CITY OF PLYMOUTH, WISCONSIN
TUESDAY, NOVEMBER 28, 2023 COMMITTEE OF THE WHOLE MEETING
6:30 PM, COUNCIL CHAMBERS
CITY HALL, 128 SMITH STREET

AGENDA

1. **Call to order and roll call**

2. **Approve the minutes from October 31, 2023**

3. **Discussion on Mill Pond Dam Process**

4. **Adjourn**

It is likely a quorum of members of other governmental bodies of the municipality may be in attendance at the above stated meeting to gather information. No action will be taken by any governmental body at the above stated meeting other than the governmental body specifically referred to above in this notice.

Please note that, upon reasonable notice, efforts will be made to accommodate the needs of disabled individuals through appropriate aids and services. For additional information or to request this service, please contact the City of Plymouth ADA Coordinator Leah Federwisch, located in the Plymouth Utilities office at 900 County Road PP, Plymouth, WI or call 920-893-3853.

CITY OF PLYMOUTH, WISCONSIN
TUESDAY, OCTOBER 31, 2023 COMMITTEE OF THE WHOLE MEETING
CITY HALL, 128 SMITH STREET

OFFICAL MINUTES

1. **Call to order and roll call:** Mayor Pohlman called the meeting to order at 6:15 PM. On the call of the roll the following were present: Greg Hildebrand, Jeff Tauscheck, Dave Herrmann, Angie Matzdorf, Diane Gilson, Mike Penkwitz, and John Nelson. Also present were: City Administrator/Utilities Manager Tim Blakeslee, Police Chief Ken Ruggles, Director of Public Works Cathy Austin, and Clerk/Deputy Treasurer Anna Voigt.

2. **Approve the minutes from July 26, 2023:** Motion was by Hildebrand/Tauscheck to approve the minutes from July 26. A unanimous aye vote was cast. Motion carried.

3. **Mill Pond Dam Study Report:** Blakeslee explained in 2015 the City of Plymouth receive a notice from the Wisconsin Department of Natural Resources required the spillway capacity of the Mullet River Dam be brought into compliance within 10 years. As part of the 2023 budget, the City included funding to hire an engineering firm to provide services to assist the City in making the decision on whether to remove the dam or make necessary upgrades/replace the dam to meet the DNR regulations. Adam Schnieder from Ayres did a presentation explaining the options for the dam. He reviewed 4 options: Crest Gate, Slide Gates, Split-Leaf Gates and removal of the dame. Hildebrand stated he would like the options to go to a referendum. Nelson asked if it was possible for trash racks to be installed. Schnieder stated that it wouldn't really be an option due to the back up of debris. Herrmann asked if there were a great deal of maintenance for the options. Schnieder answered that it was minimal but all of them would need some. Gilson asked how long the project would take. Schnieder stated that it would take all summer.

4. **Adjourn:** Motion was made by Gilson/Matzdorf to adjourn the meeting at 7:05 PM. A unanimous aye vote was cast. Motion carried.

City of Plymouth
128 Smith St. - P.O. Box 107
Plymouth, WI 53073-0107

Telephone: **(920) 893-3745**
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DATE: November 21, 2023

TO: Committee of the Whole

FROM: Tim Blakeslee, City Administrator/Utilities Manager

RE: Discussion on Mullet River Dam Process

Background: In 2015, the City of Plymouth received a notice from the Wisconsin Department of Natural Resources (WDNR) that required the spillway capacity of the Mullet River Dam to be brought into compliance with NR333.06 within 10 years (2025). As part of the 2023 Budget, the City included funding to hire an engineering firm to provide services to assist the City in making the decision on whether to remove the dam completely or make necessary upgrades/replace the dam to meet DNR regulations. The City issued a Request for Qualifications (RFQ) in early 2023 and received proposals from Kapur & Associates and Ayres Associates. In March 2023, Ayres Associates was selected to complete a study providing options available. Ayres has significant experience in both dam removal and dam upgrade/replacement. In addition, The City of Plymouth was also allocated $1,000,000 in the 24-25 State Budget for the removal or restoration of the dam.

Ayres has reviewed the options and completed the Mullet River Dam Spillway Improvement and Dam Removal Feasibility Study. The study is included as Attachment 1. Ayres presented the study and the four various dam removal and replacement options on October 28, 2023.

The next step is to determine a pathway forward for a decision on the dam. Staff has prepared three options for council consideration. Minor adjustments to timing can be made with Option 1 and Option 2, but should direction be to move forward with Option 3, decisions would need to be made quickly as the deadline for finalizing referendum language is January 23, 2023 for the April 2024 election.

Option 1 - Public Hearing and Council Decision

- Public Hearing (January 30, 2024
- Council Decision (February 13, 2024)
  - If Removal - Move Forward With Bids
  - If Replace - Selection of Removal Option (February 27, 2024)
    - Following Selection - Move Forward With Bids

Option 2 - Open House, Public Hearing, and Council Desicion

- Discussion with Council on Public Open House Information (December 12, 2023)
- Public Open House (January 9, 2024)
- Public Hearing (January 30, 2024)
- Council Decision (February 13, 2024)
  - If Removal - Move Forward With Bids
  - If Replace - Selection of Removal Option (February 27, 2024)
    - Following Selection - Move Forward With Bids

Option 3 - - Open House, Public Hearing, Referendum, and Council Desicion

- Discussion with Council on Referendum Information and Selection of Rebuild Option for Referendum (December 12, 2023)
- Decision on Referendum Languague (January 9, 2024)
- Public Open House (March 12, 2024)
- Public Hearing (March 26, 2024)
- Public Open House (January 9, 2024)
- Referendum Held (April 2, 2024)
- Council Decision (April 11, 2024
  - If Removal - Move Forward With Bids
  - If Replace - Move Forward With Bids

Recommendation: Provide Staff direction on Mullet River Dam Process

Attachment: Mullet River Dam Spillway Improvement and Dam Removal Feasibility Study

Mullet River Dam

Spillway Improvement and Dam Removal Feasibility Study

Prepared for:

City of Plymouth
Plymouth, Wisconsin

September 2023

Mullet River Dam

Spillway Improvement and Dam Removal Feasibility Study

3433 Oakwood Hills Parkway
Eau Claire, WI 54701-7698
715.834.3161
www.AyresAssociates.com

Ayres Project No. 37-0116.00
File: i:\37\plymouth, city of\37-0116.00 mullet river dam engineering services\report\mullet river dam - feasibility study 9-7-23.docx

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Executive Summary

Situation

Mullet River Dam is located on the Mullet River in Section 22, T15N, R21E in Sheboygan County, WI. The dam's impounded area, Plymouth Millpond, is approximately 41 acres, and the contributing watershed area is about 54 mi^2. Downstream of the dam, the Mullet River flows for approximately 15 miles to the Sheboygan River, which discharges into Lake Michigan. As reported by the Wisconsin Department of Natural Resources (WDNR), the dam is primarily used for recreational purposes. Normal pool is maintained at approximately 833.4 feet (all elevations given in this report are with respect to NAVD 88). From northwest to southeast, project features include a 38-ft long fixed crest spillway, a 23.5-ft long sharp-crested flashboard spillway, a 4-ft diameter (corrugated metal pipe) CMP whistle tube, and an earthen embankment with a minimum crest elevation of about 834.6 ft. The fixed crest spillway elevation is approximately 833.8 ft, and the crest of the sharp-crested flashboard spillway is approximately 832.1 ft with the top of the boards at 833.0 ft. Per WDNR records, the discharge capacity of the dam is 550 cfs.

A dam failure analysis (DFA) was completed for Mullet River Dam in 2015 and later approved by the WDNR. The DFA assigned a hazard rating of "Low" to the dam. With this hazard rating, per Table I in Wisconsin State Statutes Chapter NR 333.07(1), the dam's spillways must be capable of passing the 100-year flood without overtopping the embankment. (The 100-yr flood is a flood that has a 1-in-100 chance of being exceeded in magnitude during a given year.) If meeting this requirement is not possible, Chapter NR 333.07(2)(a) states that "all dams which will be submerged by flows less than the minimum hydraulic capacity specified in Table I shall be designed to pass the flow of the river at submergence."

The 2015 DFA concluded that, as currently configured, Mullet River Dam does not meet NR 333 spillway capacity requirements. Therefore, the WDNR issued a directive for the City to increase spillway capacity to achieve compliance with NR 333. The current due date to meet this directive is 2025.

Tasks

Ayres was retained by the City of Plymouth to evaluate potential spillway upgrades for Mullet River Dam to increase its capacity as required by the WDNR's directive. For each spillway upgrade alternative, our evaluations include conceptual drawings, a description of benefits and drawbacks, and an engineer's opinion of probable cost. In addition to spillway modification alternatives, we were also tasked with evaluating a dam removal option.

Actions

To complete the feasibility study, we:

1. Obtained from the City a 1-dimensional (1-D) HEC-RAS hydraulic model of the study area. Per our understanding, this model was used for the 2015 DFA.
2. Verified that the provided HEC-RAS model of Mullet River produced results consistent with the results of the DFA.
3. Modified the existing dam's geometry within the HEC-RAS model to represent alternatives capable of meeting the WDNR's spillway capacity requirements. We developed three spillway modification alternatives: 1) crest gate, 2) stainless steel slide gates, and 3) stainless steel split-leaf gates.

4. Developed concept-level drawings of the three dam modification alternatives, as well as a dam removal scenario.
5. Compiled and described the pros and cons associated with each of the three modification alternatives and the dam removal scenario.
6. Analyzed the floodplain impacts associated with implementing each of the alternatives.
7. Estimated total project costs—including construction and engineering services (design/permitting, bidding, and construction administration)—for each of the spillway modification alternatives and the dam removal scenario.
8. Provided recommendations to assist the City with determining the next steps and described available funding mechanisms.

Alternatives

Option 1: Crest Gate with Hydraulic Controls

A crest gate consists of a single reinforced steel panel that can be rotated around the axis of a fixed hinge to various levels of opening and closure. A crest gate can be operated fully closed, fully open, or at intermediate levels between. For this option, opening and closing the crest gate is controlled using a hydraulic pump and piston. The hydraulic controls would be housed in a small enclosure adjacent to the dam. Our hydraulic simulations indicated that a 34 ft long by 9.5 ft high crest gate would meet all design objectives.

An example crest gate that Ayres and SteelFab Inc. designed for the Milwaukee River in Grafton, Wisconsin is shown in Figure 1. Note that the Grafton crest gate is 20 ft wide by 8-ft high. Another crest gate example, designed by Ayres and Rodney Hunt is currently being installed at Sheboygan Marsh. A photo of the Sheboygan Marsh crest gate being fitted into place is provided in Figure 2. The Sheboygan Marsh crest gate is 25 ft wide and 8 ft high. Steel crest gates usually have service lives of 50 years or more. Significant maintenance items include changing of hydraulic fluid (usually recommended by manufacturers every 5-10 years), painting (may be needed every 15-20 years), and replacment of side seals (may be needed every 15-20 years).

Figure 1. Hydraulically operated crest gate on the Milwaukee River in Grafton, WI (Photo: Ayres)

Figure 2. Crest gate being installed in new spillway at Sheboygan Marsh (Photo: Aaron Brault)

Advantages of crest gates include the following:

- Intuitive and variable water level control. For example, if the operator desires to lower the upstream pool level by one inch, lowering the gate crest by one inch will likely come close to accomplishing this task. Relationships between gate opening and upstream water level are more complicated with bottom opening gates.
- Crest gates generally pass ice and floating debris better than bottom-opening gates.
- Crest gates open (rotate downward) by releasing the hydraulic pressure in the cylinder, thus allowing upstream water pressure to push the gate down. During emergencies, this is advantageous because the gate can be quickly opened even without access to electrical power. If crest gates need to be closed (raised) during a time when electrical power is not available, the hydraulics are operable using a backup handpump.

Disadvantages of crest gates include the following:

- Crest gates are generally more expensive than other gate types.
- Top-draw releases through a crest gate may not provide the sediment-flushing capabilities of bottom-draw gates.
- Ice may form and accumulate at the downstream base of the crest gate, which may prevent the gate from fully opening during cold-period operations. If the upstream water pressure is not sufficient to break the ice and open the gate, ice buildup is often mitigated against using heated sills and/or side seals, and ice buildup can also be removed mechanically or with steam/hot water.
- The plumbing required for the hydraulic operator and a suitable enclosure for the hydraulic pump add cost to this alternative.

In addition to the crest gate, a 27-foot-long fixed crest ogee spillway would be constructed on the northwest end of the structure. This will not need any operation and will help pass flood flows. The crest of the ogee spillway is proposed to match that of the existing fixed crest spillway (i.e., elevation 833.8 ft).

We estimate the total cost of implementing the crest gate alternative at Mullet River Dam to be approximately $2,550,000.

Option 2: Two Stainless Steel Slide Gates

Slide gates are configured to open and close vertically. As a slide gate is lifted above its concrete sill, water from the upstream impoundment flows underneath. For Mullet River Dam, we determined that two 10-ft wide by 9.5-ft high stainless steel slide gates would be required to provide sufficient flood capacity. Each gate would have its own electric operator, and an operator bridge would be required for access. An example photograph of three slide gates with a similar configuration to that which would be installed at Mullet River Dam is provided in Figure 3. Similar to the crest gate option, the service life of stainless-steel crest gates could be 50 years or more. Significant maintenance items for these gates include rebuilding gearboxes and replacing side seals. These are both items that usually are not needed more frequently than every 15-20 years, and in some cases, are never needed throughout the lifespan of a gate.

Figure 3: Three stainless steel slide gates in Ogdensburg, WI (Photo: Ayres)

Advantages of slide gates include the following:

- Slides gates have the lowest cost of the options analyzed for this study.
- Slide gates have lower operation and maintenance requirements than the other options analyzed.
- Bottom-draw capabilities may help with flushing sediment from the lake.

Disadvantages of slide gates include the following:

- Significant gear ratios may be required to lift these gates. This may make operation more time consuming than what is required for the other gate options analyzed, particularly if manual opening using a handwheel is required.
- Upstream water level control using a bottom-draw gate is not as straightforward as water level control using an overflow gate.
- Bottom draw gates are more likely to catch debris.
- Ice formation and accumulation may make these gates difficult to open during cold-weather operations. Sizing the gate so that it flows over the top when closed, under normal pool conditions, may help to prevent ice formation. Some dam owners also circulate water upstream of the gates or use aerators to mitigate against ice formation.

Under normal operating conditions, the two slide gates would be kept slightly opened to pass river flows and maintain a constant water elevation in the upstream millpond. To decrease lake levels, or to allow flood flows to pass through the dam, the gates could be opened further to allow for additional water to pass underneath. A downside to this approach is that the amount of opening required for each gate to achieve a desired level of lake drawdown would likely need to be required through experience and trial and error.

In addition to the slide gates, a 40-foot-long fixed crest ogee spillway would be constructed on the northwest end of the structure. This will not need any operation and will help pass flood flows. The crest of the ogee spillway is proposed to match that of the existing fixed crest spillway (i.e., elevation 833.8 ft).

While the stainless steel slide gates can generally be fabricated and installed at a cost lower than the other options, significant cost is added for this application because a sizeable steel or concrete deck would be required to allow the operator to access the gates. We estimate the cost of implementing the stainless steel slide gate alternative at Mullet River Dam to be approximately $1,850,000.

Option 3: Two Stainless Steel Split-Leaf Gates

Split-leaf gates merge two gates in one frame to allow for water to flow either over the top or below the gate assembly. The top leaf can be lowered to easily control lake levels during normal flow periods, while both the top and the bottom leaves can be raised to quickly pass flood flows. For Mullet River Dam, we determined that two 10-ft wide by 9.5-ft high stainless steel split-leaf gates would be required to provide sufficient flood capacity. Each gate would have its own electric operator, and an operator bridge would be required for access. An example photograph of two split-leaf gates with a similar configuration to that which would be installed at Mullet River Dam is provided in Figure 4. Similar to the crest gates and slide gates, the service life of stainless steel split-leaf gates could be 50 years or more. Maintenance requirements are comparable to that of the slide gate option. However, since split-leaf gates have more moving parts than a single-panel slide gate, opportunities for maintenance increase.

Figure 4: Two installed split-leaf gates (right side of photo) in Bloomer, WI (Photo: Ayres)

Advantages of split-leaf gates include the following:

- With the two leaves, weir flow or sluice flow are possible.
- Intuitive and variable water level control.
- Split-leaf gates can pass ice and floating debris over the top of the gates, and flush sediment through the bottom draw of the lower leaf.

Disadvantages of split-leaf gates include the following:

- Split-leaf gates are generally more expensive than slide gates.
- With two leaves, there are more moving parts for operation and maintenance.
- Ice formation and accumulation may make these gates difficult to open during cold-weather operations. Allowing water to flow over the top during normal pool conditions may help to prevent ice formation. Some dam owners also circulate water upstream of the gates or use aerators to mitigate against ice formation.

Under normal operating conditions, the bottom leaf would be kept fully lowered and the top panel would be lowered slightly to pass water over the top. To decrease lake levels, the top leaf can be lowered to the desired level. To allow for flood flows to pass through the dam, the top leaf can be lowered more significantly or both leaves can be raised simultaneously to open up the spillway completely.

In addition to the split-leaf gates, a 40-foot-long fixed crest ogee spillway would be constructed on the northwest end of the structure. This will not need any operation and will help pass flood flows. The crest of the ogee spillway is proposed to match that of the existing fixed crest spillway (i.e., elevation 833.8 ft).

We estimate the cost of constructing two stainless steel split-leaf gates at Mullet River Dam to be approximately $1,950,000.

Option 4: Dam Removal

For the dam removal option (hereby referred to as Option 4), we included not only a removal of the existing dam structure, but also riverbank stabilization and ecological restoration. Should the dam removal be pursued, the City may scale the project scope accordingly, up or down, based on community input, budget, and funding opportunities.

For Option 4, we investigated the feasibility of removing Mullet River Dam, in lieu of modifying it, to meet WDNR's spillway capacity requirements. Major project components, as included in our conceptual plan, include:

- Removal of the entire existing concrete dam structure.
- Streambank stabilization using riprap and rock riffles.
- Grading for channel stabilization.
- Dredging/sediment removal.
- Bio-stabilization at storm water outfalls.
- Wetland space and native plantings.

A drawing illustrating this plan is included in Appendix B. Our removal plan does not include extensive enhancements to the previous lakebed. This area would likely need to be purchased by the City or temporary construction easements obtained prior to construction. Many components could be added onto this option if desired.

Currently there are eight storm water outfalls that discharge into the mill pond that would need to be extended to meet the proposed river channel. This would prove to be an additional challenge that would need to be addressed if this option is desired.

The costs associated with basic dam removal and lakebed rehabilitation are approximately $1,250,000. A detailed cost breakdown is provided in Appendix D.

To enhance the previous lakebed with scenic areas, fishing nodes, or other public spaces, land acquisition would be a large challenge and financial hurdle. Due to this, our Option 4 looked solely at removing the dam and stabilizing the existing lakebed and channel. For a more robust look into possible enhancements, see the *Mullet River Corridor Study* completed by MSA Professional Services in November 2015.

Following are the steps required in the State of Wisconsin to pursue removal of a dam (from the WDNR *Dam Abandonment and Removal Fact Sheet*):

1. Prepare conceptual drawings, a narrative description of the proposed dam removal project, and contact the WDNR's Regional Water Management Engineer to discuss the project and confirm the requirements for pursuing the dam removal.
2. Prepare detailed drawings and specifications (construction-ready level of detail), prepared and stamped by a professional engineer licensed in the State of Wisconsin, and submit to the WDNR a Chapter 31 permit application to remove the dam. Along with the drawings and specifications, the permit application will require a detailed narrative description of the project, including the:

    - Purpose of the project.
    - Drawdown procedure to be used prior to dismantling the dam.
    - Parts of the dam to be removed.
    - Method by which the dam is to be removed.
    - Disposal site for the dam materials.
    - Stream channel and flowage bed restoration and protection needs.

    To support the permit application, the dam owner will also need to include a:

    - Hydrologic and hydraulic report. For dam removals, these reports usually must include an estimate of the 100-yr flood and a computed profile of the 100-yr flood, both upstream and downstream, without the dam in place.
    - Sediment management plan. This plan that explains existing sediment conditions, how sediment transport will be managed during dam removal, and how the bed will be stabilized after removal. Sediment sampling and testing is usually required prior to a dam removal.

3. After the dam owner submits the Chapter 31 permit application, the owner must prepare and publish a notice to inform the public of the proposed dam removal. Public hearings are not required, but state law requires that one must be held if requested in response to the public notice. If there are any objections to the dam removal, state law requires a 120-day waiting period. During this waiting period, the dam owner should be prepared to defend and justify the request for abandonment.
4. After the Chapter 31 permit application has been submitted, public notice and hearing requirements have been met, and the owner has responded to WDNR review comments and requests for more information, a Chapter 31 permit to remove the dam may be issued.

Summary of Alternatives

Estimated total project costs for all four alternatives are summarized in Table 1. For each alternative, costs include engineering services (design, bidding, and construction administration), construction, permitting, and a 30-percent contingency.

Table 1. Estimated Total Project Costs

Alternative	Estimated Total Project Cost
Option 1: Crest Gate	$2,550,000
Option 2: Slide Gates	$1,850,000
Option 3: Split-Leaf Gates	$1,950,000
Option 4: Dam removal	$1,250,000

Of the three gate options analyzed, Option 2 (slide gates) is the lowest cost alternative and affords relatively minor operation and maintenance requirements. Option 1 (crest gates) is the most expensive alternative but provides the best debris and water level control. Option 3 (split-leaf gates) provides some of the water level control benefits associated with the crest gate option, but at a lower cost and with more operational requirements.

Floodplain Impacts

All the alternatives described in this report will impact the Mullet River's 100-yr floodplain. The alternatives analyzed significantly increase the capacity of flow through the dam, so the maximum headwater is significantly lowered for all cases. The reduction in headwater from the existing condition for each alternative is shown in Table 2. As a result of being able to pass increased flow early in the storm, the maximum downstream water surface elevations are also lowered for all alternatives, but these changes are minor. The maximum reduction in downstream water surface elevation from the existing condition for each alternative is shown in Table 3. More documentation on hydraulic modeling and complete results are provided in Appendix A.

The Mullet River Dam is within a Special Flood Hazard Area (SFHA)—specifically Zone AE—which will be inundated by the 100-yr flood. Due to this SFHA and the proposed changes in water surface elevations, upstream and downstream, FEMA will require that the owner obtain a permit for floodplain development for any of the alternatives selected. As part of the permit application process, the owner will need to apply for a Conditional Letter of Map Revision (CLOMR). After the permit for floodplain development is approved and the CLOMR is issued by FEMA, dam repairs or removal can take place (presuming the WDNR's Chapter 31 permit has also been issued). Following construction, the owner will need to apply for FEMA to issue a Letter of Map Revision (LOMR). It is important for the owner to keep these FEMA requirements in mind because they are in addition to the WDNR's Chapter 31 requirements and have their own associated timelines and costs.

Table 2: Q100 Headwater Elevations

Alternative	Q100 Headwater Elevation (ft)	Reduction in Headwater Elevation (ft)
Existing	836.57	-
Crest Gate	834.54	2.03
Slide Gates	834.54	2.03
Split-Leaf Gates	834.54	2.03
Dam Removal	830.59	5.98

Table 3: Q100 Tailwater Elevations

Alternative	Q100 Tailwater Elevation (ft)	Reduction in Tailwater Elevation (ft)
Existing	831.12	-
Crest Gate	830.93	0.19
Slide Gates	831.11	0.01
Split-Leaf Gates	831.11	0.01
Dam Removal	831.15	+0.03

Table 4: Q100 Water Surface Elevations 1-Mile Downstream of Dam

Alternative	Q100 Tailwater Elevation (ft)	Reduction in Tailwater Elevation (ft)
Existing	819.41	-
Crest Gate	819.39	0.02
Slide Gates	819.41	0.00
Split-Leaf Gates	819.41	0.00
Dam Removal	819.43	+0.02

Funding Opportunities

The City of Plymouth has received a $1,000,000 funding commitment from the Wisconsin DNR for the repair or removal of the Mullet River Dam for the 2023-2025 biennial budget. This is a unique opportunity, as this grant does not have a cost-share associated with it, as do most of the dam grant programs. A WDNR Municipal Dam Grant application will need to be submitted and the process will need to be followed, but the grant money has already been approved by the WDNR.

For the dam removal alternative, additional grant opportunities may be available to ease the financial burden. Costs associated with obtaining and restoring the land in the lakebed to provide recreational opportunities could be defrayed through a Knowles-Nelson Stewardship Grant. This grant program is provided to local governments who are proposing land acquisition projects that provide public access for outdoor recreation purposes.

Another possible funding opportunity for the dam removal option is the U.S. Army Corps of Engineers Section 206 program. This program helps to develop aquatic ecosystem restoration and protection to improve the quality of the environment. Under this program, the feasibility phase is federally funded up to $100,000 and any additional costs are shared on a 50/50 basis with the applicant. Design and construction costs are shared 65 percent federal and 35 percent applicant. The City is responsible for the costs associated with provision of lands and/or easements, but these costs are applied to the 35 percent that the City is responsible for. Under the Section 206 program, the Corps of Engineers leads the entire project from feasibility phase through construction.

Should the City decide to move forward with a dam removal, we recommend a planning study and outreach program be initiated to solicit input from the community on the overall vision for the project, to determine a budget, and to identify additional sources of funding based on what the community decides.

Conclusions

If the City decides to keep the Mullet River Dam in place, options 1 through 3 will all meet the WDNR's directive to increase spillway capacity. All three options use gate types that are commonly employed at similar dams and have long service lives with generally minimal maintenance requirements.

If cost is the City's primary concern, then Option 2 (slide gates) will likely prove to be the lowest-cost alternative. If ease of operation and superior water level control are the City's primary concern, then Option 1 or 3 (Crest gates or split-leaf gates) are likely the best alternatives.

Dam removal and lakebed restoration is also a feasible alternative that could possibly be accomplished at a lower total cost than the dam rehabilitation alternatives. A significant challenge with dam removal, however, will be acquiring the flowed lands or, at minimum, obtaining temporary construction easements to allow the project to move forward. Given the large number of private properties around the mill pond, obtaining access or acquiring the flowed lands would likely be a costly and time-consuming endeavor.

Study Limitations

The goal of this feasibility study is to provide the City of Plymouth with information that can be used to assist with developing a plan to repair or remove Mullet River Dam. Technical analyses completed for this study were of an appropriate level of detail for the planning phase of a project, but they not of a design level of detail. Therefore, the alternatives presented may be subject to modification and refinement during the design phase. Furthermore, the cost estimates provided here are engineers' opinions of probable total project costs. We based these cost estimates on published construction data, our own experience with similar local projects, and budgetary cost estimates provided to us by a gate vendor. Estimates for engineering fees, which include design and permitting, bidding, and construction administration, are generally 10 to 20 percent of the total construction costs. We believe our cost estimates to be conservative and appropriate for budgetary planning purposes. But we do not guarantee that actual project costs will fall within the estimates provided here.

Appendix A

Hydraulic Report

MEMORANDUM

To:	City of Plymouth		
From:	Austin Rieder, PE		
Date:	September 7, 2023	Project No.:	37-0116.00
Re:	Mullet River Dam Feasibility Study - Hydraulics		

Hydrology

An independent hydrologic analysis was not completed as part of this hydraulic study. The 100-year FIS hydrograph for the Mullet River was taken directly from the Dam Failure Analysis (DFA) completed by Kapur & Associates in 2015. The peak of the hydrograph is consistent with the peak flow listed in the Sheboygan County Flood Insurance Study (FIS).

Model Development

We completed the hydraulic analysis using HEC-RAS version 6.3. The existing dam break analysis utilized unsteady flow data from a HEC-HMS hydrograph. The geometric data was a combination of WDNR HEC-2 data, Kapur and Associates field data, Sheboygan County LiDAR, and WisDOT bridge data.

For the purpose of this feasibility study, the existing model was utilized to model the dam-in-place without failure. This condition served as a comparison for the proposed alternatives. For the proposed alternatives, the existing inline structure was manipulated to include differing gated structures. The gate structure sizes were increased until the capacity to pass the 100-year hydrograph without overtopping the embankment was reached.

Alternatives Evaluated

We considered proposed design alternatives based on the following design criteria:

- Pass the 100-year flood or submergence flood without overtopping any portion of the dam not designed for overtopping.
- Pass the 100-year flood without increasing the 100-year flood profile.

Based on these criteria, the following alternatives were evaluated:

- One 34-ft wide by 9.5-ft high crest gate with 27-ft wide ogee fixed crest spillway.
- Two 10-ft wide by 9.5-ft high slide gates with 40-ft wide ogee fixed crest spillway.
- Two 10-ft wide by 9.5-ft high split-leaf gates with 40-ft wide ogee fixed crest spillway.
- Complete dam removal.

The crest of the gates in all three gated alternatives was set to match the existing flash board crest elevation of 833.0 feet. All three gated alternatives also utilize a fixed crest ogee spillway to increase the dam's capacity at higher pool elevations. The crest of the ogee spillway was set to match the existing

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fixed crest weir elevation of 833.8 feet. For the crest gate alternative, the ogee spillway is 27-feet wide and for the slide gates and split-leaf gates alternatives, the ogee spillway is 40-feet wide.

Results

According to the Sheboygan County FIS, the 100-year storm results in a headwater elevation of 836.8 feet for the existing conditions or 2.2 feet of overtopping flow. All four alternatives modeled greatly increase the capacity of the dam and thus, result in the ability to pass the 100-year storm without overtopping. The HEC-RAS tabular output is provided on the following pages.

HEC-RAS Model Results Table

HEC-RAS River: Mullet Reach: Plymouth Profile: Max WS

Reach	River Sta	Profile	Plan	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)	
Plymouth	527	Max WS	Pro Slide Gates	3203.10	828.70	834.99		835.10	0.000413	2.66	1291.19	287.36	0.20
Plymouth	527	Max WS	No Dam	3250.93	828.70	833.23		833.49	0.001702	4.16	813.85	255.10	0.38
Plymouth	527	Max WS	Pro Crest Gates	3179.18	828.70	834.95		835.05	0.000419	2.66	1278.56	286.56	0.20
Plymouth	527	Max WS	Existing	3206.30	828.70	836.72		836.77	0.000153	1.94	1812.99	317.13	0.13
Plymouth	526.9	Max WS	Pro Slide Gates	3197.73	828.10	834.88		834.92	0.000188	1.78	1834.04	370.60	0.14
Plymouth	526.9	Max WS	No Dam	3240.05	828.10	832.33		832.51	0.001704	3.48	932.02	337.37	0.37
Plymouth	526.9	Max WS	Pro Crest Gates	3174.40	828.10	834.83		834.88	0.000190	1.78	1817.16	369.99	0.14
Plymouth	526.9	Max WS	Existing	3207.04	828.10	836.68		836.71	0.000070	1.31	2529.65	400.43	0.09
Plymouth	526.8	Max WS	Pro Slide Gates	3197.00	827.20	834.87		834.89	0.000059	1.07	3003.19	516.04	0.08
Plymouth	526.8	Max WS	No Dam	3235.90	827.20	832.14		832.20	0.000411	1.97	1642.17	473.50	0.19
Plymouth	526.8	Max WS	Pro Crest Gates	3173.16	827.20	834.82		834.84	0.000059	1.07	2979.46	515.60	0.08
Plymouth	526.8	Max WS	Existing	3207.11	827.20	836.68		836.69	0.000024	0.82	3954.32	533.06	0.05
Plymouth	526.75	Max WS	Pro Slide Gates	3198.25	827.10	834.87		834.88	0.000026	0.75	4257.58	670.43	0.05
Plymouth	526.75	Max WS	No Dam	3235.87	827.10	832.13		832.16	0.000161	1.32	2455.22	642.29	0.12
Plymouth	526.75	Max WS	Pro Crest Gates	3174.19	827.10	834.82		834.83	0.000026	0.75	4226.65	670.00	0.05
Plymouth	526.75	Max WS	Existing	3207.22	827.10	836.68		836.69	0.000011	0.59	5488.72	687.47	0.04
Plymouth	526.7	Max WS	Pro Slide Gates	3197.61	827.00	834.87		834.87	0.000027	0.73	4431.26	779.22	0.05
Plymouth	526.7	Max WS	No Dam	3234.91	827.00	832.09		832.12	0.000226	1.39	2323.31	726.30	0.14
Plymouth	526.7	Max WS	Pro Crest Gates	3172.96	827.00	834.82		834.83	0.000028	0.73	4395.27	778.61	0.05
Plymouth	526.7	Max WS	Existing	3206.67	827.00	836.68		836.69	0.000011	0.56	5876.00	812.10	0.04
Plymouth	526.6	Max WS	Pro Slide Gates	3198.76	826.60	834.86		834.87	0.000047	0.82	3939.70	879.91	0.07
Plymouth	526.6	Max WS	No Dam	3234.07	826.60	831.99		832.04	0.000498	1.88	1716.92	611.81	0.20
Plymouth	526.6	Max WS	Pro Crest Gates	3173.50	826.60	834.81		834.82	0.000047	0.83	3899.02	878.73	0.07
Plymouth	526.6	Max WS	Existing	3206.98	826.60	836.68		836.68	0.000016	0.59	5708.49	1094.33	0.04
Plymouth	526.5	Max WS	Pro Slide Gates	3196.95	826.20	834.85		834.86	0.000033	0.62	5204.88	1323.02	0.05
Plymouth	526.5	Max WS	No Dam	3233.34	826.20	831.90		831.95	0.000426	1.66	1946.92	744.94	0.18
Plymouth	526.5	Max WS	Pro Crest Gates	3173.22	826.20	834.81		834.81	0.000034	0.62	5143.61	1318.47	0.05
Plymouth	526.5	Max WS	Existing	3207.10	826.20	836.68		836.68	0.000010	0.41	7830.81	1471.04	0.03
Plymouth	526.4	Max WS	Pro Slide Gates	3197.89	825.55	834.85		834.85	0.000018	0.68	5701.60	1384.07	0.04
Plymouth	526.4	Max WS	No Dam	3233.17	825.55	831.85		831.88	0.000130	1.32	2492.40	669.95	0.11
Plymouth	526.4	Max WS	Pro Crest Gates	3173.36	825.55	834.80		834.81	0.000018	0.68	5637.28	1382.25	0.04
Plymouth	526.4	Max WS	Existing	3206.54	825.55	836.68		836.68	0.000007	0.48	8303.66	1467.19	0.03
Plymouth	526.3	Max WS	Pro Slide Gates	3197.72	824.90	834.84		834.85	0.000021	0.75	5229.50	1127.23	0.05
Plymouth	526.3	Max WS	No Dam	3232.64	824.90	831.79		831.83	0.000164	1.53	2252.70	684.43	0.12
Plymouth	526.3	Max WS	Pro Crest Gates	3172.86	824.90	834.79		834.80	0.000022	0.75	5177.20	1124.69	0.05
Plymouth	526.3	Max WS	Existing	3206.64	824.90	836.67		836.68	0.000008	0.55	7372.72	1203.41	0.03
Plymouth	526.2	Max WS	Pro Slide Gates	3197.23	824.10	834.83		834.84	0.000033	1.01	4065.61	912.16	0.06
Plymouth	526.2	Max WS	No Dam	3232.43	824.10	831.71		831.77	0.000209	1.92	1801.83	545.28	0.14
Plymouth	526.2	Max WS	Pro Crest Gates	3172.57	824.10	834.78		834.79	0.000033	1.01	4023.15	906.52	0.06
Plymouth	526.2	Max WS	Existing	3206.43	824.10	836.67		836.67	0.000013	0.73	5904.06	1078.32	0.04
Plymouth	526.1	Max WS	Pro Slide Gates	3196.92	823.50	834.81		834.83	0.000032	1.04	3880.63	825.94	0.06
Plymouth	526.1	Max WS	No Dam	3232.53	823.50	831.65		831.70	0.000170	1.87	1772.85	443.12	0.13
Plymouth	526.1	Max WS	Pro Crest Gates	3172.37	823.50	834.77		834.78	0.000032	1.04	3842.10	822.20	0.06
Plymouth	526.1	Max WS	Existing	3206.26	823.50	836.66		836.67	0.000014	0.77	5544.47	974.08	0.04
Plymouth	526	Max WS	Pro Slide Gates	3196.83	823.30	834.54	830.14	835.03	0.001368	5.64	585.68	102.68	0.36
Plymouth	526	Max WS	No Dam	3232.47	823.30	830.59		832.55	0.010286	11.24	287.69	60.81	0.91
Plymouth	526	Max WS	Pro Crest Gates	3172.34	823.30	834.54	828.60	834.94	0.000989	5.05	647.12	102.65	0.30
Plymouth	526	Max WS	Existing	3206.21	823.30	836.57	830.24	836.74	0.000428	3.68	1251.02	411.80	0.21
Plymouth	525.95			Inl Struct									
Plymouth	525.9	Max WS	Pro Slide Gates	3196.84	823.00	831.11		831.76	0.002292	6.46	495.19	83.51	0.47
Plymouth	525.9	Max WS	No Dam	3232.40	823.00	831.15		831.80	0.002302	6.49	498.35	83.72	0.47
Plymouth	525.9	Max WS	Pro Crest Gates	3172.31	823.00	830.93		831.77	0.003485	7.34	432.25	82.57	0.57
Plymouth	525.9	Max WS	Existing	3206.17	823.00	831.12		831.77	0.002289	6.46	496.46	83.59	0.47
Plymouth	525.7	Max WS	Pro Slide Gates	3196.82	821.44	831.08		831.45	0.000722	4.85	663.43	74.92	0.28
Plymouth	525.7	Max WS	No Dam	3232.34	821.44	831.12		831.49	0.000728	4.89	666.27	74.93	0.29
Plymouth	525.7	Max WS	Pro Crest Gates	3172.26	821.44	831.04		831.40	0.000722	4.84	660.49	74.90	0.28
Plymouth	525.7	Max WS	Existing	3206.23	821.44	831.09		831.46	0.000722	4.86	664.59	74.92	0.29
Plymouth	525.6	Max WS	Pro Slide Gates	3196.66	821.00	830.26	827.26	831.43	0.002808	8.67	372.17	44.62	0.52
Plymouth	525.6	Max WS	No Dam	3232.10	821.00	830.29	827.26	831.47	0.002842	8.74	373.32	44.63	0.53
Plymouth	525.6	Max WS	Pro Crest Gates	3172.26	821.00	830.23	827.24	831.39	0.002802	8.64	370.67	44.61	0.52
Plymouth	525.6	Max WS	Existing	3205.96	821.00	830.27	827.27	831.44	0.002810	8.69	372.76	44.63	0.52
Plymouth	525.5			Bridge									
Plymouth	525.4	Max WS	Pro Slide Gates	3196.49	821.00	829.79		831.10	0.003390	9.18	351.22	44.46	0.57
Plymouth	525.4	Max WS	No Dam	3231.48	821.00	829.80		831.13	0.003454	9.27	351.57	44.46	0.57
Plymouth	525.4	Max WS	Pro Crest Gates	3171.85	821.00	829.76		831.06	0.003381	9.14	349.86	44.45	0.57
Plymouth	525.4	Max WS	Existing	3205.73	821.00	829.80		831.11	0.003393	9.19	351.77	44.46	0.57
Plymouth	525.35	Max WS	Pro Slide Gates	3196.31	820.85	829.61		830.93	0.003447	9.20	350.27	44.40	0.57
Plymouth	525.35	Max WS	No Dam	3231.19	820.85	829.62		830.96	0.003518	9.29	350.39	44.40	0.58
Plymouth	525.35	Max WS	Pro Crest Gates	3172.00	820.85	829.58		830.89	0.003437	9.16	348.94	44.38	0.57

HEC-RAS River: Mullet Reach: Plymouth Profile: Max WS (Continued)

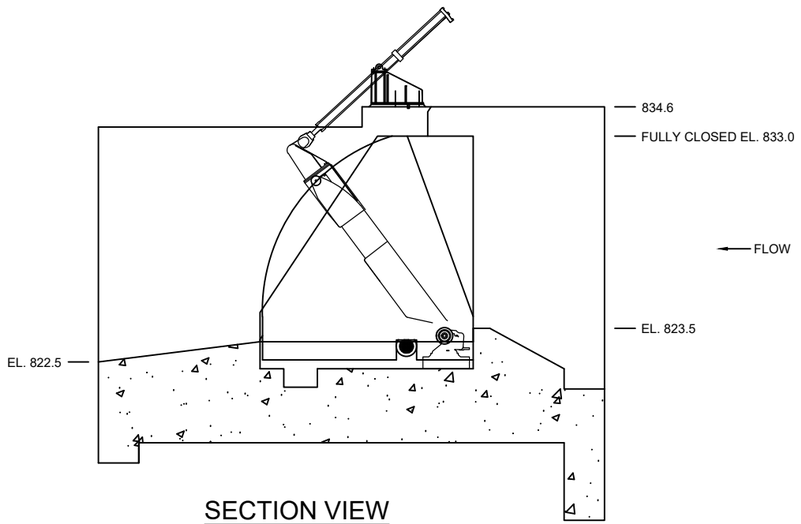
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Plymouth	525.35	Max WS	Existing	3205.83	820.85	829.63		830.94	0.003450	9.21	350.81	44.40	0.57
Plymouth	525.3	Max WS	Pro Slide Gates	3195.71	820.60	829.54		829.89	0.001852	5.89	852.88	194.39	0.35
Plymouth	525.3	Max WS	No Dam	3229.44	820.60	829.51		829.87	0.001927	6.00	846.60	194.20	0.36
Plymouth	525.3	Max WS	Pro Crest Gates	3171.38	820.60	829.51		829.86	0.001860	5.89	846.26	194.19	0.35
Plymouth	525.3	Max WS	Existing	3205.41	820.60	829.55		829.90	0.001848	5.89	855.58	194.47	0.35
Plymouth	525.1	Max WS	Pro Slide Gates	3195.58	820.60	829.48		829.90	0.001250	6.28	869.45	197.23	0.38
Plymouth	525.1	Max WS	No Dam	3229.44	820.60	829.45		829.88	0.001302	6.40	862.75	197.02	0.38
Plymouth	525.1	Max WS	Pro Crest Gates	3171.38	820.60	829.45		829.86	0.001255	6.28	862.87	197.02	0.38
Plymouth	525.1	Max WS	Existing	3205.34	820.60	829.50		829.91	0.001248	6.29	872.13	197.31	0.38
Plymouth	525.0	Max WS	Pro Slide Gates	3195.56	820.40	829.49		829.73	0.000753	4.85	1094.66	227.21	0.29
Plymouth	525.0	Max WS	No Dam	3229.63	820.40	829.46		829.71	0.000784	4.94	1086.92	226.84	0.29
Plymouth	525.0	Max WS	Pro Crest Gates	3171.36	820.40	829.46		829.70	0.000756	4.85	1087.01	226.85	0.29
Plymouth	525.0	Max WS	Existing	3205.17	820.40	829.51		829.75	0.000752	4.86	1097.80	227.36	0.29
Plymouth	524.9	Max WS	Pro Slide Gates	3195.18	820.40	829.48		829.72	0.000759	4.87	1091.68	227.07	0.29
Plymouth	524.9	Max WS	No Dam	3229.63	820.40	829.44		829.70	0.000790	4.95	1083.83	226.70	0.29
Plymouth	524.9	Max WS	Pro Crest Gates	3171.35	820.40	829.45		829.69	0.000761	4.86	1084.02	226.71	0.29
Plymouth	524.9	Max WS	Existing	3205.46	820.40	829.49		829.74	0.000758	4.87	1094.81	227.22	0.29
Plymouth	524.6	Max WS	Pro Slide Gates	3195.30	820.60	829.16		829.46	0.001025	5.43	1138.58	362.73	0.33
Plymouth	524.6	Max WS	No Dam	3228.89	820.60	829.11		829.42	0.001089	5.57	1118.78	361.24	0.34
Plymouth	524.6	Max WS	Pro Crest Gates	3170.97	820.60	829.12		829.43	0.001037	5.45	1124.74	361.69	0.33
Plymouth	524.6	Max WS	Existing	3205.19	820.60	829.18		829.48	0.001020	5.42	1144.20	363.15	0.33
Plymouth	524.3	Max WS	Pro Slide Gates	3195.30	820.60	829.15		829.45	0.001032	5.45	1135.21	362.48	0.33
Plymouth	524.3	Max WS	No Dam	3228.76	820.60	829.10		829.42	0.001097	5.59	1115.17	360.96	0.34
Plymouth	524.3	Max WS	Pro Crest Gates	3171.05	820.60	829.11		829.42	0.001045	5.46	1121.30	361.43	0.34
Plymouth	524.3	Max WS	Existing	3205.14	820.60	829.17		829.47	0.001026	5.44	1140.86	362.90	0.33
Plymouth	524.2	Max WS	Pro Slide Gates	3195.22	818.00	829.01		829.22	0.000587	4.39	1304.29	369.04	0.25
Plymouth	524.2	Max WS	No Dam	3228.61	818.00	828.95		829.17	0.000622	4.50	1280.84	366.29	0.26
Plymouth	524.2	Max WS	Pro Crest Gates	3171.00	818.00	828.97		829.19	0.000592	4.39	1289.91	367.35	0.26
Plymouth	524.2	Max WS	Existing	3204.90	818.00	829.03		829.24	0.000585	4.39	1310.18	369.73	0.25
Plymouth	524.15	Max WS	Pro Slide Gates	3195.09	815.00	828.91		829.10	0.000587	3.86	1304.16	447.03	0.24
Plymouth	524.15	Max WS	No Dam	3228.54	815.00	828.83		829.04	0.000629	3.97	1271.99	444.09	0.25
Plymouth	524.15	Max WS	Pro Crest Gates	3170.88	815.00	828.87		829.06	0.000594	3.87	1285.97	445.37	0.24
Plymouth	524.15	Max WS	Existing	3204.87	815.00	828.92		829.11	0.000584	3.86	1311.59	447.70	0.24
Plymouth	524.1	Max WS	Pro Slide Gates	3195.10	816.00	828.76		829.07	0.000761	4.97	1075.05	358.95	0.29
Plymouth	524.1	Max WS	No Dam	3228.31	816.00	828.68		829.01	0.000814	5.11	1045.84	351.56	0.30
Plymouth	524.1	Max WS	Pro Crest Gates	3170.92	816.00	828.72		829.03	0.000767	4.97	1060.17	355.20	0.29
Plymouth	524.1	Max WS	Existing	3204.91	816.00	828.78		829.09	0.000758	4.96	1081.13	360.47	0.29
Plymouth	524.0	Max WS	Pro Slide Gates	3195.09	816.00	828.10	823.47	829.26	0.001672	8.70	370.83	87.79	0.45
Plymouth	524.0	Max WS	No Dam	3227.88	816.00	827.99	823.51	829.20	0.001763	8.87	367.22	87.17	0.47
Plymouth	524.0	Max WS	Pro Crest Gates	3170.87	816.00	828.06	823.44	829.22	0.001664	8.66	369.65	87.58	0.45
Plymouth	524.0	Max WS	Existing	3204.86	816.00	828.11	823.47	829.28	0.001675	8.71	371.31	87.87	0.46
Plymouth	523.85			Bridge									
Plymouth	523.7	Max WS	Pro Slide Gates	3195.09	816.00	827.70		829.00	0.002727	9.14	349.74	32.77	0.49
Plymouth	523.7	Max WS	No Dam	3227.62	816.00	827.55		828.91	0.002898	9.35	345.03	32.76	0.50
Plymouth	523.7	Max WS	Pro Crest Gates	3170.87	816.00	827.67		828.95	0.002709	9.09	348.72	32.77	0.48
Plymouth	523.7	Max WS	Existing	3204.85	816.00	827.71		829.01	0.002734	9.15	350.15	32.77	0.49
Plymouth	523.6	Max WS	Pro Slide Gates	3195.07	816.00	828.32		828.43	0.000396	3.60	1541.75	263.32	0.19
Plymouth	523.6	Max WS	No Dam	3227.97	816.00	828.21		828.32	0.000424	3.70	1510.99	260.64	0.19
Plymouth	523.6	Max WS	Pro Crest Gates	3170.89	816.00	828.29		828.39	0.000396	3.59	1532.01	262.48	0.19
Plymouth	523.6	Max WS	Existing	3204.84	816.00	828.34		828.45	0.000395	3.60	1545.76	263.67	0.19
Plymouth	523.5	Max WS	Pro Slide Gates	3195.05	816.00	827.12		828.05	0.001870	8.33	476.87	51.95	0.46
Plymouth	523.5	Max WS	No Dam	3226.89	816.00	826.91		827.90	0.002047	8.59	465.91	51.86	0.48
Plymouth	523.5	Max WS	Pro Crest Gates	3170.86	816.00	827.09		828.01	0.001860	8.29	475.37	51.93	0.46
Plymouth	523.5	Max WS	Existing	3204.82	816.00	827.13		828.06	0.001874	8.34	477.50	51.95	0.46
Plymouth	523.4	Max WS	Pro Slide Gates	3195.05	816.00	827.01	823.01	827.96	0.001942	8.42	470.97	51.90	0.47
Plymouth	523.4	Max WS	No Dam	3226.89	816.00	826.78	823.05	827.80	0.002138	8.70	459.31	51.81	0.49
Plymouth	523.4	Max WS	Pro Crest Gates	3170.87	816.00	826.98	822.96	827.92	0.001931	8.38	469.51	51.89	0.46
Plymouth	523.4	Max WS	Existing	3204.81	816.00	827.02	823.01	827.97	0.001947	8.44	471.58	51.90	0.47
Plymouth	523.25			Bridge									
Plymouth	523.1	Max WS	Pro Slide Gates	3195.05	816.00	826.90		827.87	0.002012	8.51	465.51	51.86	0.47
Plymouth	523.1	Max WS	No Dam	3226.60	816.00	826.66		827.70	0.002229	8.82	453.03	51.76	0.50
Plymouth	523.1	Max WS	Pro Crest Gates	3170.87	816.00	826.88		827.84	0.002000	8.47	464.11	51.85	0.47
Plymouth	523.1	Max WS	Existing	3204.81	816.00	826.91		827.89	0.002017	8.53	466.09	51.86	0.47
Plymouth	523.0	Max WS	Pro Slide Gates	3195.05	816.00	826.78		827.77	0.002100	8.62	459.06	51.81	0.48
Plymouth	523.0	Max WS	No Dam	3225.88	816.00	826.52		827.59	0.002341	8.95	445.69	51.70	0.51
Plymouth	523.0	Max WS	Pro Crest Gates	3170.85	816.00	826.75		827.74	0.002087	8.58	457.70	51.80	0.48
Plymouth	523.0	Max WS	Existing	3204.81	816.00	826.79		827.79	0.002105	8.64	459.62	51.81	0.48
Plymouth	522	Max WS	Pro Slide Gates	3194.54	816.00	825.49		826.83	0.003372	9.96	392.72	51.29	0.60

HEC-RAS River: Mullet Reach: Plymouth Profile: Max WS (Continued)

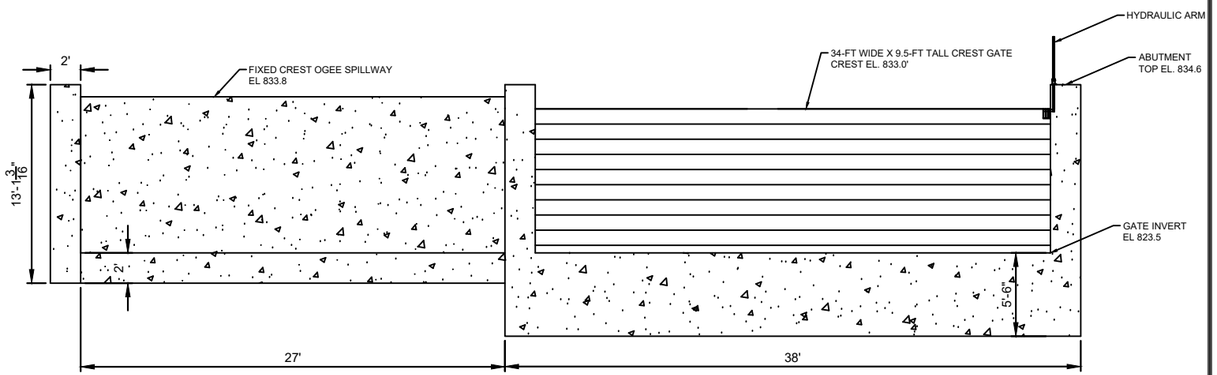
Reach	River Sta	Profile	Plan	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Plymouth	522	Max WS	No Dam	3217.18	816.00	824.91		826.48	0.004352	10.80	362.76	51.05	0.67
Plymouth	522	Max WS	Pro Crest Gates	3170.56	816.00	825.48		826.80	0.003339	9.90	392.03	51.28	0.59
Plymouth	522	Max WS	Existing	3203.87	816.00	825.50		826.84	0.003384	9.98	393.01	51.29	0.60
Plymouth	521.9	Max WS	Pro Slide Gates	3194.59	816.00	825.64	821.89	825.81	0.000693	4.31	1694.57	693.91	0.25
Plymouth	521.9	Max WS	No Dam	3218.32	816.00	825.02		825.32	0.001194	5.40	1293.13	603.36	0.32
Plymouth	521.9	Max WS	Pro Crest Gates	3170.54	816.00	825.63	821.84	825.79	0.000691	4.30	1683.66	691.61	0.25
Plymouth	521.9	Max WS	Existing	3203.89	816.00	825.65	821.89	825.81	0.000693	4.31	1699.19	694.89	0.25
Plymouth	521.75			Bridge									
Plymouth	521.6	Max WS	Pro Slide Gates	3186.99	816.00	824.84		825.18	0.001380	5.73	1183.20	576.09	0.35
Plymouth	521.6	Max WS	No Dam	3217.98	816.00	824.94		825.26	0.001281	5.56	1245.43	591.68	0.33
Plymouth	521.6	Max WS	Pro Crest Gates	3163.21	816.00	824.77		825.13	0.001441	5.82	1146.17	566.61	0.35
Plymouth	521.6	Max WS	Existing	3196.51	816.00	824.86		825.20	0.001356	5.69	1198.69	580.01	0.34
Plymouth	521.3	Max WS	Pro Slide Gates	3185.60	813.70	824.36		824.55	0.000626	5.04	1470.94	405.33	0.28
Plymouth	521.3	Max WS	No Dam	3216.81	813.70	824.50		824.68	0.000596	4.96	1527.33	422.53	0.27
Plymouth	521.3	Max WS	Pro Crest Gates	3162.24	813.70	824.28		824.47	0.000642	5.08	1438.02	394.95	0.28
Plymouth	521.3	Max WS	Existing	3195.48	813.70	824.39		824.58	0.000619	5.03	1484.69	409.59	0.27
Plymouth	521.0	Max WS	Pro Slide Gates	3185.55	813.41	824.12		824.34	0.000441	4.67	1300.16	277.32	0.26
Plymouth	521.0	Max WS	No Dam	3216.51	813.41	824.26		824.48	0.000422	4.60	1340.99	285.77	0.26
Plymouth	521.0	Max WS	Pro Crest Gates	3161.72	813.41	824.03		824.26	0.000452	4.70	1276.06	272.21	0.27
Plymouth	521.0	Max WS	Existing	3195.18	813.41	824.15		824.38	0.000437	4.65	1310.10	279.40	0.26
Plymouth	520.9	Max WS	Pro Slide Gates	3185.43	812.49	823.85		824.39	0.000825	6.50	947.98	366.75	0.36
Plymouth	520.9	Max WS	No Dam	3216.53	812.49	824.02		824.52	0.000761	6.31	1012.73	381.36	0.35
Plymouth	520.9	Max WS	Pro Crest Gates	3161.76	812.49	823.74		824.31	0.000865	6.61	908.66	357.59	0.37
Plymouth	520.9	Max WS	Existing	3195.11	812.49	823.89		824.42	0.000810	6.46	963.98	370.42	0.36
Plymouth	520.7	Max WS	Pro Slide Gates	3185.41	812.49	823.77	819.67	824.37	0.000890	6.72	901.95	376.81	0.38
Plymouth	520.7	Max WS	No Dam	3216.49	812.49	823.95	819.71	824.50	0.000819	6.52	972.16	398.00	0.36
Plymouth	520.7	Max WS	Pro Crest Gates	3161.75	812.49	823.66	819.64	824.28	0.000936	6.83	859.58	363.42	0.39
Plymouth	520.7	Max WS	Existing	3195.09	812.49	823.82	819.68	824.40	0.000873	6.67	919.37	382.18	0.37
Plymouth	520.55			Bridge									
Plymouth	520.4	Max WS	Pro Slide Gates	3185.40	812.49	820.95		822.75	0.003671	10.89	317.23	53.58	0.72
Plymouth	520.4	Max WS	No Dam	3207.37	812.49	821.02		822.81	0.003600	10.86	320.89	53.76	0.72
Plymouth	520.4	Max WS	Pro Crest Gates	3161.74	812.49	820.93		822.72	0.003653	10.84	316.11	53.53	0.72
Plymouth	520.4	Max WS	Existing	3195.09	812.49	820.96		822.77	0.003678	10.91	317.68	53.60	0.72
Plymouth	520.3	Max WS	Pro Slide Gates	3185.42	812.49	820.46		822.57	0.004703	11.75	291.29	52.27	0.81
Plymouth	520.3	Max WS	No Dam	3216.62	812.49	820.68		822.68	0.004275	11.45	303.02	52.87	0.78
Plymouth	520.3	Max WS	Pro Crest Gates	3161.73	812.49	820.45		822.53	0.004665	11.68	290.60	52.24	0.81
Plymouth	520.3	Max WS	Existing	3195.04	812.49	820.47		822.58	0.004717	11.77	291.58	52.29	0.81
Plymouth	520.1	Max WS	Pro Slide Gates	3185.06	812.38	820.25		820.74	0.001509	6.25	889.26	384.85	0.45
Plymouth	520.1	Max WS	No Dam	3216.43	812.38	819.59		820.36	0.002585	7.58	655.33	314.52	0.58
Plymouth	520.1	Max WS	Pro Crest Gates	3161.45	812.38	820.23		820.72	0.001509	6.24	882.46	383.88	0.45
Plymouth	520.1	Max WS	Existing	3194.75	812.38	820.26		820.74	0.001510	6.26	892.01	385.23	0.45
Plymouth	519.8	Max WS	Pro Slide Gates	3185.02	812.27	820.30		820.37	0.000184	2.33	1652.86	442.44	0.16
Plymouth	519.8	Max WS	No Dam	3216.40	812.27	819.70		819.80	0.000291	2.74	1391.79	431.29	0.20
Plymouth	519.8	Max WS	Pro Crest Gates	3161.41	812.27	820.28		820.35	0.000183	2.32	1645.06	442.11	0.16
Plymouth	519.8	Max WS	Existing	3194.79	812.27	820.30		820.38	0.000184	2.33	1656.05	442.58	0.16
Plymouth	519.2	Max WS	Pro Slide Gates	3185.04	812.13	820.27		820.33	0.000111	1.85	1876.80	389.56	0.13
Plymouth	519.2	Max WS	No Dam	3216.39	812.13	819.67		819.74	0.000162	2.10	1646.33	373.58	0.15
Plymouth	519.2	Max WS	Pro Crest Gates	3161.36	812.13	820.26		820.31	0.000111	1.84	1870.03	389.10	0.13
Plymouth	519.2	Max WS	Existing	3194.67	812.13	820.28		820.33	0.000111	1.85	1879.58	389.74	0.13
Plymouth	518.9	Max WS	Pro Slide Gates	3184.99	811.14	820.27		820.31	0.000084	1.63	2100.27	394.41	0.10
Plymouth	518.9	Max WS	No Dam	3216.32	811.14	819.66		819.71	0.000120	1.85	1866.55	375.50	0.12
Plymouth	518.9	Max WS	Pro Crest Gates	3161.40	811.14	820.25		820.29	0.000083	1.62	2093.41	393.87	0.10
Plymouth	518.9	Max WS	Existing	3194.68	811.14	820.28		820.32	0.000084	1.63	2103.06	394.63	0.10
Plymouth	518.6	Max WS	Pro Slide Gates	3184.96	810.60	819.41	819.39	820.71	0.003396	8.89	386.81	179.59	0.53
Plymouth	518.6	Max WS	No Dam	3216.35	810.60	819.43	819.42	820.74	0.003386	8.89	390.41	181.07	0.53
Plymouth	518.6	Max WS	Pro Crest Gates	3161.34	810.60	819.39	819.37	820.69	0.003405	8.89	384.10	178.47	0.53
Plymouth	518.6	Max WS	Existing	3194.64	810.60	819.41	819.40	820.72	0.003394	8.89	387.90	180.04	0.53

Appendix B

Conceptual Drawings



SECTION VIEW



DOWNSTREAM ELEVATION VIEW

DES BY	ARR				NOT FOR CONSTRUCTION			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 1 CREST GATES	SHEET NO. 1
DR BY	ARR	PROJ NO	37-0116.00	---			---				
CHK BY	AJS	DATE	SEP 2023	---			---				
				NO	DATE	REVISION	NO	DATE	REVISION		

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9/7/2023
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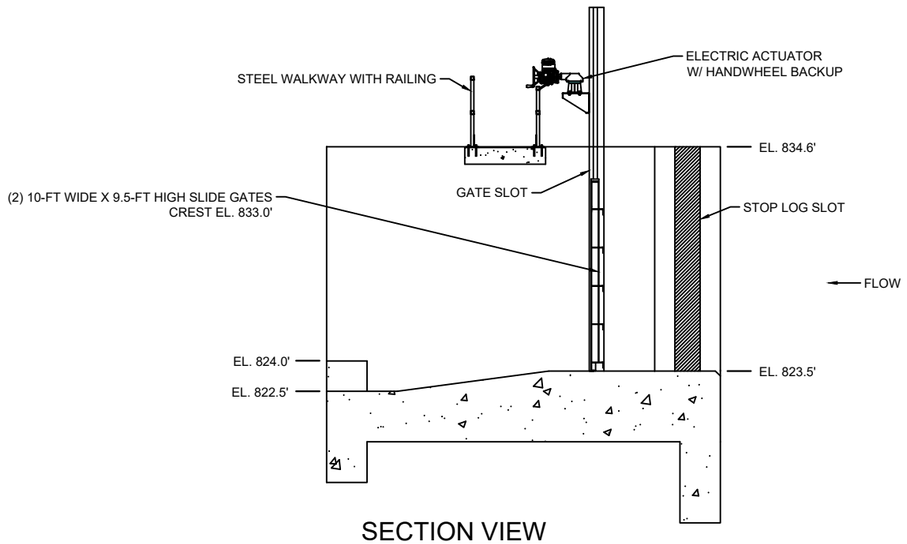
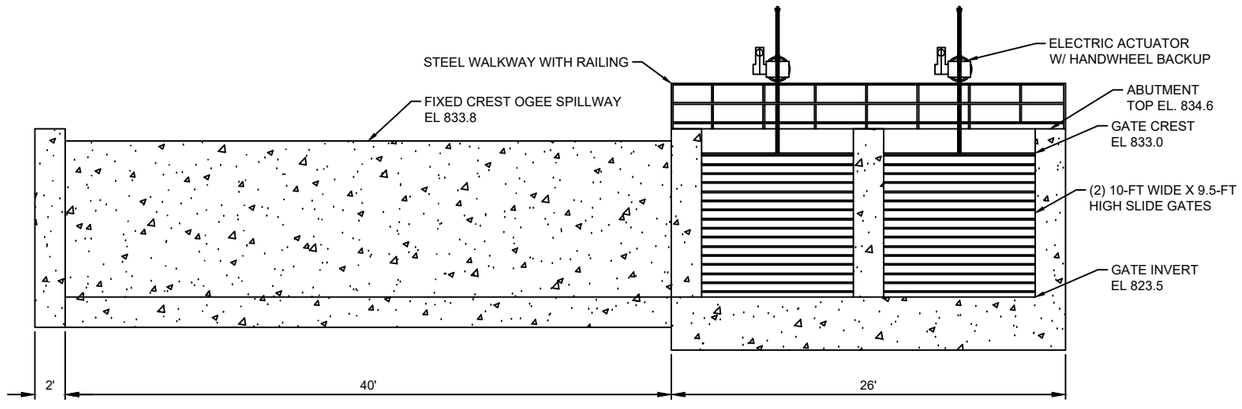
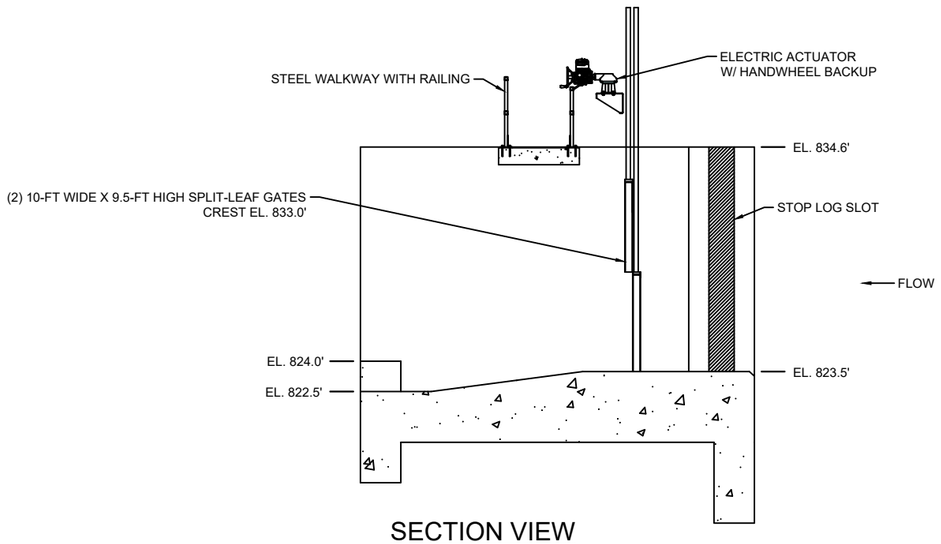


SECTION VIEW

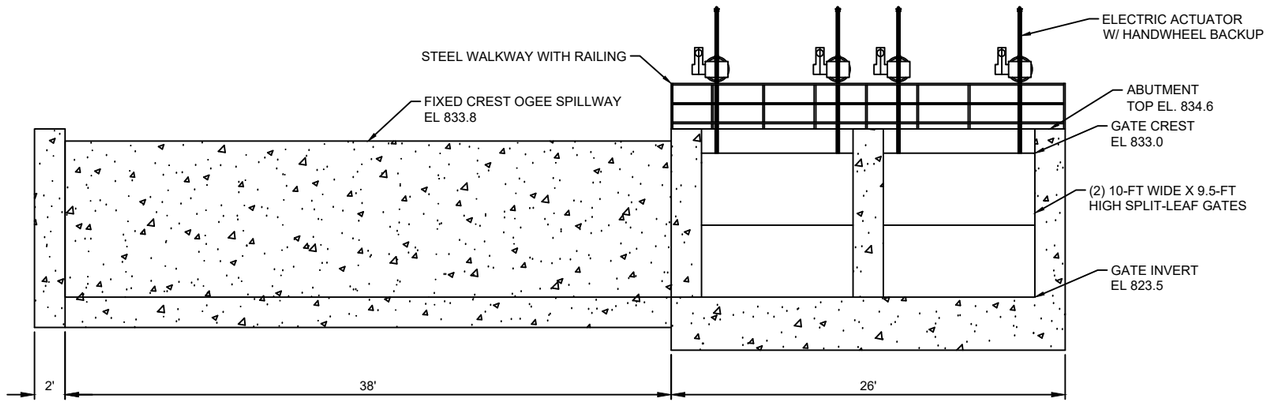


DOWNSTREAM ELEVATION VIEW

DES BY	ARR				NOT FOR CONSTRUCTION	----			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 2 SLIDE GATES	SHEET NO. 2
DR BY	ARR	PROJ NO	37-0116.00	----			----					
CHK BY	AJS	DATE	SEP 2023	NO	DATE	REVISION	NO	DATE	REVISION			



SECTION VIEW



DOWNSTREAM ELEVATION VIEW

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DES BY	ARR				NOT FOR CONSTRUCTION				MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 3 - SPLIT LEAF GATES	SHEET NO. 3
DR BY	ARR	PROJ NO	37-0116.00	----			----						
CHK BY	AJS	DATE	SEP 2023	----			----						
				NO	DATE	REVISION	NO	DATE	REVISION				

DES BY	ARR				NOT FOR CONSTRUCTION			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 4 - DAM REMOVAL	SHEET NO. 4
DR BY	ARR	PROJ NO	37-0116.00	---			---				
CHK BY	AJS	DATE	SEP 2023	---			---				
				NO	DATE	REVISION	NO	DATE	REVISION		

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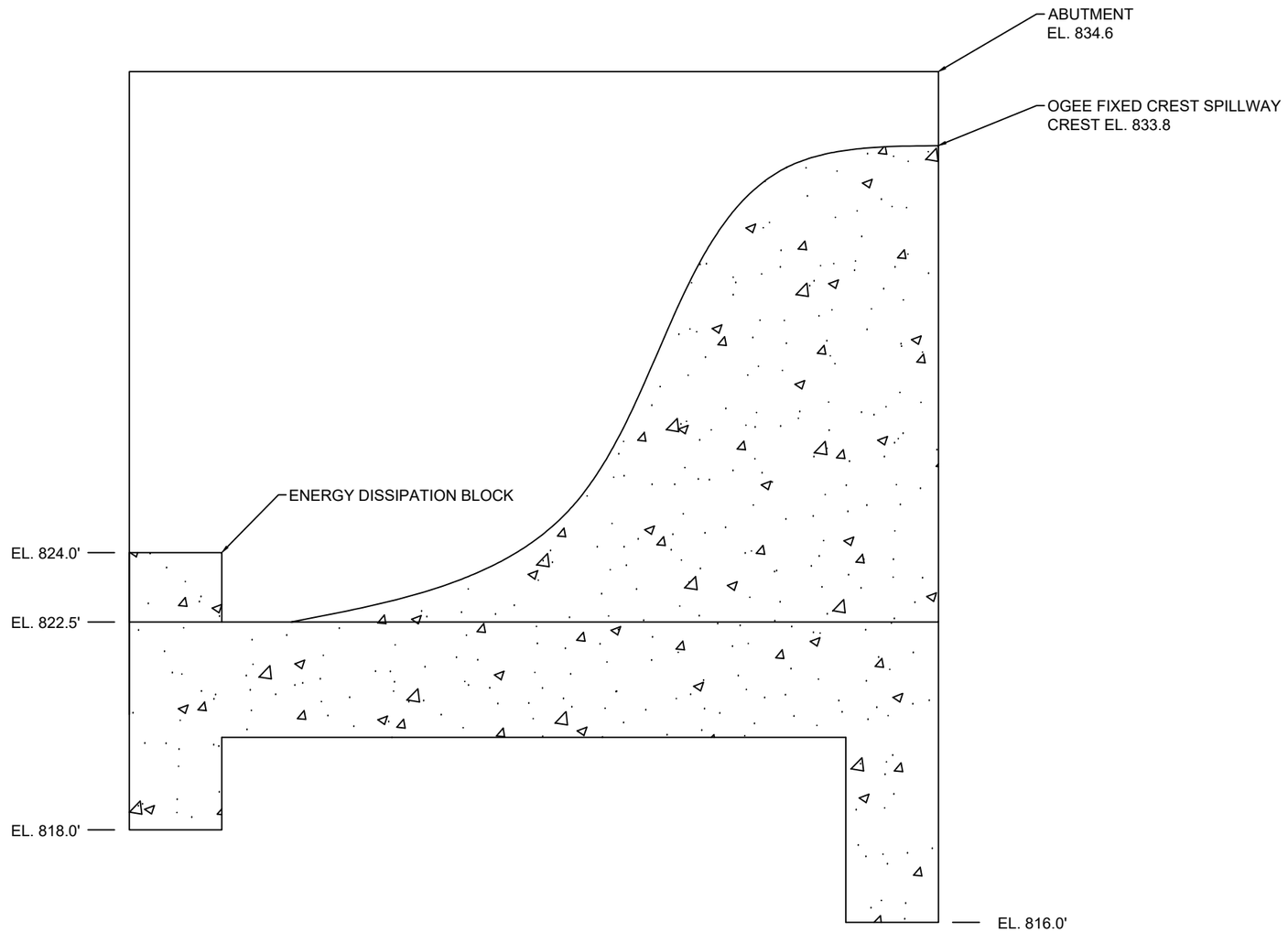

OGEE SPILLWAY SECTION VIEW (TYPICAL FOR OPTIONS 1 THROUGH 3)

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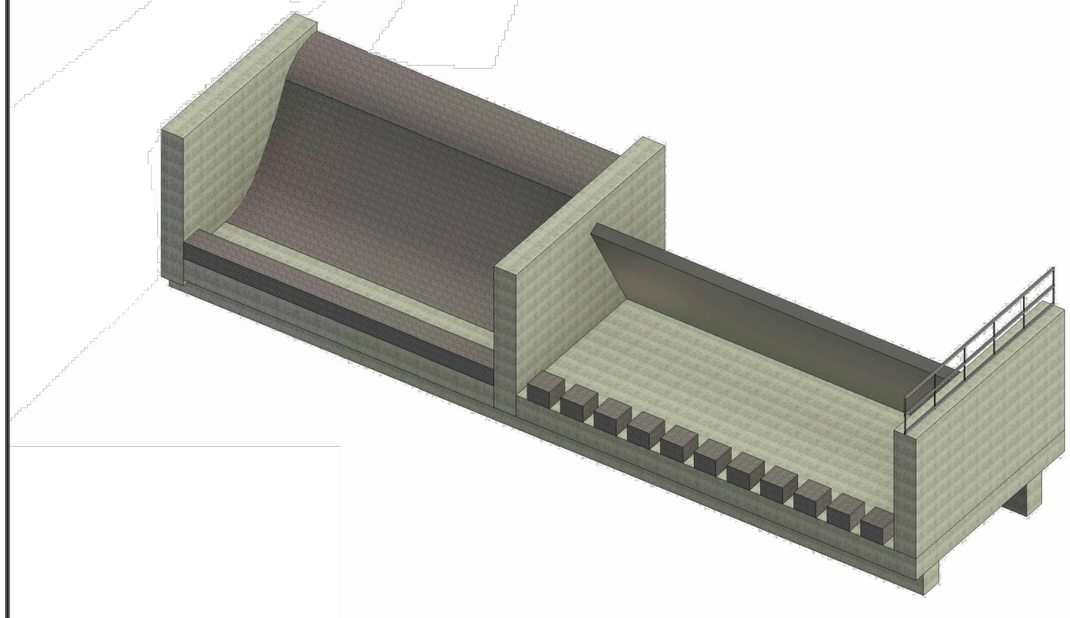
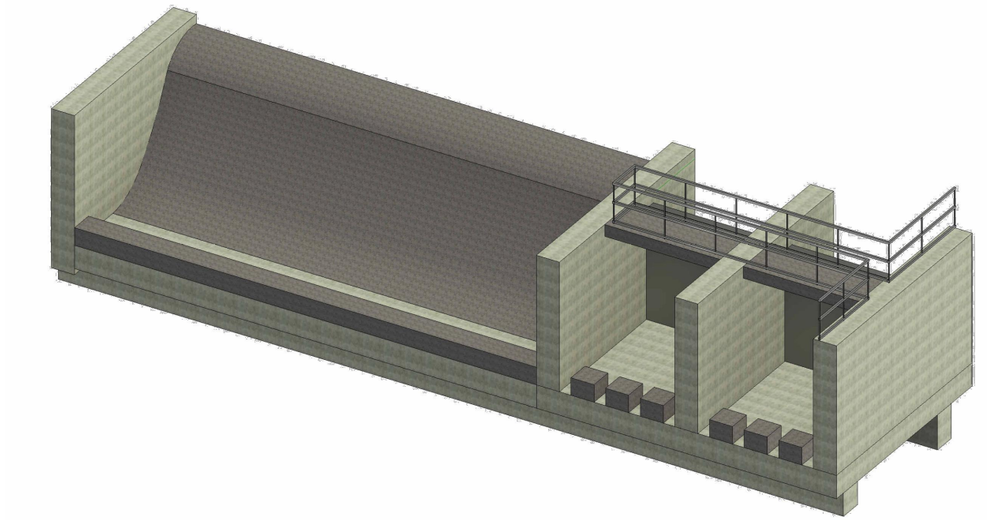
DES BY	ARR				NOT FOR CONSTRUCTION	----			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OGEE SPILLWAY SECTION (TYPICAL)	SHEET NO.
DR BY	ARR	PROJ NO	37-0116.00	----			----						5
CHK BY	AJS	DATE	SEP 2023	----			----						
				NO	DATE	REVISION	NO	DATE	REVISION				

Appendix C

3-D Renderings



OPTION 1 - CREST GATES



OPTION 2 - SLIDE GATES AND OPTION 3 - SPLIT-LEAF GATES

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DES BY	ARR				NOT FOR CONSTRUCTION	----			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	3D RENDERINGS	SHEET NO.
DR BY	ARR	PROJ NO	37-0116.00	----			----						6
CHK BY	AJS	DATE	SEP 2023	----			----						
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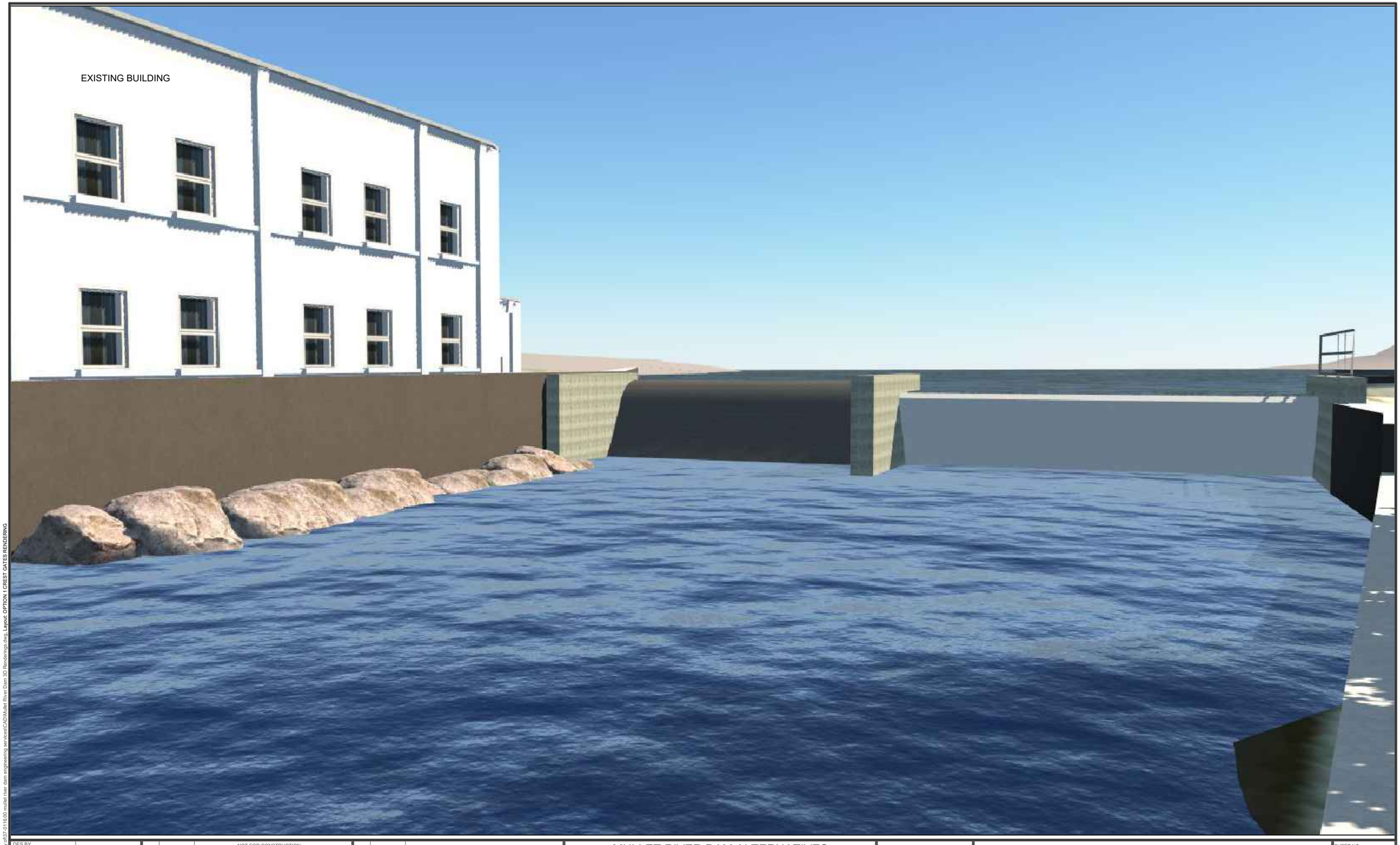

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DR BY	ARR	PROJ NO	37-0116.00	----			----					
CHK BY	AJS	DATE	SEP 2023	----			----					
				NO	DATE	REVISION	NO	DATE	REVISION			

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9/7/2023
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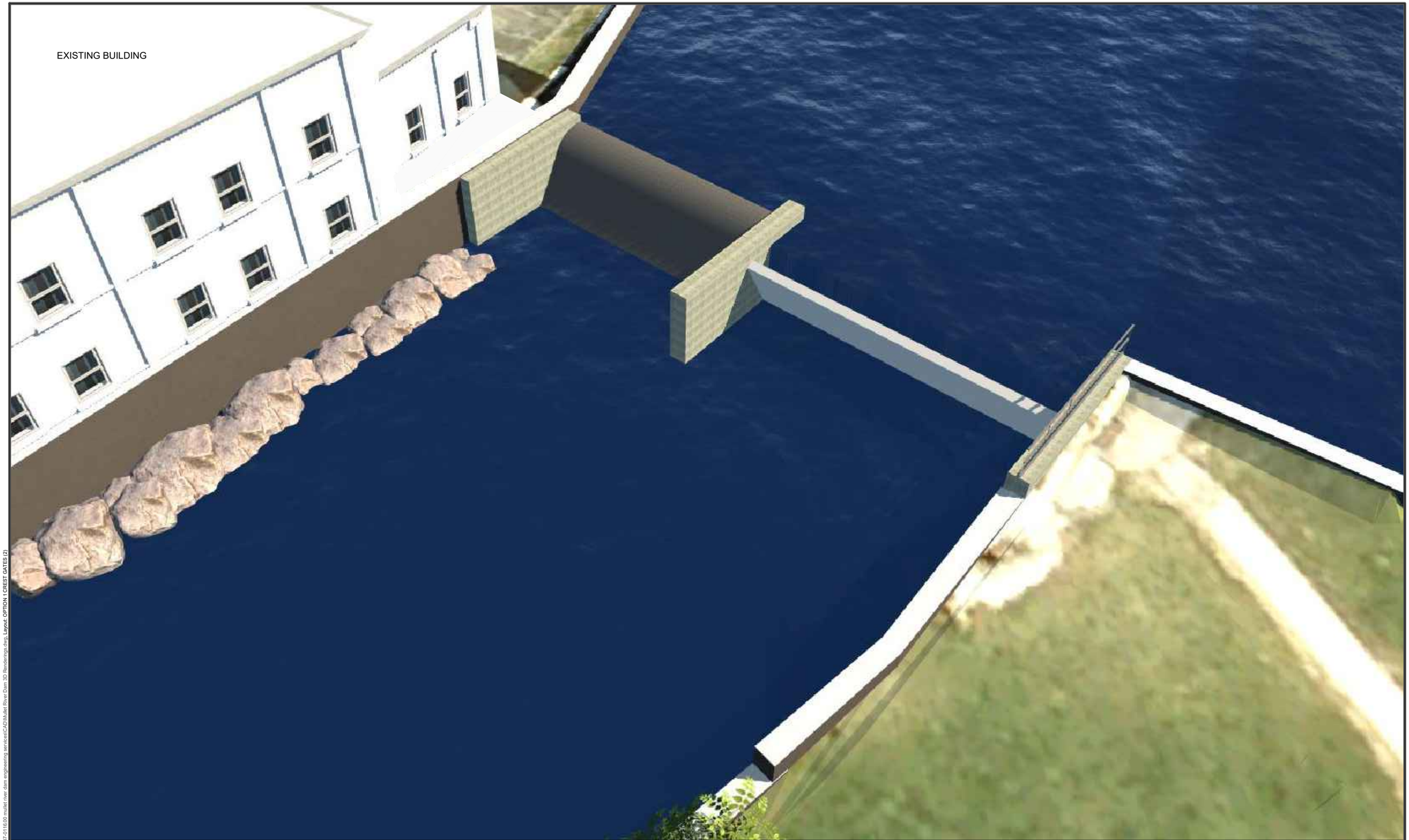

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DR BY	ARR	PROJ NO	37-0116.00	---		---						8
CHK BY	AJS	DATE	SEP 2023	NO	DATE	REVISION	NO	DATE	REVISION			

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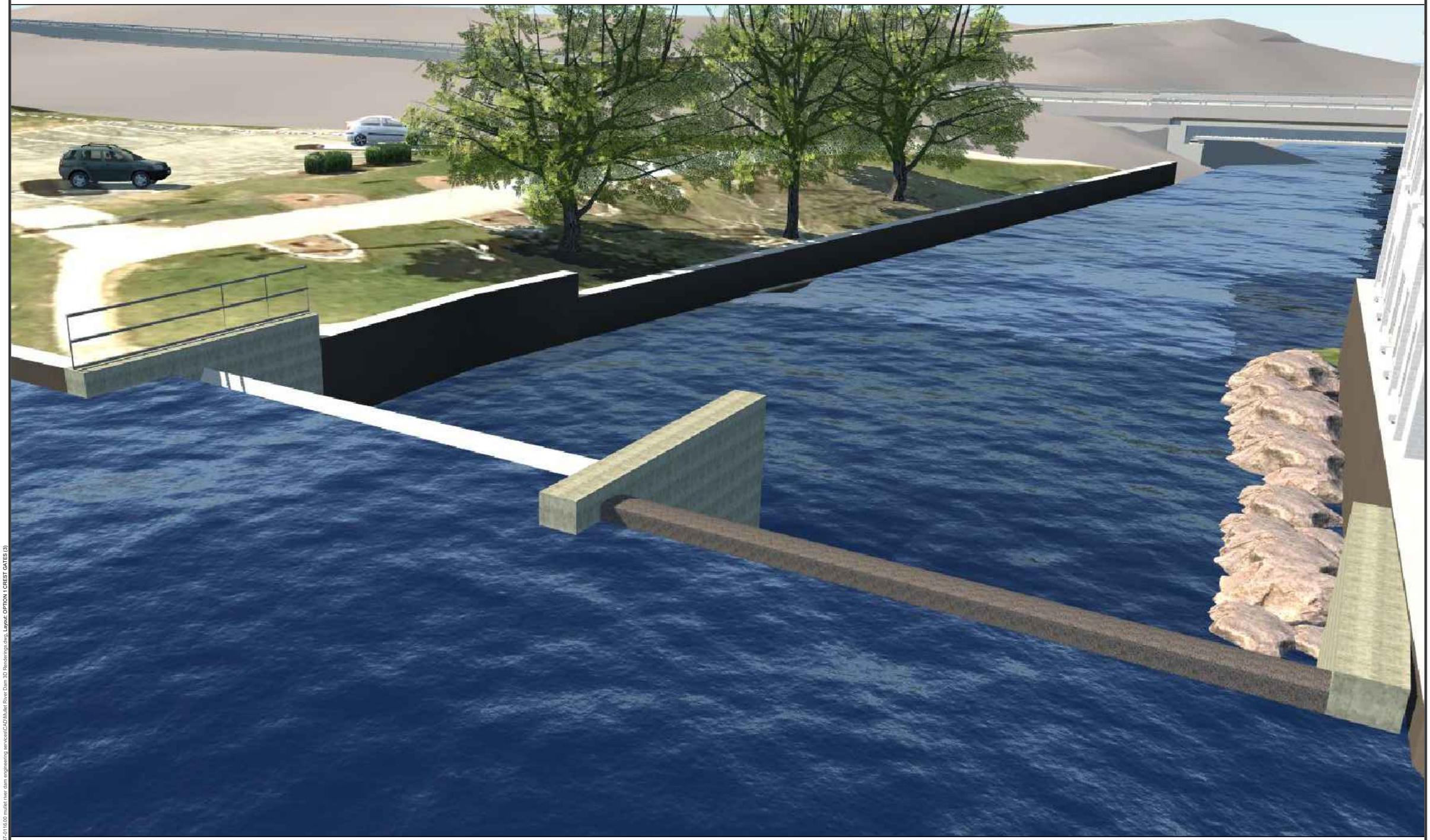

DES BY	ARR				NOT FOR CONSTRUCTION	----			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 1 CREST GATES RENDERING	SHEET NO. 9
DR BY	ARR	PROJ NO	37-0116.00	----		----						
CHK BY	AJS	DATE	SEP 2023	----		----						
				NO	DATE	REVISION	NO	DATE	REVISION			

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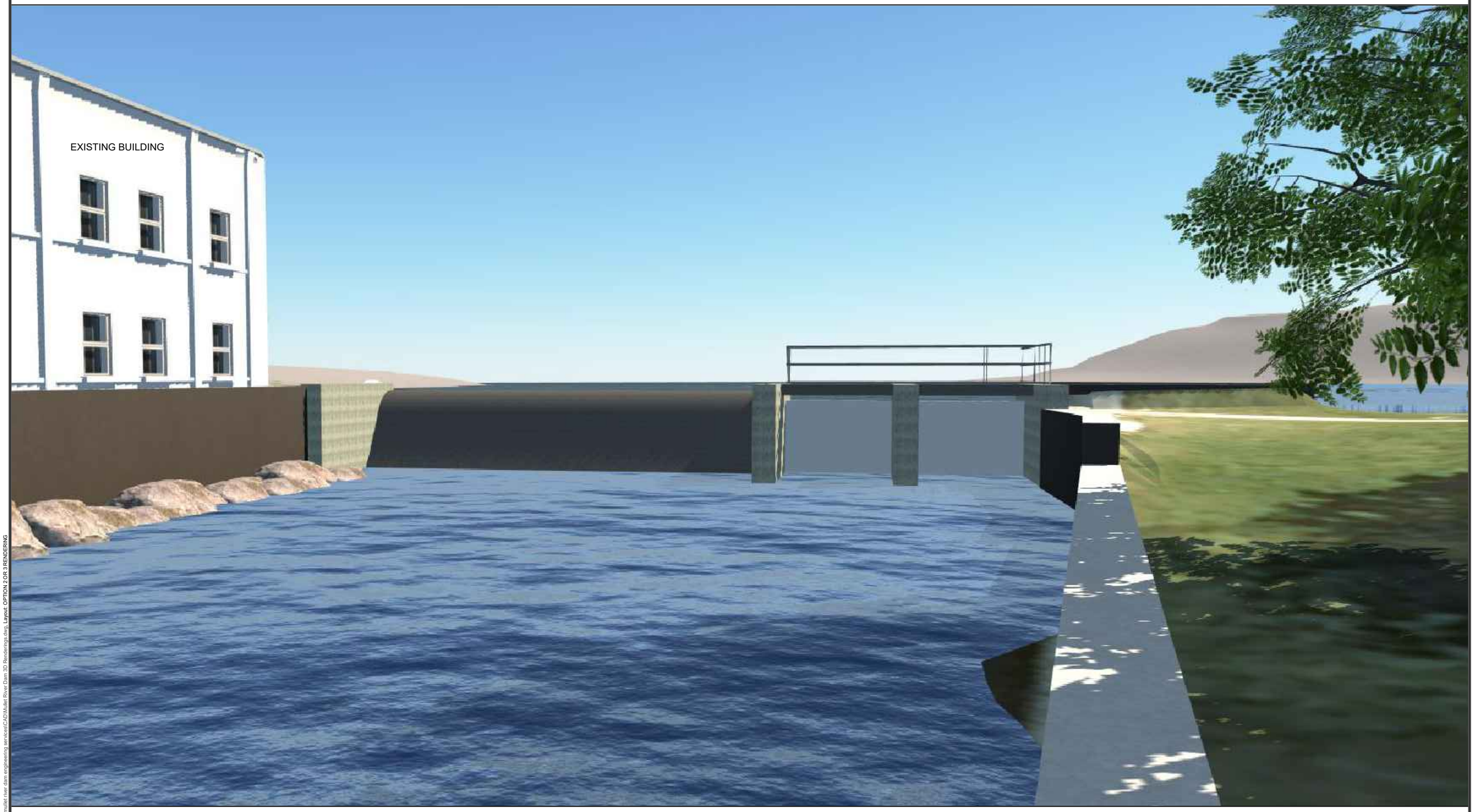

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DR BY	ARR	PROJ NO	37-0116.00	----			----					
CHK BY	AJS	DATE	SEP 2023	NO	DATE	REVISION	NO	DATE	REVISION			

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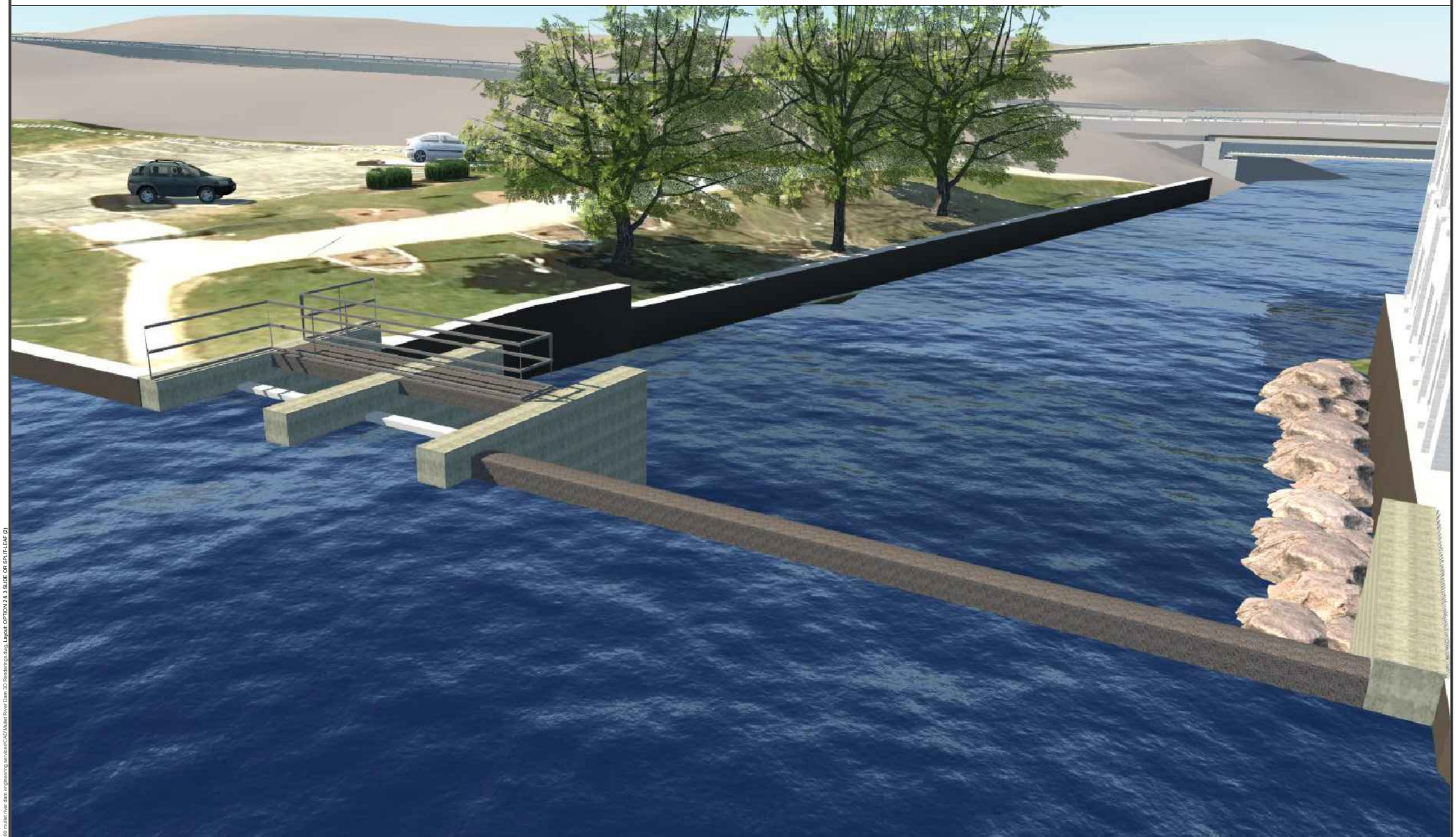

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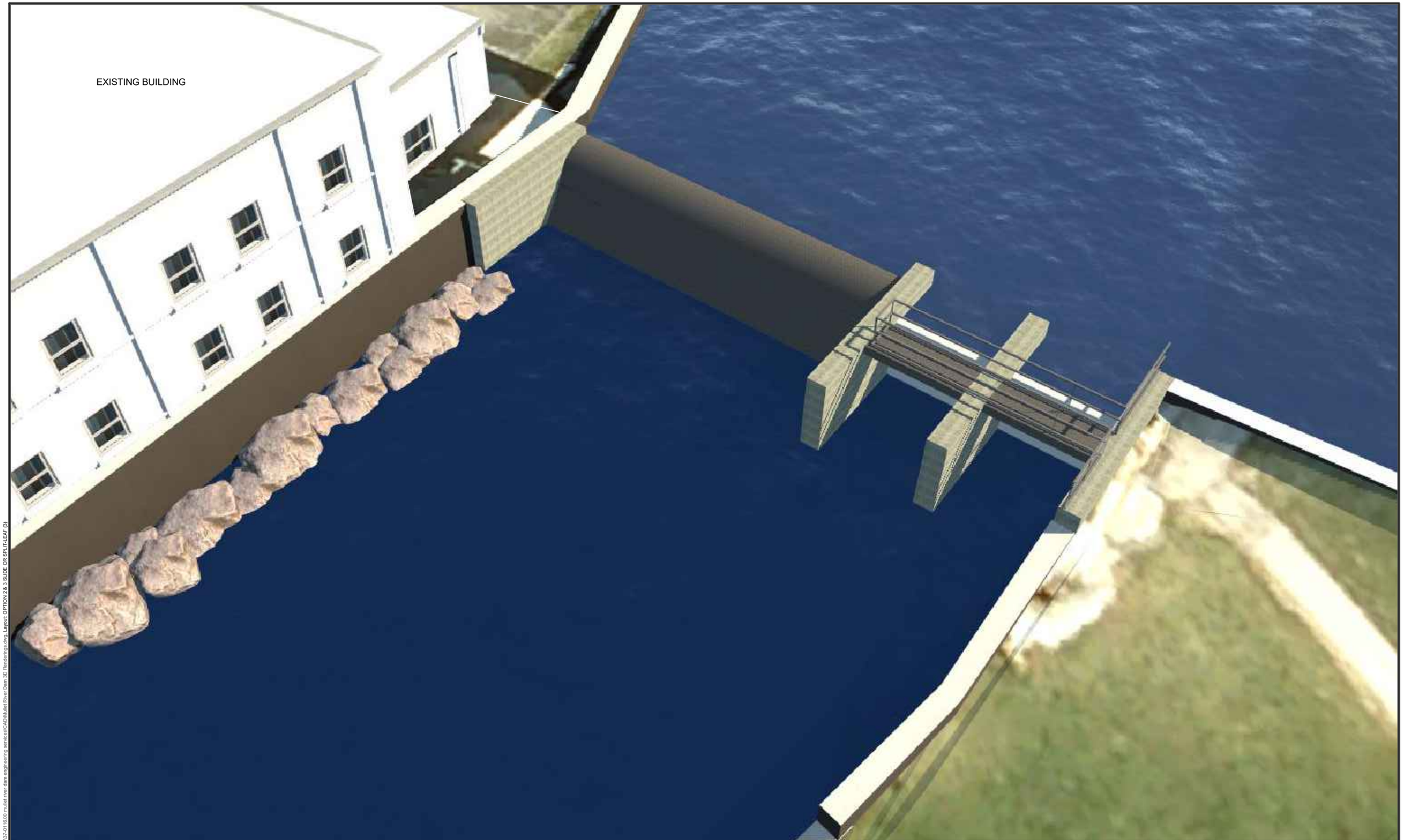

DES BY	ARR				NOT FOR CONSTRUCTION	----			MULLET RIVER DAM ALTERNATIVES CITY OF PLYMOUTH SHEBOYGAN COUNTY, WI	AYRES EAU CLAIRE, WI	OPTION 2 OR 3 RENDERING	SHEET NO. 12
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CHK BY	AJS	DATE	SEP 2023	----		----						
				NO	DATE	REVISION	NO	DATE	REVISION			

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Appendix D

Cost Estimates

Opinion of Probable Cost
Option 1 - Crest Gate Structure (Hydraulically Operated)

Mullet River Dam
City of Plymouth

Sep-23

	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
1	Mobilization	LS	1	$ 148,760.00	$ 148,760.00
2	Dewatering and streamflow diversion	LS	1	$ 50,000.00	$ 50,000.00
3	Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
4	Selective Concrete Demolition	CY	105	$ 400.00	$ 42,000.00
5	Cast-in-Place Concrete Abutments	CY	32	$ 1,800.00	$ 57,600.00
6	Cast-in-Place Concrete Ogee Spillway	CY	70	$ 1,200.00	$ 84,000.00
7	Cast-in-Place Concrete Foundation	CY	115	$ 1,800.00	$ 207,000.00
8	Cast-in-Place Energy Dissipation	CY	5	$ 1,800.00	$ 9,000.00
9	Furnish crest gate with hydraulic controls	LS	1	$ 800,000.00	$ 800,000.00
10	Install crest gate with hydraulic controls	LS	1	$ 180,000.00	$ 180,000.00
11	3-phase electrical hookup	LS	1	$ 30,000.00	$ 30,000.00
12	Enclosure for hydraulic controls	LS	1	$ 10,000.00	$ 10,000.00
13	Heavy riprap	CY	100	$ 80.00	$ 8,000.00

Subtotal:	$1,636,360
Contingency of 30%	$490,908
Construction Total:	**$2,127,268**
WDNR's Chapter 30 Plan Approval Permit	$803
Fees Total	**$803**
Engineering/Construction Administration (20% of costs):	$425,454
Engineering Total	**$425,454**
Project Total:	**$2,553,525**

Opinion of Probable Cost
Option 2 - Slide Gate Structure

Mullet River Dam
City of Plymouth

Sep-23

	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
1	Mobilization	LS	1	$ 106,440.00	$ 106,440.00
2	Dewatering and Streamflow Diversion	LS	1	$ 50,000.00	$ 50,000.00
3	Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
4	Selective Concrete Demolition	CY	105	$ 400.00	$ 42,000.00
5	Cast-in-Place Concrete Abutments	CY	66	$ 1,800.00	$ 118,800.00
6	Cast-in-Place Concrete Ogee Spillway	CY	93	$ 1,200.00	$ 111,600.00
7	Cast-in-Place Concrete Foundation	CY	115	$ 1,800.00	$ 207,000.00
8	Cast-in-Place Energy Dissipation	CY	6	$ 1,800.00	$ 10,800.00
9	Furnish 10 ft x 9.5 ft SS Slide Gates	Ea.	2	$ 161,500.00	$ 323,000.00
10	Install Stainless Steel Slide Gates	Ea.	2	$ 64,600.00	$ 129,200.00
11	3-phase electrical hookup	LS	1	$ 30,000.00	$ 30,000.00
11	Furnish and Install Steel Operator Deck	SF	96	$ 250.00	$ 24,000.00
12	Heavy Riprap	CY	100	$ 80.00	$ 8,000.00

Subtotal:	$1,170,840
Contingency of 30%	$351,252
Construction Total:	**$1,522,092**
WDNR's Chapter 30 Plan Approval Permit	$803
Fees Total	**$803**
Engineering/Construction Administration (20% of costs):	$304,418
Engineering Total	**$304,418**
Project Total:	**$1,827,313**

Opinion of Probable Cost
Option 3 - Split-Leaf Gate Structure

Mullet River Dam
City of Plymouth

Sep-23

	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
1	Mobilization	LS	1	$ 114,420.00	$ 114,420.00
2	Dewatering and Streamflow Diversion	LS	1	$ 50,000.00	$ 50,000.00
3	Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
4	Selective Concrete Demolition	CY	105	$ 400.00	$ 42,000.00
5	Cast-in-Place Concrete Abutments	CY	66	$ 1,800.00	$ 118,800.00
6	Cast-in-Place Concrete Ogee Spillway	CY	93	$ 1,200.00	$ 111,600.00
7	Cast-in-Place Concrete Foundation	CY	115	$ 1,800.00	$ 207,000.00
8	Cast-in-Place Energy Dissipation	CY	6	$ 1,800.00	$ 10,800.00
9	Furnish 10 ft x 9.5 ft SS Split-Leaf Gates	Ea.	2	$ 190,000.00	$ 380,000.00
10	Install Stainless Steel Slide Gates	Ea.	2	$ 76,000.00	$ 152,000.00
11	3-phase electrical hookup	LS	1	$ 30,000.00	$ 30,000.00
12	Furnish and Install Steel Operator Deck	SF	96	$ 250.00	$ 24,000.00
13	Heavy Riprap	CY	100	$ 80.00	$ 8,000.00

Subtotal:	$1,258,620
Contingency of 30%	$377,586
Construction Total:	**$1,636,206**
WDNR's Chapter 30 Plan Approval Permit	$803
Fees Total	**$803**
Engineering/Construction Administration (20% of costs):	$327,241
Engineering Total	**$327,241**
Project Total:	**$1,964,250**

Opinion of Probable Cost
Option 4 - Dam Removal

Mullet River Dam
City of Plymouth

Sep-23

	DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
1	Mobilization	LS	1	$ 77,048.50	$ 77,048.50
2	Dewatering and Streamflow Diversion	LS	1	$ 25,000.00	$ 25,000.00
3	Erosion Control	LS	1	$ 10,000.00	$ 10,000.00
4	Turbidity Barrier and Sediment Collection	LS	1	$ 30,000.00	$ 30,000.00
5	Selective Concrete Demolition	CY	105	$ 500.00	$ 52,500.00
6	Riprap Stabilization and Permanent Erosion Control	CY	1000	$ 100.00	$ 100,000.00
7	Dredging and Grading	CY	5000	$ 23.00	$ 115,000.00
8	Remove and Loading of Sediment	CY	1000	$ 22.00	$ 22,000.00
9	Bank Stabilization	SY	25000	$ 5.00	$ 125,000.00
10	Hauling and Final Disposal	CY	6105	$ 7.00	$ 42,735.00
11	Temporary Seeding of Bare Lakebed	AC	30	$ 875.00	$ 26,250.00
12	Native Plant Seeding	AC	30	$ 1,800.00	$ 54,000.00
13	Rock Riffles	LS	1	$ 15,000.00	$ 15,000.00
14	Reconstruction of D/S Retaining Wall	LF	140	$ 450.00	$ 63,000.00
15	Biostabilization for Storm Water Outfalls	EA	8	$ 10,000.00	$ 80,000.00
16	Minor Sidewalk and Utility Relocation	LS	1	$ 10,000.00	$ 10,000.00

Subtotal:	$847,534
Contingency of 30%	$254,260
Construction Total:	**$1,101,794**
WDNR's Chapter 30 Plan Approval Permit	$803
Fees Total	**$803**
Engineering/Construction Administration (10% of costs):	$110,179
Engineering Total	**$110,179**
oject Total:	**$1,212,776**