 100+00 - 1024+50

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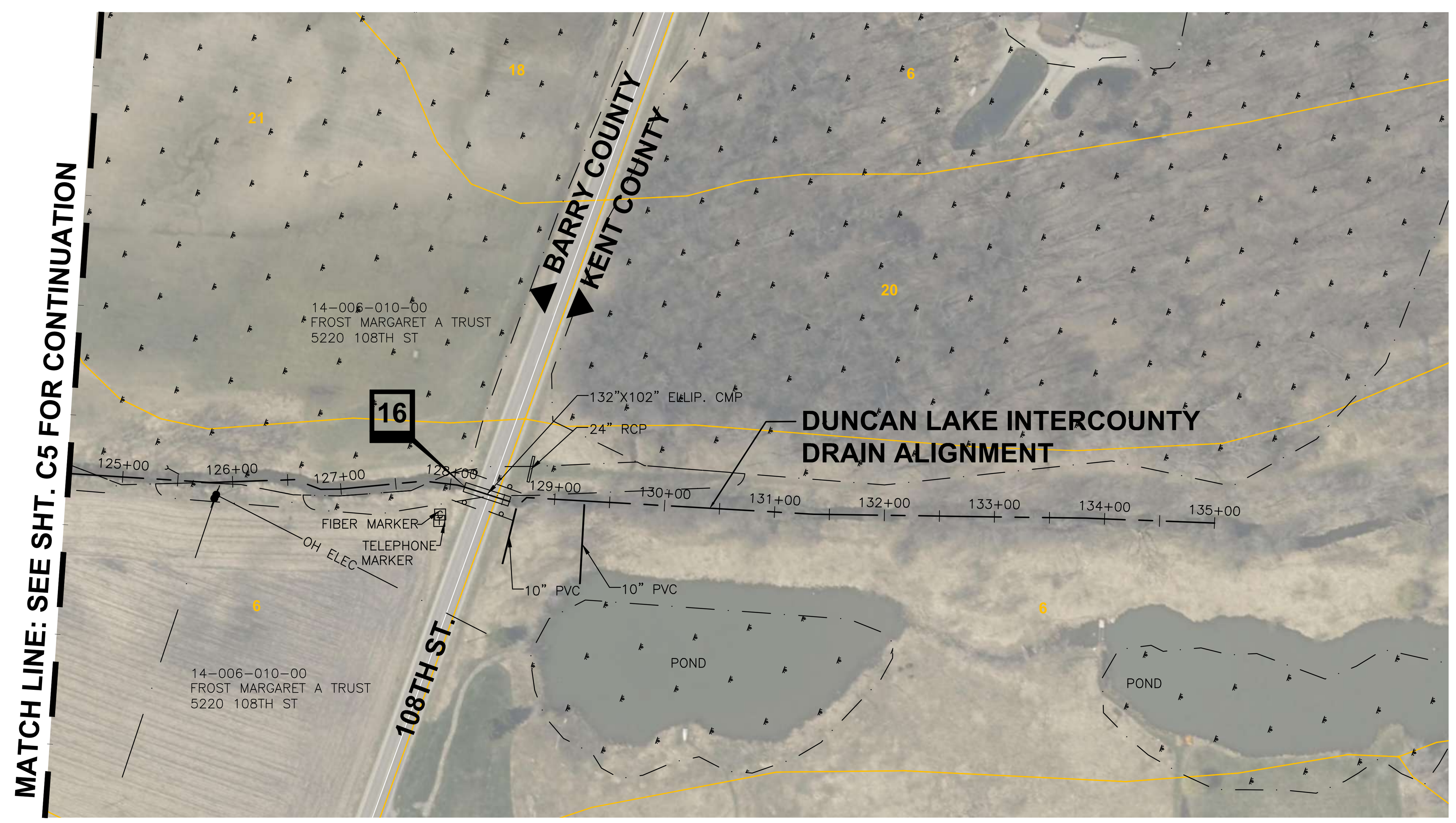


PLAN VIEW

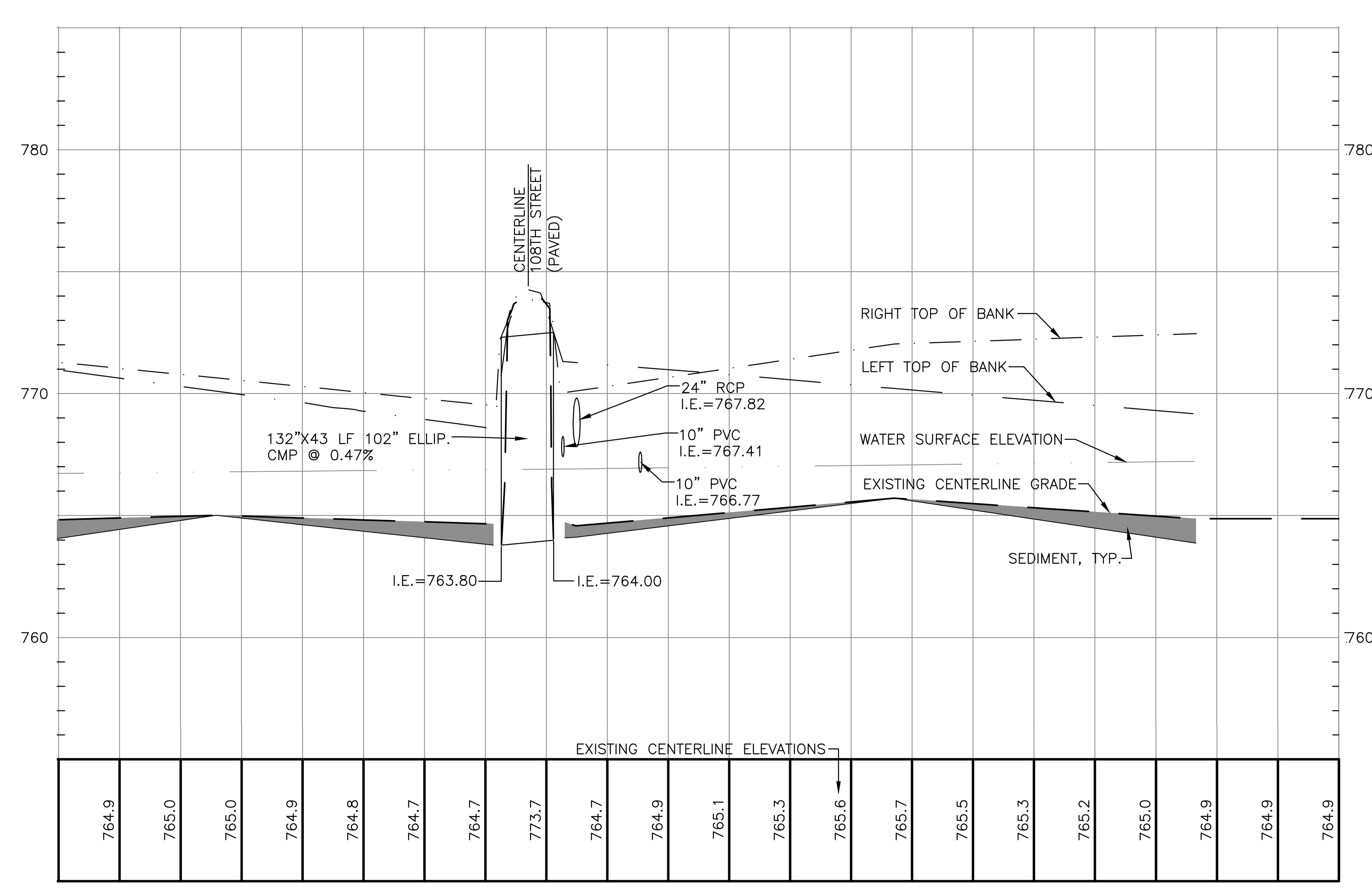
0 100 200
Horizontal Scale in Feet

LEGEND

WETLAND (USFWS NATIONAL WETLAND INVENTORY)

56A SOIL TYPE (USDA NRCS WEBSOIL SURVEY)

16



CENTERLINE PROFILE

SCALE: HORIZONTAL: 1" = 100'
VERTICAL: 1" = 5'

3 WORKING DAYS
BEFORE YOU DIG
CALL MISS DIG
1-800-482-7171

ALL UTILITIES AS SHOWN ARE APPROXIMATE LOCATIONS DERIVED FROM ACTUAL MEASUREMENTS AND AVAILABLE RECORDS. THEY SHOULD NOT BE INTERPRETED TO BE EXACT LOCATION NOR SHOULD IT BE ASSUMED THAT THEY ARE THE ONLY UTILITIES IN THE AREA.

2121 3 Mile Rd. NW
Walker, MI 49544
Ph: 616-301-7888
www.LREM.com
LRE ENGINEERS & SURVEYORS

REVISIONS: NO.	ISSUED FOR	DATE
1.	PRELIMINARY REVIEW	2/25/2022

CLIENT: DUNCAN LAKE INTERCOUNTY DRAIN DRAINAGE DISTRICT BOARD

PROJECT: DUNCAN LAKE INTERCOUNTY DRAIN
KENT, ALLEGAN & BARRY COUNTY, MICHIGAN

PROJECT NUMBER: 22-008	DATE
SURVEYED BY: CVF, ADK	02/2022
DESIGNED BY: DJF	03/2022
DRAFTED BY: LGG	02/2022
QA/QC:	03/2022

SHEET NAME: PLAN & PROFILE
STA: 124+50 - 135+00

SHEET NUMBER
C6