# Feasibility Analysis for a Gravity Outfall
# Fish Lake – Crystal Lake – Mud Lake

## Town of Roxbury
## Dane County, Wisconsin

## Town of West Point
## Columbia County, Wisconsin
**April 2020**


Prepared by:

MSA Professional Services, Inc.
1230 South Boulevard
Baraboo, WI 53913
Phone: 608-355-8844
www.msa-ps.com

Project No. 1017021



MSA

# Feasibility Analysis of Gravity Outfall
# Fish Lake - Crystal Lake – Mud Lake
# Town of Roxbury

## TABLE OF CONTENTS



## LIST OF TABLES



## LIST OF APPENDICES

# CHAPTER 1 – BACKGROUND INFORMATION

## 1.1 BACKGROUND INFORMATION

Fish Lake, Crystal Lake and Mud Lake are located near the border of Dane County and Columbia County in the Township of Roxbury (Dane County) and in the Township of West Point (Columbia County). Fish Lake and Mud Lake (sometimes referred to as Mud Bay) are connected by culverts under Fish Lake Road but for the purposes of this report, they are referred to separately as they are distinctively different bodies of water. Water levels in these 3 lakes have been rising over the past four plus decades prompting property owners around the lakes to form a Lake District. The District has attempted to control the water levels in the Lakes by pumping but these efforts have been costly and largely ineffective, influenced by prolonged periods of above average precipitation.

Historically, the lakes have never had an overland gravity overflow. They are essentially “kettle” lakes that rely on seepage to the aquifer along with evaporation to control the water levels. That history changed in 2019 as Crystal Lake overflowed its banks to flow into Fish Lake. If current trends continue, Fish Lake and Mud Lake will continue to rise to the current level of Crystal Lake and then the three combined lakes will overflow a height of land south of Mud Lake and the runoff will then continue overland to the west eventually discharging to Wisconsin River through a quarry currently operated by Lycon, Incorporated.

Past lake level increases have resulted in the displacement of residents and in the loss of property. Recreational enjoyment of these resources has also be severely impacted as lake access is restricted. Recent, rapid water level increases have resulted in the inundation of Town Roads, dramatically impacting the ability of emergency responders to serve the Town residents and also resulting in large expenses to the taxpayers to maintain reasonable access to property.

In 2019, at the request of the Lake District and State Legislators, the Wisconsin Department of Natural Resources did an overview of 7 discharge options to convey water away from the three lakes (Table included as Appendix A). This overview was not an extensive engineering review of any of the options, but rather a synopsis of the permits required and the permit process if any of these options were to be pursued. A public meeting was hosted by the Town of Roxbury on October 7, 2019 where these options were presented and public opinion was expressed.

The general sentiment expressed at the public meeting by the legislators and the regulators was of a willingness to work together toward a long-term sustainable solution to the water level issue. It was also stated that the process needed to originate with the local units of government to determine what the proposed solution would be. As the solution is likely well beyond the financial wherewithal of the Towns, assistance would be sought from the State and/or Counties and through grants if available.

### 1.1.1 PURPOSE OF THIS REPORT

The Townships have met jointly and are working toward an intergovernmental agreement to cover costs that will be incurred during the front end of this process. They have engaged MSA Professional Services, to evaluate the viability of a gravity outfall from the Lakes to the Wisconsin

River. The intent of this analysis is to identify a route and preliminarily size the conveyance components in order to develop a cost estimate of the improvements. This effort will also provide a document that will aid in further discussions with regulating agencies, property owners and other key stakeholders. It will also enable the Townships to solicit financial support for the project.

# CHAPTER 2 – THE OUTFALL

## 2.1 DESIRED OUTCOME

The goal of the water conveyance system described herein would be initially to draw the levels of the lakes down to what would be considered the historical ordinary high water mark for each lake and then ultimately to provide a level of control where water levels can be managed and maintained. It would also be the intent to implement this system with the minimum practical impact to the Wisconsin River which is classified as an Exceptional Resource Water (ERW).

Based on current regulatory requirements, the target elevation for Fish Lake and Mud Lake would be 858.7. (Currently at 865.5). The target elevation for Crystal Lake would be 868.2. (Currently at 873.4) It should be noted that these stated elevations are based on historical high water marks that have been realized only in the past 20 years. Ultimately, levels that are one to two feet lower than these most recent elevations would be beneficial in the ongoing management of the lake levels by allowing some level of storage and slow release.

By achieving this stated goal, the road system around the lakes that is currently inundated, could be reactivated allowing for better emergency response, safety and convenience to the travelling public and access to the lakes for recreational purposes.

### 2.1.1 THE CONVEYANCE SYSTEM

As stated previously, the current methodology for controlling the lake levels was by pumping of the lake water from two locations. The Fish Lake pumping station discharged to the Wisconsin River across from the Village of Prairie du Sac. That pump station is completely submerged and has been taken out of service. The Crystal Lake pumping station discharged to the Roxbury Creek in the Crane Lake Marsh near County Highway J in the Town of Roxbury. The use of that pump system has been somewhat sporadic due to water quality levels in Crystal Lake during different times of the year. When both pump systems were in service, the maximum discharge from the lakes was approximately 4 cubic feet per second (cfs). During dry periods of weather some progress could be noted on lake level control but any gains were quickly eliminated during heavy rains and/or prolonged periods of precipitation. This pumping came at a high cost for electricity to power the pumps.

The recommended conveyance system which is the subject of this analysis is a gravity pipe outfall from the combined lake system to the Wisconsin River. A gravity pipe will have a higher initial cost to install due to the deeper excavation required to achieve the necessary pipe gradient, however there will not be the operating costs associated with electrical power as there is no pumping required.

Previous studies have shown that there is a groundwater relationship between Fish Lake and Crystal Lake. Historically, Crystal Lake has been approximately 9-10 feet higher in elevation than Fish Lake. Studies have shown that lowering Fish Lake in elevation by one foot would result in a lowering of Crystal Lake by approximately one tenth of a foot. For this reason it is felt that any solution that does not include a drawdown structure on Crystal Lake would not provide the level

of relief that is desired for the entire area. The concept shown for this analysis includes a pipe from Crystal Lake to Mud Lake along the north side of Schoepp Road.

A number of different pipe sizes were analyzed for the gravity outfall. Two scenarios were considered in this analysis. The first is the lake drawdown scenario. The larger the outfall pipe, the less time that will be required to draw down the lakes from the current high levels to the proposed management levels.
The second discharge scenario would be the normal operating range of the lake management system. Flows during this scenario will be considerably less than the drawdown rates as level control outlet structures would be utilized to discharge at a lower rate over a longer period of time. The lakes can then be managed at levels that allow for some storage of larger rainfall events without significant increases in the discharge flows.

Since the lake drawdown period can be considered a temporary condition and since the normal operating flow of the system will be lower, it is important to consider the economics of the system in choosing the size of the pipe.

Flow capacity of a gravity pipe is a combination of the size of the pipe and the slope that the pipe is installed at. The steeper the pipe slope, the more capacity that it will have. In this system it is desirable to utilize a relatively flat pipe slope in order to avoid deep excavation for the installation. For the purposes of this report, a pipe slope of 0.10% was utilized which results in approximately 12 feet of fall from Fish Lake to State Highway 188. Table 1 below shows the flow capacities of various pipe sizes at a slope of 0.10% and the associated duration that it would take to draw down the lake for each pipe size.

| Culvert Pipe Size | Capacity Flowing Full | Volume Per Day | Drawdown Duration |
|---|---|---|---|
| 24-inch diameter | 8 cubic feet per second | 16 Acre Feet/Day | 510 Days |
| 30-inch diameter | 14 cubic feet per second | 28 Acre Feet/Day | 290 Days |
| 36-inch diameter | 24 cubic feet per second | 48 Acre Feet/Day | 170 Days |
| 42-inch diameter | 34 cubic feet per second | 68 Acre Feet/Day | 120 Days |
| 48-inch diameter | 50 cubic feet per second | 100 Acre Feet/Day | 82 Days |
| 60-inch diameter | 90 cubic feet per second | 180 Acre Feet/Day | 45 Days |

**TABLE 1 – PIPE CAPACITIES**

For the purposes of this report and the associated cost estimates, a pipe size of 42-inch diameter was chosen from Fish Lake to the Wisconsin River. A 30-inch diameter pipe was chosen for the Crystal Lake to Mud Lake segment. Further analysis may be warranted during final design of the system.

### 2.1.2 THE ROUTE

The old adage that “the shortest distance between two points is a straight line” would seem to indicate that the most direct route from the lakes to the river would be a straight line. Due to the nature of a gravity pipe system being installed at a specific grade, the topography of the land along the route dictates a more meandering course. Exhibits 1 & 2 in Appendix A show the approximate route that is the basis of this analysis. For the most part the route follows the path

that the water will flow overland in the event that the lakes exceed the current maximum capacity. This results in the shallowest possible excavation and hence the least cost for installation for the pipe between Fish Lake and State Highway 188. Preliminary discussions with the landowner west of STH 188 indicated no willingness to allow the flow from the lakes to pass through their property so from that point the route shifts to the north and through an area of deeper excavation. Ultimately the pipe is shown to discharge into the Clifton Road right-of-way adjacent to lands owned by the Wisconsin Department of Natural Resources. Depth of excavation was taken into account in the cost estimating for the project. Preliminary plan and profile drawings are included in Appendix B which show the depth of the installation along the selected route.

It should be noted that easements will be required along the route as it passes through private property. Since all of the pipe will be buried and the surface of the land restored to pre-existing condition, there should be minimal negative impact to the affected properties.

# CHAPTER 3 – WATER QUALITY

## 3.1.1 BACKGROUND

A detailed analysis of water quality is beyond the scope of this analysis however some measures have been considered in the design to account for this issue.

As previously discussed, there have been two distinct pumping systems designed to control the lake levels. The Fish Lake pump station discharged to the Wisconsin River near to the area being considered for this proposed gravity outfall. The Crystal Lake pump station discharged along Mussen Road to County Trunk Highway Y near the Crane Lake marsh. Lake water quality issues and the impact to receiving waters has been a point of contention in the past and intake structures have been revamped and pumping curtailed at times when the water quality in the lakes did not meet the required standards. Historically the water quality in Fish Lake has been better than its counterpart Crystal Lake.

Currently the 3 lakes are essentially acting as one. Water from Crystal Lake has been flowing overland into Fish Lake for months and Fish Lake and Mud Lake are essentially one water body at this time. Some consideration will need to be given to this situation during the drawdown period as effective treatment will not be feasible at the flow rates that will be required to bring the lake levels down.

## 3.1.2 DESIGN CONSIDERATIONS

As mentioned earlier, the system presented in this report includes a drawdown structure from each of the lakes. The Crystal Lake outlet would be discharged first to the wetland area north of Schoepp Road where some treatment will occur. The overflow from this wetland area would flow to Mud Lake where additional settling of solids and treatment can occur.

Feedback from the Department of Natural Resources has indicated a desire to disconnect Mud Lake from Fish Lake for the purpose of better managing the fishery. So Mud Lake would have its own dedicated outlet to gravity outfall.

Finally, Fish Lake would have a dedicated outlet to the gravity pipe. Under this design configuration, after the drawdown period, each of lakes to could be managed to their own levels and according to the water quality conditions imposed as a part of the permitting process.

# CHAPTER 4 – COST

## 4.1 PROJECT COST

The estimated cost of construction for the layout as show in Appendix B including engineering and contingencies is $5,800,000. A detailed breakdown of this cost is shown in Table 2 below.

**TABLE 2 – PRELIMINARY CONSTRUCTION COST ESTIMATE**

**PRELIMINARY CONSTRUCTION COST ESTIMATE**
**FISH/CRYSTAL/MUD LAKES GRAVITY OUTFALL TO WISCONSIN RIVER**
**TOWNS OF ROXBURY AND WEST POINT**
**Feb-20**

Estimate

| ITEM NO. | ITEM DESCRIPTION | EST QTY | UNITS | UNIT PRICE | TOTAL PRICE |
|---|---|---|---|---|---|
| | **Fish Lake & Mud Lake Outfalls** | | | | |
| 1 | Mobilization, Bonds and Insurance | 1 | LS | $ 25,000.00 | $ 25,000.00 |
| 2. | Traffic Control | 1 | LS | $ 2,000.00 | $ 2,000.00 |
| 3. | Erosion Control | 1 | LS | $ 20,000.00 | $ 20,000.00 |
| 4. | 42-inch Storm Sewer (10 ft minus depth) | 9,550 | LF | $ 140.00 | $ 1,337,000.00 |
| 5. | 42-Inch Storm Sewer (15 ft depth) | 2,000 | LF | $ 170.00 | $ 340,000.00 |
| 6. | 42-Inch Storm Sewer (20 ft depth) | 1,450 | LF | $ 200.00 | $ 290,000.00 |
| 7. | 42-Inch Storm Sewer (25 ft depth) | 800 | LF | $ 250.00 | $ 200,000.00 |
| 8. | 42-Inch Storm Sewer (30 ft depth) | 650 | LF | $ 300.00 | $ 195,000.00 |
| 9. | 42-Inch Storm Sewer (40 ft depth) | 1,300 | LF | $ 350.00 | $ 455,000.00 |
| 10. | 42-Inch Class IV Bore and Jack | 150 | LF | $ 500.00 | $ 75,000.00 |
| 11. | 30-Inch Storm Sewer | 1,000 | LF | $ 120.00 | $ 120,000.00 |
| 12. | Storm Manholes | 12 | EA | $ 4,000.00 | $ 48,000.00 |
| 13. | 30-Inch Storm Sewer | 1,300 | LF | $ 150.00 | $ 195,000.00 |
| 14. | 42-Inch Endwall | 1 | EA | $ 800.00 | $ 800.00 |
| 15. | Lake Outlet Structure | 2 | EA | $ 15,000.00 | $ 30,000.00 |
| 16. | Medium Random RipRap | 200 | CY | $ 60.00 | $ 12,000.00 |
| 17. | Surface Restoration | 1 | LS | $ 100,000.00 | $ 100,000.00 |
| 18. | Dewatering | 1 | LS | $ 300,000.00 | $ 300,000.00 |
| 19. | Cofferdam Construction for Inlet Structure | 1 | LS | $ 100,000.00 | $ 100,000.00 |
| | Subtotal | | | | $ 3,844,800.00 |
| | 10% Contingency | | | | $ 384,480.00 |
| | Engineering | | | | $ 576,720.00 |

| | | | | | |
|---|---|---|---|---|---|
| | **TOTAL** | | | $ | 4,806,000.00 |

| ITEM NO. | ITEM DESCRIPTION | EST QTY | UNITS | UNIT PRICE | TOTAL PRICE |
|---|---|---|---|---|---|
| | **Crystal Lake Outfall** | | | | |
| 20. | Traffic Control | 1 | LS | $ 2,000.00 | $ 2,000.00 |
| 21. | Erosion Control | 1 | LS | $ 20,000.00 | $ 20,000.00 |
| 22. | 30-Inch Storm Sewer (10 ft minus depth) | 2,800 | LF | $ 120.00 | $ 336,000.00 |
| 23. | 30-Inch Storm Sewer (added depth) | 1,000 | LF | $ 250.00 | $ 250,000.00 |
| 24. | Storm Manholes | 4 | EA | $ 3,500.00 | $ 14,000.00 |
| 25. | 30-Inch Endwall | 2 | EA | $ 650.00 | $ 1,300.00 |
| 26. | Open Swale Excavation | 100 | LF | $ 100.00 | $ 10,000.00 |
| 27. | Lake Outlet Structure | 1 | EA | $ 15,000.00 | $ 15,000.00 |
| 28. | Medium Random RipRap | 40 | CY | $ 60.00 | $ 2,400.00 |
| 29. | Surface Restoration | 1 | LS | $ 50,000.00 | $ 50,000.00 |
| 30. | Dewatering | 1 | LS | $ 40,000.00 | $ 40,000.00 |
| 31. | Cofferdam Construction for Inlet Structure | 1 | LS | $ 50,000.00 | $ 50,000.00 |
| | Subtotal | | | | $ 790,700.00 |
| | 10% Contingency | | | | $ 79,070.00 |
| | Engineering | | | | $ 118,605.00 |
| | **TOTAL** | | | | $ 988,375.00 |

Not Included
Legal and Administrative Costs
Easement or Property Acquistion Fees

# CHAPTER 5 – SUMMARY

## 5.1 EXECUTIVE SUMMARY

Fish Lake, Crystal Lake and Mud Lake have continued to rise over the past decades. Absent a natural outlet for the lakes, the rising levels have displaced residents and inundated property resulting in a diminished enjoyment of the resource. It has also resulted in costs to the taxpayers to maintain access to properties. Emergency response time has also been impacted by the loss of connecting roads due to the high water.

Pumping the lakes as an effort to control the water levels has been largely ineffective and expensive. An alternate exists that is a gravity outfall pipe to the Wisconsin River. A gravity pipe will have a large initial cost to install but will not have the operating costs associated with the pump systems.

The gravity system as outlined in this report would draw down the lakes to historic levels where transportation around the lakes and enjoyment of the resource can be restored. Once the drawdown has been achieved, the lake levels will be able to be managed with greatly reduced discharge flows.

# APPENDIX A

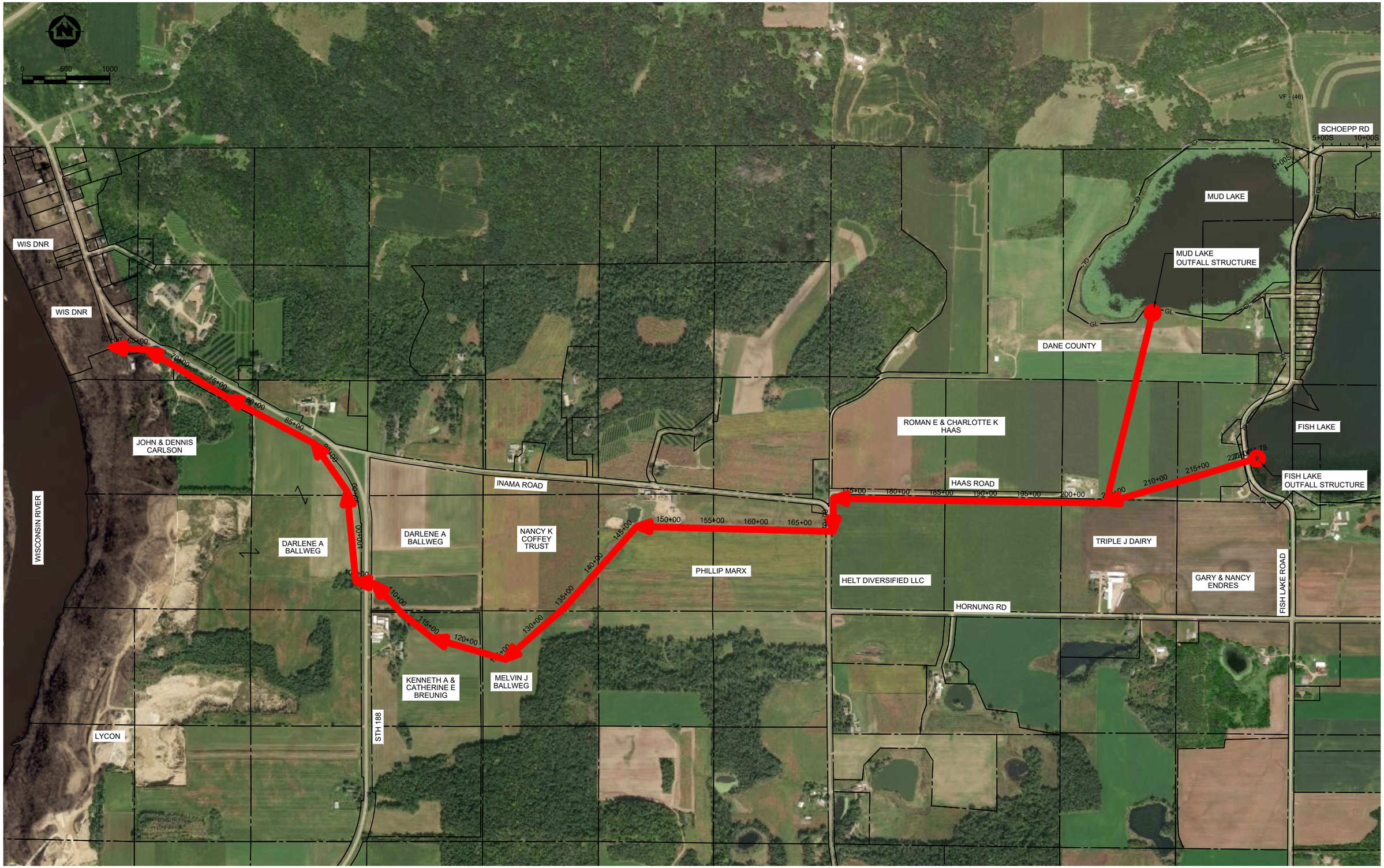
# DEPARTMENT OF NATURAL RESOURCES EXHIBT

# Crystal Lake/Fish Lake/Mud Lake Regulatory Requirements for Options Under Consideration

| Water Body | Proposed Discharge Location | Receiving Water Designation | Required Permit for Pumping | Estimated Time for Permit | Concerns | Considerations |
|---|---|---|---|---|---|---|
| Crystal Lake | Roxbury Creek (Current Permitted Discharge) | Discharges to Exceptional Resource Water (ERW) and Limits must be protective | Ineligible for a general permit due to impacts to ERW. Individual WPDES Permit Required | Permit in place. 2 to 3 months for a permit modification if needed | Current BOD limits are controling and difficult to attain during the warmer months. TSS must meet background concentrations in the LWR which may be challenging. Current maximum daily flow rate Is 1.5 MGD. A permit modification will be required to change effluent limits along with an anit-degradation demonstration | Develop Flow-Based limits which requires stream flow monitoring. Additional TSS data may be collected to modify limits |
| Crystal Lake | Lower Wisconsin River | ERW | Ineligible for a general permit due to impacts to ERW. Individual WPDES Permit Required | 2 to 3 months | Limits would be similar to the Roxbury Creek Discharge. BOD limits may be higher. Significant opposition to a direct discharge to the LWR in the past. Permit likely to be challenged delaying implementaton. | Likely not a viable solution both short and long term. |
| Crystal Lake | Lake Wisconsin | Impaired Water. Approved TMDL in place | Likely eligible for a general permit | 2 weeks | The TMDL has set aside phosphorus allocation for general permits. The dicharge would need to be monitored under the general permit to determine the mass of phosphorus discharged and pumping would need to stop once the mass allocation is attained. A Wetlands and Waterway permit may be needed for an intake and discharge structure. | |
| Crystal Lake | Lodi/Spring Creek | ERW/Class II Trout Stream | Ineligible for a general permit due to impacts to ERW. Individual WPDES Permit Required | 2 to 3 months | Limits for a discharge to an ERW must be set at background concentrations which will likely be difficult to attain. Likely high public opposition to a dishcarge due to public use of the State Wildlife Area and concerns with impacts to flooding in the Village of Lodi. A floodplain anaysis my be needed to determine potential impacts from the additional water. Any discharge would impact the Master Plan for the State Wildlife Area and require approval by the Natural Resources Board. | |
| Crystal Lake | Lodi Marsh | Discharges to ERW and Limits must be protective. Must not negatively impact wetlands | Ineligible for a general permit due to impacts to ERW. Individual WPDES Permit Required | 2 to 3 months | Limits for a discharge to an ERW must be set at background concentrations which will be highly difficult to attain. High public opposition to a dishcarge due to public use of the State Wildlife Area and concerns with impacts to flooding in the Village of Lodi. A floodplain anaysis my be needed to determine potential impacts from the additional water. Any discharge would impact the Master Plan for the State Wildlife Area and require approval by the Natural Resources Board. The Lodi Marsh contains unique and fragile wetlands that may require more stringent limits. | |
| Fish Lake | Lower Wisconsin River (Current Permitted Discharge) | ERW | Ineligible for a general permit due to impacts to ERW. Individual WPDES Permit Required | Permit in place. 2 to 3 months for a modification if needed | The maximum allowable flow rate in the current permit is 1.5 MGD. An increased discharge may required new limits and a permit modification. | |
| Crystal Lake (constructed overflow) | Fish Lake | Impaired Water (total phosphorus and chlorophyll) | **Enlargement and Protection of Waterways:** Chapter 30.19 Individual permit for enlarging an artificial water body that connects with an existing navigable waterway.<br>**Dams:** Chapter 31 permit to construct a dam. Department to set water level and public rights stage.<br>**Water Quality:** Chapter 40.06 permit for trasport of invasives.<br>**Wetlands:** Individual permit if disturbance is >10,000 sq. ft.<br>**Stormwater:** General permit for earthwork. | 6+ months | *Aquative invasive species transport (yellow bass, carp, milfoil, etc.) from Crystal Lake to Fish Lake<br>*Aquatic Invasive Species Early Detection Monitoring<br>*Flowage or flooding easements from each impacted property owner<br>*Floodplain impacts regulated by Dane/Columbia Zoning Departments<br>*Fish/Mud Lake water levels | *Consider impacts to landowners as well as to Mud Lake and beyond.<br>*Structure for control of invasive species<br>*Navigability of artificial waterway |

# APPENDIX B

# PLAN VIEWS

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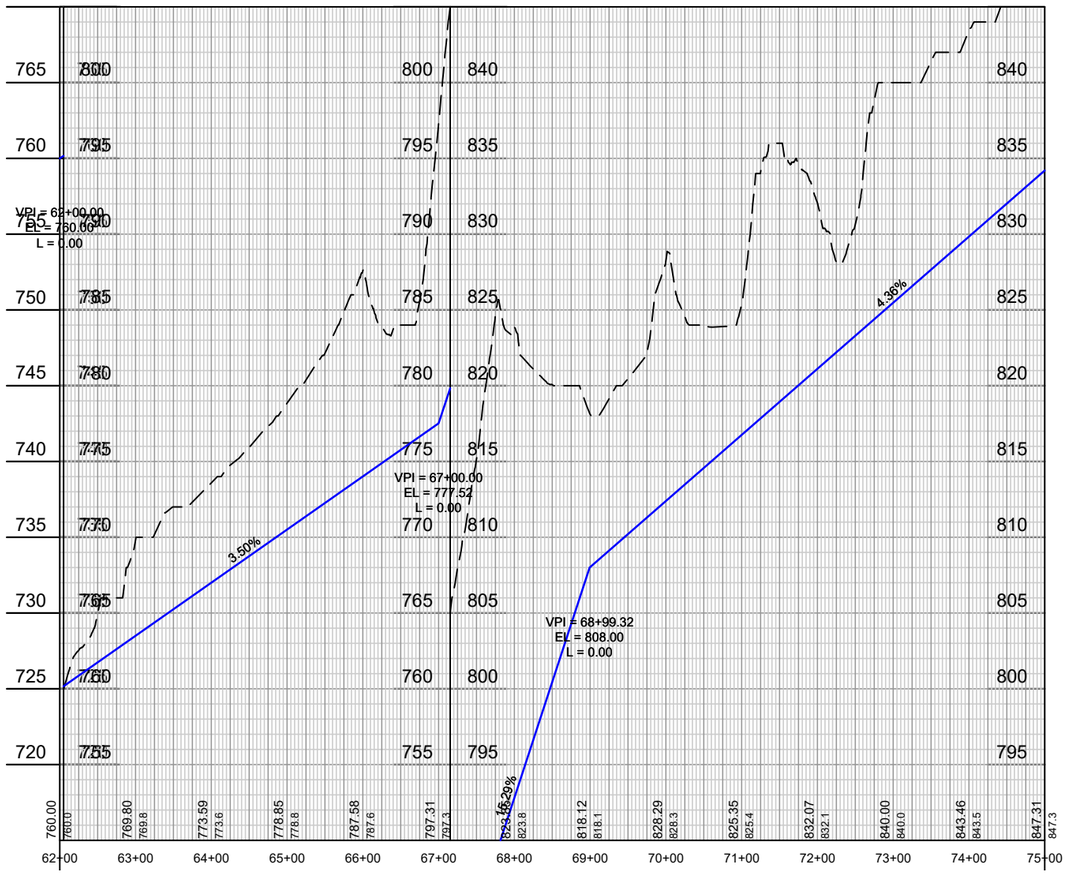
# APPENDIX C

# PLAN & PROFILE VIEWS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PLAN & PROFILE - FISH LAKE OVERFLOW

PROJECT NO. 01017021

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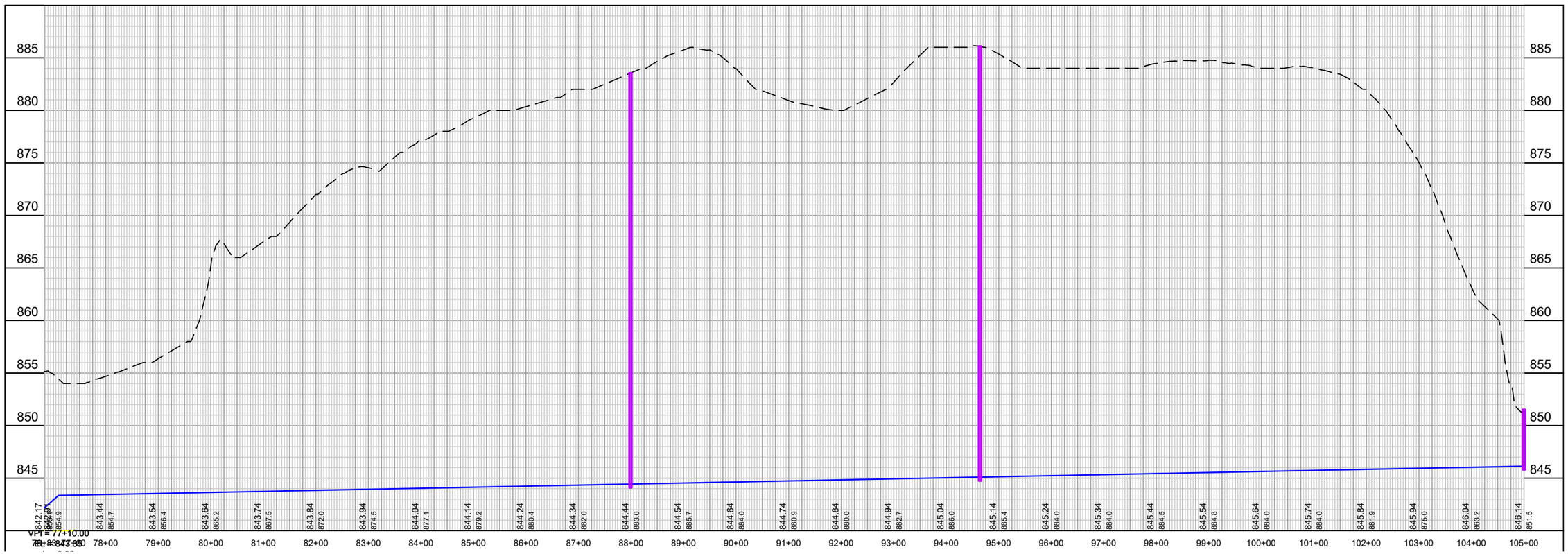


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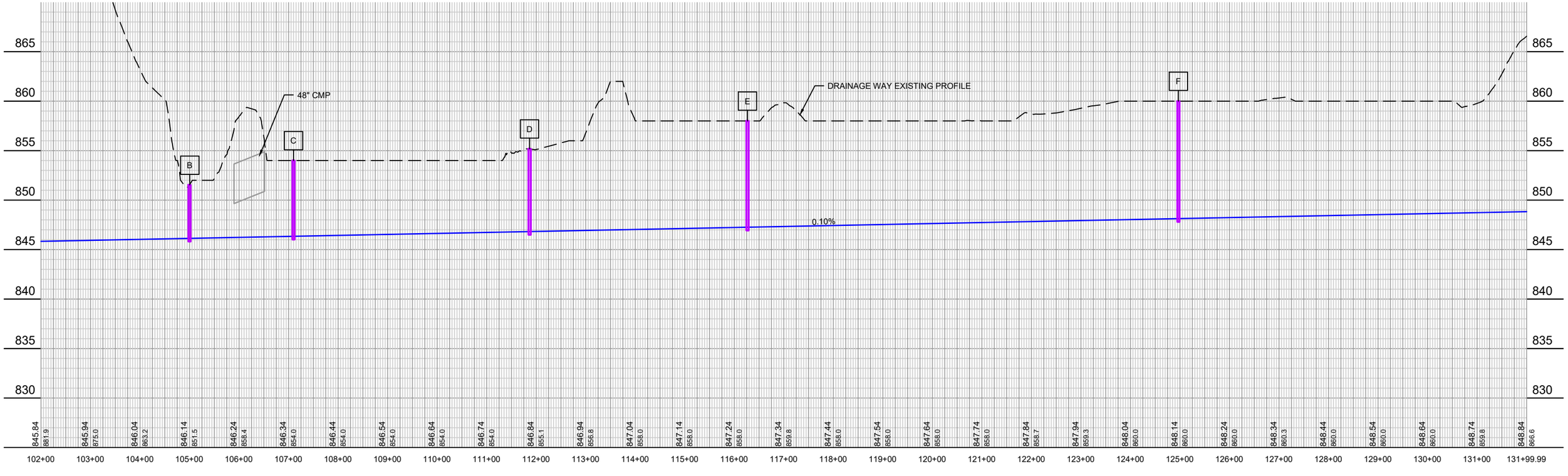


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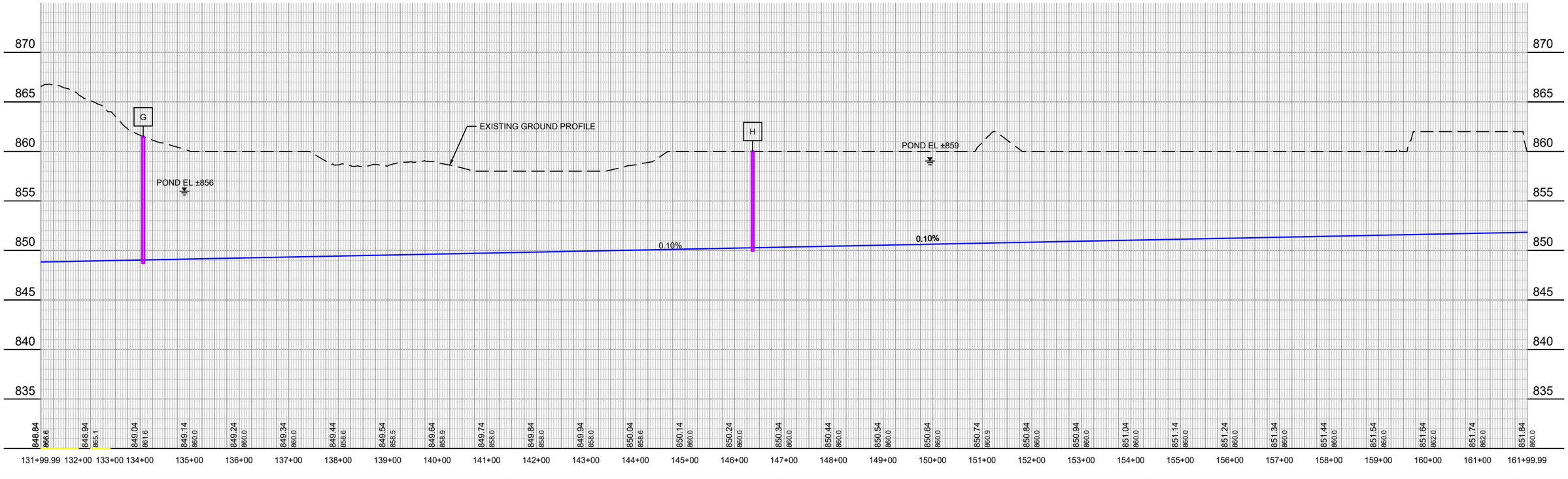


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PROJECT NO. 01017021

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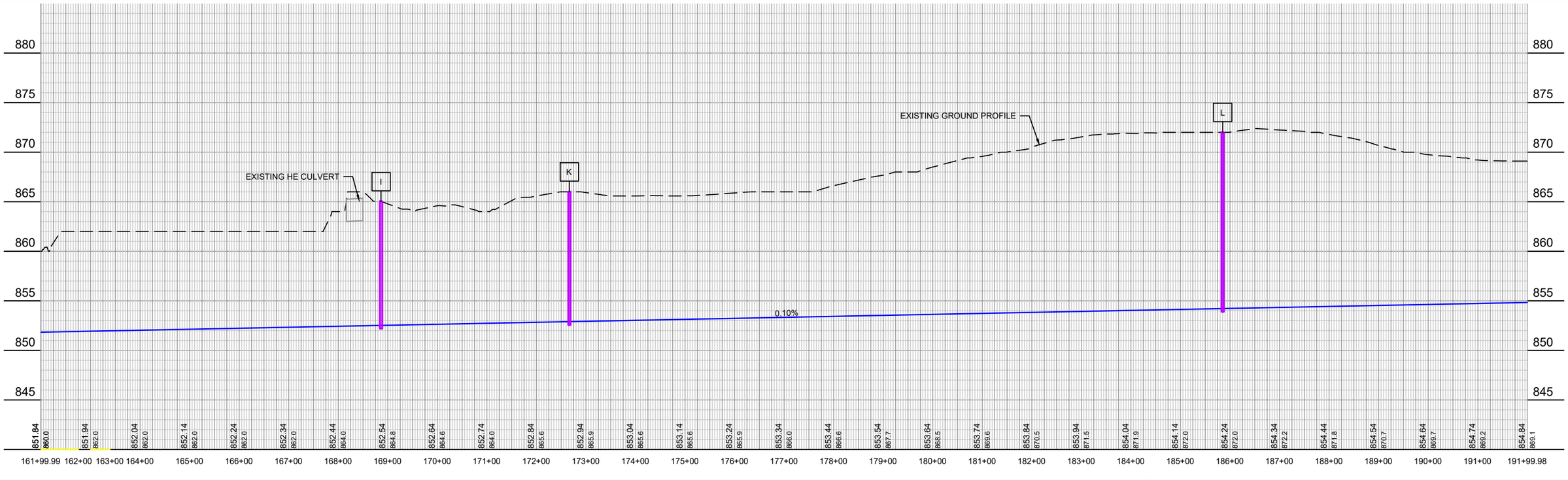


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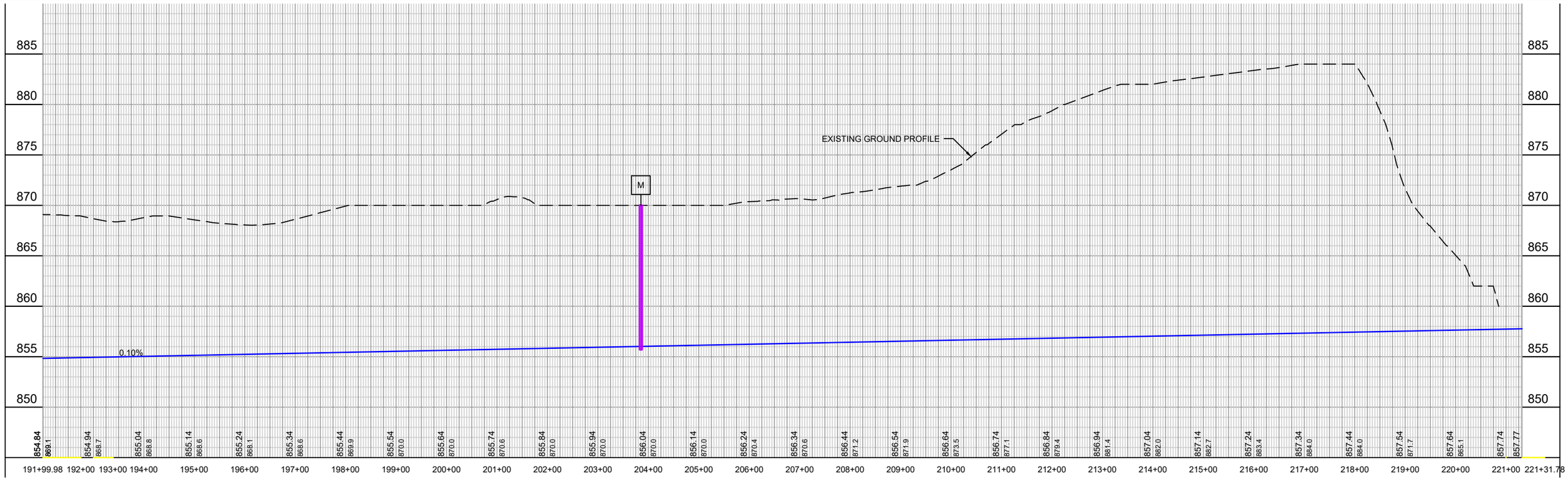


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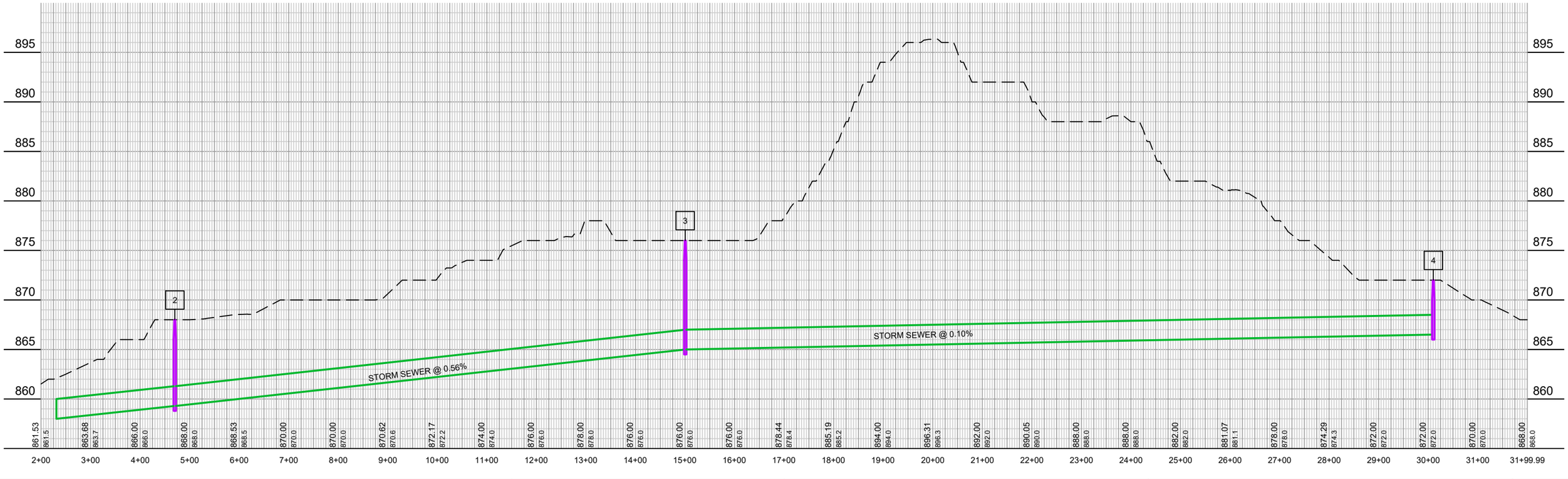
SHEET
P6


| | | NO. | DATE | REVISION | BY |
|---|---|---|---|---|---|
| PROJECT DATE: . | DRAWN BY: JDH | . | . | . | . |
| | DESIGNED BY: INIT | . | . | . | . |
| | CHECKED BY: ---- | . | . | . | . |

PLOT DATE: Monday, March 16, 2020 8:57:26 AM, G:\01\01017\01017021\CADD\Construction Documents\VFG - Schoepp Road - (13) - (14).dwg

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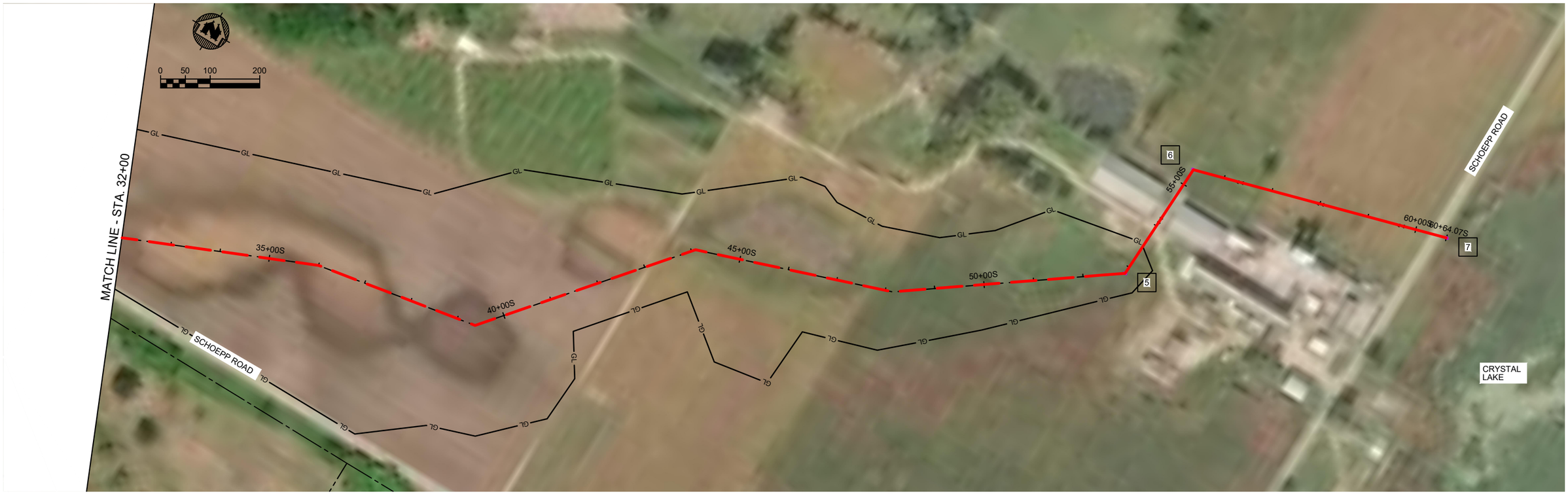
PROJECT NO. 01017021

SHEET P7





| | | NO. | DATE | REVISION | BY |
|---|---|---|---|---|---|
| PROJECT DATE: . | DRAWN BY: JDH | . | . | . | . |
| | DESIGNED BY: INIT | . | . | . | . |
| | CHECKED BY: ---- | . | . | . | . |

PLOT DATE: Monday, March 16, 2020 8:59:32 AM, G:\01\01017\01017021\CADD\Construction Documents\VFG - Schoepp Road - (13) - (15).dwg

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SHEET P8