TIP OF THE MITT WATERSHED COUNCIL
HEALING THE BEAR
ENGINEERING ALTERNATIVES FOR THE LAKE STREET DAM

OHM Advisors
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Executive Summary

Tip of the Mitt Watershed Council (TOTMWC), in partnership with the City of Petoskey and with funding from the Great Lakes Fishery Trust (GLFT), contracted OHM Advisors to conduct a study of engineering alternatives for long-term management of the Lake Street Dam. The Lake Street Dam is the lowermost barrier on the Bear River, located in downtown Petoskey. The dam is aging and will require maintenance and repair in the future. The TOTMWC and the City are interested in removal of the dam based on community and stakeholder preferences. Dam removal may improve fisheries, reduce ownership costs, increase public safety, and reduce liabilities.

The existing dam consists of a cast-in-place concrete gravity structure constructed in 1917. OHM Advisors completed a dam safety inspection in 2018. River cross sections were obtained by topographic field survey. Flood and low flow discharges at the Lake Street Dam were estimated by the Hydrologic Studies and Dam Safety Unit of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Water Resources Division (WRD). The primary flows of concern for restoring native fish passage are the spring mean (March to May) of 170 cfs and fall mean of 101 cfs (September to November).

The Project Team engaged stakeholders and the public through two open houses, three stakeholder meetings, a project website, and an online community survey. The key takeaways from the community survey were that the primary community uses are fishing and paddling, users believe dam removal will improve fishing and paddling, and people are concerned about the impact of sea lamprey if allowed to pass upstream. The Project Team identified and discussed three primary management approaches: leave as-is, partially remove or modify, or completely remove the dam. Modification or partial removal design alternatives include partially removing the dam to create a low-head, fixed-crest weir, or modifying the dam to create a low-head, adjustable-crest weir. Either alternative may be combined with a trap-and-sort fishway, but the adjustable-crest weir may allow some additional fish passage during periods outside the lamprey spring migration period of April to June without an additional fishway structure.

OHM Advisors worked with the Project Team, and the Michigan Department of Transportation (MDOT) and the US Fish and Wildlife Service (USFWS) to identify critical design parameters. Conceptual designs were developed, and the potential performance of each concept was evaluated in the HEC-RAS hydraulic modeling software. Simulations suggest that each alternative may achieve all desired outcomes when specified operational requirements are met. Estimated costs are summarized in Table 1.

Table 1. Cost Estimates for Modifications to the Lake Street Dam

Design Alternative	Estimated Cost to Design and Construct
Fixed-crest weir with trap-and-sort fishway	$1,050,000
Adjustable-crest weir	$1,640,000
Complete dam removal	$1,090,000

Based on the results of the usage survey, input from project stakeholders, conceptual hydraulic performance evaluation, and the estimated cost to design and construct, OHM Advisors recommends a fixed-crest alternative over an adjustable-crest. The additional fish passage gained from an adjustable-crest weir is minimal and does not justify the additional expense.

OHM Advisors also recommends further consideration of complete removal of the dam with the understanding that an alternate sea lamprey barrier may be constructed as part of recreational facility improvements at the River Road Sports Complex, approximately 3.3 miles upstream of the existing dam. This alternative restores significant fish habitat to native non-jumping species and promotes paddler passage while maintaining reasonable lamprey control measures. This alternative is not the cheapest, but it has the option to be combined with other improvements at the park that would expand public uses of the Bear River.

Purpose and Scope

The purpose of this project is to conduct an engineering alternatives study for the lowermost barrier on the Bear River, the largest tributary to Little Traverse Bay. The Lake Street Dam is aging and will require maintenance and repair in the future. The dam prevents native non-jumping fish species from accessing the upstream watershed. However, the dam also provides an effective barrier against the upstream infestation of invasive sea lamprey. Potential alternatives for the Lake Street Dam include complete or partial removal, modification, or no change. The project was funded by a grant from the Great Lakes Fishery Trust (GLFT) obtained by the Tip of the Mitt Watershed Council (TOTMWC). The intent of the study is to provide the City of Petoskey, the owner, with a basis for prioritizing the future management of the Lake Street Dam. The study was organized into four tasks as described in the following sections of this report. This report is intended to accompany the schematic drawings developed in the study. The study relied on collaboration with the Project Team.

The Project Team was comprised of representatives from the following organizations:

- City of Petoskey
- Little Traverse Bay Bands of Odawa Indians Department of Natural Resources
- Michigan Department of Natural Resources
- Michigan Department of Environment, Great Lakes, and Energy
- Michigan Trout Unlimited (Dr. Bryan Burroughs)
- Tip of the Mitt Watershed Council
- Trout Unlimited (Miller-Van Winkle Chapter)

Project deliverables included:

- Base maps with stream cross section plots
- Existing and proposed conditions hydraulic analysis
- Scour analysis
- Project kickoff open house and engineering study open house presentations
- ESRI Story Map
- Conceptual Cost Estimates
- Schematic Drawings
- Feasibility Study Report (Draft and Final)

Task 1 – Field Survey and Base Mapping

Under this task, background information was gathered, and river cross sections were obtained. OHM Advisors completed an inspection of the Lake Street Dam in June 2018 for the City of Petoskey. The purpose of the inspection was to comply with Part 315, (Dam Safety), Natural Resources and Environmental Protection, PA 451 of 1994, (The Dam Safety Act). The inspection identified some needed repair and maintenance work but no structural deficiencies that would lead to the immediate failure of the dam. Recommendations from the 2018 report included:

- Implement regular monitoring and begin a service log.
- Armor the bed of the channel at the toe of the concrete basin (between the dam and the Lake Street Bridge)
- Repair the cracks, spalling, and erosion present in the concrete retaining walls between the dam and the Lake Street Bridge)

The report also encouraged consideration of the removal of the dam based on community and stakeholder preferences, as well as a national movement toward dam removals. Dam removal may:

- Improve fisheries
- Reduce maintenance/repair/replacement costs
- Increase public safety
- Reduce liabilities

The existing dam consists of a cast-in-place concrete gravity structure measuring approximately 31'-8" in length between the retaining walls and 4.7' in height from crest to toe. A concrete basin extends horizontally from the toe of the dam approximately 6.0' downstream. The dam was constructed in 1917. It was preceded by a wooden dam built in 1881 and rebuilt in 1885 after it was washed away. There is no record of inspections before the 2018 inspection.

River cross sections were obtained by topographic field survey. The survey extended approximately 240 feet upstream, terminating just north of the US31 bridge, and 300 feet downstream of the dam, terminating at the river's mouth at the marina. Surveyed cross sections extended approximately 50 feet on either side of the river centerline. The surveyed cross sections were supplemented with federal LIDAR data obtained from USGS and used to create a digital elevation model (DEM) of the site. The DEM is a digital representation of the ground surface, including the streambed, that can be used in the River Analysis System (RAS) developed by the US Army Corps of Engineers Hydraulic Engineering Center (HEC); the software is commonly referred to as HEC-RAS.

Task 2 – Hydrology and Hydraulics

The Lake Street Dam is located on the Bear River in downtown Petoskey. The dam is the lowermost barrier on the river. As part of the Little Traverse Bay Watershed, the Bear River originates from Walloon Lake and flows 14.5 miles in a northerly direction to its confluence with the Bay in Petoskey. The Bear River, shown in Figure 1 below, is the largest tributary to Little Traverse Bay. Major tributaries of the River include Hay

Marsh Creek, a warm-water tributary draining extensive wetlands in the southern headwaters, and Spring Brook, a cold-water tributary draining the headwaters to the southeast.

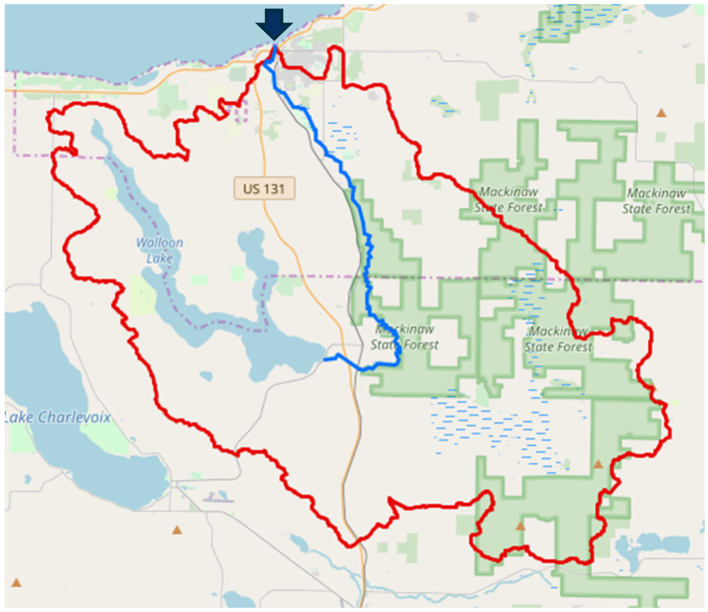

Figure 1. Bear River Watershed

The Bear River watershed encompasses an area of approximately 116 square miles. The watershed boundaries are depicted in Figure 1 above.

Flood and low flow discharges at the Lake Street Dam were estimated by the Hydrologic Studies and Dam Safety Unit of the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Water Resources Division (WRD). The primary flows of concern for restoring native fish passage are the spring mean (March to May) and fall mean (September to November). These are the critical migration periods for the target fish passage. Other flows considered in the study include the summer low flow, annual mean, and 100-year flood to characterize the hydraulics through the full spectrum of flow. The 100-year flood flow is used to determine the 100-year floodplain elevation.

Table 2. Bear River Flows at the Lake Street Dam

Scenario	Flow (cfs)
Summer Low (August Mean)	80
Annual Mean	98
Fall Mean (September to November)	101
Spring Mean (March to May)	170
10-year Flood	800
25-year Flood	900
100-year Flood	1100

The flows listed in Table 2 were simulated in HEC-RAS to evaluate the existing hydraulic profiles. The Bear River HEC-RAS model was developed from the digital elevation model developed in Task 1. The simulations were steady state, meaning that the flow was not varied over a time series. The simulations were performed with a mixed flow regime, in which flow in some sections of the study reach is supercritical and flow in other sections is subcritical. In other words, some sections are slower moving with relatively uniform relaxed flow (subcritical) while others are fast and turbulent (supercritical). The boundary conditions included the long-term average water surface elevation of Lake Michigan, 578.84 FEET, and the normal depth of the upstream reach based on the surveyed channel slope. The simulations represent simplified conceptual designs and the output should only be used for conceptual comparisons. Future design models should be calibrated by conducting hydrologic and hydraulic measurements in the field during the critical design period, and then adjusting model parameters (primarily roughness factors) until the model can accurately replicate observed conditions.

It should be noted that the 100-year flood flow simulation suggests possible flooding may occur upstream of the Lake Street Dam, but this study was not intended to map floodplains and the purpose of the 100-year flood flow simulation is simply to provide a base flood elevation estimate. The HEC-RAS model has been calibrated solely by anecdotal information and engineering judgement, and the results of these simulations should be considered purely conceptual. Future management should include flow metering of the Bear River near the Lake Street Dam in order to provide more data from which future models for preliminary and final design may be thoroughly calibrated.

Task 3 – Community Engagement

Under this task the Project Team engaged stakeholders and the public through two open houses, three stakeholder meetings, a project website, and an online community survey. The project website was developed as an ESRI Story Map, available at http://bit.ly/2MkkG6zBearRiver, to provide the public with information and receive feedback. The online community survey provided the Project Team with critical information regarding primary uses of this reach of the Bear River as well as public opinions related to the dam's management. The following takeaways were gathered from the community survey:

- The primary uses of the river are fishing and paddling.
- There is a perception that removal of the dam will result in more fish being caught, and that it would allow paddlers to pass through to the Petoskey Marina.
- There is concern for the impact of invasive species, specifically the potential for sea lamprey infestation in the upper Bear River and Walloon Lake.

The public response affirms the engineering alternatives' goals of allowing for fish passage while minimizing sea lamprey and other invasive species from accessing upstream. In collaboration with the Project Team, primary management approaches were identified and discussed. The primary approaches include:

1. No change – the Lake Street Dam is not modified or removed. This alternative does not preclude other maintenance and repair work recommended in the 2018 inspection report.
2. Partial removal or modification – the Lake Street Dam is partially removed or modified such that it still provides an effective barrier against sea lamprey infestation while improving fish passage and reducing the hazard to paddlers.

3. Full removal – the Lake Street Dam is completely removed, thus completely restoring fish passage but also eliminating the existing sea lamprey barrier.

The primary approaches were presented to stakeholders and it was determined that leaving the dam as-is is generally not a desirable outcome. Representatives of the fishing community emphasized that the existing dam is a favorite spot for locals and visiting anglers, but the close concentration of people trying to get a fish can lead to conflicts and can make the location less suitable for families and youth. The existing dam also poses a hazard to paddlers and swimmers. However, because of the concerns for sea lamprey invasion and the potential to increase scour potential at the US31 bridge, both the US Fish and Wildlife Service (USFWS) and the Michigan Department of Transportation (MDOT) have indicated that they would prefer to see the dam left intact, but neither agency is explicitly opposed to other alternatives that address these concerns.

Regarding full removal, it was identified that this may not be a desirable option for all stakeholders unless a new lamprey barrier is constructed. The City has no legal mandate to provide a lamprey barrier but federal funding for dam removal may be contingent on the construction of another barrier. The alternate barrier could be constructed separately before or after dam removal, but if the dam is removed prior to construction of an upstream barrier, it is likely that at least one chemical treatment would be required to control lamprey populations. This option also raises the question of where to construct a new barrier. The primary purpose of removing the barrier is to provide additional habitat for native non-jumping fish species, so it does not make sense to move the barrier further downstream. The existing dam is already near the mouth of the river and moving it closer would only accentuate the existing fish passage limitations. If a new barrier is to be constructed, it should be sited upstream of the Lake Street Dam. There are multiple sites upstream of the Lake Street Dam where a new lamprey barrier could be constructed. These sites are listed with some high-level pros and cons in Table 3. The locations are shown on Sheet 10 of the schematic plan set.

Table 3. Potential Alternate Lamprey Barrier Locations

	Location Description	Approximate River Mileage[1]	Pros	Cons
A	**Lake Street (Existing)**	0.05	City property, easy access, may keep or modify existing structure	Limited river mileage
B	**US31**	0.11	Existing constriction and abutments may reduce construction cost	Limited river mileage, MDOT ownership
C	**Bridge Street**	0.69	Road and sidewalk access, easy walking distance from town	Limited river mileage, whitewater course interference?, limited upstream floodplain capacity
D	**Sheridan Rd**	1.12	Partial City ownership, potential to combine with road work	Mixed ownership, limited upstream floodplain capacity
E	**Railroad Trestle**	1.41	Existing constriction and abutments may reduce construction cost	No City ownership, limited upstream floodplain capacity
F	**S. Howard Rd**	1.66	Partial City ownership	Limited upstream floodplain capacity
G	**River Road Sports Complex**	3.3	Partial ownership (City, Township, NCMC), public fish viewing opportunity, combine with paddler access improvements, combine with pedestrian bridge, good river mileage available for fish, potential to combine with public recreational facilities improvements	
H	**McDougal Rd**	3.94	Partial Township ownership, additional river mileage available for fish, may be combined with road stream crossing improvements	No existing river access other than the road
I	**Click Rd**	4.54	Partial Township ownership, additional river mileage available for fish	No existing river access
J	**Evergreen Trail**	6.42	MDNR ownership, still downstream of major tributaries but offers the most river miles for fish habitat out of the above alternatives	No existing river access other than the road
	1. Approximate river mileage does not follow the true centerline of the River and is expected to be slightly underestimated.			

The USFWS has indicated that they could potentially support upstream relocation of a physical lamprey barrier from the Lake Street Dam but that their treatment costs increase for each exposed river mile. A barrier further upstream than the locations listed above may expose some tributaries of the Bear River to sea lamprey infestation which would drastically increase the amount of river miles that may require chemical lamprey treatments. The USFWS is planning to conduct a survey of the watershed in the summer of 2020 to quantify the potential impacts of upstream lamprey infestation.

There are some advantages to keeping a barrier in the location of the existing dam. The structure is tied into the existing retaining walls of the Lake Street Bridge. The site is easily accessed from Lake Street and the property is owned by the City on all sides, except the MDOT right of way to the south at the US31 bridge. The existing location is already a favorite fishing spot among anglers. The dam is located near enough to Little Traverse Bay and the water is turbulent enough downstream of the dam that sea lamprey may be able to spawn but are unable to find suitable habitat to remain and grow. The USFWS has not had to chemically treat downstream of the dam since the channel was armored, and treatment of the River upstream of the Lake Street dam has not been necessary. The USFWS has also stated concern that native lamprey populations in the watershed may attract sea lamprey further upstream if the physical barrier is removed.

Considering the arguments for keeping a lamprey barrier in the location of the existing dam, there are additional advantages to partially removing and/or modifying the dam instead of fully removing it and replacing it with a new barrier. Construction costs and site impacts may be reduced by keeping much of the existing structure in place. This is one of the primary management approaches and the basis for two of the engineering alternatives discussed in the next section.

Task 4 – Conceptual Engineering Alternatives

Identification of Potential Alternatives

The Project Team identified partial dam removal/modification or complete removal combined with cross vane style grade controls as potential management approaches. Within the partial removal/modification approach there are two primary alternatives and numerous design variations that are possible. The alternatives and notable variations are listed below and analyzed throughout this section.

- **Alternative #1: Low head, fixed-crest weir (permanent barrier)**
  This alternative would remove approximately 3 feet from the crest of the existing dam. This alternative could be combined with a trap-and-sort addition to allow fish passage while maintaining the lamprey barrier.
- **Alternative #2: Low head, adjustable-crest weir (seasonal barrier)**
  This alternative would remove the existing dam down to and potentially including its concrete base and replace it with either a pneumatic gate or inflatable dam that can be raised during the April to June lamprey migration period and lowered for the remainder of the year.
- **Alternative #3: Complete dam removal**
  This alternative would remove the existing dam completely. The work would need to include channel modifications and grade control construction. This alternative is not legally contingent upon construction of another lamprey barrier, but funding options may be limited unless a new barrier is planned.

Critical design parameters were established in support of the project goals. The parameters were identified in discussion with subject matter experts on fish passage, stream restoration, and lamprey control with Michigan

DNR, Michigan Trout Unlimited, and US Fish and Wildlife Service. Meeting minutes from these technical meetings are provided in Appendix C. Critical design parameters are listed in Table 4.

Table 4. Critical Design Parameters

Project Goal	Critical Design Parameters
Promote fish passage	• Maximum mean channel velocities of 3 to 4 feet per second. This is most critical during the spring and fall migration periods (March to May and September to November) • Minimum centerline water depth of 12 to 14 inches. • Grade controls should consist of cross vanes, step pools, riffles or other structures that promote varied flow and depth for habitat and passage throughout high and low flow seasons.
Allow paddler passage	• Minimum clearance of 4.3 feet from top of water to bottom of bridge superstructure
Prevent sea lamprey migration	• Minimum water drop of 18 inches, maintained in all flow conditions up to the 25-year flood. • A 15-centimeter overhanging lip is preferred at the crest of the weir.

For the purposes of this conceptual study, three conditions were simulated in HEC-RAS.

1. Existing conditions
2. Fixed-crest weir with upstream grade controls
3. Adjustable-crest weir in lowered position with upstream grade controls

The design flows were simulated for each alternative to evaluate performance against the critical design parameters. The simulations represent simplified conceptual designs and the output should only be used for conceptual comparisons. Future design models should be calibrated by conducting hydrologic and hydraulic measurements in the field during the critical design period. Grade controls were modeled as simple in-line broad crested weirs and the trap-and-sort alternative was treated as no change from existing conditions, since the trap-and-sort fishway would likely be constructed adjacent to or downstream of the existing dam with no significant hydraulic impact. The seasonal alternative was modeled only for the lowered-crest condition (representing the seasonal lowering of the dam) because the raised-crest condition is represented by fixed-crest alternative. Simulation results suggest that either alternative may achieve all desired outcomes under the select operational conditions as indicated in Table 5. HEC-RAS simulation results are provided in Appendix A.

Table 5. Project Goal Performance Matrix

	Design Alternative		
	Alternative #1	Alternative #2	Alternative #3
Desired Outcome	Fixed-crest Weir	Adjustable-crest Weir	Complete Removal
Restore Native Fish Passage	✓(with trap-and-sort)	✓ (lowered condition, restricted migration windows)	✓
Promote Paddle Sports Uses	✓*	✓*	✓*
Prevent Lamprey Migration	✓	✓ (raised condition)	×

*Paddle Sports Usage Note: The water crest drop would be reduced, and the undertow danger could be reduced as well but even the existing clearances under the Lake Street bridge and the pedestrian bridge do not meet the recommended 4.3 feet of clearance. The clearance from the bottom of bridge to top of water at Lake Street was measured at approximately 44 inches (3.7 feet) on 5/27/2020. Reducing the dam height will reduce the risk to paddlers but passage should still be considered 'at own risk' due to the limited under clearance. The channel could be modified in a complete removal scenario to improve clearances at the City's discretion. Flow metering and a calibrated hydraulic model should be developed to provide a basis of design for the proposed modifications.

Regarding channel modification extents, hydraulic simulations indicate that spring mean channel velocities may reach approximately 6 fps in the reach immediately downstream of the Lake Street Bridge under existing conditions. Additional historic flow monitoring indicates that the mean channel velocities in the reaches upstream of the US31 bridge may reach 6 to 8 fps. These velocities exceed the critical design parameters for fish passage but occur outside the work limits of the proposed alternatives. The Project Team agreed that it would be advantageous to maintain the design criteria of 3 to 4 fps within the scope of proposed work regardless of the existing upstream and downstream exceedances.

Regarding scour, the design alternatives will likely affect the hydraulic profile at the US31 bridge. This is of special concern because MDOT has classified the bridge as scour critical. This designation means that the bridge is especially vulnerable to changes in velocity and depth and that special precautions must be taken during project design to mitigate additional scour at the bridge. This will require coordination with the MDOT Hydraulics Unit.

There is no anticipated change to the scour potential at the Lake Street Bridge for the partial removal/modification alternatives because the proposed hydraulic profile downstream of the dam is unchanged from existing. The 2018 inspection report included recommendations to repair the existing scour at the toe of the concrete basin between the dam and the Lake Street Bridge, but the scour hole currently provides a pool from which jumping fish make their attempts to cross over the dam. Filling this scour hole may result in reducing fish passage and may negatively impact the amount of fish being caught by anglers at the location. It may be more beneficial to armor the existing hole such that the current stream bed grades are maintained.

Scour at the Lake Street Bridge will likely be affected if any channel modifications occur downstream of the bridge in the case of a complete removal of the Lake Street Dam. The extent of the scour potential will need to be evaluated during design to determine appropriate countermeasures. Scour countermeasures may include armoring at the bridge or downstream grade controls.

Regarding full dam removal, there are many possibilities for the proposed channel. Channel slope will be a critical consideration for any of the proposed modifications. Starting at the existing contraction north of the US31 Bridge right-of-way, there is a channel slope of approximately 1.5% to the toe of the existing dam. Reducing the slope from 1.5% would require filling the channel downstream or cutting the channel upstream (likely into the MDOT ROW). Filling the channel downstream could further reduce the clearance under the Lake Street Bridge which increase the hazard to paddlers and could increase flood potential at Lake Street because the cross-sectional area beneath the bridge span would be reduced. Therefore, 1.5% slope is effectively the minimum achievable slope in this reach without significant upstream channel modifications. From the toe of the existing dam the average channel slope downstream to the Bay is a little over 2.5%. This is a relatively high gradient. If modifications are carried all the way downstream to the Bay, an average slope of about 2% could be achieved, as shown on Sheet 11 of the accompanying schematic plans. It is possible to improve the under clearance at both the Lake Street and pedestrian bridges which would potentially open passage for paddlers all the way to the Bay. In any channel modification scenario, cross vane or step pool grade control methods could be employed to provide resting pools for fish passage.

Conceptual Cost Estimates

The following estimates have been developed for the Lake Street Dam engineering alternatives. The estimates should be considered Class 4 in the Association for the Advancement of Cost Engineering (AACE) estimate classification system. A Class 4 estimate is a study or feasibility level estimate representing a project that is between 1% and 15% defined with an expected accuracy range of -30% to +50%. Detailed estimates are included in Appendix B.

Maintenance Recommendations Only	$ 90,000
Alternative #1 – Fixed-Crest Weir	$1,050,000
Alternative #2 – Adjustable-Crest Weir	$1,640,000
Alternative #3 – Complete Removal	$1,090,000

For Alternative #3, the estimate does not include the cost to design/construct a new barrier at an alternate location. It is assumed that this would be completed as part of a separate project. The full removal estimate accounts for two grade controls; additional channel modification downstream of the existing dam is not included.

Conclusions and Recommendations

The City has many options available and should continue to engage with stakeholders and the local community to identify the best long-term management approach for the Lake Street Dam. This study provides a foundation for the discussion moving forward and should be used as a guide. A summary of the alternatives, key takeaways, pros and cons, and recommendations for further assessment are provided in this section.

The primary management approaches identified in this study are:

1. Partially remove the dam and maintain a fixed-crest weir at the existing location
2. Partially remove or fully remove the dam and maintain an adjustable-crest weir at the existing location
3. Completely remove the dam and do not construct a barrier in the existing location.

A summary of considerations for each alternative is shown in Table 6. Summary of Engineering Alternatives Considerations..

Table 6. Summary of Engineering Alternatives Considerations.

		Alternative #0	Alternative #1	Alternative #2	Alternative #3
Project Goal		**Maintain Existing Structure**	**Fixed-crest/partial removal**	**Adjustable-crest/partial removal**	**Complete Removal**
Fish Passage	Passing Species	Jumping only	Jumping, some non-jumping	Jumping, some non-jumping	All
	Method	Anglers	Anglers/Volunteers	Lowered barrier condition	Stepped grade controls
	Other Comments		trap-and-sort add-on possible	limited window to lower barrier	Alternate barrier sites possible
Lamprey Control	Method	Physical fixed-crest weir	Physical fixed-crest weir (lower head)	Inflateable/pnuematic dam or stop log weir	none
	Permanent or Seasonal	Permanent	Permanent	Seasonal	Permanent
	Location	Lake Steet	Lake Steet	Lake Steet	*alternate site
	Other Comments				
Paddler Usage	Drop/Undertow Hazard	High	Medium	Low to Medium	Low
	Bridge Clearance	3.7ft*	3.7ft*	3.7ft*	Variable
Estimated Project Costs	AACE Class 4, Project Total	$ 90,000.00	$ 1,050,000.00	$ 1,640,000.00	$ 1,090,000.00

*The existing clearance from top of water to bottom of bridge is approximately 3.7 feet, as measured in the field on 5/27/2020. The clearance will change with flow but it should be assumed that the desired clearance of 4.3 feet will not be met without regrading the channel from the Lake Street dam to the Bay.

A partial removed of the existing dam and maintenance of a fixed-crest weir will likely be the least expensive management approach, short of leaving the dam as-is. It will require the least amount of sediment removal for construction and the fewest modifications to the existing infrastructure.

Regarding an adjustable-crest weir, most fish migrate in the spring at the same time as the lamprey. This would lead to the lamprey barrier likely being in a raised position for most of the fish migration period and thus not achieving the desired fish passage. For this reason, an adjustable crest weir is unlikely to achieve a significant increase in passage versus a fixed-crest weir.

Full removal of the dam will provide the most benefit to fish habitat. It is important to continue to work with stakeholders to identify the appropriate balance between fish habitat restoration and sea lamprey control. Although a new barrier is not necessarily required prior to removal of the Lake Street dam, it is important to at least identify and begin preparation for construction of a new barrier prior to removal of the dam.

The River Road Sports Complex is an attractive alternate barrier location that could restore approximately 3.3 river miles of habitat to native non-jumping fish species. The location is partially owned by the City and a barrier could be constructed as a recreational facility improvement. It would be possible to combine it with a new pedestrian bridge, fish viewing platform, and paddler access. Moving the barrier to this upstream location may increase the chemical treatment costs for the USFWS lamprey control program, but costs should not be prohibitive because the location is still downstream of any major tributaries. There is potential that the MDNR could reduce expenditures on fish stocking programs in the watershed since more habitat would be restored, so the costs for treatment may be offset.

Based on the results of the usage survey, input from project stakeholders, conceptual hydraulic performance evaluation, and the estimated cost to design and construct, OHM Advisors recommends a fixed-crest alternative over an adjustable-crest. The additional fish passage gained from an adjustable-crest weir is minimal and does not justify the additional expense.

OHM Advisors also recommends further consideration of complete removal of the dam with the understanding that an alternate sea lamprey barrier may be constructed as part of recreational facility improvements at the River Road Sports Complex. This alternative restores significant fish habitat to native non-jumping species and promotes paddler passage while maintaining reasonable lamprey control measures. This alternative is not the cheapest, but it has the option to be combined with other improvements at the park that would expand public uses of the Bear River.

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Appendix A: HEC-RAS Output

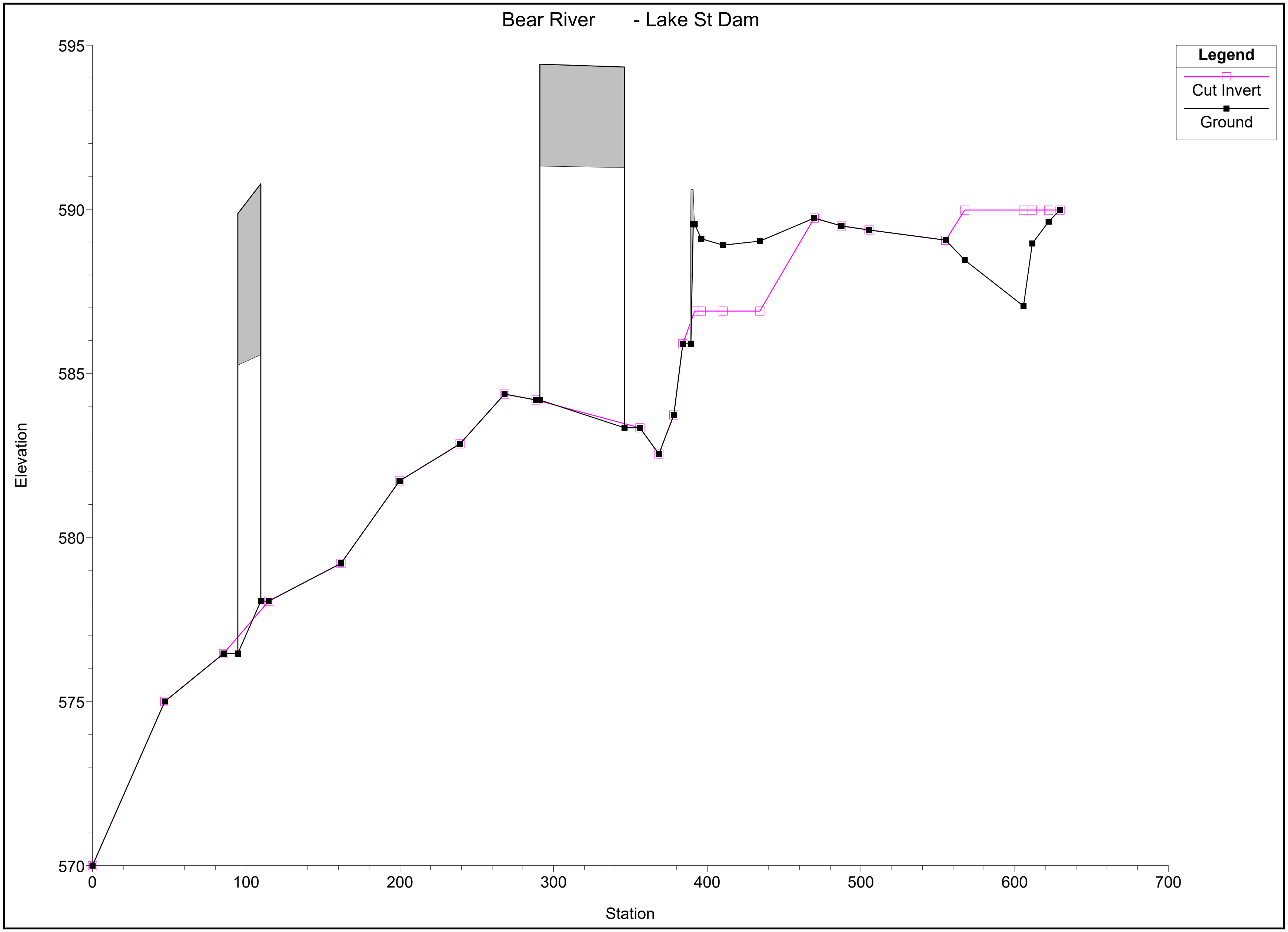
The following plots and tables summarize the results of HEC-RAS simulations. For the purposes of this conceptual study, three conditions were modeled in HEC-RAS.

1. Existing conditions
2. Fixed-crest weir with upstream grade controls
3. Adjustable-crest weir in lowered position with upstream grade controls

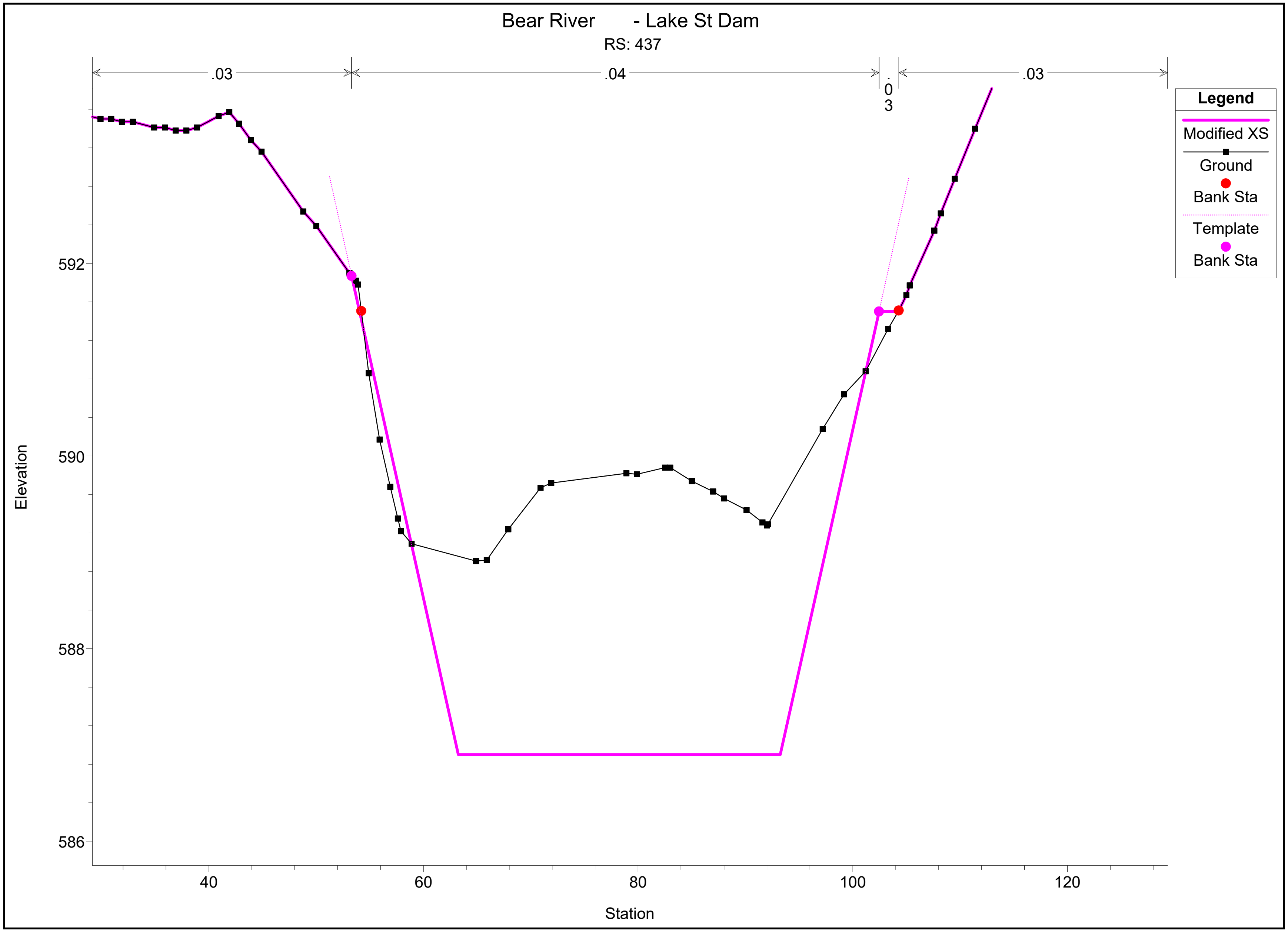
Each condition was modeled with three hydraulic profiles representing select design flows. The flows are:

1. Summer low flow (August mean) of 80 cfs
2. Spring mean flow (March to May) of 170 cfs
3. 25-year flood flow of 900 cfs

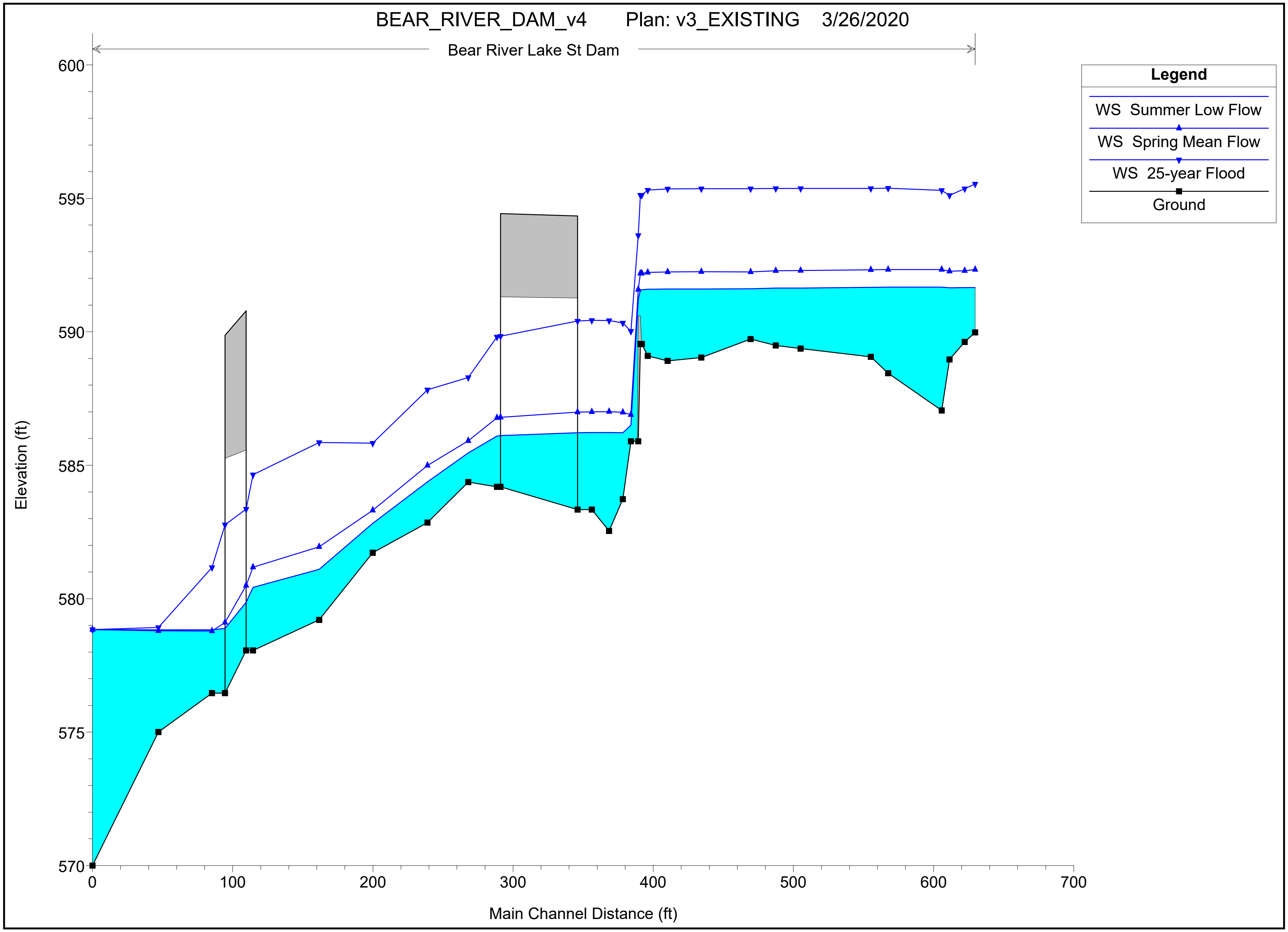
A hydraulic profile plot and tabular summary is provided for each condition. It should be emphasized that these are conceptual simulations and final designs may have varied results. It is recommended that further hydraulic modeling is completed in conjunction with preliminary and final design. Further development of the HEC-RAS analysis should include flow metering for model calibration.

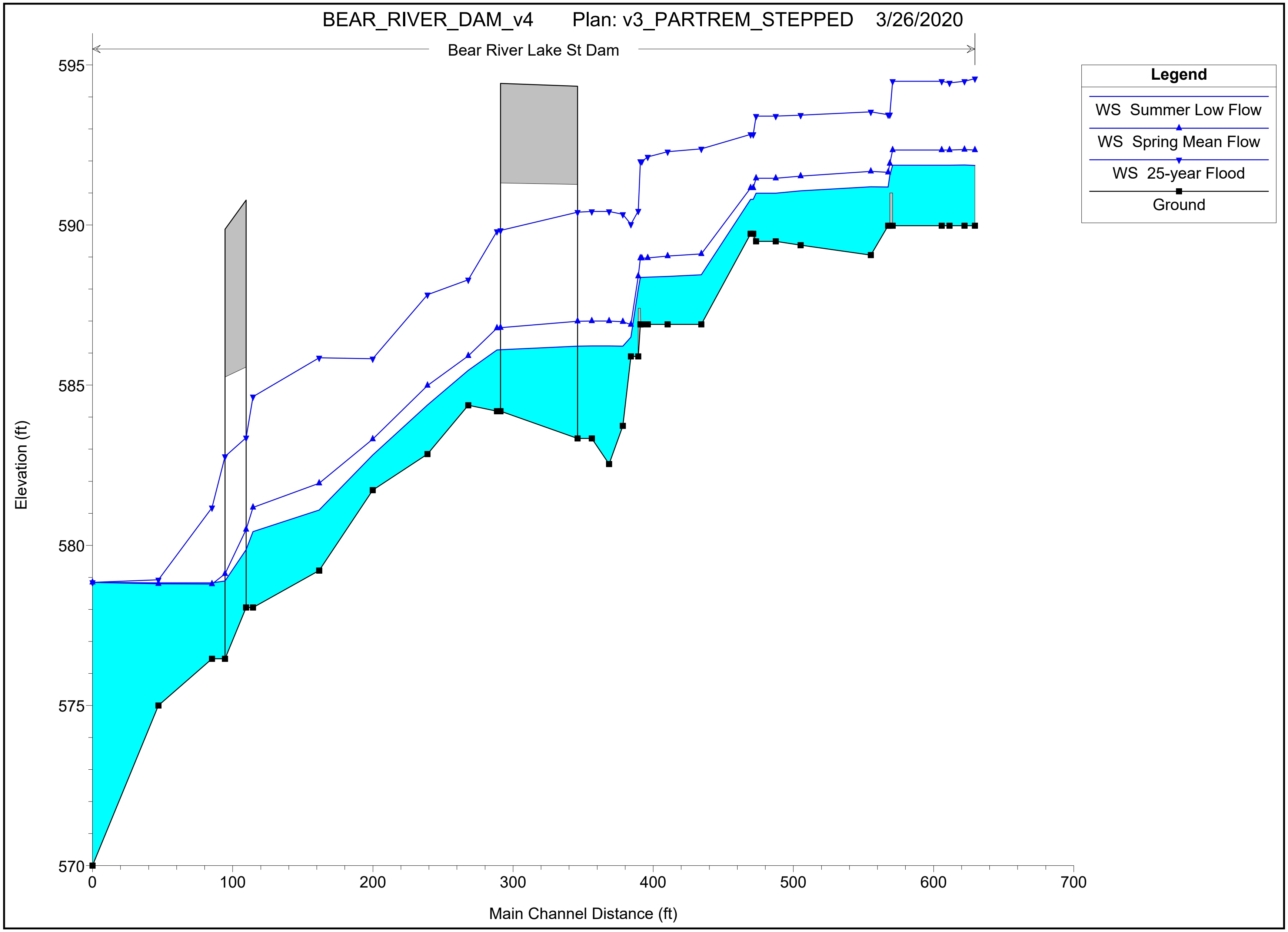


Bear River - Lake St Dam
Legend
Cut Invert
Ground
Elevation
595
590
585
580
575
570
Station
0
100
200
300
400
500
600
700

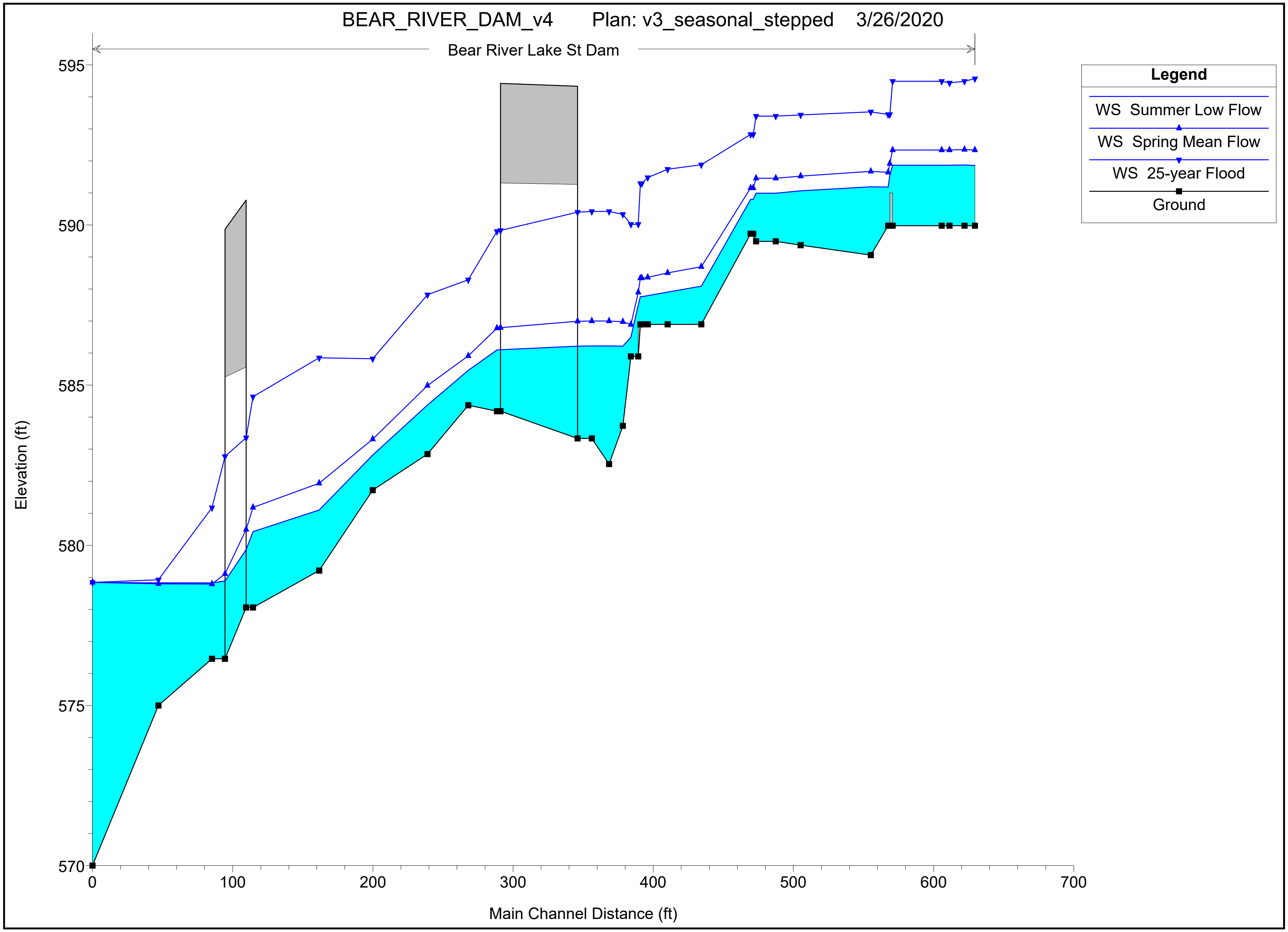


Bear River - Lake St Dam
RS: 437
.03
.04
.
0
3
.03
Legend
Modified XS
Ground
Bank Sta
Template
Bank Sta
592
590
588
586
Elevation
40
60
80
100
120
Station

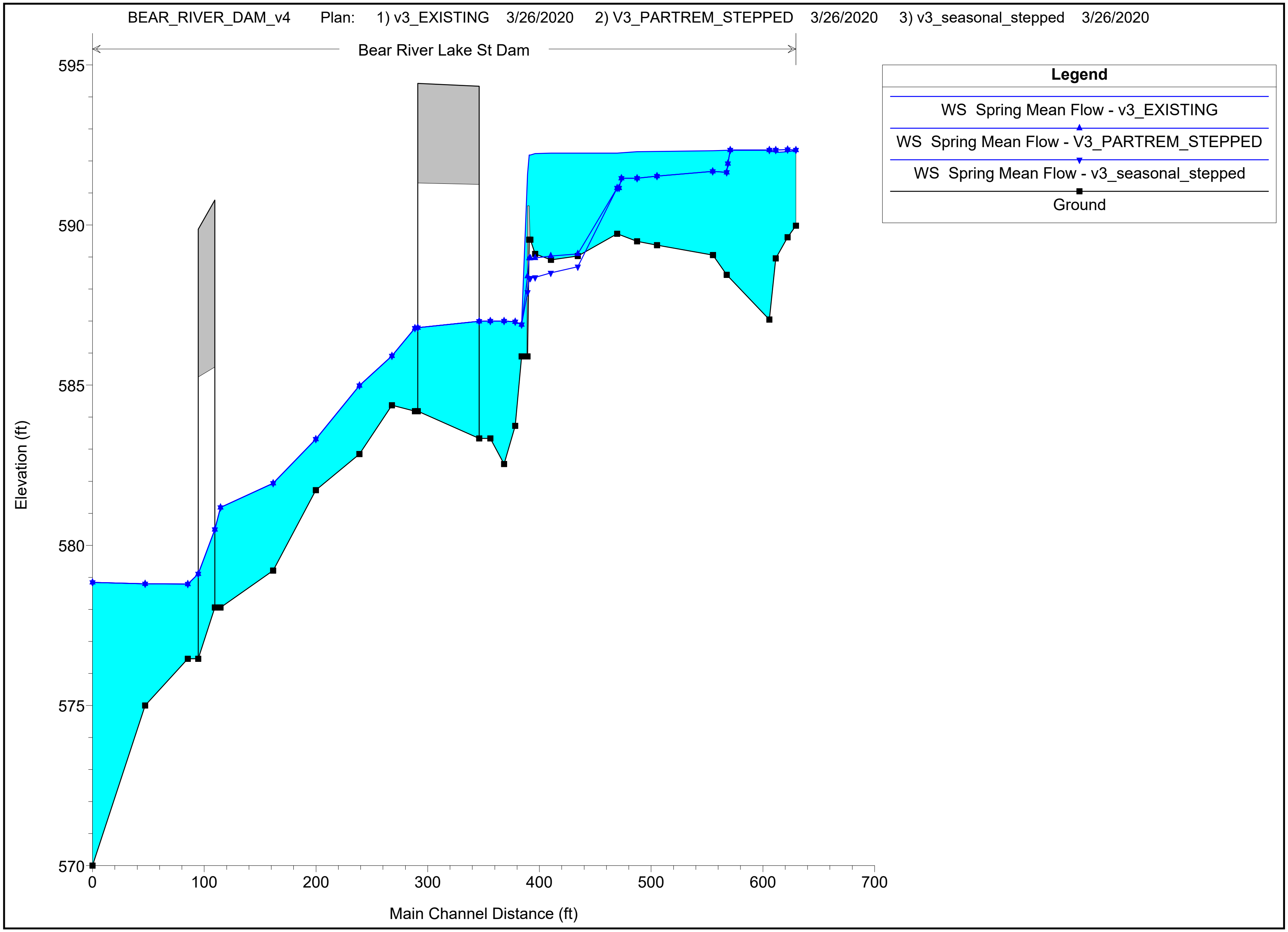

BEAR_RIVER_DAM_v4 Plan: v3_EXISTING 3/26/2020
Bear River Lake St Dam
Legend
WS Summer Low Flow
WS Spring Mean Flow
WS 25-year Flood
Ground
Elevation (ft)
600
595
590
585
580
575
570
0
100
200
300
400
500
600
700
Main Channel Distance (ft)



BEAR_RIVER_DAM_v4 Plan: v3_PARTREM_STEPPED 3/26/2020
Bear River Lake St Dam
Legend
WS Summer Low Flow
WS Spring Mean Flow
WS 25-year Flood
Ground
Elevation (ft)
595
590
585
580
575
570
0
100
200
300
400
500
600
700
Main Channel Distance (ft)



BEAR_RIVER_DAM_v4 Plan: v3_seasonal_stepped 3/26/2020
Bear River Lake St Dam
Legend
WS Summer Low Flow
WS Spring Mean Flow
WS 25-year Flood
Ground
Elevation (ft)
595
590
585
580
575
570
0
100
200
300
400
500
600
700
Main Channel Distance (ft)


BEAR_RIVER_DAM_v4 Plan: 1) v3_EXISTING 3/26/2020 2) V3_PARTREM_STEPPED 3/26/2020 3) v3_seasonal_stepped 3/26/2020
Bear River Lake St Dam
Legend
WS Spring Mean Flow - v3_EXISTING
WS Spring Mean Flow - V3_PARTREM_STEPPED
WS Spring Mean Flow - v3_seasonal_stepped
Ground
Elevation (ft)
595
590
585
580
575
570
0
100
200
300
400
500
600
700
Main Channel Distance (ft)

HEC-RAS Plan: v3_EXISTING   River: Bear River   Reach: Lake St Dam

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	666	Summer Low Flow	80.00	589.98	591.65	591.00	591.73	0.002199	2.28	35.07	35.75	0.41
Lake St Dam	666	Spring Mean Flow	170.00	589.98	592.33	591.51	592.43	0.002049	2.62	64.92	50.89	0.41
Lake St Dam	666	25-year Flood	900.00	589.98	595.54	593.19	595.74	0.000763	3.64	259.19	69.62	0.31
Lake St Dam	659	Summer Low Flow	80.00	589.62	591.65		591.72	0.001279	2.05	38.93	30.50	0.32
Lake St Dam	659	Spring Mean Flow	170.00	589.62	592.29		592.42	0.001558	2.89	59.04	32.78	0.37
Lake St Dam	659	25-year Flood	900.00	589.62	595.36		595.72	0.001275	5.01	204.98	62.89	0.40
Lake St Dam	648	Summer Low Flow	80.00	588.96	591.65	590.52	591.70	0.000858	1.91	41.92	26.23	0.27
Lake St Dam	648	Spring Mean Flow	170.00	588.96	592.27	591.10	592.40	0.001329	2.90	58.98	28.74	0.35
Lake St Dam	648	25-year Flood	900.00	588.96	595.11	593.41	595.68	0.002005	6.21	155.05	49.56	0.49
Lake St Dam	633	Summer Low Flow	80.00	587.05	591.68	588.90	591.69	0.000092	0.91	87.55	42.76	0.10
Lake St Dam	633	Spring Mean Flow	170.00	587.05	592.33	589.54	592.37	0.000203	1.57	109.08	48.10	0.15
Lake St Dam	633	25-year Flood	900.00	587.05	595.30	591.86	595.58	0.000667	4.31	218.09	63.57	0.30
Lake St Dam	594	Summer Low Flow	80.00	588.45	591.67	589.58	591.68	0.000105	0.81	98.21	47.52	0.10
Lake St Dam	594	Spring Mean Flow	170.00	588.45	592.33	590.05	592.36	0.000191	1.31	130.53	50.97	0.14
Lake St Dam	594	25-year Flood	900.00	588.45	595.38	591.85	595.53	0.000404	3.15	295.61	70.24	0.23
Lake St Dam	582	Summer Low Flow	80.00	589.06	591.67		591.68	0.000207	0.99	80.88	48.74	0.14
Lake St Dam	582	Spring Mean Flow	170.00	589.06	592.32		592.36	0.000308	1.51	113.64	51.58	0.17
Lake St Dam	582	25-year Flood	900.00	589.06	595.37		595.52	0.000458	3.21	304.05	75.09	0.24
Lake St Dam	532	Summer Low Flow	80.00	589.37	591.64		591.67	0.000557	1.23	65.21	60.60	0.21
Lake St Dam	532	Spring Mean Flow	170.00	589.37	592.29		592.34	0.000515	1.62	106.36	64.96	0.22
Lake St Dam	532	25-year Flood	900.00	589.37	595.37		595.49	0.000412	2.85	350.84	105.62	0.23
Lake St Dam	515	Summer Low Flow	80.00	589.49	591.63		591.66	0.000472	1.18	68.16	59.69	0.19
Lake St Dam	515	Spring Mean Flow	170.00	589.49	592.29		592.33	0.000481	1.57	109.72	66.11	0.21
Lake St Dam	515	25-year Flood	900.00	589.49	595.37		595.48	0.000385	2.75	368.64	115.25	0.22
Lake St Dam	497	Summer Low Flow	80.00	589.73	591.61		591.64	0.000792	1.53	52.25	44.58	0.25
Lake St Dam	497	Spring Mean Flow	170.00	589.73	592.25		592.31	0.000948	2.06	83.19	54.92	0.29
Lake St Dam	497	25-year Flood	900.00	589.73	595.36		595.47	0.000462	2.82	377.92	145.70	0.24
Lake St Dam	461	Summer Low Flow	80.00	589.03	591.60		591.62	0.000291	1.03	77.61	56.60	0.16
Lake St Dam	461	Spring Mean Flow	170.00	589.03	592.25		592.28	0.000366	1.49	115.21	61.43	0.19
Lake St Dam	461	25-year Flood	900.00	589.03	595.36		595.45	0.000317	2.58	418.31	140.00	0.20
Lake St Dam	437	Summer Low Flow	80.00	588.91	591.60		591.62	0.000139	0.87	92.31	50.62	0.11
Lake St Dam	437	Spring Mean Flow	170.00	588.91	592.24		592.27	0.000231	1.36	126.33	56.29	0.15
Lake St Dam	437	25-year Flood	900.00	588.91	595.35		595.44	0.000289	2.62	414.60	123.70	0.20
Lake St Dam	423	Summer Low Flow	80.00	589.10	591.60		591.61	0.000203	1.03	77.76	43.79	0.14
Lake St Dam	423	Spring Mean Flow	170.00	589.10	592.23		592.27	0.000333	1.61	106.44	48.31	0.18
Lake St Dam	423	25-year Flood	900.00	589.10	595.31		595.44	0.000398	3.05	352.43	109.65	0.23
Lake St Dam	417	Summer Low Flow	80.00	589.54	591.58	590.47	591.61	0.000494	1.46	54.89	35.21	0.20
Lake St Dam	417	Spring Mean Flow	170.00	589.54	592.19	590.86	592.26	0.000770	2.23	76.92	36.86	0.27
Lake St Dam	417	25-year Flood	900.00	589.54	595.13	592.70	595.42	0.001017	4.51	219.37	53.50	0.35
Lake St Dam	416		Inl Struct									
Lake St Dam	407	Summer Low Flow	80.00	585.90	586.50	586.50	586.80	0.005275	4.41	18.14	30.35	1.01
Lake St Dam	407	Spring Mean Flow	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	407	25-year Flood	900.00	585.90	590.02		590.80	0.001317	7.05	127.65	31.80	0.62
Lake St Dam	402	Summer Low Flow	80.00	583.73	586.22	584.92	586.24	0.000398	1.36	58.87	33.31	0.18
Lake St Dam	402	Spring Mean Flow	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	402	25-year Flood	900.00	583.73	590.34		590.65	0.001134	4.52	199.40	35.72	0.33
Lake St Dam	393	Summer Low Flow	80.00	582.54	586.23		586.24	0.000081	0.80	101.31	38.88	0.09
Lake St Dam	393	Spring Mean Flow	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	393	25-year Flood	900.00	582.54	590.42		590.61	0.000468	3.45	266.05	39.67	0.23
Lake St Dam	383	Summer Low Flow	80.00	583.34	586.23	584.22	586.24	0.000508	0.80	99.99	42.57	0.09
Lake St Dam	383	Spring Mean Flow	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	383	25-year Flood	900.00	583.34	590.43	586.27	590.59	0.002107	3.23	281.08	43.69	0.22
Lake St Dam	320		Bridge									
Lake St Dam	316	Summer Low Flow	80.00	584.19	586.10		586.14	0.004544	1.77	45.21	31.03	0.26
Lake St Dam	316	Spring Mean Flow	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	316	25-year Flood	900.00	584.19	589.80		590.25	0.008017	5.45	171.15	36.92	0.42
Lake St Dam	295	Summer Low Flow	80.00	584.37	585.47	585.47	585.81	0.087250	4.70	17.02	25.54	1.01
Lake St Dam	295	Spring Mean Flow	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	295	25-year Flood	900.00	584.37	588.29	588.12	589.66	0.039885	9.56	98.23	31.83	0.90
Lake St Dam	266	Summer Low Flow	80.00	582.85	584.38	583.93	584.52	0.017159	2.99	27.11	24.23	0.49

HEC-RAS Plan: v3_EXISTING River: Bear River Reach: Lake St Dam (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	266	Spring Mean Flow	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	266	25-year Flood	900.00	582.85	587.83	586.77	588.75	0.019330	7.91	120.63	29.55	0.65
Lake St Dam	227	Summer Low Flow	80.00	581.72	582.82	582.82	583.20	0.084723	4.97	16.11	21.42	1.01
Lake St Dam	227	Spring Mean Flow	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	227	25-year Flood	900.00	581.72	585.82	585.82	587.55	0.046169	10.70	87.72	26.24	0.97
Lake St Dam	189	Summer Low Flow	80.00	579.21	581.10	580.33	581.20	0.008873	2.54	31.57	20.74	0.36
Lake St Dam	189	Spring Mean Flow	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	189	25-year Flood	900.00	579.21	585.85		586.55	0.009589	6.76	138.92	24.52	0.48
Lake St Dam	142	Summer Low Flow	80.00	578.06	580.42	579.86	580.60	0.019342	3.36	23.81	17.57	0.51
Lake St Dam	142	Spring Mean Flow	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55
Lake St Dam	142	25-year Flood	900.00	578.06	584.64	583.35	585.86	0.020674	8.90	102.57	19.18	0.67
Lake St Dam	115		Bridge									
Lake St Dam	112	Summer Low Flow	80.00	576.46	578.83		578.91	0.005495	2.27	35.31	17.35	0.28
Lake St Dam	112	Spring Mean Flow	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	112	25-year Flood	900.00	576.46	581.17	581.17	583.35	0.054065	11.84	76.48	17.77	1.00
Lake St Dam	74	Summer Low Flow	80.00	575.00	578.83		578.85	0.000278	1.20	66.82	17.69	0.11
Lake St Dam	74	Spring Mean Flow	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	74	25-year Flood	900.00	575.00	578.92	579.37	581.61	0.032797	13.15	68.46	17.70	1.18
Lake St Dam	27	Summer Low Flow	80.00	570.00	578.84	570.87	578.84	0.000026	0.51	155.75	18.04	0.03
Lake St Dam	27	Spring Mean Flow	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07
Lake St Dam	27	25-year Flood	900.00	570.00	578.84	574.37	579.36	0.003293	5.78	155.75	18.04	0.35

HEC-RAS Plan: V3_PARTREM_STEPPED   River: Bear River   Reach: Lake St Dam

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	666	Summer Low Flow	80.00	589.98	591.86	591.00	591.92	0.001327	1.86	43.04	40.82	0.32
Lake St Dam	666	Spring Mean Flow	170.00	589.98	592.34	591.51	592.44	0.001982	2.59	65.61	50.97	0.40
Lake St Dam	666	25-year Flood	900.00	589.98	594.57	593.19	594.92	0.001834	4.77	193.97	64.31	0.46
Lake St Dam	659	Summer Low Flow	80.00	589.98	591.88		591.90	0.000571	1.25	64.13	37.59	0.17
Lake St Dam	659	Spring Mean Flow	170.00	589.98	592.36		592.42	0.001194	2.06	82.55	39.50	0.25
Lake St Dam	659	25-year Flood	900.00	589.98	594.49		594.89	0.003354	5.09	179.85	56.58	0.46
Lake St Dam	648	Summer Low Flow	80.00	589.98	591.87		591.90	0.000577	1.25	63.89	37.57	0.17
Lake St Dam	648	Spring Mean Flow	170.00	589.98	592.34		592.41	0.001218	2.07	82.01	39.45	0.25
Lake St Dam	648	25-year Flood	900.00	589.98	594.44		594.86	0.003711	5.19	173.41	47.83	0.48
Lake St Dam	633	Summer Low Flow	80.00	589.98	591.87	590.57	591.89	0.000557	1.25	65.24	45.60	0.17
Lake St Dam	633	Spring Mean Flow	170.00	589.98	592.34	590.95	592.40	0.001053	2.01	87.40	48.13	0.24
Lake St Dam	633	25-year Flood	900.00	589.98	594.49	592.79	594.81	0.002351	4.73	200.27	58.13	0.40
Lake St Dam	630		Inl Struct									
Lake St Dam	594	Summer Low Flow	80.00	589.98	591.18		591.25	0.002683	2.05	38.97	34.80	0.34
Lake St Dam	594	Spring Mean Flow	170.00	589.98	591.64		591.79	0.004038	3.07	55.42	36.63	0.44
Lake St Dam	594	25-year Flood	900.00	589.98	593.45		594.04	0.006155	6.37	148.66	56.96	0.62
Lake St Dam	582	Summer Low Flow	80.00	589.06	591.19		591.22	0.000575	1.37	58.35	46.45	0.22
Lake St Dam	582	Spring Mean Flow	170.00	589.06	591.68		591.75	0.000913	2.09	81.41	48.78	0.28
Lake St Dam	582	25-year Flood	900.00	589.06	593.54		593.94	0.002038	5.13	181.17	59.73	0.48
Lake St Dam	532	Summer Low Flow	80.00	589.37	591.07		591.16	0.003616	2.39	33.47	46.25	0.50
Lake St Dam	532	Spring Mean Flow	170.00	589.37	591.53		591.66	0.003608	2.92	58.25	59.53	0.52
Lake St Dam	532	25-year Flood	900.00	589.37	593.43		593.82	0.002565	5.05	184.74	73.07	0.52
Lake St Dam	515	Summer Low Flow	80.00	589.49	590.99	590.68	591.09	0.004358	2.46	32.51	49.35	0.53
Lake St Dam	515	Spring Mean Flow	170.00	589.49	591.46	591.05	591.59	0.003546	2.94	57.94	57.92	0.52
Lake St Dam	515	25-year Flood	900.00	589.49	593.40	592.43	593.77	0.002517	4.97	187.76	74.31	0.52
Lake St Dam	510		Inl Struct									
Lake St Dam	497	Summer Low Flow	80.00	589.73	590.80	590.80	591.07	0.092784	4.20	19.05	36.10	1.02
Lake St Dam	497	Spring Mean Flow	170.00	589.73	591.16	591.16	591.57	0.080125	5.15	33.02	41.05	1.01
Lake St Dam	497	25-year Flood	900.00	589.73	592.83	592.83	593.71	0.056587	7.57	121.77	71.30	0.97
Lake St Dam	461	Summer Low Flow	80.00	586.90	588.45	587.50	588.49	0.003493	1.56	51.25	36.19	0.23
Lake St Dam	461	Spring Mean Flow	170.00	586.90	589.10	587.87	589.18	0.004754	2.25	75.71	38.80	0.28
Lake St Dam	461	25-year Flood	900.00	586.90	592.38	589.73	592.62	0.005584	3.91	231.47	62.78	0.34
Lake St Dam	437	Summer Low Flow	80.00	586.90	588.40		588.44	0.001277	1.62	49.43	36.00	0.24
Lake St Dam	437	Spring Mean Flow	170.00	586.90	589.03		589.11	0.001738	2.33	72.96	38.53	0.30
Lake St Dam	437	25-year Flood	900.00	586.90	592.29		592.55	0.001757	4.09	222.21	56.75	0.34
Lake St Dam	423	Summer Low Flow	80.00	586.90	588.37		588.42	0.000906	1.81	44.15	30.00	0.26
Lake St Dam	423	Spring Mean Flow	170.00	586.90	588.97		589.09	0.001370	2.73	62.18	30.00	0.33
Lake St Dam	423	25-year Flood	900.00	586.90	592.12		592.51	0.001798	4.99	181.19	46.93	0.43
Lake St Dam	417	Summer Low Flow	80.00	586.90	588.37	587.51	588.42	0.000914	1.82	44.02	30.00	0.26
Lake St Dam	417	Spring Mean Flow	170.00	586.90	588.97	587.90	589.08	0.001384	2.74	61.98	30.00	0.34
Lake St Dam	417	25-year Flood	900.00	586.90	591.99	589.96	592.49	0.002272	5.68	158.99	36.47	0.47
Lake St Dam	416		Inl Struct									
Lake St Dam	407	Summer Low Flow	80.00	585.90	586.50	586.50	586.80	0.005275	4.41	18.14	30.35	1.01
Lake St Dam	407	Spring Mean Flow	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	407	25-year Flood	900.00	585.90	590.02		590.80	0.001317	7.05	127.65	31.80	0.62
Lake St Dam	402	Summer Low Flow	80.00	583.73	586.22	584.92	586.24	0.000398	1.36	58.87	33.31	0.18
Lake St Dam	402	Spring Mean Flow	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	402	25-year Flood	900.00	583.73	590.34		590.65	0.001134	4.52	199.40	35.72	0.33
Lake St Dam	393	Summer Low Flow	80.00	582.54	586.23		586.24	0.000081	0.80	101.31	38.88	0.09
Lake St Dam	393	Spring Mean Flow	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	393	25-year Flood	900.00	582.54	590.42		590.61	0.000468	3.45	266.05	39.67	0.23
Lake St Dam	383	Summer Low Flow	80.00	583.34	586.23	584.22	586.24	0.000508	0.80	99.99	42.57	0.09
Lake St Dam	383	Spring Mean Flow	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	383	25-year Flood	900.00	583.34	590.43	586.27	590.59	0.002107	3.23	281.08	43.69	0.22
Lake St Dam	320		Bridge									
Lake St Dam	316	Summer Low Flow	80.00	584.19	586.10		586.14	0.004544	1.77	45.21	31.03	0.26
Lake St Dam	316	Spring Mean Flow	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	316	25-year Flood	900.00	584.19	589.80		590.25	0.008017	5.45	171.15	36.92	0.42
Lake St Dam	295	Summer Low Flow	80.00	584.37	585.47	585.47	585.81	0.087250	4.70	17.02	25.54	1.01

HEC-RAS Plan: V3_PARTREM_STEPPED River: Bear River Reach: Lake St Dam (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	295	Spring Mean Flow	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	295	25-year Flood	900.00	584.37	588.29	588.12	589.66	0.039885	9.56	98.23	31.83	0.90
Lake St Dam	266	Summer Low Flow	80.00	582.85	584.38	583.93	584.52	0.017159	2.99	27.11	24.23	0.49
Lake St Dam	266	Spring Mean Flow	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	266	25-year Flood	900.00	582.85	587.83	586.77	588.75	0.019330	7.91	120.63	29.55	0.65
Lake St Dam	227	Summer Low Flow	80.00	581.72	582.82	582.82	583.20	0.084723	4.97	16.11	21.42	1.01
Lake St Dam	227	Spring Mean Flow	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	227	25-year Flood	900.00	581.72	585.82	585.82	587.55	0.046169	10.70	87.72	26.24	0.97
Lake St Dam	189	Summer Low Flow	80.00	579.21	581.10	580.33	581.20	0.008873	2.54	31.57	20.74	0.36
Lake St Dam	189	Spring Mean Flow	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	189	25-year Flood	900.00	579.21	585.85		586.55	0.009589	6.76	138.92	24.52	0.48
Lake St Dam	142	Summer Low Flow	80.00	578.06	580.42	579.86	580.60	0.019342	3.36	23.81	17.57	0.51
Lake St Dam	142	Spring Mean Flow	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55
Lake St Dam	142	25-year Flood	900.00	578.06	584.64	583.35	585.86	0.020674	8.90	102.57	19.18	0.67
Lake St Dam	115		Bridge									
Lake St Dam	112	Summer Low Flow	80.00	576.46	578.83		578.91	0.005495	2.27	35.31	17.35	0.28
Lake St Dam	112	Spring Mean Flow	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	112	25-year Flood	900.00	576.46	581.17	581.17	583.35	0.054065	11.84	76.48	17.77	1.00
Lake St Dam	74	Summer Low Flow	80.00	575.00	578.83		578.85	0.000278	1.20	66.82	17.69	0.11
Lake St Dam	74	Spring Mean Flow	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	74	25-year Flood	900.00	575.00	578.92	579.37	581.61	0.032797	13.15	68.46	17.70	1.18
Lake St Dam	27	Summer Low Flow	80.00	570.00	578.84	570.87	578.84	0.000026	0.51	155.75	18.04	0.03
Lake St Dam	27	Spring Mean Flow	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07
Lake St Dam	27	25-year Flood	900.00	570.00	578.84	574.37	579.36	0.003293	5.78	155.75	18.04	0.35

HEC-RAS Plan: v3_seasonal_stepped River: Bear River Reach: Lake St Dam

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	666	Summer Low Flow	80.00	589.98	591.86	591.00	591.92	0.001327	1.86	43.04	40.82	0.32
Lake St Dam	666	Spring Mean Flow	170.00	589.98	592.34	591.51	592.44	0.001982	2.59	65.61	50.97	0.40
Lake St Dam	666	25-year Flood	900.00	589.98	594.57	593.19	594.92	0.001834	4.77	193.97	64.31	0.46
Lake St Dam	659	Summer Low Flow	80.00	589.98	591.88		591.90	0.000571	1.25	64.13	37.59	0.17
Lake St Dam	659	Spring Mean Flow	170.00	589.98	592.36		592.42	0.001194	2.06	82.55	39.50	0.25
Lake St Dam	659	25-year Flood	900.00	589.98	594.49		594.89	0.003354	5.09	179.85	56.58	0.46
Lake St Dam	648	Summer Low Flow	80.00	589.98	591.87		591.90	0.000577	1.25	63.89	37.56	0.17
Lake St Dam	648	Spring Mean Flow	170.00	589.98	592.34		592.41	0.001218	2.07	82.01	39.45	0.25
Lake St Dam	648	25-year Flood	900.00	589.98	594.44		594.86	0.003711	5.19	173.41	47.83	0.48
Lake St Dam	633	Summer Low Flow	80.00	589.98	591.87	590.57	591.89	0.000557	1.25	65.24	45.60	0.17
Lake St Dam	633	Spring Mean Flow	170.00	589.98	592.34	590.95	592.40	0.001053	2.01	87.39	48.13	0.24
Lake St Dam	633	25-year Flood	900.00	589.98	594.49	592.79	594.81	0.002350	4.73	200.27	58.13	0.40
Lake St Dam	630		Inl Struct									
Lake St Dam	594	Summer Low Flow	80.00	589.98	591.18		591.25	0.002679	2.05	38.99	34.80	0.34
Lake St Dam	594	Spring Mean Flow	170.00	589.98	591.64		591.79	0.004033	3.07	55.45	36.64	0.44
Lake St Dam	594	25-year Flood	900.00	589.98	593.45		594.04	0.006149	6.37	148.70	56.97	0.62
Lake St Dam	582	Summer Low Flow	80.00	589.06	591.19		591.22	0.000574	1.37	58.38	46.45	0.22
Lake St Dam	582	Spring Mean Flow	170.00	589.06	591.68		591.75	0.000912	2.09	81.44	48.79	0.28
Lake St Dam	582	25-year Flood	900.00	589.06	593.54		593.94	0.002037	5.13	181.20	59.74	0.48
Lake St Dam	532	Summer Low Flow	80.00	589.37	591.07		591.16	0.003607	2.39	33.50	46.28	0.49
Lake St Dam	532	Spring Mean Flow	170.00	589.37	591.53		591.66	0.003596	2.92	58.31	59.54	0.52
Lake St Dam	532	25-year Flood	900.00	589.37	593.43		593.82	0.002563	5.04	184.79	73.08	0.52
Lake St Dam	515	Summer Low Flow	80.00	589.49	590.99	590.68	591.09	0.004358	2.46	32.51	49.35	0.53
Lake St Dam	515	Spring Mean Flow	170.00	589.49	591.46	591.05	591.59	0.003546	2.94	57.94	57.92	0.52
Lake St Dam	515	25-year Flood	900.00	589.49	593.40	592.43	593.77	0.002517	4.97	187.76	74.31	0.52
Lake St Dam	510		Inl Struct									
Lake St Dam	497	Summer Low Flow	80.00	589.73	590.80	590.80	591.07	0.092784	4.20	19.05	36.10	1.02
Lake St Dam	497	Spring Mean Flow	170.00	589.73	591.16	591.16	591.57	0.080125	5.15	33.02	41.05	1.01
Lake St Dam	497	25-year Flood	900.00	589.73	592.83	592.83	593.71	0.056587	7.57	121.77	71.30	0.97
Lake St Dam	461	Summer Low Flow	80.00	586.90	588.09	587.50	588.16	0.008493	2.07	38.57	34.76	0.35
Lake St Dam	461	Spring Mean Flow	170.00	586.90	588.70	587.87	588.82	0.009489	2.81	60.40	37.19	0.39
Lake St Dam	461	25-year Flood	900.00	586.90	591.88	589.73	592.19	0.008691	4.47	201.47	57.79	0.42
Lake St Dam	437	Summer Low Flow	80.00	586.90	587.91		588.00	0.004865	2.48	32.28	34.04	0.45
Lake St Dam	437	Spring Mean Flow	170.00	586.90	588.51		588.67	0.004529	3.18	53.42	36.44	0.46
Lake St Dam	437	25-year Flood	900.00	586.90	591.74		592.08	0.002714	4.68	192.81	51.67	0.42
Lake St Dam	423	Summer Low Flow	80.00	586.90	587.80		587.93	0.004525	2.98	26.86	30.00	0.55
Lake St Dam	423	Spring Mean Flow	170.00	586.90	588.36		588.60	0.004162	3.87	43.91	30.00	0.56
Lake St Dam	423	25-year Flood	900.00	586.90	591.48		592.02	0.003146	5.90	152.47	43.26	0.55
Lake St Dam	417	Summer Low Flow	80.00	586.90	587.77	587.51	587.92	0.005001	3.07	26.05	30.00	0.58
Lake St Dam	417	Spring Mean Flow	170.00	586.90	588.34	587.90	588.58	0.004394	3.94	43.18	30.00	0.58
Lake St Dam	417	25-year Flood	900.00	586.90	591.30	589.96	591.99	0.003667	6.68	134.74	33.12	0.58
Lake St Dam	416		Inl Struct									
Lake St Dam	407	Summer Low Flow	80.00	585.90	586.50	586.50	586.80	0.005275	4.41	18.14	30.35	1.01
Lake St Dam	407	Spring Mean Flow	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	407	25-year Flood	900.00	585.90	590.02		590.80	0.001317	7.05	127.65	31.80	0.62
Lake St Dam	402	Summer Low Flow	80.00	583.73	586.22	584.92	586.24	0.000398	1.36	58.87	33.31	0.18
Lake St Dam	402	Spring Mean Flow	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	402	25-year Flood	900.00	583.73	590.34		590.65	0.001134	4.52	199.40	35.72	0.33
Lake St Dam	393	Summer Low Flow	80.00	582.54	586.23		586.24	0.000081	0.80	101.31	38.88	0.09
Lake St Dam	393	Spring Mean Flow	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	393	25-year Flood	900.00	582.54	590.42		590.61	0.000468	3.45	266.05	39.67	0.23
Lake St Dam	383	Summer Low Flow	80.00	583.34	586.23	584.22	586.24	0.000508	0.80	99.99	42.57	0.09
Lake St Dam	383	Spring Mean Flow	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	383	25-year Flood	900.00	583.34	590.43	586.27	590.59	0.002107	3.23	281.08	43.69	0.22
Lake St Dam	320		Bridge									
Lake St Dam	316	Summer Low Flow	80.00	584.19	586.10		586.14	0.004544	1.77	45.21	31.03	0.26
Lake St Dam	316	Spring Mean Flow	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	316	25-year Flood	900.00	584.19	589.80		590.25	0.008017	5.45	171.15	36.92	0.42
Lake St Dam	295	Summer Low Flow	80.00	584.37	585.47	585.47	585.81	0.087250	4.70	17.02	25.54	1.01

HEC-RAS Plan: v3_seasonal_stepped River: Bear River Reach: Lake St Dam (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Lake St Dam	295	Spring Mean Flow	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	295	25-year Flood	900.00	584.37	588.29	588.12	589.66	0.039885	9.56	98.23	31.83	0.90
Lake St Dam	266	Summer Low Flow	80.00	582.85	584.38	583.93	584.52	0.017159	2.99	27.11	24.23	0.49
Lake St Dam	266	Spring Mean Flow	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	266	25-year Flood	900.00	582.85	587.83	586.77	588.75	0.019330	7.91	120.63	29.55	0.65
Lake St Dam	227	Summer Low Flow	80.00	581.72	582.82	582.82	583.20	0.084723	4.97	16.11	21.42	1.01
Lake St Dam	227	Spring Mean Flow	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	227	25-year Flood	900.00	581.72	585.82	585.82	587.55	0.046169	10.70	87.72	26.24	0.97
Lake St Dam	189	Summer Low Flow	80.00	579.21	581.10	580.33	581.20	0.008873	2.54	31.57	20.74	0.36
Lake St Dam	189	Spring Mean Flow	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	189	25-year Flood	900.00	579.21	585.85		586.55	0.009589	6.76	138.92	24.52	0.48
Lake St Dam	142	Summer Low Flow	80.00	578.06	580.42	579.86	580.60	0.019342	3.36	23.81	17.57	0.51
Lake St Dam	142	Spring Mean Flow	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55
Lake St Dam	142	25-year Flood	900.00	578.06	584.64	583.35	585.86	0.020674	8.90	102.57	19.18	0.67
Lake St Dam	115		Bridge									
Lake St Dam	112	Summer Low Flow	80.00	576.46	578.83		578.91	0.005495	2.27	35.31	17.35	0.28
Lake St Dam	112	Spring Mean Flow	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	112	25-year Flood	900.00	576.46	581.17	581.17	583.35	0.054065	11.84	76.48	17.77	1.00
Lake St Dam	74	Summer Low Flow	80.00	575.00	578.83		578.85	0.000278	1.20	66.82	17.69	0.11
Lake St Dam	74	Spring Mean Flow	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	74	25-year Flood	900.00	575.00	578.92	579.37	581.61	0.032797	13.15	68.46	17.70	1.18
Lake St Dam	27	Summer Low Flow	80.00	570.00	578.84	570.87	578.84	0.000026	0.51	155.75	18.04	0.03
Lake St Dam	27	Spring Mean Flow	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07
Lake St Dam	27	25-year Flood	900.00	570.00	578.84	574.37	579.36	0.003293	5.78	155.75	18.04	0.35

HEC-RAS River: Bear River Reach: Lake St Dam Profile: Spring Mean Flow

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)	
Lake St Dam	666	Spring Mean Flow	v3_EXISTING	170.00	589.98	592.33	591.51	592.43	0.002049	2.62	64.92	50.89	0.41
Lake St Dam	666	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.98	592.34	591.51	592.44	0.001982	2.59	65.61	50.97	0.40
Lake St Dam	666	Spring Mean Flow	v3_seasonal_stepped	170.00	589.98	592.34	591.51	592.44	0.001982	2.59	65.61	50.97	0.40
Lake St Dam	659	Spring Mean Flow	v3_EXISTING	170.00	589.62	592.29		592.42	0.001558	2.89	59.04	32.78	0.37
Lake St Dam	659	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.98	592.36		592.42	0.001194	2.06	82.55	39.50	0.25
Lake St Dam	659	Spring Mean Flow	v3_seasonal_stepped	170.00	589.98	592.36		592.42	0.001194	2.06	82.55	39.50	0.25
Lake St Dam	648	Spring Mean Flow	v3_EXISTING	170.00	588.96	592.27	591.10	592.40	0.001329	2.90	58.98	28.74	0.35
Lake St Dam	648	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.98	592.34		592.41	0.001218	2.07	82.01	39.45	0.25
Lake St Dam	648	Spring Mean Flow	v3_seasonal_stepped	170.00	589.98	592.34		592.41	0.001218	2.07	82.01	39.45	0.25
Lake St Dam	633	Spring Mean Flow	v3_EXISTING	170.00	587.05	592.33	589.54	592.37	0.000203	1.57	109.08	48.10	0.15
Lake St Dam	633	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.98	592.34	590.95	592.40	0.001053	2.01	87.40	48.13	0.24
Lake St Dam	633	Spring Mean Flow	v3_seasonal_stepped	170.00	589.98	592.34	590.95	592.40	0.001053	2.01	87.39	48.13	0.24
Lake St Dam	594	Spring Mean Flow	v3_EXISTING	170.00	588.45	592.33	590.05	592.36	0.000191	1.31	130.53	50.97	0.14
Lake St Dam	594	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.98	591.64		591.79	0.004038	3.07	55.42	36.63	0.44
Lake St Dam	594	Spring Mean Flow	v3_seasonal_stepped	170.00	589.98	591.64		591.79	0.004033	3.07	55.45	36.64	0.44
Lake St Dam	582	Spring Mean Flow	v3_EXISTING	170.00	589.06	592.32		592.36	0.000308	1.51	113.64	51.58	0.17
Lake St Dam	582	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.06	591.68		591.75	0.000913	2.09	81.41	48.78	0.28
Lake St Dam	582	Spring Mean Flow	v3_seasonal_stepped	170.00	589.06	591.68		591.75	0.000912	2.09	81.44	48.79	0.28
Lake St Dam	532	Spring Mean Flow	v3_EXISTING	170.00	589.37	592.29		592.34	0.000515	1.62	106.36	64.96	0.22
Lake St Dam	532	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.37	591.53		591.66	0.003608	2.92	58.25	59.53	0.52
Lake St Dam	532	Spring Mean Flow	v3_seasonal_stepped	170.00	589.37	591.53		591.66	0.003596	2.92	58.31	59.54	0.52
Lake St Dam	515	Spring Mean Flow	v3_EXISTING	170.00	589.49	592.29		592.33	0.000481	1.57	109.72	66.11	0.21
Lake St Dam	515	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.49	591.46	591.05	591.59	0.003546	2.94	57.94	57.92	0.52
Lake St Dam	515	Spring Mean Flow	v3_seasonal_stepped	170.00	589.49	591.46	591.05	591.59	0.003546	2.94	57.94	57.92	0.52
Lake St Dam	497	Spring Mean Flow	v3_EXISTING	170.00	589.73	592.25		592.31	0.000948	2.06	83.19	54.92	0.29
Lake St Dam	497	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	589.73	591.16	591.16	591.57	0.080125	5.15	33.02	41.05	1.01
Lake St Dam	497	Spring Mean Flow	v3_seasonal_stepped	170.00	589.73	591.16	591.16	591.57	0.080125	5.15	33.02	41.05	1.01
Lake St Dam	461	Spring Mean Flow	v3_EXISTING	170.00	589.03	592.25		592.28	0.000366	1.49	115.21	61.43	0.19
Lake St Dam	461	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	586.90	589.10	587.87	589.18	0.004754	2.25	75.71	38.80	0.28
Lake St Dam	461	Spring Mean Flow	v3_seasonal_stepped	170.00	586.90	588.70	587.87	588.82	0.009489	2.81	60.40	37.19	0.39
Lake St Dam	437	Spring Mean Flow	v3_EXISTING	170.00	588.91	592.24		592.27	0.000231	1.36	126.33	56.29	0.15
Lake St Dam	437	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	586.90	589.03		589.11	0.001738	2.33	72.96	38.53	0.30
Lake St Dam	437	Spring Mean Flow	v3_seasonal_stepped	170.00	586.90	588.51		588.67	0.004529	3.18	53.42	36.44	0.46
Lake St Dam	423	Spring Mean Flow	v3_EXISTING	170.00	589.10	592.23		592.27	0.000333	1.61	106.44	48.31	0.18
Lake St Dam	423	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	586.90	588.97		589.09	0.001370	2.73	62.18	30.00	0.33
Lake St Dam	423	Spring Mean Flow	v3_seasonal_stepped	170.00	586.90	588.36		588.60	0.004162	3.87	43.91	30.00	0.56
Lake St Dam	417	Spring Mean Flow	v3_EXISTING	170.00	589.54	592.19	590.86	592.26	0.000770	2.23	76.92	36.86	0.27
Lake St Dam	417	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	586.90	588.97	587.90	589.08	0.001384	2.74	61.98	30.00	0.34
Lake St Dam	417	Spring Mean Flow	v3_seasonal_stepped	170.00	586.90	588.34	587.90	588.58	0.004394	3.94	43.18	30.00	0.58
Lake St Dam	416			Inl Struct									
Lake St Dam	407	Spring Mean Flow	v3_EXISTING	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	407	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	407	Spring Mean Flow	v3_seasonal_stepped	170.00	585.90	586.89	586.89	587.39	0.004592	5.66	30.02	30.51	1.01
Lake St Dam	402	Spring Mean Flow	v3_EXISTING	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	402	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	402	Spring Mean Flow	v3_seasonal_stepped	170.00	583.73	586.98	585.36	587.05	0.000568	2.01	84.59	33.71	0.22
Lake St Dam	393	Spring Mean Flow	v3_EXISTING	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	393	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	393	Spring Mean Flow	v3_seasonal_stepped	170.00	582.54	587.01		587.03	0.000158	1.31	131.60	39.03	0.13
Lake St Dam	383	Spring Mean Flow	v3_EXISTING	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	383	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	383	Spring Mean Flow	v3_seasonal_stepped	170.00	583.34	587.00	584.62	587.03	0.000887	1.28	133.14	42.76	0.13
Lake St Dam	320			Bridge									
Lake St Dam	316	Spring Mean Flow	v3_EXISTING	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	316	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	316	Spring Mean Flow	v3_seasonal_stepped	170.00	584.19	586.78		586.88	0.005698	2.56	66.77	32.09	0.31
Lake St Dam	295	Spring Mean Flow	v3_EXISTING	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	295	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	295	Spring Mean Flow	v3_seasonal_stepped	170.00	584.37	585.91	585.91	586.46	0.071051	5.94	28.71	26.66	1.00
Lake St Dam	266	Spring Mean Flow	v3_EXISTING	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	266	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	266	Spring Mean Flow	v3_seasonal_stepped	170.00	582.85	584.99	584.41	585.25	0.018573	4.12	42.27	25.27	0.54
Lake St Dam	227	Spring Mean Flow	v3_EXISTING	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	227	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	227	Spring Mean Flow	v3_seasonal_stepped	170.00	581.72	583.32	583.32	583.94	0.070537	6.34	26.93	22.23	1.00
Lake St Dam	189	Spring Mean Flow	v3_EXISTING	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	189	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	189	Spring Mean Flow	v3_seasonal_stepped	170.00	579.21	581.94	580.84	582.13	0.009322	3.47	49.21	21.39	0.40
Lake St Dam	142	Spring Mean Flow	v3_EXISTING	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55

HEC-RAS River: Bear River Reach: Lake St Dam Profile: Spring Mean Flow (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)	
Lake St Dam	142	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55
Lake St Dam	142	Spring Mean Flow	v3_seasonal_stepped	170.00	578.06	581.18	580.49	581.50	0.019619	4.53	37.60	18.38	0.55
Lake St Dam	115			Bridge									
Lake St Dam	112	Spring Mean Flow	v3_EXISTING	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	112	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	112	Spring Mean Flow	v3_seasonal_stepped	170.00	576.46	578.79		579.17	0.026426	4.91	34.64	17.34	0.61
Lake St Dam	74	Spring Mean Flow	v3_EXISTING	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	74	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	74	Spring Mean Flow	v3_seasonal_stepped	170.00	575.00	578.79		578.90	0.001292	2.57	66.19	17.69	0.23
Lake St Dam	27	Spring Mean Flow	v3_EXISTING	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07
Lake St Dam	27	Spring Mean Flow	V3_PARTREM_STEPPED	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07
Lake St Dam	27	Spring Mean Flow	v3_seasonal_stepped	170.00	570.00	578.84	571.44	578.86	0.000117	1.09	155.75	18.04	0.07

Appendix B: Conceptual Cost Estimate Details

Estimate details for the engineering alternatives for the Lake Street Dam are shown in the table below.

Lake Street Dam Alternatives - Conceptual Cost Estimate

Item	Description	Maintenance Repairs Only	Alternative #1 Fixed-crest Weir	Alternative #2 Adjustable-crest Weir	Alternative #3 Complete Removal
1	Construction Subtotal	$ 45,000.00	$ 575,000.00	$ 900,000.00	$ 600,000.00
1.1	Lake Street Wingwall Repairs	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00
1.2	Lake Street Dam Modifications		$ 55,000.00	$ 55,000.00	$ 55,000.00
1.21	Partial or Complete Removal of Existing Structure		$ 105,000.00	$ 145,000.00	$ 145,000.00
1.22	Pnuematic or Inflatable Adjustable Crest - Seasonal Barrier			$ 300,000.00	
1.23	Partial or No Removal with Trap and Sort Fishway		$ 40,000.00		
1.3	Grade Control Structure 1 RipRap/stone Vane		$ 30,000.00	$ 30,000.00	$ 30,000.00
1.3.1	GCS #1 Sheet Piling		$ 65,000.00	$ 65,000.00	$ 65,000.00
1.4	Grade Control Structure 2 RipRap/stone Vane		$ 45,000.00	$ 45,000.00	$ 45,000.00
1.4.1	GCS #2 Sheet Piling		$ 90,000.00	$ 90,000.00	$ 90,000.00
1.5	Channel Modifications - Dredging and Grading		$ 100,000.00	$ 125,000.00	$ 125,000.00
3	Construction Mobilization = 10% of Construction Subtotal	$ 4,500.00	$ 57,500.00	$ 90,000.00	$ 60,000.00
4	Design, geotech, permitting, surveying, CE, etc. = 35% of Construction Subtotal	$ 15,750.00	$ 201,250.00	$ 315,000.00	$ 210,000.00
5	Contingency = 25% of Design & Construction	$ 16,312.50	$ 208,437.50	$ 326,250.00	$ 217,500.00
TOTAL	TOTAL ESTIMATED PROJECT COST	$ 90,000.00	$ 1,050,000.00	$ 1,640,000.00	$ 1,090,000.00

Appendix C: Technical Meeting Minutes and Correspondence

1. Fish Passage
   with Trout Unlimited and Michigan Department of Natural Resources
   &
   Sea Lamprey Barriers
   with US Fish and Wildlife Service...33-37
2. US31 Scour Countermeasures
   with Michigan Department of Transportation Hydraulics Unit...................................38-41
3. Balancing Fish Habitat with Sea Lamprey Control
   With Dr. Bryan Burroughs (Michigan Trout Unlimited)..42-46

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meeting minutes

About the meeting:

Subject:	Bear River Lake St. Dam – Engineering Alternatives Work Session		
Date:	March 11, 2020	**Time:**	1:00pm to 2:00pm
Location:	Zoom Meeting		
Call in:	Bryan Burroughs – Michigan Trout Unlimited, byranburroughs@michigantu.org Heather Hettinger – DNR, HettingerH@michigan.gov Kevin Mann – USFWS, kevin_mann@fws.gov Matthew Symbal – USFWS, Matthew_Symbal@fws.gov Jennifer Buchanan – TOTMWC, jen@watershedcouncil.org Lucas Porath – OHM Advisors, Lucas.Porath@ohm-advisors.com Lucas Fitzpatrick – OHM Advisors, Lucas.Fitzaptrick@ohm-advisors.com		

Desired outcomes/objectives:
Clarify design parameters to achieve desired fish passage and prevent lamprey migration

Please prepare ahead of time:

☒ **Read:** Please review the draft PowerPoint
☒ **Bring:** This agenda
☐ **Other:**

Meeting leader or facilitator:

Name: Lucas Fitzpatrick, Engineer, OHM Advisors

Time slot:	Topic:	Notes:
	✓ Ice breaker **Agenda items:**	
1:05-1:15	✓ Recap of alternatives ✓ Findings to date	Intro and overview by Jen Buchanan Project recapped, findings to date indicate that downstream velocities may be limiting
1:15-1:30	✓ Design parameter discussion 1. What is the max ft/s that we can allow to achieve desired fish passage?	1. Initial discussion with Byran Burroughs identified a general guideline of 3-4 feet per second (fps). Our existing spring flows downstream of the dam are around 6 fps. Heather noted that during the

	kayak park project they metered flows around 6 to 8 fps in the reaches upstream of the dam. The group decided that we should aim for 3 to 4 fps regardless of the upstream and downstream conditions because it would still be advantageous for promoting fish passage and habitat.
2. What is the minimum water depth that we can allow to achieve desired fish passage?	2. Bryan recommended a minimum water depth of 1 foot. Heather concurred with 12 to 14 inches as a typical design minimum. This is also a good guideline for paddling sports as well.
3. What seasonal flow(s) are most critical to achieve desired fish passage?	3. Spring mean flows (March to May) are most critical. Fall mean flows (Sep to Nov) are secondary. Little migration occurs during remainder of the year.
4. Are there preferred habitat features?	4. Bryan recommended a series of rest pools created by installing cross vanes. The cross vanes are designed for central focusing of the flow which creates the pools. Other benefits include paddle sports passage and summer low flow fish passage. Riffles were also discussed as a potential habitat feature that may be created incidentally to channel armoring with riprap. The primary preference would be to utilize cross vanes but a

		combination of cross vane and riffle features may be acceptable.
	5. Are there preferred grade controls?	5. See above comments. It is preferable to select grade controls that provide benefits throughout all seasons (cross vanes promote low flow passage).
	6. Has anyone had experience good or bad with rock weir cross vanes, j-hooks, or other control structures?	6. See above comments. The group is in favor of using cross vanes as the primary grade control structure.
	7. Is there any concern with using heavy rip rap to armor the channel?	7. There is no concern with using heavy rip rap to armor the channel so long as the desired minimum depths are achieved. The use may create a riffle effect which may provide beneficial habitat variation.
	8. What is the USFWS preferred lamprey barrier?	8. The FWS prefers non-seasonal fixed head barriers, citing the overlapping spring migration period as a concern. Seasonal alternatives may be discussed further but must not pose an unacceptable risk of upstream lamprey infestation. FWS has barrier protocols that may be shared with the team for reference. The hydraulics for 10yr, 15yr, and 25yr flows with the proposed design were requested for preliminary review and comments by FWS. The FWS developed an opinion on management approaches for the dam in 2011 in response to an

		inquiry by MDNR. FWS to provide this opinion to the project team for reference on this project.
	9. GLFC recommends a 2 to 4 foot drop with a lip, is that top of weir to toe of weir? Or water crest drop?	9. The FWS recommended standard is an 18 inch minimum drop from water crest to tailwater surface, NOT physical weir height from top of weir to toe of weir. The water drop height is dependent on flow and thus multiple flows should be considered in design to ensure adequate defense against lamprey migration throughout the Bear River's spectrum of flows.
	10. DP Zeilinski et al. *Alternative Sea Lamprey Barrier Technologies* states lamprey barrier have vertical differential of 45cm with 15cm overhanging lip, is this top to toe or water crest?	10. See above comments. A lip is preferred. 45 centimeters is approximately 18 inches.
	11. US31 (MDOT) Bridge – Scour Critical, countermeasures will be needed for dam removal.	11. Heavy rip rap will likely be required to armor the US31 bridge abutments and piers, and the modified channel to reduce velocities and protect banks. This was related to the minimum depth and riprap discussion above. OHM is contacting MDOT to discuss countermeasure requirements.

✓ Funding Strategies for future project discussed	Two primary sources: 1. National Fish and Wildlife's Sustain Our Great Lakes program. (pre-proposals typically due in February) 2. MDNR Fisheries Habitat Grant Program (pre-proposals due in July)
✓	Jen has experience with both grant programs.
✓	Heather is a reviewer for the MDNR Grant.
✓	Project deliverables are intended to be usable for future grant applications so further discussion on grant application requirements would be beneficial for final product development.
	Bryan has experience with other funding sources and would be available to discuss those if desired.
Action items:	
✓	USFWS to provide typical lamprey barrier protocols, the 2011 FWS opinion letter regarding the Lake Street Dam, and example success stories for reference. (by the March 25th meeting, sooner if possible to be incorporated into the presentation)
✓	OHM to provide preliminary hydraulics to FWS for review and comment. (sent 3/12/2020)
✓	
✓	

Additional notes and next meeting:

Next meeting will be March 25th at 10:00am at the Petoskey City Hall in the Council Chambers

cc:

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meeting minutes

About the meeting:

Subject:	Bear River Lake St. Dam – US31 Bridge Discussion		
Date:	April 7, 2020	**Time:**	10:00 am to 11:00 am
Location:	Teams Meeting		
Attendance:	Andrew Zwolinski – MDOT, ZwolinskiA@michigan.gov Brandon Boatman – MDOT, BoatmanB@michigan.gov Chad Strocki – MDOT, StrockiC@michigan.gov Erik Carlson – MDOT, CarlsonE2@michigan.gov Lucas Fitzpatrick – OHM Advisors, Lucas.Fitzaptrick@ohm-advisors.com		

Desired outcomes/objectives:
Identify probable project impacts on the US31 bridge and MDOT requirements and protocols

Meeting leader or facilitator:

Name: Lucas Fitzpatrick, Engineer, OHM Advisors

Time slot:	Topic:	Notes:
	Agenda items:	
10:00-10:05	✓ Project Overview in relation to US31 bridge	Intro and overview by Luke Fitzpatrick. US31 Bridge listed as scour critical, probable changes to hydraulic profile at the bridge resulting from any modification or removal of the Lake Street Dam.
10:05-10:45	✓ Design parameters discussion 1. General site plan, potential grade control methods and locations	1. MDOT expressed concern about long term sediment transport through porous barriers resulting in bed loss at the bridge. MDOT has experience this at other locations where cross vane type rock weirs were placed downstream of MDOT structures. The gaps between stones allows sediment to pass through the barrier. MDOT would like to see the uppermost barrier downstream of

		the bridge backed by sheet piling to create a hard wall barrier to prevent long term sediment loss at the bridge. **ACTION ITEM: OHM to discuss with the project team adding sheet pile backing to the uppermost grade control.**
	2. Potential location of grade control near the bridge – ROW conflicts.	2. One of the proposed grade control locations may be near or within the ROW. MDOT's ROW at this location is unclear. If any structure must be placed within the MDOT ROW a maintenance agreement with the Gaylord TSC will be required. MDOT prefers that no structures are constructed within the ROW. **ACTION ITEM: MDOT to provide clarification on ROW at the US31 Bridge over the Bear River.**
	3. Scour Countermeasures at the US31 Bridge	3. Responsibility for countermeasures typically falls on MDOT, but currently no MDOT work planned for this location. There is potential that cost-sharing with the City would be pursued if additional countermeasures will be required due to modification/removal of the dam. MDOT will develop scour countermeasure recommendations based on the final modification/removal design.

	ACTION ITEM: MDOT to look into precedent for countermeasure responsibility/cost-sharing.
4. US31 Bridge is on the historical register – will the City need to coordinate with SHPO for countermeasures?	4. No, if additional countermeasures will be required, to be determined by MDOT, then MDOT will coordinate with SHPO internally.
5. Permit requirements?	5. A permit would be required for any work within the ROW. City/Consultant will need to coordinate with Gaylord TSC for permitting if it is determined that any work will take place within the ROW.
6. Communication	6. Keep this group informed of project developments. **ACTION ITEM: MDOT to continue discussion internally and coordinate with Gaylord TSC to bring in a local contact for future developments.** **ACTION ITEM: City/Consultant to keep MDOT informed of project developments, especially during preliminary and final design.**
Action items:	MDOT – 1. Confirm ROW at the US31 Bridge

		2. Investigate precedent for countermeasure responsibility/ cost-sharing 3. Establish contact with local TSC OHM – 1. Discuss with the project team sheet pile backing of cross vane structure to limit sediment transport through the structure. 2. Keep MDOT in the informed of project developments

Additional notes and next meeting:

Next project stakeholder meeting TBD due to coronavirus.

cc:

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meeting minutes

About the meeting:

Subject: Bear River Lake St. Dam – Trout Unlimited (Bryan Burroughs) Advisory Meeting

Date: May 21, 2020 **Time:** 9:30 am to 10:45 am

Location: Zoom Meeting

Attendance:

- OHM Advisors
  - Amanda Porath
  - Luke Fitzpatrick
- Tip of the Mitt Watershed Council
  - Jen Buchanan
- Michigan Trout Unlimited
  - Bryan Burroughs

Recording: N/A

Desired outcomes/objectives:
Follow up from the 5-6-2020 stakeholder meeting.

Meeting leader or facilitator:

Name: Jen Buchanan, Tip of the Mitt Watershed Council

Topic:	Notes:
Agenda items:	
✓ Intro	✓ Updates from Jen B. ○ Open house 6/22 or 6/23 ○ **[Date/time finalized after meeting, 5:30pm on 6/23]**
✓ Sea Lamprey and Fish Passage Follow-up	✓ Bryan Burroughs: ○ Management over the last few decades has generally prioritized sea lamprey control over promoting fish passage. Without a physical barrier, rivers get put into the USFWS chemical treatment rotation. The FWS promotes physical barriers to reduce its chemical treatment costs.

	○ About 3 dozen native Great Lakes fish species are typically blocked by physical sea lamprey barriers. The loss of habitat for these species is a hidden cost. ○ The balance between lamprey control vs fish habitat becomes an optimization problem. Ideally, management will provide biologically significant fish habitat without providing ecologically significant sea lamprey habitat. ▪ A fish ladder with manual trap/sort/pass management may be the best option for passing fish over a physical lamprey barrier. This can be a complicated design process because of differences in passage ability between a variety of desired fish species. Bryan would be interested in assisting with design of this structure if selected. ○ Due to USFWS sea lamprey control public outreach, and the leach-like parasitic characteristics of sea lamprey, public opinions generally side absolutely with lamprey control. There is a general lack of public understanding that physical sea lamprey barriers often come at the cost of fish habitat, and that a balanced management approach may be more beneficial than 100% one way or the other. ○ In the Bear River, this balance translates to moving a physical barrier to an upstream location, ideally somewhere in the high gradient reach of the River downstream of any significant tributaries. ▪ Sea lamprey may spawn in the high-gradient rocky/cobble areas but the juveniles occupy lower gradient sedimentary conditions for the first 7 years of their life cycle. ▪ By placing a physical barrier somewhere in the high gradient, fish habitat in the Bear River is improved, and sea lamprey may be able to spawn but would likely be carried downstream and spend their juvenile cycle in the Little Traverse Bay. By preventing the infestation of the

	tributaries and slower upper reaches of the River, treatment costs are reduced (versus a no barrier solution) while fish habitat is improved. The overall federal cost may be a wash once the cost of stocking the Bear River is considered. o Regarding an adjustable crest weir, most fish migrate in the spring at the same time as the lamprey. This would lead to the lamprey barrier likely being in a raised position for most of the fish migration period and thus not achieving the desired fish passage. For this reason, an adjustable crest weir is unlikely to achieve a significant increase in passage versus a fixed crest weir. o Luke: Should we include an alternative to wait on FishPass (Boardman River, Traverse City) to gather more research and re-evaluate lamprey control and fish passage methods at a future date with the latest research. ▪ Bryan: Research is not expected to produce conclusions until 2026/2027. A definitive solution is unlikely to be identified. We already know that manual trap/sort/pass works well.
✓ General Design Follow-up	✓ Bryan Burroughs: o We should consider additional grade controls downstream of the Lake Street Dam. The limited distance between the current upper and lower proposed work bounds will make grade control difficult if removing the dam. ▪ High gradient rivers in Michigan are typically only around a 0.4% slope and we would likely be exceeding that slope in places. By extending the work limits downstream, we can include more steps at a lower drop for each. May have cost savings on sediment removal o Luke: We can look at additional grade controls downstream but analysis will be limited to potential pros/cons etc. Hydraulic

	analysis to be performed in prelim/final design phases, not as part of this study. - We had discussed possibilities earlier in the project with Trout Unlimited/MDNR/TOTMWC regarding extending work downstream to reduce velocities. It was agreed that many fish were making it to the dam already but could not pass the structure so we decided to leave the downstream reach as is in the initial alternatives analysis. - Potential that paddler clearance may be reduced and flood risk may be increased if downstream bed is raised. o Regarding alternative sites: - There is no legal mandate that another barrier be constructed prior to removing the existing dam, however, if federal funding is being sought USFWS may have veto power if the removal will result in significant increases to chemical treatment costs. - The City may chose to move forward with dam removal without another barrier in place but stakeholders should at least be making an effort to work with USFWS on identifying a suitable alternative barrier location, especially if federal funds will be sought for the project. - Multiple potential sites have been identified upstream of the existing dam but downstream of the nearest significant tributary. The preferred location is the sports park located on River Rd approximately 2.2 miles (not river miles) southeast of the existing dam. This site is already on the City's radar for recreational facilities improvements and surrounding property owners are likely to be cooperative. There is potential to combine a lamprey barrier with a new pedestrian bridge that is desired at this location. The alternative locations will be compiled on a map with callouts and brief descriptions.

✓ Action Items	✓ **OHM to incorporate above comments into draft report and plans to be issued by 6/5/2020** ✓ **Bryan Burroughs to provide list of potential alternative barrier sites that were shared at this meeting**

Additional notes and next meeting:

Next meeting will be the Public Open House via Zoom Webinar at 6/23 at 5:30pm

cc: Office File