MOTT MACDONALD

Priest Lake Water Management Study

Work Progress Briefing – 9/18/2017

IDAHO WATER RESOURCE BOARD

Preliminary

10/05/2017 4:36:57 PM

Briefing Purpose & Agenda

1 Provide Status Update

2 Obtain input on status of work

3 Coordination for Stakeholder & Public Outreach

4 Next Steps

SCHEDULE

Task 1- Project Management

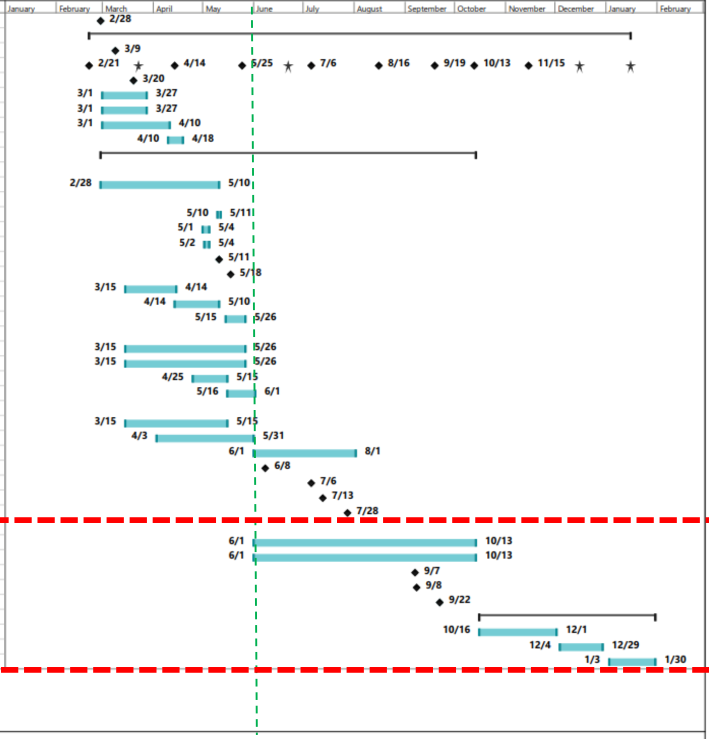
- Public Outreach Plan
  Complete
- Project Management Plan
  Complete – Send final to IDWR

Task 2 – Scope of Work

- 2,1 Data Collection
  100% completed;
- 2.2 Basis of Analysis
  100% Completed
- 2.3 Lake & River System H&H
  90% Completed
- 2.4 Thorofare/Dam Improvements
  65% Completed
- Meetings
  Steering Committee Meetings
  Stakeholder meetings – Periodic
  Public Meeting – 3rd week of September
  IWRB Meeting - Oct 24th
  Reporting – Nov (Draft Report), Final in December/Jan

Priest Lake Water Management Study Schedule
Idaho Water Resource Board

ID	Task Description	Duration	Start	Finish
1	**Notice to Proceed**	0 days	Tue 2/28/17	Tue 2/28/17
2	**Task 1 - Project Management**	**235 days?**	**Tue 2/21/17**	**Mon 1/15/18**
3	Kickoff Meeting	0 days	Thu 3/9/17	Thu 3/9/17
4	(8) Periodic IWRB Telecon Coordination Meetings	235 days?	Tue 2/21/17	Mon 1/15/18
17	Steering Committee Meeting #1	0 days	Mon 3/20/17	Mon 3/20/17
18	Refine Management Objectives	19 days	Wed 3/1/17	Mon 3/27/17
19	Work Plan/PM Plan	19 days	Wed 3/1/17	Mon 3/27/17
20	Public Outreach Plan	29 days	Wed 3/1/17	Mon 4/10/17
21	Public Outreach Plan Announcement	7 days	Mon 4/10/17	Tue 4/18/17
22	**Task 2 - Scope of Work**	**164 days**	**Tue 2/28/17**	**Fri 10/13/17**
23	**2.1 Data Collection**	**64 days**	**Tue 2/28/17**	**Fri 5/26/17**
24	2.1.1 Existing Data Collection	52 days	Tue 2/28/17	Wed 5/10/17
25	2.1.2 New Data Collection	9 days	Mon 5/1/17	Thu 5/11/17
26	Site Assessment	2 days	Wed 5/10/17	Thu 5/11/17
27	Hydrographic/Topographic	4 days	Mon 5/1/17	Thu 5/4/17
28	Grab Samples (Priest River)	3 days	Tue 5/2/17	Thu 5/4/17
29	Steering Committee Meeting #2	0 days	Thu 5/11/17	Thu 5/11/17
30	IWRB Board Meeting	0 days	Thu 5/18/17	Thu 5/18/17
31	2.1.3 Data Synthesis, Base Map	23 days	Wed 3/15/17	Fri 4/14/17
32	2.1.4 Interim Deliverable - Preliminary Map, Data	19 days	Fri 4/14/17	Wed 5/10/17
33	2.1.5 Final Deliverable - Map, Data	10 days	Mon 5/15/17	Fri 5/26/17
34	**2.2 Management Objectives**	**57 days**	**Wed 3/15/17**	**Thu 6/1/17**
35	2.2.1 Refine Management Objectives	53 days	Wed 3/15/17	Fri 5/26/17
36	2.2.2 Basis of Analysis & Evaluation Criteria	53 days	Wed 3/15/17	Fri 5/26/17
37	2.2.3 Regulatory Agency Preconsultation	15 days	Tue 4/25/17	Mon 5/15/17
38	2.2.4 Technical Memorandum	13 days	Tue 5/16/17	Thu 6/1/17
39	**2.3 Lake & River System H&H, Operability**	**100 days**	**Wed 3/15/17**	**Tue 8/1/17**
40	2.3.1 Hydrologic Analysis	44 days	Wed 3/15/17	Mon 5/15/17
41	2.3.2 Hydrodynamic Analysis	43 days	Mon 4/3/17	Wed 5/31/17
42	2.3.3 Pool Raise Alternatives Development/Evaluation	44 days	Thu 6/1/17	Tue 8/1/17
43	IWRB/Steering Committee Meeting #3 (with Stakeholders)	0 days	Thu 6/8/17	Thu 6/8/17
44	IWRB/Steering Committee Meeting #4 (Telecon)	0 days	Thu 7/6/17	Thu 7/6/17
45	Public Meeting #1	0 days	Thu 7/13/17	Thu 7/13/17
46	IWRB Board Meeting	0 days	Fri 7/28/17	Fri 7/28/17
47	**2.4 Priest Lake Dam/Thorofare Improvements Analysis**	**97 days**	**Thu 6/1/17**	**Fri 10/13/17**
48	2.4.1 Priest Lake Outlet Dam & Spillway Analysis	97 days	Thu 6/1/17	Fri 10/13/17
49	2.4.2 Thorofare Improvement Analysis	97 days	Thu 6/1/17	Fri 10/13/17
50	Lakes Commission Meeting	0 days	Thu 9/7/17	Thu 9/7/17
51	IWRB/Steering Committee Meeting #5	0 days	Fri 9/8/17	Fri 9/8/17
52	Public Meeting #2	0 days	Fri 9/22/17	Fri 9/22/17
53	**Task 3 - Deliverables**	**77 days**	**Mon 10/16/17**	**Tue 1/30/18**
54	3.1.1 Draft Report	35 days	Mon 10/16/17	Fri 12/1/17
55	3.1.2 Draft Review by IWRB	20 days	Mon 12/4/17	Fri 12/29/17
56	3.1.3 Final Report	20 days	Wed 1/3/18	Tue 1/30/18



★ Denotes no in person meeting that month

THOROFARE HYDRAULIC & GEOMORPH ASSESSMENT

THOROFARE

ISSUES

- Boat access to Thorofare & navigation is challenging at the Thorofare mouth
- Deteriorated breakwater structure
- Sedimentation

STUDY GOALS

- Providing sustainable modifications to improve Thorofare access, navigability, & water quality (minimize maintenance dredging needs)

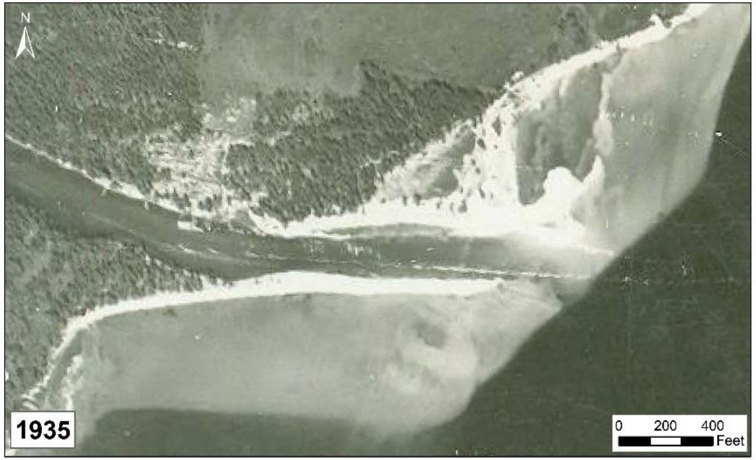
GEOMORPHIC ASSESSMENT GOALS

- Evaluate flow & sedimentation processes at Thorofare mouth to aid in evaluation of Thorofare improvement alternatives

THOROFARE HISTORY

- Historical aerial imagery suggests that alignment of Breakwater was different in 1935 and Thorofare mouth was narrower

- Widening the Thorofare mouth is likely to have reduced the flow velocities and subsequently sediment transport capacity of Thorofare



THOROFARE BREAKWATER

- Original timber pile breakwater (BW) was constructed by USFS to facilitate access to Thorofare in 1933 (IMR 1989)
- Currently, breakwater serves an additional function of providing wave shelter to lakefront properties in Sandpiper's Shore
- Breakwater structure composed of untreated timber piling and plank boards installed on cross-breams
- Breakwater is considered porous since there is a ~ 1-in gap between the plank boards and a ~ 10-in gap between bottom of planks and Thorofare bed (BW porosity ~ 20% to 35%)

BREAKWATER HISTORY

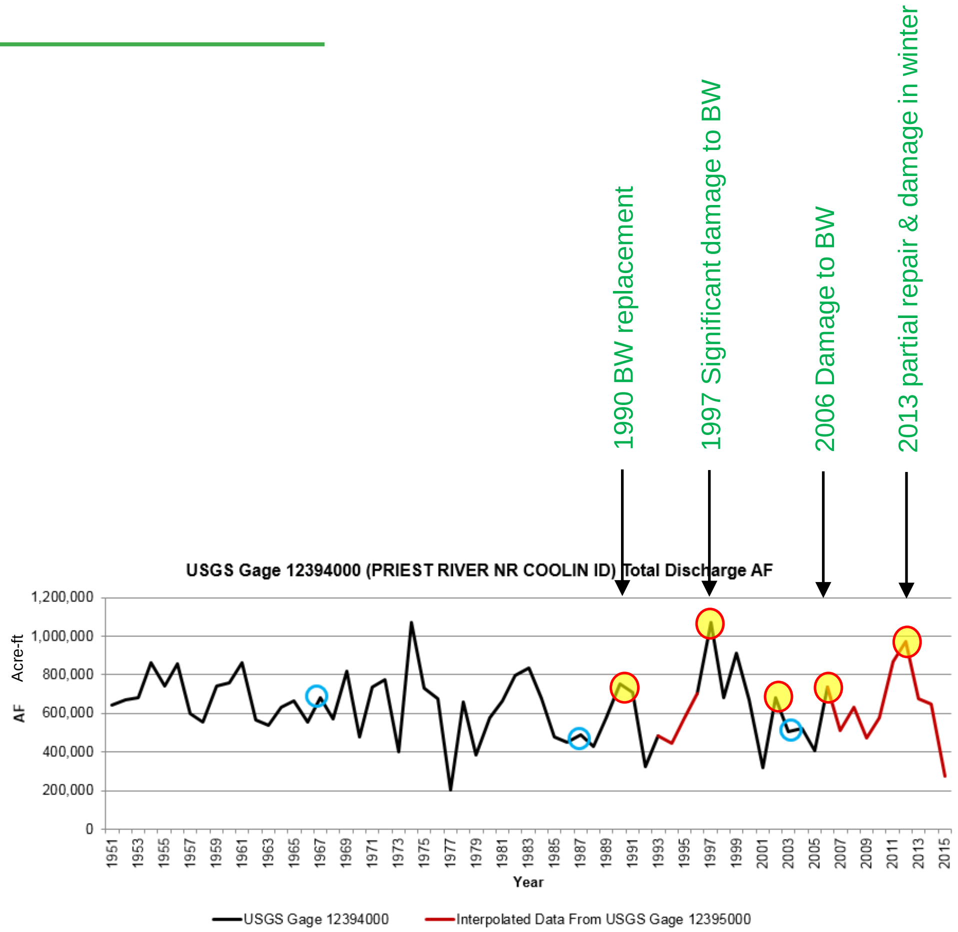
- 1920’s: Original timber pile breakwater (BW) constructed
- 1980: Easternmost 200 ft of BW was replaced
- 1990: BW replacement by InterMountain Resources
- 1997: Partial repair after damage due to spring runoff
- 2006: Partial repair after damage due to spring runoff
- 2013: Longer plank boards (14’ vs. old 8’ boards) were installed in solid ground. However, the flow in the subsequent winter scoured the bed underneath the boards. (Source: Copper Bay Construction Co.)

Observations:

- Damages to breakwater have occurred approximately every 7 to 10 years, resulting in need for (partial) repair
- Non-engineered repairs of breakwater have not withstood strong spring run-offs/ice forcing

Summary:

- Service life of breakwater ~ 30 to 40 years with periodic repairs
- Portions of Breakwater currently nearing end of service life

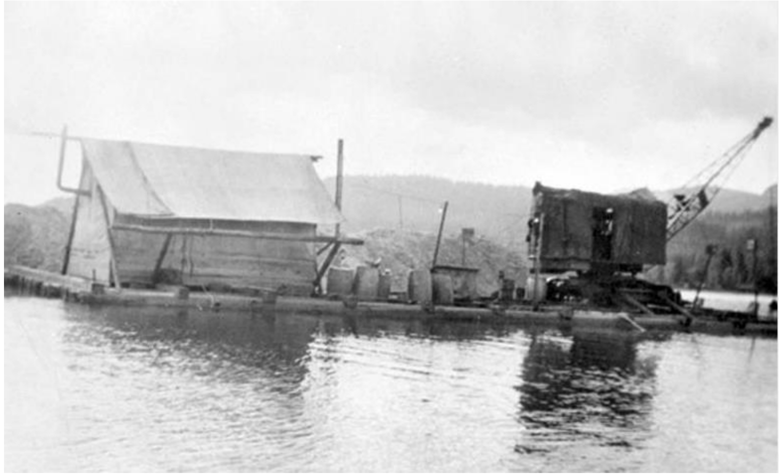


THORofare DREDGE HISTORY

- 1930’s: historical photo showing mechanical dredging of Thorofare using a barge

- 1940 – 1990’s: anecdotal accounts suggest episodic mechanical dredging

- 1990s – present: no official records of dredging but a few permits exist.



Summary:

- Regular maintenance dredging program has not been in place since 1990s; this has placed greater focus on effectiveness/performance of breakwater in directing the flow & avoiding flow spreading

THOROFARE FLOW SPREADING

- Shallow sand bar at the mouth on 3/15/2005, WL = 0.33' USGS
- Significant flow spreading & flow cutting into the sand bar and underneath the breakwater
- Aerial photo suggests ~40% of flow is going underneath the Breakwater, % to be verified with numerical modeling

Photos courtesy of Tom Weitz

THOROFARE FLOW SPREADING

- Thorofare flow forms channels underneath the breakwater.

- The channel locations & width vary with time

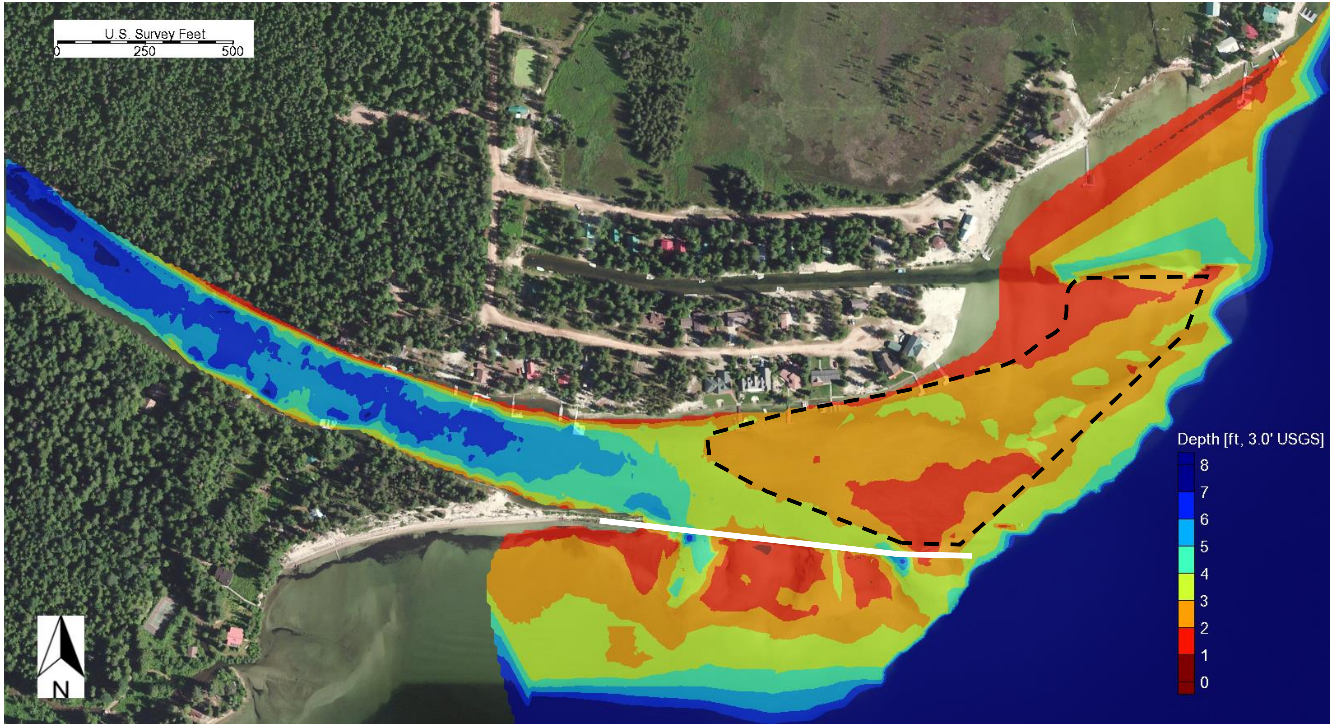
THOROFARE HYDROGRAPHY

- Only existing historical hydrographic survey of Priest Lake dates back to 1995 (DEQ 1997). Unfortunately, that survey did not cover the Thorofare

- MM completed a hydrographic survey of Thorofare in May 2017

- Color contours here represent available water depth during summer w.r.t. Lake Level at 3.0' USGS gage

- Water depths at the Mouth outlined by black dashed line is mostly shallower than 3 ft, with some areas shallower than 2 ft



Conclusion:

- Dredging & improvements to better confine Thorofare flow likely needed to maintain navigable access

- Accurate marking of Thorofare mouth by buoys would be important to help boaters access Thorofare

THOROFARE BED LOAD SEDIMENT TRANSPORT

- Bed load sediment transport is dominant sediment source in the Thorofare.

- Sources come from tributaries and Thorofare bank adjustment.

- Majority of bedload is likely transported during spring runoff high flow and certain winter high flow conditions.

- Flow diversion at the breakwater reduces sediment transport capacity of Thorofare resulting in sediment deposition in the outlet area near the breakwater.

LAKE SHORELINE - WAVE-DRIVEN SEDIMENT TRANSPORT

Wave-driven sediment sources & transport directions include:

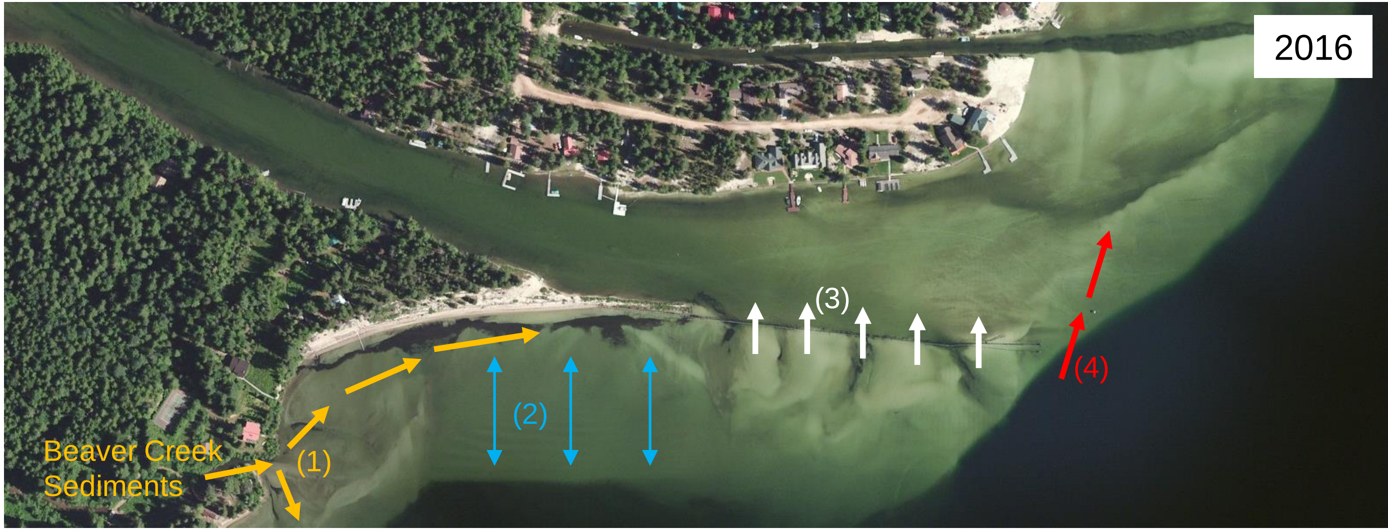
1) Beaver Creek brings sediments to its mouth, some of it moves eastward parallel to breakwater due to waves & currents

2) Waves move sediments perpendicular to shoreline

3) Waves may push some sediments through & underneath the breakwater during summer low flows

4) Portion of sediments will move past the breakwater end

Without monitoring sediment input from Beaver Creek & having consecutive surveys of the shoreline, quantification of sedimentation transport in this area is difficult.



THOROFARE GEOMORPHOLOGY SUMMARY

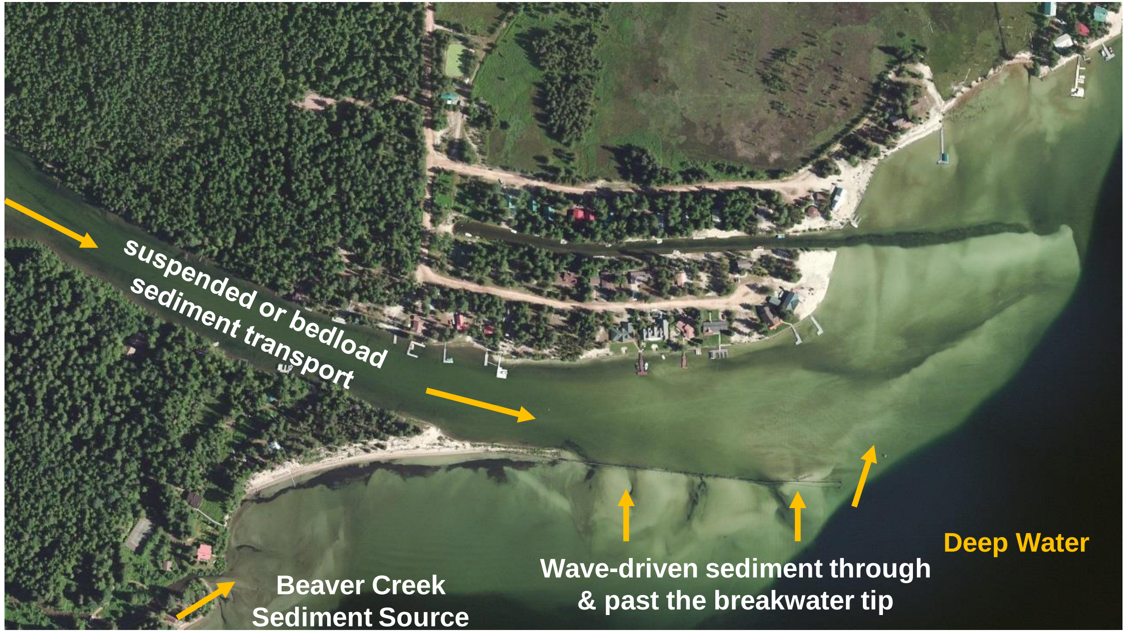
- Thorofare mouth has formed a lacustrine delta into Priest Lake.

- Sediment deposition is result of decreased transport capacity as low-gradient Thorofare meets zero-gradient Lake and flow spreading.

- Deposition has been accentuated by three factors at the mouth:

1) Widening of Thorofare channel along Breakwater
2) Reduced Thorofare discharge & velocity as water passes through or under existing timber breakwater
3) Wind-driven sediments get pushed through and around the breakwater eastern end

- Thorofare flow passes through the Breakwater and has episodically scoured the bed underneath the breakwater leading to significant spreading of the flow and reduced sediment transport capacity at the Mouth



CONCLUSIONS

Thorofare ranks low in suspended sediment transport; majority of sediment is bedload.

Sediment filling in Thorofare channel is a combination of Thorofare bedload sediment and Lake long shore wave driven sediment transport.

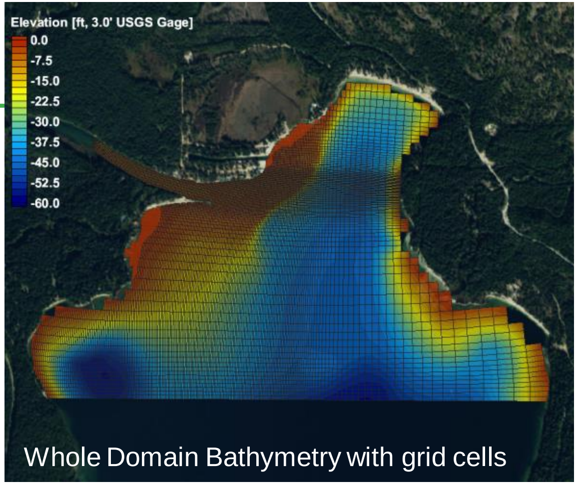
Flow confinement in the Thorofare is important for improvement of navigation sustainability. A solid feature or structure would be more effective compared to a porous breakwater in maintaining navigable access into the Thorofare.

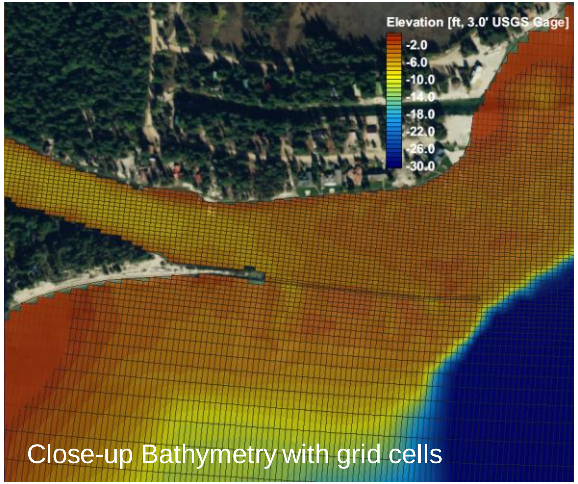
Blocking sediment movement from South into the Thorofare mouth will eliminate that sediment source and will increase sustainability of navigation thereby reducing maintenance dredging needs.

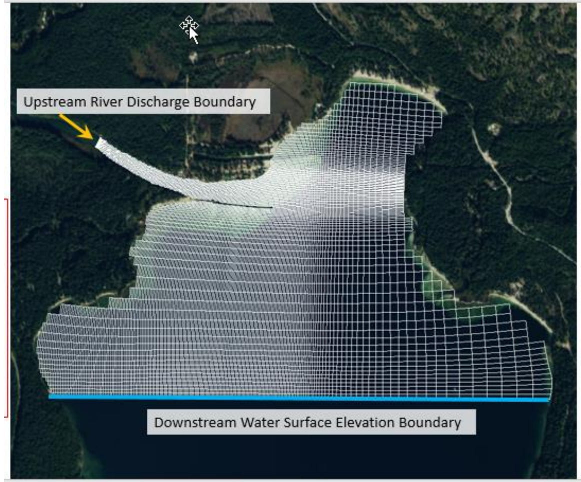
HYDRAULIC MODELING

- Delft3D-FLOW is a three-dimensional (3-D) hydrodynamic and transport simulation program which calculates non-steady flow and transport phenomena that result from river forcing on a curvilinear, boundary fitted grid.

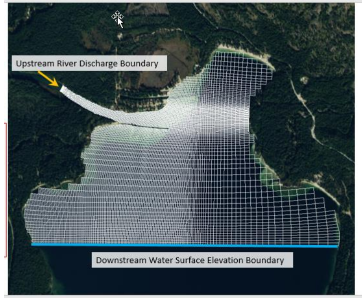
- Delft3D is widely accepted and used in industry and academia



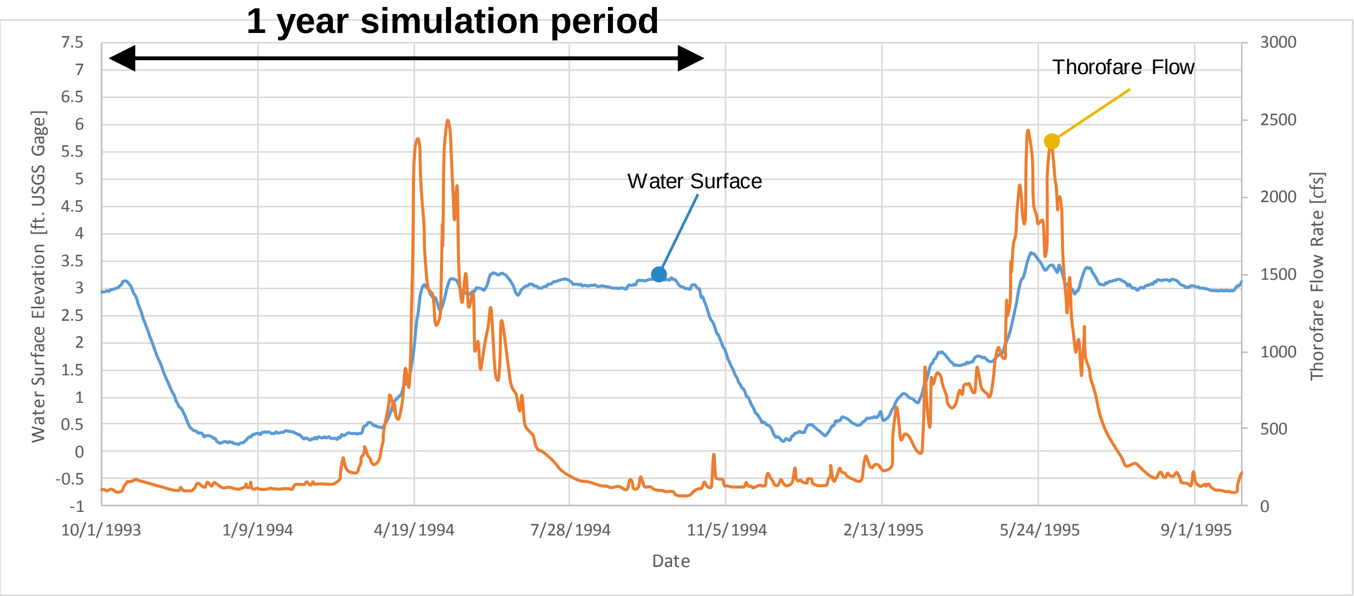




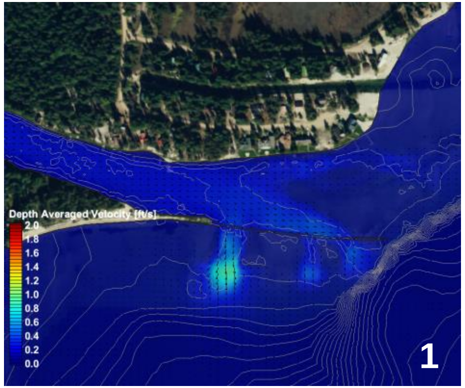
MODEL INPUT - BOUNDARY CONDITIONS

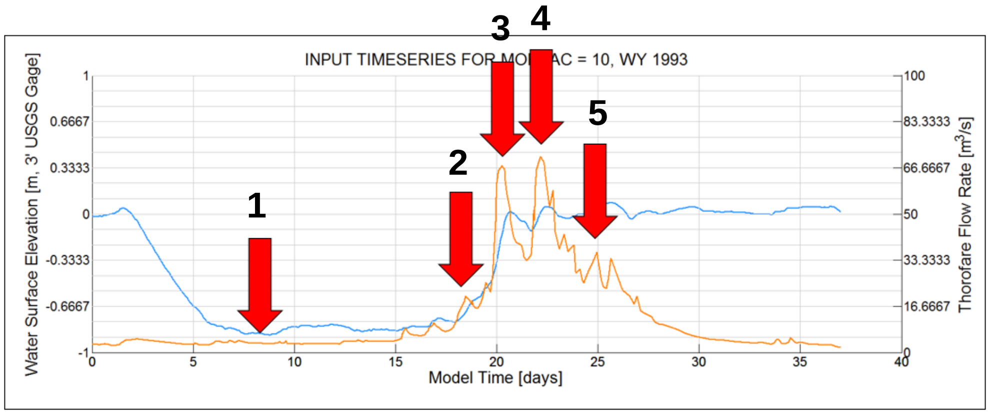


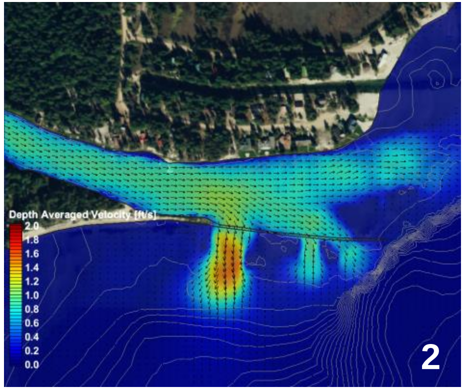
- Run a 1-year simulation in order to simulate a wide range of hydrodynamic conditions as well as see any sufficient mid to long term sedimentation.
- 1994 water year simulation

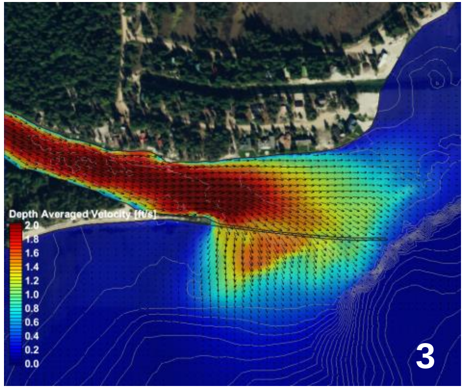


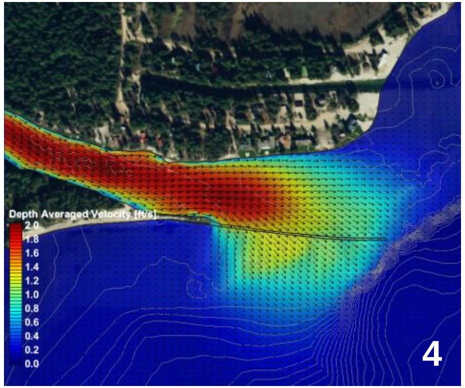
MODELING RESULTS – EXISTING CONDITIONS SUMMARY (Velocity)

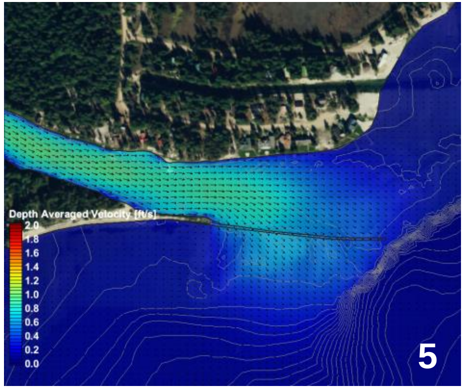






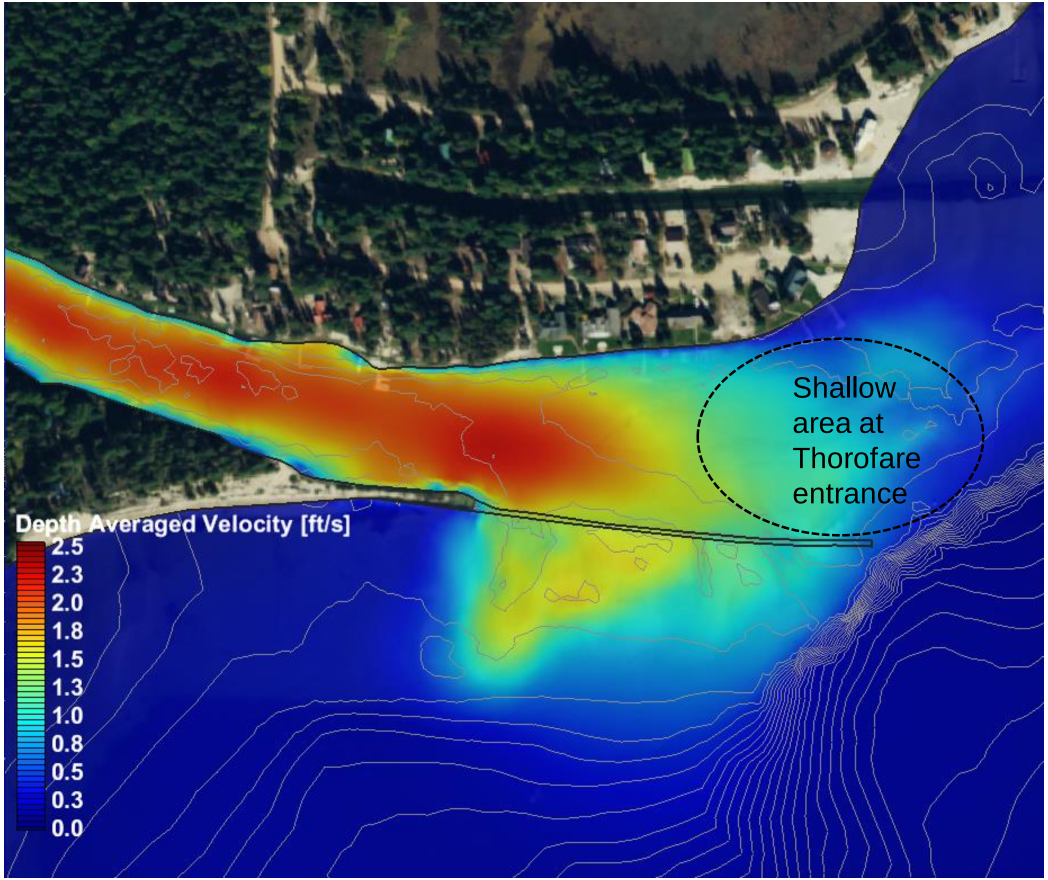




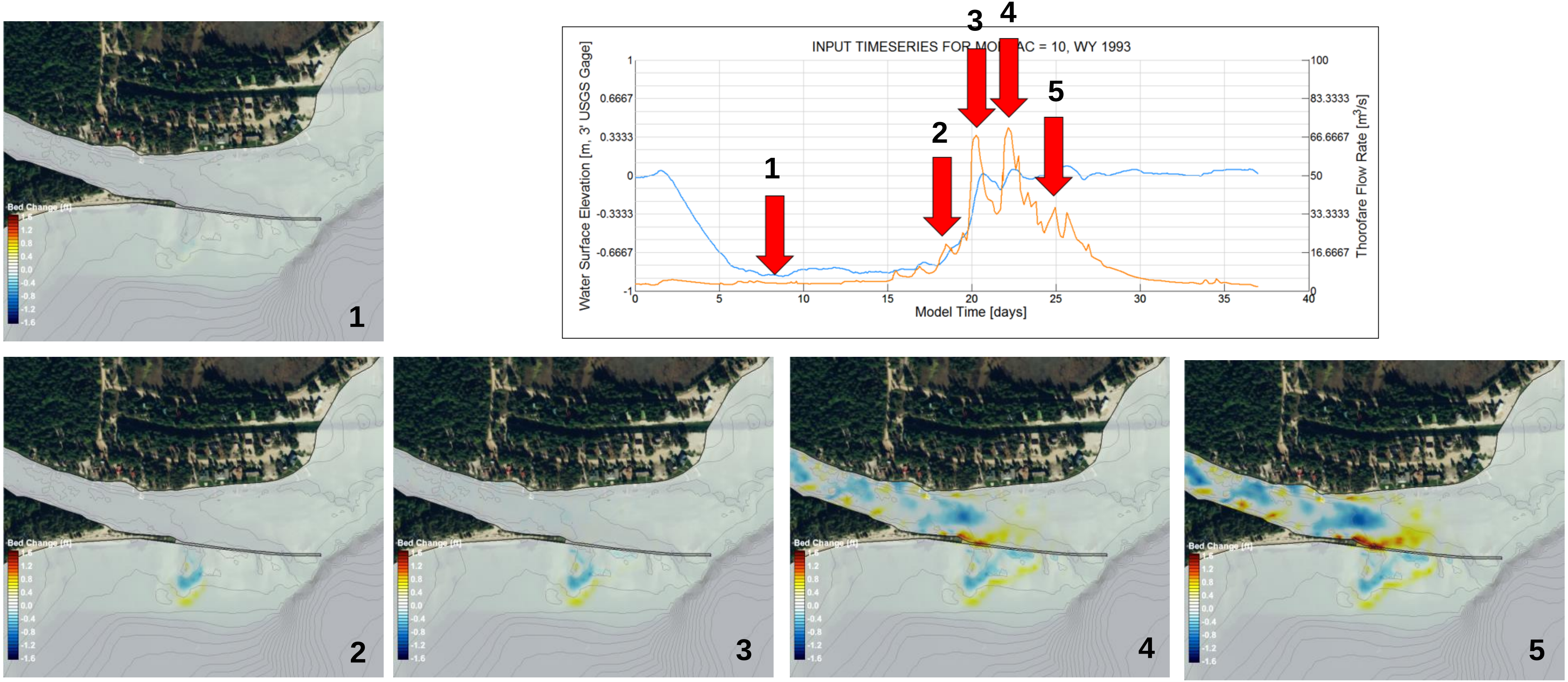


MODELING RESULTS – EXISTING CONDITIONS RESULTS (Velocity)

- Maximum Velocity: 2.2 ft/s
- Flow spreading along breakwater is represented in model results
- Significant drop in velocity at approximately ½ the length of the breakwater
- Velocity reduction zone corresponds with area of reduced depth (shoal) at entrance to Thorofare



MODELING RESULTS – EXISTING CONDITIONS (sediment transport summary)



CONCLUSIONS

- Numerical analysis simulations represent existing conditions and are a good basis for evaluating improvement alternatives.

- Confinement of flow with impermeable breakwater or similar impermeable feature improves hydraulic conditions to improve sediment transport capability within Thorofare by increasing velocities.

- Analysis of flow confinement alternatives indicate sediment transported further out through Thorofare into deeper water as compared to existing and historical conditions.

THOROFARE – POTENTIAL IMPROVEMENT ALTERNATIVES

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Improvement Alternatives:

1) No Action (maintain existing)
   - No repairs, improvements or dredging

2) Removal of Breakwater
   - Complete Removal with dredging

3) Rehabilitate Existing Porous Breakwater
   - Rehab existing damaged areas, continue repairs in future, conduct dredging to restore navigation

4) Replace Existing Porous Breakwater with Sediment Retention Feature
   - Construction new feature to replace breakwater and conduct dredging to restore navigation; see next slide for details

5) In channel flow diversion
   - Construction new feature to supplement breakwater and conduct dredging to restore navigation; see next slide for details

6) Partial in channel flow diversion

= Focus Area for Thorofare Improvements

THOROFARE – OTHER IMPROVEMENT ALTERNATIVES CONSIDERED BUT ELIMINATED

1) In Channel - LWD FEATURES

Navigable hazards for areas along north side of Thorofare

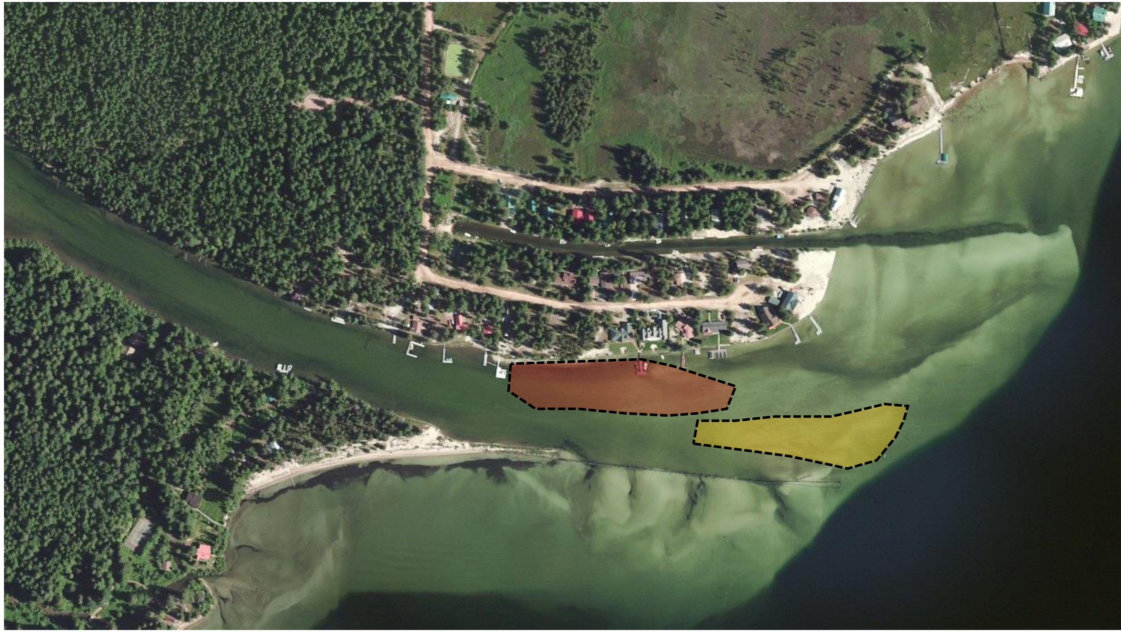
2) In Channel - NORTH SIDE GROINS

Requires connection to shoreline

Impact to docks

3) NON STRUCTURAL (DREDGING)

Not sustainable, requires frequent maintenance dredging



= Non Structural (Dredging Only)

= In Channel Features (North Side Groins, In Channel LWD)

ALTERNATIVE NO. 1 – NO ACTION

- Continued shoaling at entrance
- Continued flow diversion at breakwater
- Leakage of sediment from lake shoreline into Thorofare
- Formation of channels through breakwater
- Difficult to maintain navigation channel

ALTERNATIVE NO. 2 – REMOVE BREAKWATER

- Continued shoaling at entrance
- Increased flow diversion at breakwater
- Greater leakage of sediment from lake shoreline into Thorofare
- Increased formation of distributary channels through breakwater
- Maintaining navigation channel extremely difficult

ALTERNATIVE NO. 3 – REPAIR POUROUS BREAKWATER

- **Similar to historical conditions (past 10 years)**
- **Continued maintenance**
- **Continued lack of depth at entrance channel**
- **Frequent dredging needed**

ALTERNATIVE NO. 4a – IMPERVIOUS SEDIMENT RETENTION FEATURE

- **Reduced lake shore sediment transport into Thorofare**
- **Increased flow velocity in Thorofare to transport sediment into Lake**

ALTERNATIVE NO. 4b – IMPERVIOUS SEDIMENT RETENTION FEATURE

- Similar to Alt 4a; different alignment.
- Alternative alignment could improve sustainability of Thorofare dredging and maintenance of the required navigable depth

ALTERNATIVE NO. 4c – IMPERVIOUS SEDIMENT RETENTION FEATURE

- Similar to Alt 4b; different alignment.
- Longer distance required to get to deeper water

ALTERNATIVE NO. 4d – IMPERVIOUS SEDIMENT RETENTION FEATURE

- **Similar to Alt 4a; different type of construction materials. Variation in aesthetics, capital cost, maintenance, etc…**

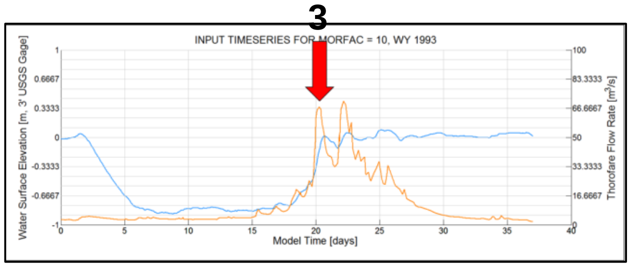
ALTERNATIVE NO. 5 – IN CHANNEL FLOW DIVERSION

- **Continued risk of breakwater breaches requiring maintenance for system to function properly**
- **Potential for some flow to still be diverted through breakwater**
- **Lake shore sediment still capable of migrating through porous breakwater**

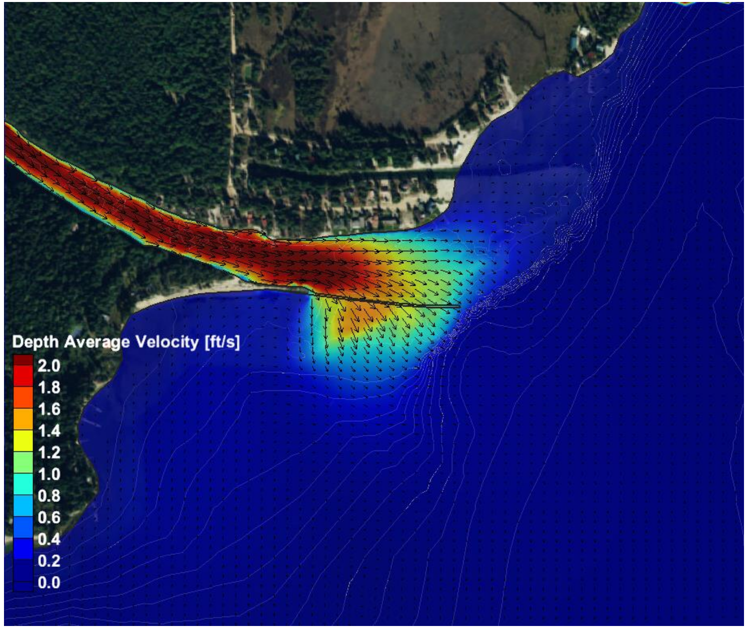
ALTERNATIVE NO. 6 – PARTIAL IN CHANNEL FLOW DEFLECTION

- Continued shoaling at the entrance
- Increased flow diversion at end of breakwater
- Increased formation of distributary channels through end of breakwater
- Maintaining navigation channel difficult

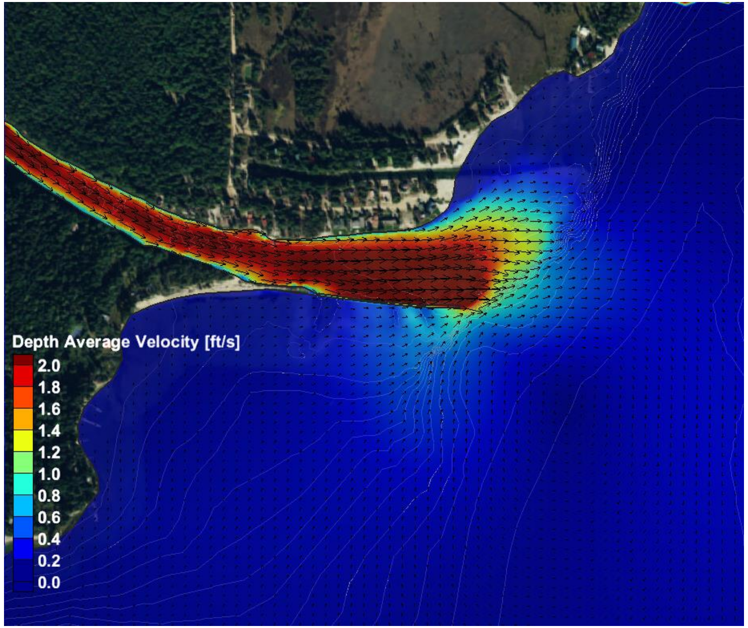
MODELING RESULTS – HYDRAULICS



Snapshot of depth-averaged velocity for Porous Breakwater vs. Solid Feature



Porous Breakwater

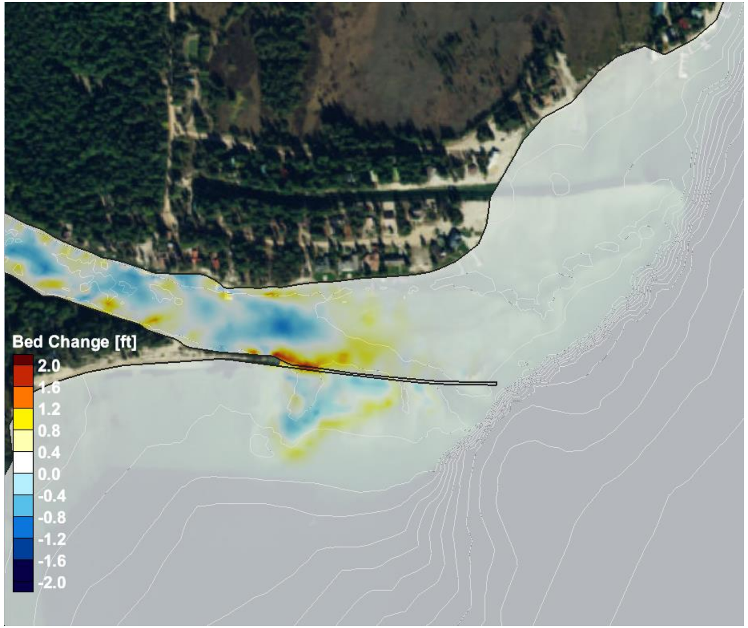


Solid Feature

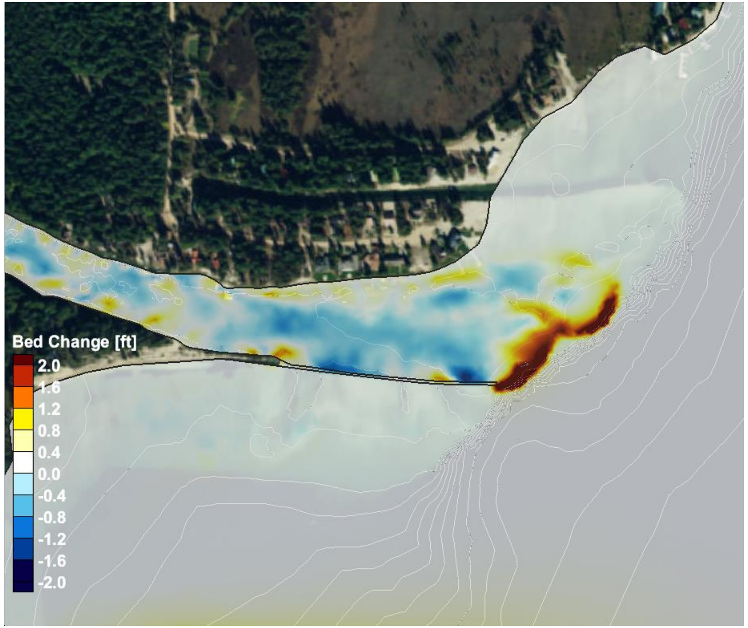
MODELING RESULTS – SEDIMENT TRANSPORT

Maximum Bed Change (sedimentation/erosion) during the simulation period

Solid Feature: transports material and deposits them in deeper water past the feature end.



Porous Breakwater



Solid Feature

THOROFARE/BREAKWATER IMPROVEMENT – ALTERNATIVE SCREENING

Alternative	Alt No.	Sustainability	Thorofare Navigation for motorized boats	Maintenance Dredging Requirements	Structure Maintenance Requirements	Wave Protection for Sandpiper Shores	Sedimentation at Thorofare Docks	Adjacent property Impacts	Aesthetics/ Natural Looking Element
No Action	1	No-Action – Reference for Comparison							
Remove Breakwater	2								
Repair Existing Porous BW	3								
Replace Existing Porous BW with Impervious Sediment Retention Feature	4a-d								
Replace Existing Porous BW with Impervious Sediment Retention Feature & Extend Seaward	4e								
In Channel Flow Diversion	5								
Partial In Channel Flow Diversion	6								

Change with respect to Status Quo (No Action):

Significantly Positive | Moderately Positive | No/Negligible Change | Moderately Negative | Significantly Negative

CONCLUSIONS

- Sensitivity testing showed that Solid Breakwater compared to Porous Breakwater better confines the flow to Thorofare and as a result, higher velocities will occur in the Thorofare mouth

- Sensitivity testing showed that Solid Breakwater compared to Porous Breakwater transports more sediments along Thorofare and deposits them in deeper water

- Flow diversion in Thorofare doesn’t occur with non-porous feature.

- Sediment retention feature to replace existing breakwater is best performing concept to meet project objectives, criteria and goals.

- Extension of Breakwater toward deeper water to be investigate further to evaluate cost/benefit.

- Slightly rotated breakwater to narrow Thorofare width to be investigated to further evaluate cost/benefit.

OUTLET STRUCTURE & POOL RAISE ASSESSMENT

OUTLET STRUCTURE EXISTING CONDITIONS (May 2017 High Flow)

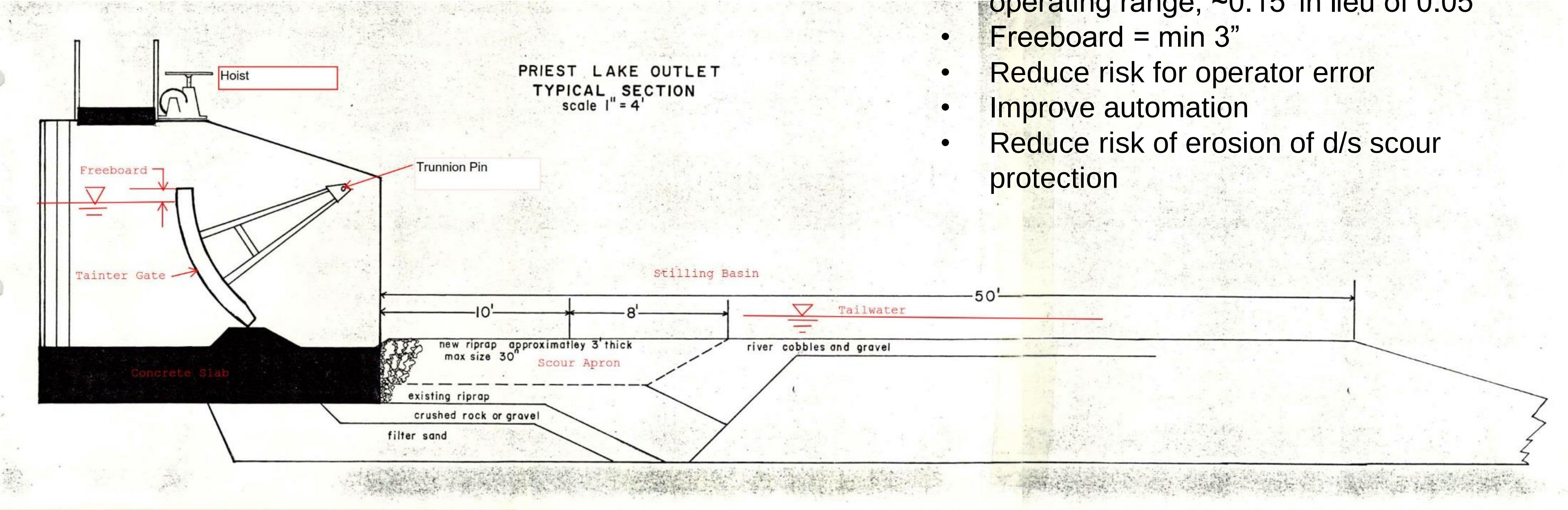
OUTLET STRUCTURE EXISTING CONDITIONS (Sept 2017 Low Flow)

OUTLET STRUCTURE ASSESSMENT

- Constructed in 1978
- Radial gates manually operated on 11 equally sized spillway bays
- Repairs to downstream scour protection in 1979 ~larger stone installed to increase scour protection
- Gates are 7' tall with 0.15' freeboard

Goals/Criteria

- Raise Pool to
  - 3.25 ft gage
  - 3.50 ft gage
- Provide larger tolerance on vertical operating range; ~0.15' in lieu of 0.05'
- Freeboard = min 3"
- Reduce risk for operator error
- Improve automation
- Reduce risk of erosion of d/s scour protection



OUTLET STRUCTURE – HYDRAULIC ASSESSMENT

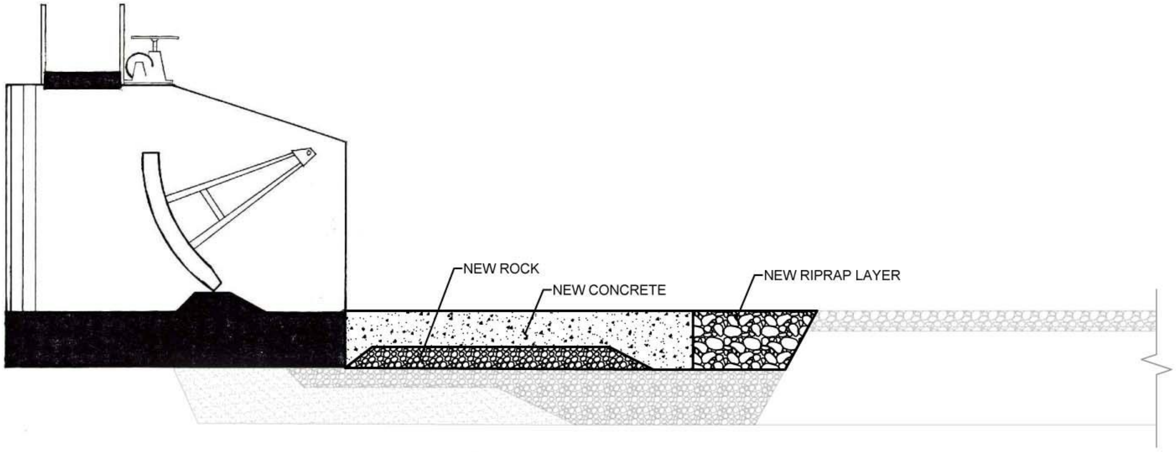
- HYDRAULICS
  - Evaluated Spring, Summer and Fall Flow Conditions
  - Hydraulic jump forms beyond concrete slab and some instances beyond riprap scour protection
  - High velocities a consideration for all flow conditions
  - Stream power (erosion potential) is increased by 9% for 6” pool raise discharge condition
- SCOUR ASSESSMENT
  - Armor Stone is undersized for certain discharge flow and gate operation conditions
    - Analysis indicates D50 of 1’ to 2.5’; current D50 estimated to be 1’.
  - Larger D_{50} and layer thickness for riprap scour protection is needed
    - Larger stone would reduce risk of scour during future operations for spring or summer conditions
  - Length of scour apron is shorter than standards indicate
  - Concrete stilling basin is a more ideal system to mitigate scour hazard and hydraulic jump; especially in light of dependence of current system on human operations.
- Summary
  - Sensitivity to specific hydraulic conditions and gate operations
    - High flow: Variable location for hydraulic jump formation depending on gate operations and discharge.
    - High Pool, high flow, few gates open = High velocities & scour potential.
  - Armor Stone is undersized and susceptible to scour during gate operations
  - Improved scour apron and more formalized concrete stilling basin should be considered

Scour Apron Mitigation Concepts

ALT #2 – EXTEND CONCRETE APRON

Evaluated 6 concepts; Alt #2 Recommended

1. USBR Type IVa Stilling Basin
2. Extend Concrete Apron
3. New Larger Riprap
4. Grouted Riprap
5. Notched Ramp/Slab
6. Gate Retrofit

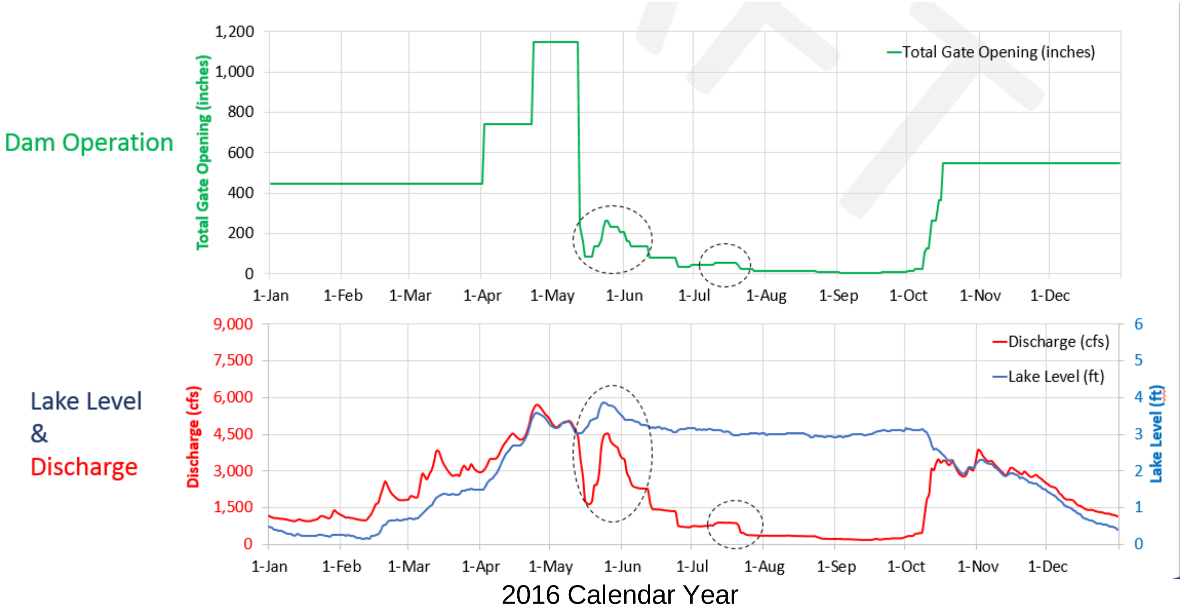


Pros:
- Improved Stilling Basin Hydraulics
- Improved gate operational flexibility
- Lower Risk of scour
- Potential for improvement to dam stability (sliding resistance)

Cons:
- Expense

OUTLET STRUCTURE – GATE OPERATIONS

- Winter. Gates fully open
- Spring. Gate opened and managed to achieve 3.0’ gage by July 1.
- Summer. Small number of gates used to manage pool and discharge.
- Fall. Opened in Oct to release storage between early Oct and Nov 1.



Gate & Gate Operation Modifications Assessment

Powered Operation & Automation Considerations

- Concepts
  - Retrofit with motor and gearbox to existing or a modified drive with starter panel
  - Valve Actuator – self contained unit; remote operation
- Alternative Concept
  - Provide power operation with remote monitoring but not remote operation
  - Focus improvements on more refined onsite real time operations of the dam
  - Improve discharge and pool measurement and monitoring system for gate operations and to improve rating curve

Radial Gate & Trunnion

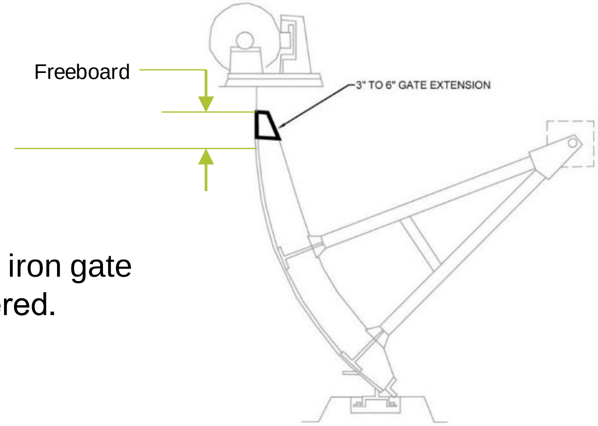
- Slight alter in angle & increase in resultant load magnitude
- Slight reduction in factor of safety
- Likely doesn't require substantial modification for smaller increase in pool; more detailed analysis

Gate Extension

- Required for pool raise as current freeboard is only 2".
- Extension likely to be stiffened steel plate with isolation of new steel and exist iron gate
- Freeboard. Freeboard for new pool level of at least 3" to 4" should be considered.

Hoist

- Slight reduction in factor of safety; more detailed analysis in next phase and review of capacity of system.
- Not significant increase in load and within safety factor.

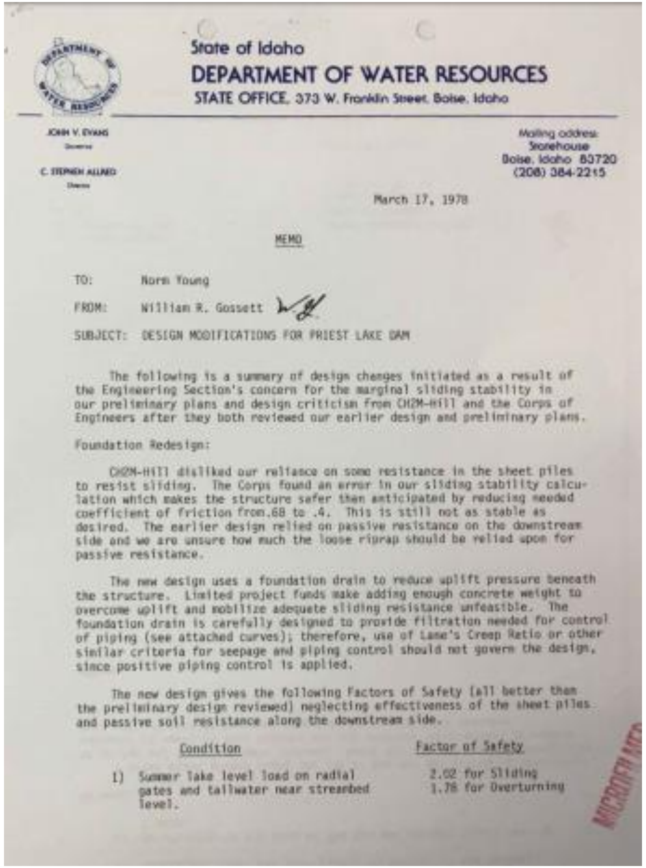


Gate Section

Dam Stability Analysis – 1978 Design/Assessment

Ch2MHill & U.S. Army Corps of Engineers Review

- STABILITY
  - Overturning
  - Sliding Resistance: Dependent upon the sheet pile wall and downstream scour apron for providing lateral resistance to achieve the required Factor of Safety.
  - Sliding & Piping – dependent on filter layer and the downstream riprap scour apron remaining in place
  - Improvements: Downstream concrete key recommended (not implemented).
  - Assessment: Recommend a key or weight of structure used to resist sliding and not sheet pile wall.
- STILLING BASIN
  - No end sill or concrete apron to control location and formation of hydraulic jump
  - Riprap may be undersized and susceptible to erosion and therefore destabilization of the dam



State of Idaho
DEPARTMENT OF WATER RESOURCES
STATE OFFICE, 373 W. Franklin Street, Boise, Idaho

JOHN V. EVANS

C. STEPHEN ALLRED

Mailing address:
Statehouse
Boise, Idaho 83720
(208) 384-2215

March 17, 1978

MEMO

TO: Norm Young

FROM: William R. Gossett

SUBJECT: DESIGN MODIFICATIONS FOR PRIEST LAKE DAM

The following is a summary of design changes initiated as a result of the Engineering Section's concern for the marginal sliding stability in our preliminary plans and design criticism from CH2M-Hill and the Corps of Engineers after they both reviewed our earlier design and preliminary plans.

Foundation Redesign:

CH2M-Hill disliked our reliance on some resistance in the sheet piles to resist sliding. The Corps found an error in our sliding stability calculation which makes the structure safer than anticipated by reducing needed coefficient of friction from .68 to .4. This is still not as stable as desired. The earlier design relied on passive resistance on the downstream side and we are unsure how much the loose riprap should be relied upon for passive resistance.

The new design uses a foundation drain to reduce uplift pressure beneath the structure. Limited project funds make adding enough concrete weight to overcome uplift and mobilize adequate sliding resistance unfeasible. The foundation drain is carefully designed to provide filtration needed for control of piping (see attached curves); therefore, use of Lane's Creep Ratio or other similar criteria for seepage and piping control should not govern the design, since positive piping control is applied.

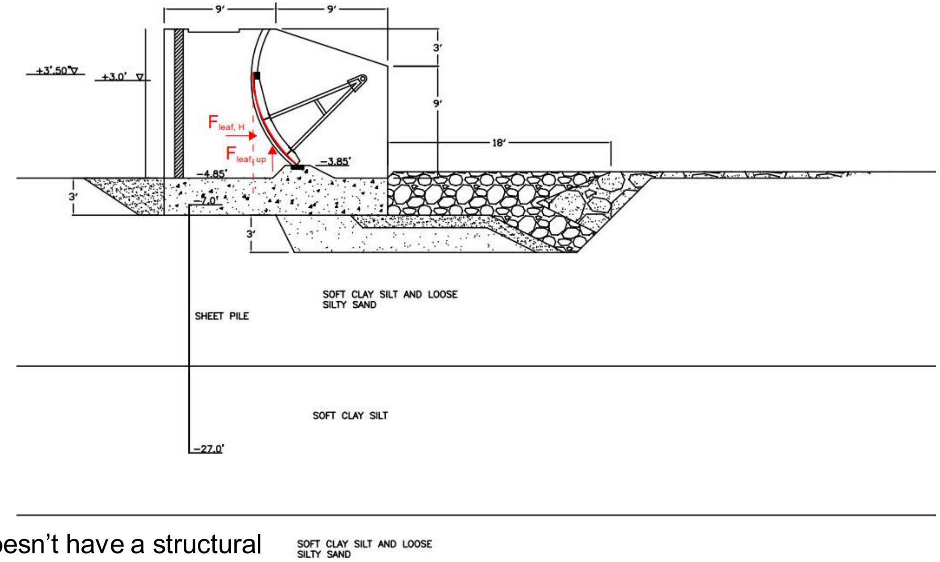
The new design gives the following Factors of Safety (all better than the preliminary design reviewed) neglecting effectiveness of the sheet piles and passive soil resistance along the downstream side.

Condition	Factor of Safety
1) Summer lake level load on radial gates and tailwater near streambed level.	2.02 for Sliding 1.76 for Overturning

Dam Stability Analysis - Background

Dam Stability Analysis

- Criteria: As outlined in the Priest Lake Basis of Analysis.
- Standards: IDWR and USBR.
- Available Data:
  - Construction Plans
  - Borings
  - Inspection Reports
- Review of Historical Data



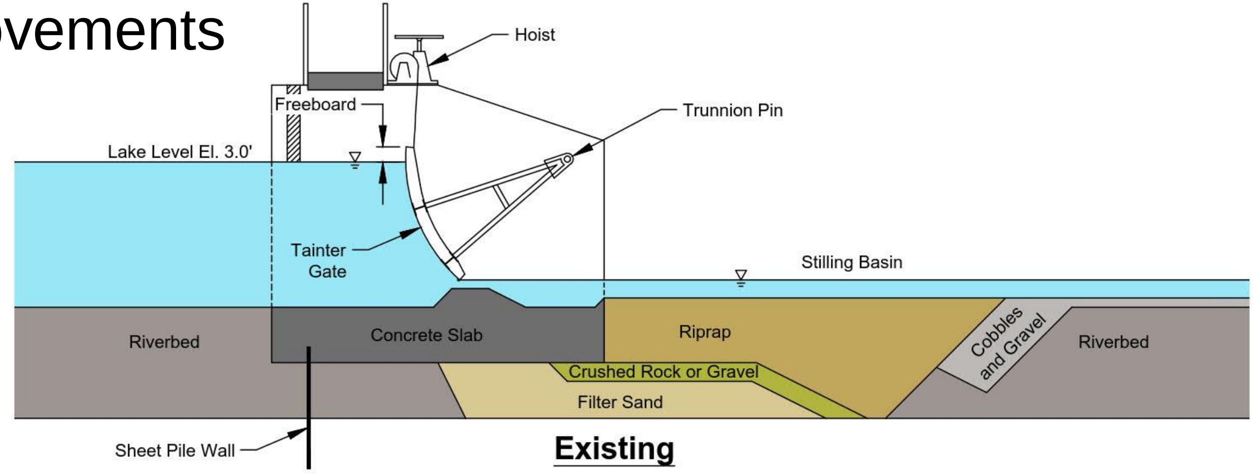
Global Stability Analysis

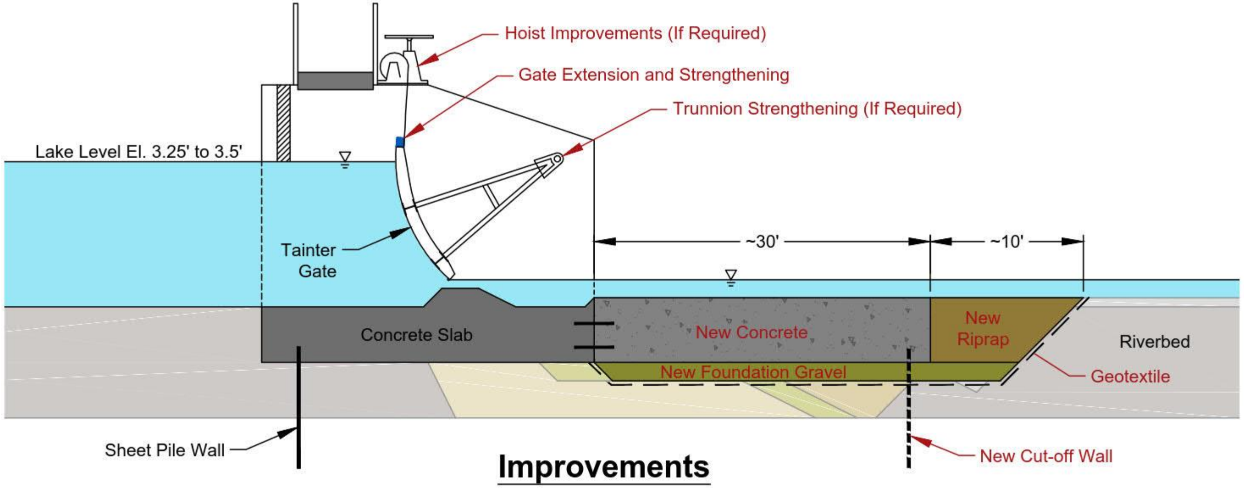
- Sliding Stability
  - Sliding stability is of concern and relies upon sheet pile wall that doesn’t have a structural connection to outlet structure. Increased pool will increase sliding load and thereby further reduce Factor of Safety. New improvements to stilling basin and scour protection likely needed.
- Seepage - Sheet pile wall provides hydraulic cutoff within center of structure; review at river bank ends of structure.
- Overturning - Ok.
- Bearing Pressure - Ok, within allowable.
- Resultant location on base - Ok, eccentricity within middle 1/3 of base
- Seismic - TBD

Dam Assessment – Conclusions

- Structure Stability
  - Improvement for stability likely needed to meet current standards to not rely upon sheet pile wall for sliding resistance.
  - Sheet pile wall does provide reduction in seepage.
- Stilling Basin
  - Improvements needed to mitigate risk of scour and corresponding impact on dam stability.
  - Alternative – Scour apron
- Gates
  - Increase height of gate for 3” to 6” pool raise looks feasible.
  - Modification to gate will be needed at top of existing gate (plate extension)
  - Gate Structure and Trunnion: Likely ok, additional analysis in next phase needed to finalize.
- Gate Operations
  - Power operation should be considered

Outlet Dam Improvements Summary





WATER LEVEL MANAGEMENT – BACKGROUND & PURPOSE

Background:

- In 2015, drought conditions made maintaining the required summer lake levels & minimum discharge from the dam very difficult. The discharge from the dam was reduced below the current policy of minimum 60 cfs to maintain the lake level and meet statutory requirements.

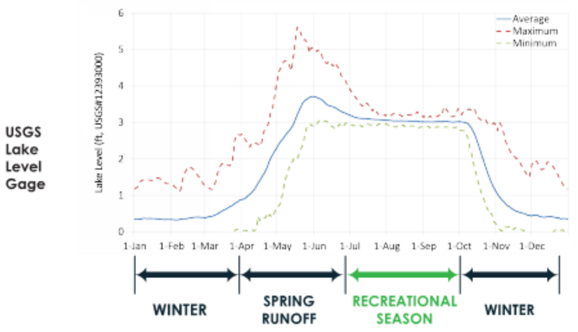
- In 2016, which had seemed to be a typical year, the same issue occurred and a crisis was nearly averted.

- These incidents highlighted the need for improvements to lake level management and measures that may need to be taken during dry or marginally dry years.

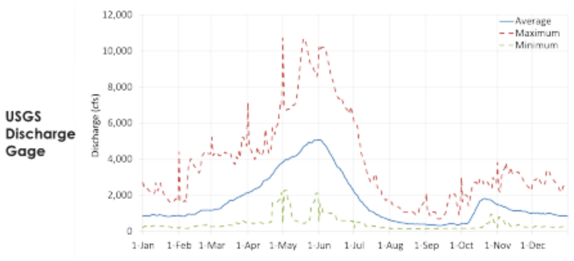
Study Purpose:

- Evaluate possible changes for a dry year water management scheme consisting of either a 3-inch or 6-inch higher lake level during part of the summer recreational season

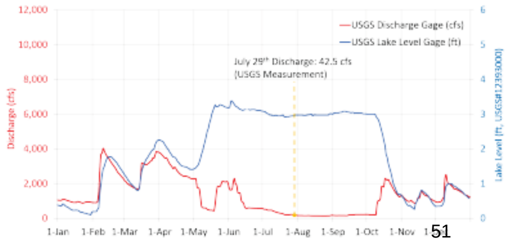
ANNUAL LAKE LEVEL VARIATION (1980 - PRESENT)



ANNUAL DISCHARGE PATTERN (1980 - PRESENT)

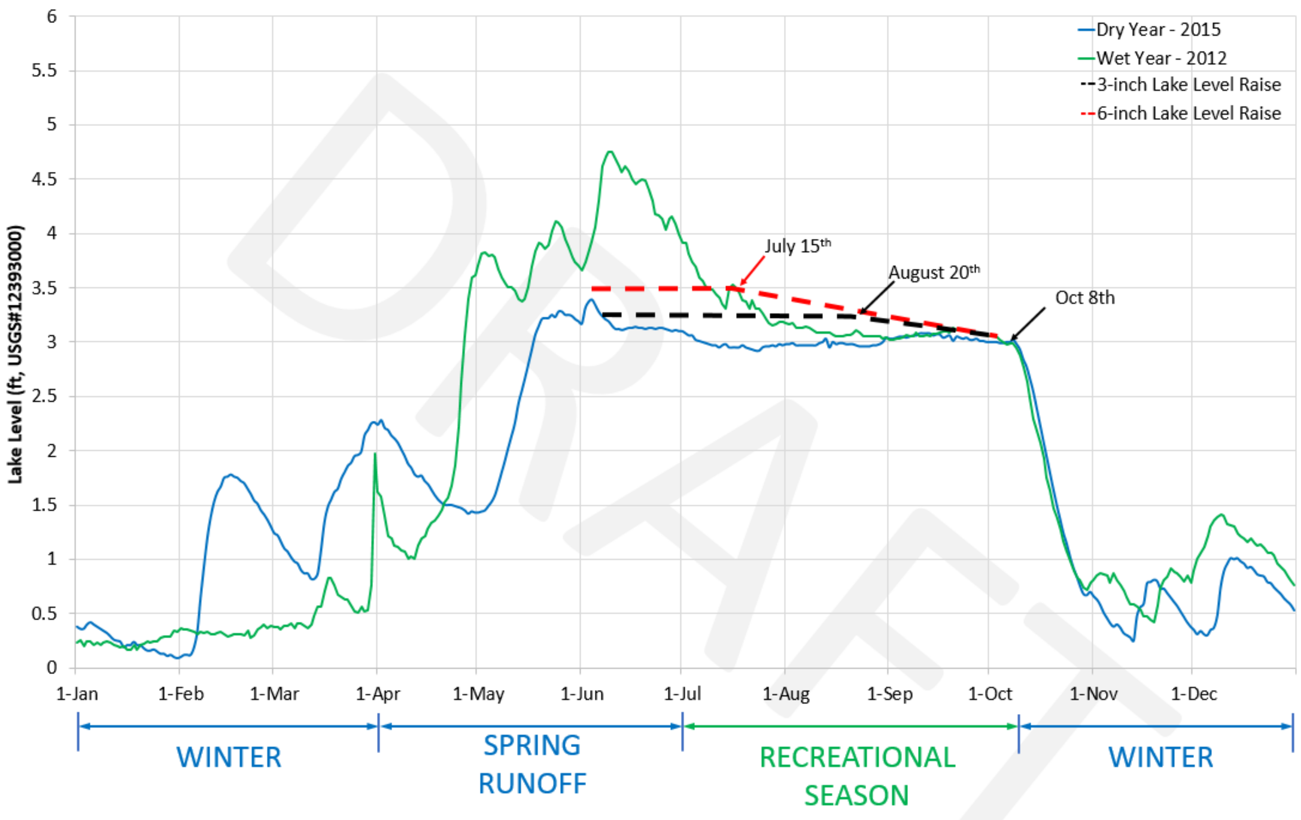


2015 LAKE LEVEL & DISCHARGE PATTERN



PRIEST LAKE WATER LEVEL - BACKGROUND

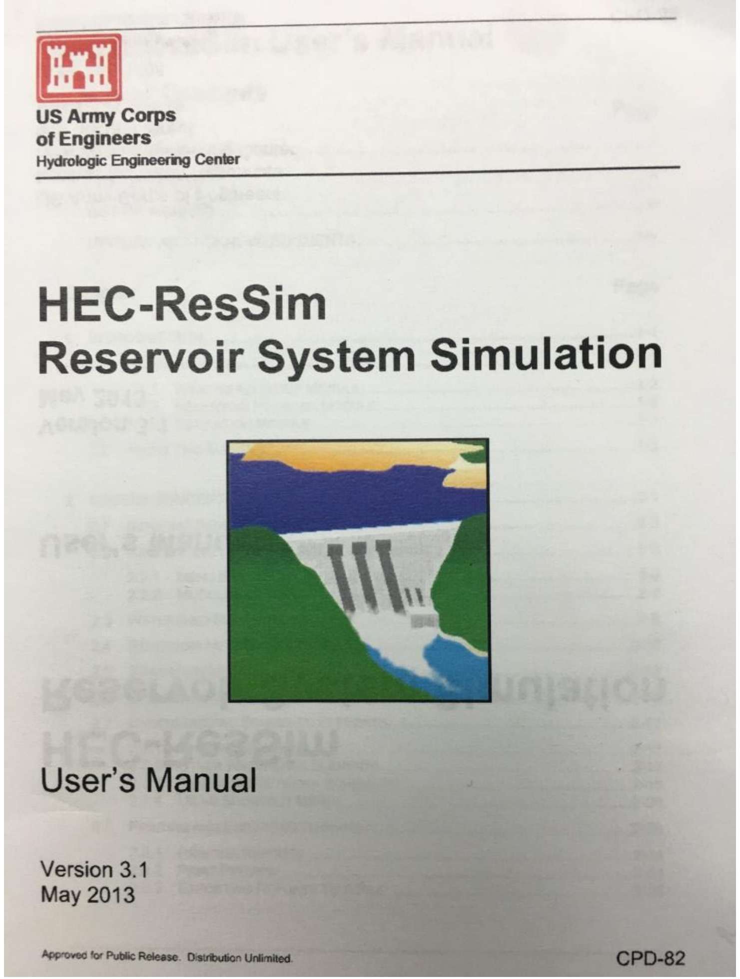
- It is typical for the lake level to be higher than required 3.0’ during the recreational season.
- Water level chart shows that in 2012, lake level was 6-in higher than 3.0’ required level till July 15th.
- Water level chart also shows that in 2012, lake level was 3-in higher than the 3.0’ required level till July 20th.
- Temporary pool raise during dry years can be thought of as managing lake level similar to natural lake level in wet years with a slight increase during month of August



LAKE MANAGEMENT OPTIONS

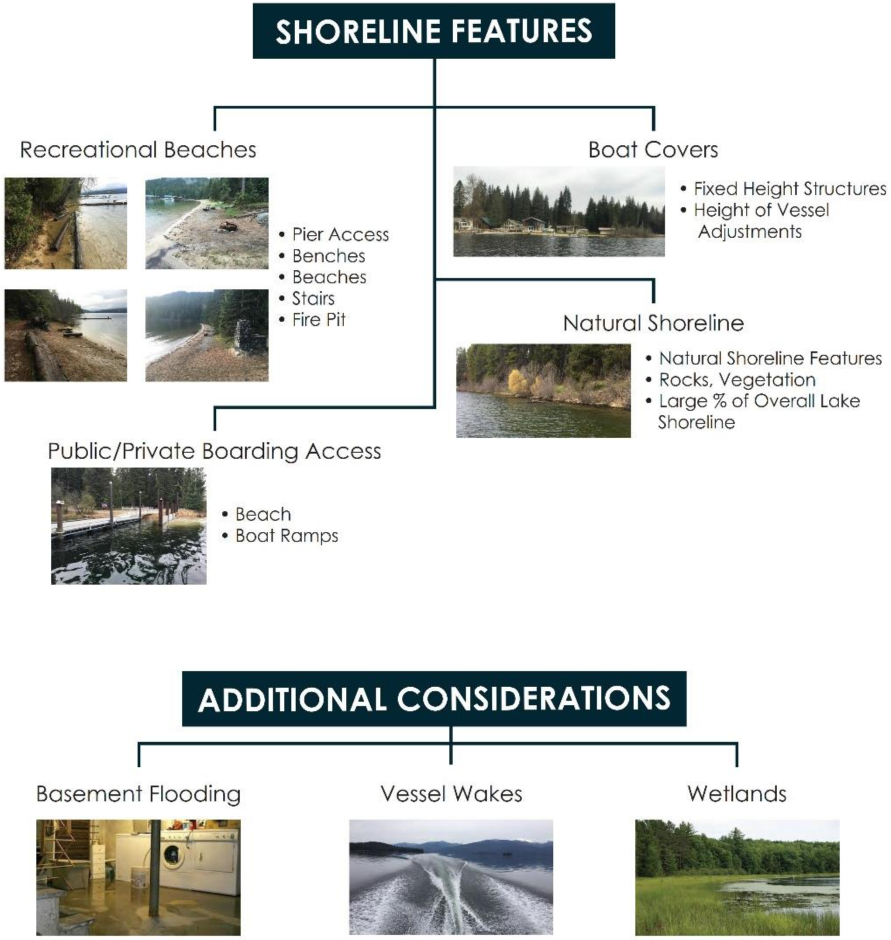
- Water Management Analysis
- Evaluation of Outlet Dam operations
- Input Data
- Simulations
- Preliminary Conclusions

- 3” Pool Raise likely will work relative to historical dry years to meet the defined criteria.
- Integration of real time streamflow data into dam operations
- Provide larger tolerance in operations to allow more flexibility (currently operated to maintain as close to 3.0’ as possible). Allow variation of 3 to 4”.



DRY YEAR POOL RAISE ASSESSMENT

Purpose: Evaluate changes from existing conditions & potential for impacts on the following elements due to pool raise (3” or 6”).



DRY YEAR POOL RAISE ASSESSMENT - SUMMARY

Temporary pool raise is being considered as an improvement measure **only** for dry and marginally dry years. Therefore, any possible impact will be limited to these years.

Alternative	Recreational Beach Use	Lake Shoreline Erosion	Access to Fixed Structures	Navigation Access to Marinas	Boat Launch Facilities	Fish Habitat	Thorofare Navigation	Wetland & Riparian Vegetation	Basement Flooding
3-inch Pool Raise									
6-inch Pool Raise	(1)		(2)						

Change with respect to a typical or a wet year:

Positive Change

No or Negligible Change

Low Impact

High Impact

Footnotes:
(1): There will be no impact on majority of the beaches. Localized areas will see loss of usable dry beach.
(2): There will be no impact on majority of fixed structures. A low percentage of structures will see low impacts.