Union Street Dam Betterment Plan

Traverse City, Michigan
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CONCEPTUAL DESIGN REPORT

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Executive Summary

Traverse City commissioned this conceptual-level study to develop an alternative to ongoing repairs and upgrades to the Union Street Dam. The betterment plan takes a fresh look at the entire structure and envisions a whitewater channel through the dam and a passive spillway. The new project would provide high quality whitewater boating, fish passage, and increased fishing access. Surrounded by an attractive park, boardwalks, and fishing areas; the "whitewater park" would be a destination that would serve Traverse City residents and attract out of town visitors. In addition, the passive spillway would improve the dam's safety and would eliminate the operations and maintenance of the existing gates, stop logs, and trash racks.

Our work concludes that the whitewater recreation channel is a good fit at the Union Street Dam, contingent on satisfying sea lamprey barrier requirements. Our scope included a site visit, three conceptual alternatives, a budget estimate, a review of prior reports, and consultation with fisheries agencies. We also performed a first pass hydraulic analysis of each of the alternatives to insure that they pass the regulatory 200-year flood event, and meet or exceed the existing spillway rating with regard to Boardman Lake levels.

The preferred alternative replaces the earth dam with a passive spillway and an open whitewater channel along the south bank of the river. Additional alternatives were developed for a passage along the right bank and in the middle of the river. A multi-purpose maintenance gate at the head of the whitewater bypass creates a large surfing wave, and its high velocity water serves as the primary lamprey barrier. Velocity barriers, however, have not been permitted in Michigan--the only agency-approved exclusion method is a plunge-type weir. However, because of the inherent safety concerns with the plunge weir, we recommend the velocity barrier. We believe that the additional expense and effort in modeling and permitting it would be worthwhile. As a fallback position, one alternative was developed using a plunge weir, however this option may require fully automated gates in order to satisfy safety concerns.

The Union Street Dam betterment project was developed in the context of the Great Lakes Ecosystem Restoration Project now ten years in the planning and implementation by the US Army Corps of Engineers (USACE). The plan includes removal or modification of three dams on the Boardman River upstream of Traverse City. Union Street Dam is to remain as a lamprey barrier and the auxiliary spillway is to be repaired. However, due to the continued operations and maintenance of the piped spillways, the City commissioned this study. The following table summarizes the budgets for this and previous studies of the project site.

Project	***Budget Estimate***	***Source***
Labyrinth Spillway and Toe Drain	$1M to $1.5M	STS Consulting, 2008
Repairs to Secondary Spillway	$0.5M	USACE, 2012
Nature-like Rock Ramp & Lamprey Barrier	$2.9M	USACE, 2012
Passive Spillway	$2.3M	This study
Whitewater Bypass & Lamprey Barrier	$4.5M	This study

The six to nine feet of drop at the dam, the reliable summer time flows, and the amphitheater-like park setting, makes the Union Street Dam an ideal location for a high quality whitewater park. The Boardman River's hydrology is particularly strong, making the site unusually reliable and valuable.

Summer flows are higher than other rivers with similar drainage areas, and flood flows are lower than comparable streams. In particular, the means to exclude lamprey would be much more challenging on a larger river with more variation in flow, and we would not have the same level of confidence in its feasibility.

Figure 1 Project Site looking upstream from Union Street Bridge

Figure 2 Primary spillway head gates and stop logs

Project Need and Purpose

Background

Union Street Dam is an element in the Great Lakes Fisheries and Ecosystem Restoration Program for the Boardman River, now ten years in planning and implementation. The US Army Corps of Engineers (USACE) is the project lead. Traverse City is part of the Implementation Team (IT), because of its ownership of Union Street Dam and former Brown Bridge Dam. The restoration plan envisions removal or modification of three dams on the Boardman River, for the purpose of restoring cold water riverine habitat upstream of Traverse City. Under the plan the Union Street Dam is to be retained as a sea lamprey barrier. USACE proposes to pay for needed repairs to Union Street Dam and provide limited upgrades so as to improve downstream fish passage and lamprey exclusion. While the plan addresses overdue repairs to the auxiliary spillway, it does not deal with the functional challenges of the dam: chiefly the manual stop logs and the gated and piped spillways. The City commissioned this study to develop a concept for a whitewater recreation channel and passive spillway that is consistent with the goals of habitat restoration. This betterment plan would create an attractive whitewater river and active park in the midst of the City with improved lighting, landscaping and fishing opportunities; in addition to addressing the shortcomings of the existing dam.

Dam Safety, Maintenance and Operation

The 2008 inspection of Union Street dam reports that the dam is generally in good physical condition with the exception of the secondary spillway pipes. However, the gates and stop logs are functionally obsolete and the piped spillways with trash racks do not meet contemporary standards for adjustable spillways (fully automated or manually adjustable with remote operation). The documented need for repairs/new facilities include:

- Relining of the auxiliary spillway pipes.
- Installation of a properly engineered toe drain.
- Realigning the water main on the dam crest.
- Removal of trees and woody vegetation on the earthen embankment.
- Installation of a staff gage to monitor water elevations on Boardman Lake.
- Updating the operations plan to include operating the stop logs/spillway in the event of a flood emergency.

In addition there are operational difficulties and safety issues that are built into the existing design.

- The primary spillway gates, originally intended to control lake levels are reported to be difficult to operate. Lake levels are now controlled by manual stop logs, and they too, are difficult to operate.
- The current FEMA flood mapping assumes that the stop logs are removed in a flood event. Depending on the time of year the stop logs would have to be removed under potentially dangers conditions, i.e. high water, cold weather and ice, darkness, etc.
- The trash racks can clog with flotsam, reducing spill capacity in a flood.
- The existing portage takeout is too close to the auxiliary spillway-an unwary boater approaching the takeout can be swept over the stop logs and onto the trash racks. There has been a near drowning at the main spillway trash racks[1].

[1] Timothy Lodge, City Engineer, personal communication

Regulatory Background. Union Street Dam is classified as a high hazard, by Michigan DEQ due to its large storage capacity and the potential for property damage and loss of life in the event of a sudden failure. Because of this it is governed by Part 315, Dam Safety, of The Natural Resources and Environmental Protection Act, 1994 PA 451. DEQ requires that high hazard dams less than 40 feet in height safely pass the 200 year flood event. They prefer (but do not require) this to be done with "as little human intervention as possible,"[2] that is, by passive spillways. There are no current DEQ compliance or enforcement issues with the dam.

The possibility of a cost share from USACE has prompted the City to look beyond the proposed replacement in kind, and conduct re-visioning of the entire dam structure. The alternatives under consideration include:

1. Continued replacement and repair of the existing structure in kind. Immediate attention is needed to the auxiliary spillway discharge pipes, downstream fish passage, the water main, and the new toe drain. Future repairs to the primary spillway as needed. (USACE, 2012)
2. A new passive overflow that eliminates the need for gates, e.g. new labyrinth spillway or chute spillway. (STS 2008)
3. Nature-like rock ramp with downstream lamprey barrier (no longer considered because of flooding concerns with the lamprey barrier). (USACE, 2012)
4. Open spillway channel with natural features for fish passage and recreation, passive overflow auxiliary spillway (this study).

Aquatic Habitat Restoration/Nuisance Species

Maintaining an effective lamprey barrier at Union Street Dam is part of the Great Lakes Ecosystem Restoration Plan, which includes the planned removal of Sabin and Boardman dams and the removal of Browns Bridge Dam (completed 2013). Without the barrier, sea lamprey would have access to the upper Boardman River and tributaries. Lampricide treatment is both expensive and particularly difficult in Boardman Lake, so exclusion is the preferred method[3]. We have conducted preliminary outreach to USFWS, USACE and Michigan DEQ to familiarize ourselves with the project requirements and exclusion methods. The agencies have provided literature on the subject of lamprey exclusion and other whitewater parks in the state. A summary of agency consultation follows.

Existing Conditions

There is an understanding with Traverse City (but no formal agreement) that any changes to the Union Street Dam will maintain or improve on existing levels of lamprey exclusion.

- The existing exclusion levels are documented in USFWS' hydraulic analysis of the spillways and fish ladder (Stanley Consultants, 2013). The analysis shows that under existing conditions, (no stop log adjustment) effective lamprey barrier is maintained through 850 cfs (two year event) with marginal exclusion at 1,100 cfs (ten year event). At higher order events there is no documented effective barrier. (USFWS states that the report does not take into account the tailwater difference at the stop logs correctly, and that the actual exclusion is the five-year event. In addition, the velocities and turbulence in the pipes would also prohibit passage[4])
- The hydraulic analysis also indicates that improved performance can be achieved with active management of stop logs: Theoretical exclusion up to 1,500 cfs (25-year event) is possible by incrementally raising the logs at both spillways and the fish ladder. In practice however, this

[2] Jim Palowski (Michigan DEQ, Dam Safety), personal communication 2015.
[3] Gregory Kilgore, USFWS, personal communication, 2015
[4] Gregory Kilgore, USFWS, email correspondence, 2015

would raise water levels so as to overtop the dam. USFWS stated the height of the stop-logs have not been changed in years, thus the baseline exclusion level is assumed to be the five-year plus event.

Lamprey Exclusion

Figure 3 Sea Lamprey (Petromyzon marinus)

- Season: Migration season can begin as early as January (staging in river) and can run into the late fall. Peak occurs sometime around the end of May, stream temperature dependent.
- Hydraulic Range: Barriers are constructed to the fullest extent possible within site characteristics, cost, feasibility. Typically, that falls somewhere between the 10-25 year flood events, but it is not specified.
- Other Projects: The level and requirement for exclusion is done on a case-by-case basis:
    - Chesaning Dam. No exclusion due to the fact that the existing dam was not an effective barrier. The dam was replaced by a naturalistic fishway, aka, roughened rock ramp.
    - Grand Rapids whitewater project: USFWS has not received a proposed plan and therefore has not reviewed it and cannot comment on it. The plan proposes a velocity barrier by means of an Obermeyer crest gate. USFWS discourages the use of Obermeyers due to operations issues—a short downtime of only a few hours when lamprey are cued up to pass can result in an invasion.
    - Argo Dam bypass, Ann Arbor: No barrier since no nuisance species present.
- Velocity Barriers: USFWS is not aware of a successful velocity barrier in the Great Lakes system and has not approved any such means.
- The velocity barrier at the McCauley River in Ontario (1992) is reported to be a failed experiment. (USFWS sent a copy of the report following the meeting.)
- Flow separation, eddy currents and interference from sidewalls or debris can create slower water where lamprey can attain and attach.

Fish Passage

The USACE's Great Lakes Ecosystem Restoration Plan specifies passage for certain species and is open on others. The undefined species include native warm water, non-jumping fish such as walleye, smallmouth bass, etc. The concern is that passage for the non-jumpers would also pass sea lamprey. However, some members of the IT would like to have a fully passable dam and a connected river system. This issue should be resolved among project stakeholders in preliminary design. The Ecosystem Restoration Plan proposes passage for the species listed below:

- The most sensitive fish is the endangered lake sturgeon. These will be trapped and trucked around the dam to the upper Boardman.
- Non-native Atlantic salmon. To be trapped and sorted at the trapping weir and used for stocking/breeding at other streams. No passage.
- Non-native steelhead trout. Passage provided at the existing pool and weir fishway (or its equivalent in the whitewater channel).
- Downstream passage for all species. The approach to the open channel should have a gentle ramp up in order to guide bottom-swimming fish. Abrupt drops (such as at the lamprey exclusion weir) should have a deep plunge pool to help minimize impact of large fish on the bottom. (The deep pool will also provide jumping fish an acceleration zone when surmounting the vertical barrier.)

Recreation

Whitewater recreation is the main focus of the project and the purpose of this report is to provide an opinion on whether recreation is possible given the other constraints of the site, particularly lamprey exclusion. The desired recreational outputs that are possible include:

- Whitewater kayaking and canoeing: an open channel with abrupt drops and pools with hydraulics (waves and "holes") for use by properly equipped and knowledgeable private boaters with their own gear. A "whitewater park" as a destination for park and play boating—users drive to the site and perform tricks in the hydraulics.
- Through passage for open canoes: a portage path for carrying or lining an open canoe around the whitewater rapids. The abrupt drops themselves would likely cause an open canoe to swamp or capsize unless the participants have prior skill in whitewater.
- Waves for river surfing, a sport popular in Europe and experiencing rapid growth in the US.
- Tubing in multi-chambered inflatable craft, with participants wearing life jackets.
- Amenities on shore for watching and spectating: attractive lighting, furnishings, landscaping, paths and bridges.
- Increased footage of shoreline access for fishing.

Figure 4 Adjustable head gate at Boise River Park, Boise, ID. A similar gate could serve as a maintenance gate and primary velocity barrier at the entrance to the recreation channel. River board surfing is a fast growing segment of the whitewater park use and well suited to rivers with lower flows such as the Boardman.

Figure 5 Confluence Park, Denver CO. The dominant summertime use is tubing and inflatables.

Prior Studies/Information Gathering

Literature Review

The dam betterment project benefits from a trove of original data and information from the Great Lakes Ecosystem Restoration Project by the US Army Corps of Engineers. This quality and quantity of basin-wide data would normally be beyond the scope of a conceptual study of the Union Street Dam. A partial list of data received, with summary bullets, includes:

FEASIBILITY STUDY FOR THE BOARDMAN RIVER with technical appendixes , USACE, 2014

- Final conceptual plan for removal of three dams and modification of Union Street Dam
- Union Street dam plan calls for rebuilding / repairing the existing spillway and installing a trap and truck fish passage facility for lake sturgeon at a downstream location.
- Includes an alternate plan for a rock ramp replacement of the existing earth dam with separate lamprey barrier at an unspecified downstream location. (This plan was dropped from consideration to the excessive height of the structure would negate any benefits of the rock ramp as well as raise the regulatory floodplain.)

BOARDMAN RIVER PLAN, University of Michigan School of Natural Resources and Environment, 2013

- Includes a conceptual plan for recreational whitewater bypass at Union Street Dam (Cites Confluence Park in Denver, CO as a project precedent)
- Proposes new boardwalk on the north bank connecting to Hannah Park, , enhanced public space and park atmosphere

FIXED-CREST BARRIER DESIGN CRITERIA V4 Great Lakes Fisheries Commission, (undated)

- Outlines protocols for plunging type fixed weirs to exclude lamprey
- Does not include velocity barriers

SAFETY INSPECTION OF UNION STREET DAM, STS/Michael Carpenter PE, 2008

- Enumerates list of needed repairs including relining the auxiliary spillway pipes and a new toe drain.
- Suggests either a new passive spillway or an open recreation channel/spillway.

SEA LAMPREY BARRIERS: NEW CONCEPTS AND RESEARCH NEEDS Chris Katopodis, Ellis K Moon, Lee Hansen, 1994 for the Great Lakes Fisheries Commission

- Provides swimming data for sea lamprey and other species—useful in planning for velocity barriers.

Union Street Dam, Inspection Services, Task 5.1- Inspection Report, Task Order No. F12PD00574, Stanley Consultants (Bill Holman P.E.), 3/20/2014 for US Fish and Wildlife Service

- Provides background hydrology and hydraulics for the site
- Describes a detailed hydraulic analysis of the effectiveness of lamprey exclusion of existing the primary and secondary spillways and the fish ladder under a variety of stoplog settings.

- Concludes that with stop-logs left in place (no management of lake levels) the USFWS lamprey criteria are met up to 850 cfs.[5]
- Concludes that active management (raising and lowering stop-logs) the USFWS lamprey criteria can be theoretically met up to 1500 cfs. However this practice would overtop the earthen dam crest at higher flows.

Drawing Data

- Drawings provided by the City include
- Design drawings of Union Street Dam Fish Passage (Mead and Hunt, Inc., 1986)
- Design drawings of Union Street Dam spillway (Consumers Power Co. 1965)
- Base mapping, AutoCAD format

Hydraulic Model

HecRAS model of entire Boardman River
HecRAS model detail of the Union Street Dam

[5] See following section on Hydrology and Hydraulics

Hydrology / Hydraulics

Hydrology

Discharge of the Boardman River is measured at the USGS gage station #04127000, at Mayfield (1952 to 1989) and USGS gage station # 04126970 at Brown's Bridge (1997 to 2014)
Browns Bridge drainage 141 square miles
Mayfield drainage 182 square miles
Contributing drainage area of the site, approximately 275.5 square miles[6].

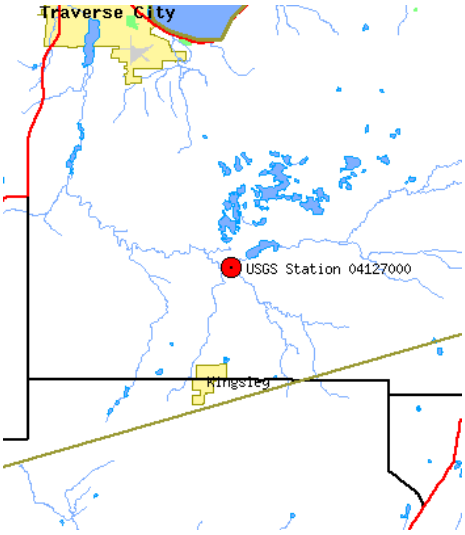


Figure 6 location map of USGS Browns Bridge gage 0412700.

	January	February	March	April	May	June	July	August	Septembe	October	November	December
90 Percentile	193	191	206	259	229	209	183	167	165	175	187	193
75 Percentile	215	213	236	313	268	236	207	195	191	206	217	221
50 Percentile	246	242	277	388	318	271	239	225	226	248	264	259
20 Percentile	295	291	366	516	395	333	285	271	278	307	335	330
5 Percentile	349	356	539	709	493	462	358	331	389	405	437	419

Figure 7 Table of proportioned flow at the Union Street Dam (1952 to 2014). Gaged flow x 195.4% (Browns Bridge) to 151.4% (Mayfield) to account for the added drainage at the project site.

Exceedance	Discharge (CFS)
90 percentile	183
75 Percentile	213
50 Percentile	254
20 Percentile	327
5 Percentile	463

Figure 8 Table of overall yearly exceedances, Browns Bridge and Mayfield gages, proportioned to the added drainage of the project site.

[6] Michigan DEQ, 2015, Appendix 1

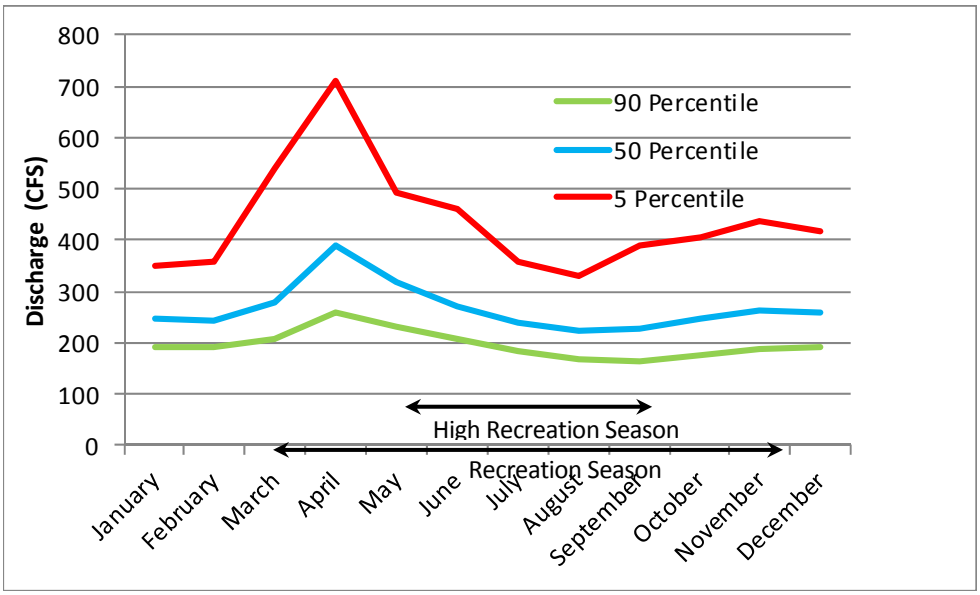


Figure 9 Graph of flow exceedance at the site

Discussion

The river's hydrology is notable for the unusually narrow range between the 10th and 95th percentile discharges. This will make the site more predictable and reliable—two factors which would encourage visits from out of town, especially those for overnight stays. Also notable are comparatively high flows in the summer—these exceed rivers in other parts of the country with much larger drainages.

Recreation Hydraulics

Flow in man-made whitewater courses typically ranges from 150 cfs to over 1,000 cfs, depending on the availability of water at the particular river. The Boardman River is in the lower quartile of flow for whitewater parks but is nonetheless a viable site. Likely uses for the park include:

Whitewater canoe passage

- Introductory kayaking and "play-boating" (i.e. surfing on standing waves)
- Stand-up paddleboards
- River surfing
- Tubing[7]

Hosting advanced whitewater boating or high level competitive events would benefit from special water releases from Boardman Lake[8]. Nonetheless, high quality recreation experience can be derived from modest flow, particularly in the realm of river surfing, pictured below. For the Union Street dam bypass we propose a functional flow of 200 cfs to 500 cfs with a median of 260 cfs.

7 Provided that participants are required to have multi-chambered floatation device and Coast Guard approved personal floatation devices.

8 Special releases of on the order of 500 cfs would be possible by lowering the entrance gate and drawing on the storage of Boardman Lake. In this event there would need to be a procedure for recharging the lake without unduly reducing in-stream flow. Our preliminary estimate shows that a release of 250 cfs additional flow (over incoming flow) would lower the Boardman Lake less than 1 inch per hour. Such releases would need to address regulatory concerns and possible negative perceptions among lakefront interests.

Flood Hydraulics

Background. The current State of Michigan standard for spillways at high hazard dams 40 feet or less in height is the 200 year flood event. This flow therefore, will govern the design. Two HEC-RAS hydraulic models were provided to us by AECOM, USACE's consultant for the Great Lakes Ecosystem Restoration Project: one overall model and one for the Union Street dam. The later was developed by USACE/AECOM for the alternative rock ramp concept for Union Street Dam. We employed the Union Street model to develop existing conditions headwater and tailwater tables as a basis for the pre-design hydraulic work for the spillway and white water passage.

Existing Conditions - From HEC-RAS				
Flow (cfs)	Flow Event	Headwater Elevation (Feet)	Tailwater Elevation (Feet)	MDEQ Event
150	N/A	589.69	580.03	
250	N/A	589.85	580.56	
500	N/A	590.18	581.67	
850	2-yr	590.55	582.90	
1100	5-yr	590.78	583.66	
1300	10-yr	590.96	584.23	1200
1500	25-yr	591.12	584.75	
1600	50-yr	591.2	585.00	1700
1800	100-yr	591.4	585.48	1800
1900	200-yr	591.68	585.71	2000
2100	500-yr	592.44	586.14	2400

Figure 10 Existing conditions headwater and tailwater table

The existing conditions model assumes that all stop logs are removed during flood events. However, this may not actually be practiced. A further conflict we note is that the hydraulic analysis for lamprey exclusion (Stanley Consultants, 2013) recommends that the stop logs be in place during certain higher flows in order to meet minimal exclusion hydraulic criteria. Therefore the table above is the best case scenario. Additionally, debris accumulating on the trash racks may further reduce spillway capacity. The removal of the two upstream dams are reported to have negligible effect on the higher order floods but will likely affect the one and two-year events and lower[9]. MDEQ provides up to date regulatory flood flows at any river station upon request. Such a request should be made at the beginning of preliminary design.

Proposed Hydraulics

The alternatives presented in the next section have the potential to maintain or improve the hydraulics of the dam with respect to:

- Flood capacity of the spillway
- Lake levels
- Lamprey exclusion

A basic hydraulic analysis of each of the alternatives was estimated with weir formulas and hand calculations since a full analysis is beyond the scope of this study and beyond the capabilities of HecRAS. The next phase of work should include one and two-dimensional analysis of the selected alternative(s) and a preliminary design.

[9] Troy Naperala, AECOM, personal communication, 4-23-15.

Alternative Descriptions

General

The conceptual alternatives focus primarily on basic hydraulics of the dam:

- Meeting accepted safety criteria for boating
- Meeting current low head, high hazard dam safety standards for spillway capacity (200 year event)
- Meeting or exceeding the lamprey exclusion level of the existing dam.
- Providing passage for jumping fish species (steelhead)
- Providing downstream fish passage
- Providing diverse recreational uses

Of these, the most challenging is the lamprey exclusion. A common thread of the presented alternatives is that the low flow lamprey exclusion is at the upstream-most end of the recreation channel, and flood conveyance is directed around the low flow barrier, not through it. This is a fundamental hydraulic principal that helps minimize the backwater effect from flooding at the low point in the barrier and its corresponding height. It also maximizes the amount of vertical drop available to the recreation features. This is in contrast to the prior studies that placed the lamprey exclusion downstream, and in-line with flood flows. The prior studies found that backwater effect from flooding necessitated an inordinately tall barrier leaving little, if any drop, for the recreation features.

The scope of this study included a concept level hydraulic analysis employing weir formulas for preliminary spillway sizing. The existing conditions HEC-RAS model developed by USACE was used for the headwater and tailwater ratings. The next step in project development would include a full hydraulic analysis of the spillways and open channels employing one and two dimensional hydraulic modeling. Full hydraulic analysis is beyond the intended scope of this study.

Site amenities, where shown on the accompanying figures are illustrative only. They are important to the public enjoyment of the space, but they are independent of the feasibility of the dam rehabilitation. Selection of the amenities for the public space itself should be done with stakeholder input and designed by a qualified landscape architecture / planning firm.

Alternative 1Basic University of Michigan Scheme –AS PRESENTED 4-23-15

1. Reconstruct the primary spillway as a secondary (flood) spillway to extend its life and improve its functionality:
    a. Replace slide gates with automated (or manual) overshot gates
    b. Install new trash racks with lower slope to improve safety (impingement)
    c. New catwalk and railing for rack cleaning and gate actuators
    d. Extend gate bays upstream of piped inlet to accommodate longer profile of overshot gates and low slope trash racks
    e. Relining of existing piped discharges as required
2. Whitewater recreation / fish passage channel parallel to the south shoreline, approximately 400 feet in length and extending upstream into the Boardman pool– adjacent to residential property

3. Lamprey exclusion consists of three abrupt velocity barriers in series with the tallest and most effective at the upstream-most drop. The drops also provide whitewater hydraulics conducive to "park and play" boating and river surfing.
4. Modulating entrance gate for maintenance and variable recreational hydraulics e.g. adjustability from green wave to retentive hole.
5. A non-overtop divider island with bank fishing
6. Approximate 130-foot long passive spillway with:
    a. Stepped profile to reduce the possibility of overly-retentive hydraulics
    b. Overhanging rim and vertical plunge that conforms to accepted lamprey exclusion methods
7. Portage and fisherman access path along the left bank with a canoe takeout at upstream end and put-in at the downstream end
8. Minimal river park area adjacent to WW park
    a. Retaining walls as required along left (south) shoreline in order to meet existing grades
    b. Short (economical) pedestrian bridge to the earth dam
    c. Connections to existing boardwalks and extensions of the river boardwalk upstream to Cass Street

Merits and Demerits of Alternative 1

Positive	**Negative**
Simple layout	Velocity barrier does not have a record of being permitted in MI
Improved canoe portage	Abuts residential property
Entrance gate allows for special water releases	Existing water main alignment is on top of dam crest—requires considerable lateral relocation
Increased frontage on river for fishing	Requires active gates for flood flows
Pedestrian bridge is short and cost effective	Rehabilitation of primary spillway gate bays may not be economical if hidden deficiencies are discovered
	May require river bottom land acquisition
	Active spillway gates may not meet existing lamprey exclusion levels

Alternative 1B Refinement of University of Michigan Scheme

1. Refinements include:
    a. Eliminates the active gates-- entirely passive longer spillway
    b. Entire project footprint shifts west and north to reduce crowding of the south (residential) shoreline and crowding of the Cass Street bridge.
2. Whitewater recreation / fish passage channel parallel to the south shoreline, approximately 400 feet in length and extending upstream into the Boardman pool– adjacent to residential property.
3. Lamprey exclusion consisting of three velocity barriers in series with the largest and most effective at the upstream-most drop. The drops also provide whitewater hydraulics conducive to "park and play" boating and river surfing.

4. Modulating entrance gate for maintenance and variable recreational hydraulics e.g. changeability from green wave to retentive hole. This is the final line of defense against lamprey.
5. A non-overtop divider island with bank fishing
6. Approximate 200-foot long passive spillway with:
    a. Stepped profile to reduce the possibility of overly-retentive hydraulics
    b. Overhanging rim and vertical plunge that conforms to accepted lamprey exclusion methods
7. Portage and fisherman's access path along the left bank with a canoe takeout at upstream end and put-in at the downstream end
8. Park improvements including
    a. Pedestrian bridge to north shoreline with fishing overlook and access to the island
    b. Connections to existing boardwalks and extensions of the river boardwalk upstream to Cass Street

Merits and Demerits of Alternative 1B

Positive	**Negative**
Simple layout with predominantly passive spillway	Velocity barrier does not have a record of being permitted in MI
Improve canoe portage	Abuts residential property
Entrance gate allows for special water releases	Requires lateral relocation of water main—existing alignment penetrates dam cut-off wall
Increased frontage on river for fishing	Pedestrian bridge is lengthy (expensive)
	May require river bottom land acquisition

Alternative 2 Accepted Lamprey Barrier

1. Whitewater recreation / fish passage channel in the middle of the river, approximately 300 feet in length beginning at the approximate centerline of the existing dam
2. Long semicircular passive weir with hydraulic profile (18" vertical plunge) and geometry (overhanging lip) that conforms to accepted lamprey exclusion methods. Note that the weir is low hazard but is not intended to be boatable or have recreational value.
3. Automated crest gate to keep the hydraulics of the lamprey exclusion weir within acceptable standards for boater safety, i.e. limiting the amount of water going over the rim and the amount of vertical drop. Note that the gates may not be required to be lowered in order meet accepted lamprey exclusion—however, they are required to meet boater safety standards.
4. Significant park development on both sides of river adjacent to recreation channel. Includes connection to all existing boardwalks and trails and extensions of the river boardwalk upstream to Cass Street.
5. Continuous portage path along the left shore beginning upstream of the automated spill gates and continuing downstream to a launch beach. A canoe lining channel is adjacent to much of its length.

Merits and Demerits of Alternative 2

Positive	**Negative**
Uses agency-approved method of lamprey exclusion	Only two whitewater drops

Lamprey barrier does not rely on automated gates	Entrance feature has no recreational value and is not intended to be run in a boat. Does not allow through passage from lake
Improved canoe portage	Requires automated crest gates for flood control and to meet boater safety criteria
Automated crest gates allow for a narrower range of water levels for Boardman Lake	May require river bottom land acquisition (for entrance weir)
Increased frontage on river for fishing	Long pedestrian bridge required to cross river
Significant parkland development both sides of river adjacent to whitewater course	Hardened spillway through park
Majority of park frontage is on public property	
Only minor lateral realignment of water main needed	

Alternative 3 Maximum Development

1. Whitewater recreation / fish passage channel parallel to the north shoreline, approximately 400 feet in length and extending upstream into the Boardman pool.
2. Lamprey exclusion consisting of three velocity barriers in series with the largest and most effective at the upstream-most drop. The drops also provide whitewater hydraulics conducive to "park and play" boating and river surfing.
3. Modulating entrance gate for maintenance and variable recreational hydraulics e.g. adjustability from green wave to retentive hole. This is the final line of defense against lamprey.
4. A non-overtop divider island with bank fishing
5. Passive spillway crest with:
    1. Stepped profile to reduce the possibility of overly-retentive hydraulics
    2. Overhanging rim and vertical plunge that conforms to accepted lamprey exclusion methods
    3. Pedestrian-friendly crest (it is dry 95% of the time)
6. Automated crest gates to pass flood flows and to regulate lake levels to a narrower band than existing conditions.
7. Significant park development on both sides of river adjacent to recreation channel and upstream. Includes connection to all existing boardwalks and trails and extension of the river right boardwalk east to Cass Street.
8. Kiddie splash channel (doubles as a canoe lining channel)
9. Continuous portage path along the left shore beginning upstream of the automated spill gates and continuing downstream to the launch beach. A canoe lining channel is adjacent to much of its length.

Merits and Demerits of Alternative 3

Positive	**Negative**
Predominantly passive spillway (with additional length it could be all passive, though this would take away park land)	Velocity barrier does not have a record of being permitted in MI
Improved canoe portage	Abuts private (church) property
Entrance gate allows for special water releases	Requires lateral displacement of water main—existing alignment penetrates dam cut-off wall

Increased frontage on river for fishing	Long pedestrian bridge required to cross river
Does not abut residential property	May require river bottom land acquisition
Increased frontage on river for fishing	Hardened spillway through park
Automated crest gates allow for a narrower range of water levels for Boardman Lake	Requires automated crest gates for flood control (or sacrifice of park space for additional passive weir)
Significant parkland development both sides of river adjacent to whitewater course	

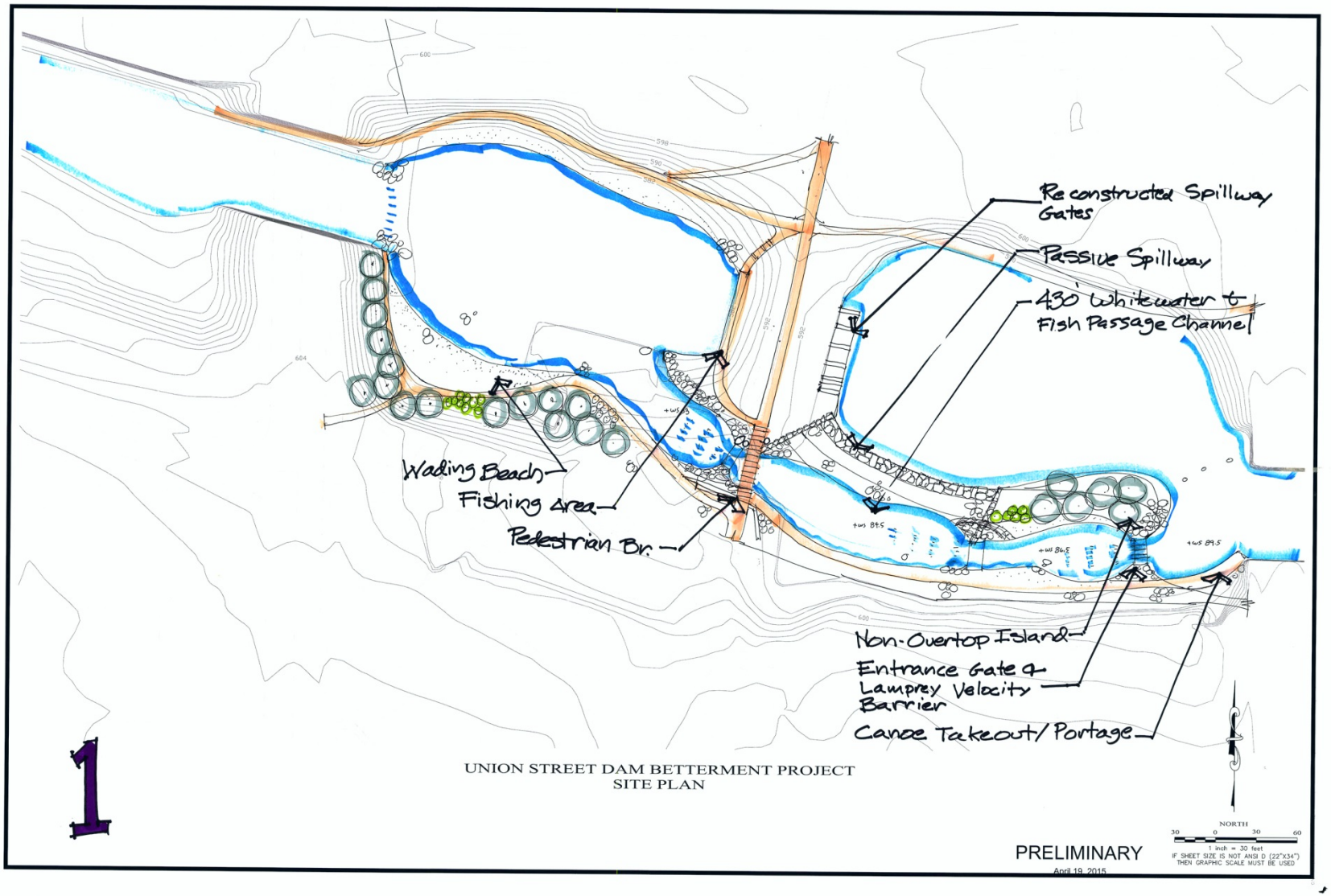


Figure 11 Alternative 1, Refinement of University of Michigan Scheme

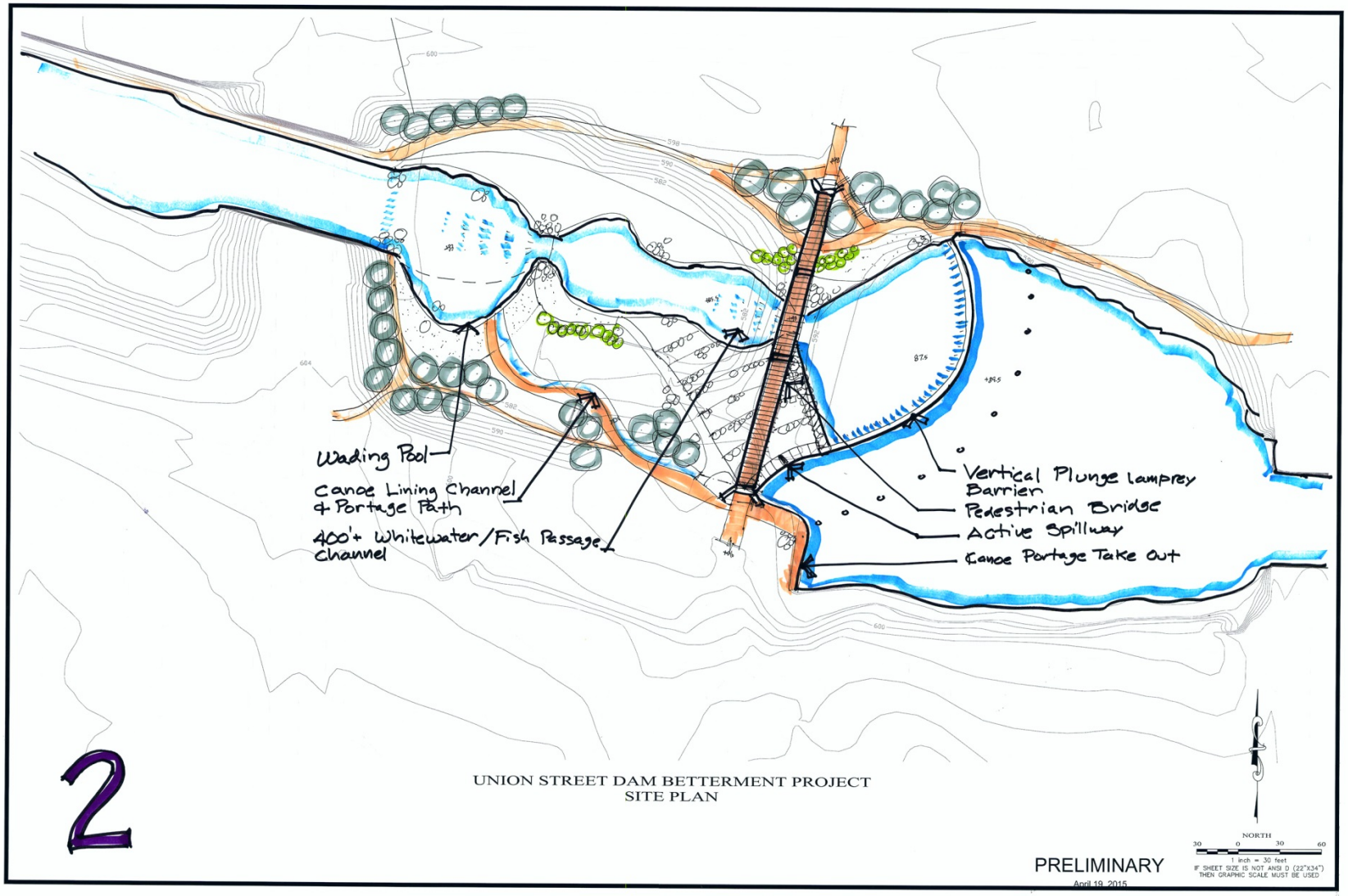


Figure 12 Alternative 2, Middle of River. Utilizes a plunge type weir

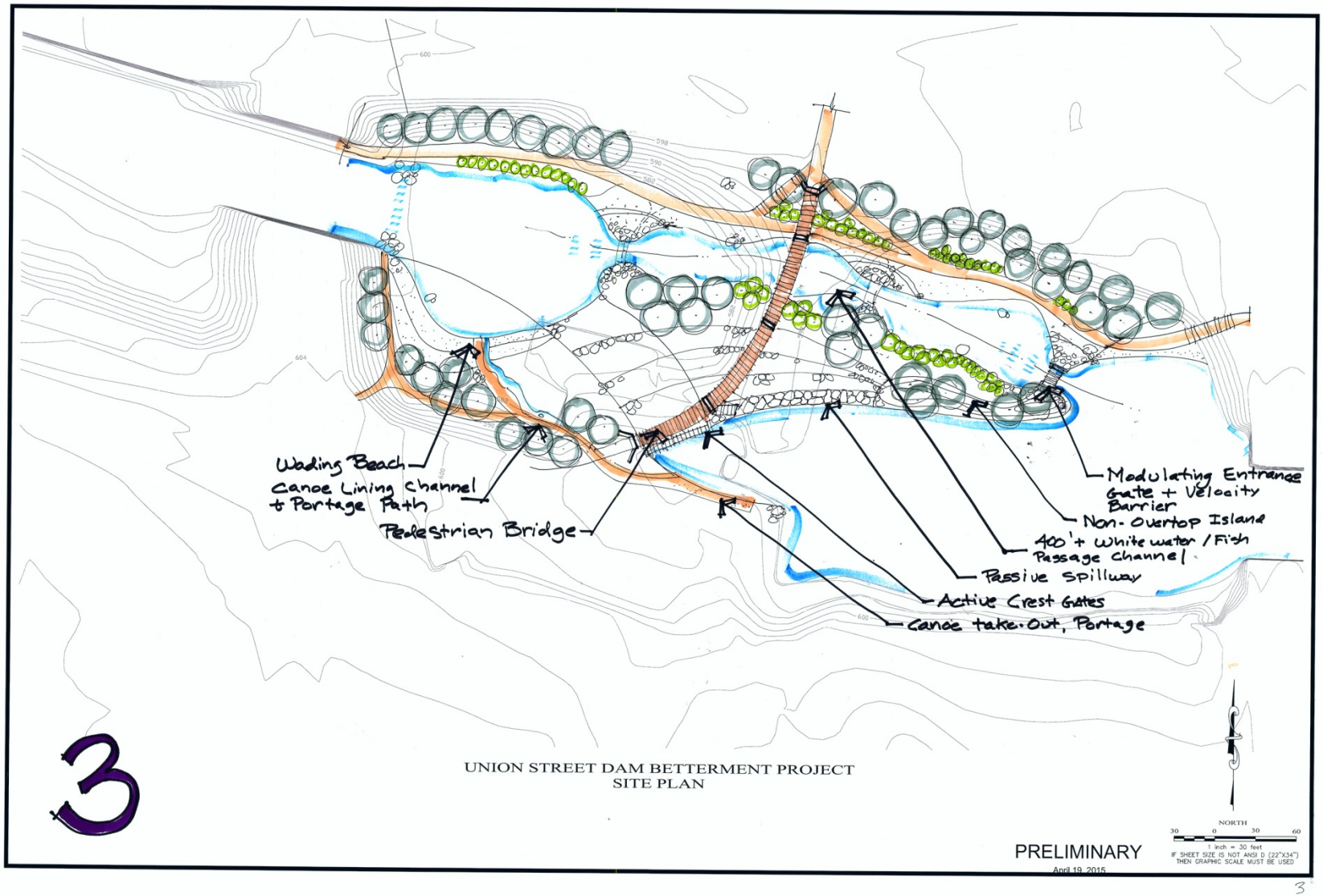


Figure 13 Alternative 3, Maximum Development

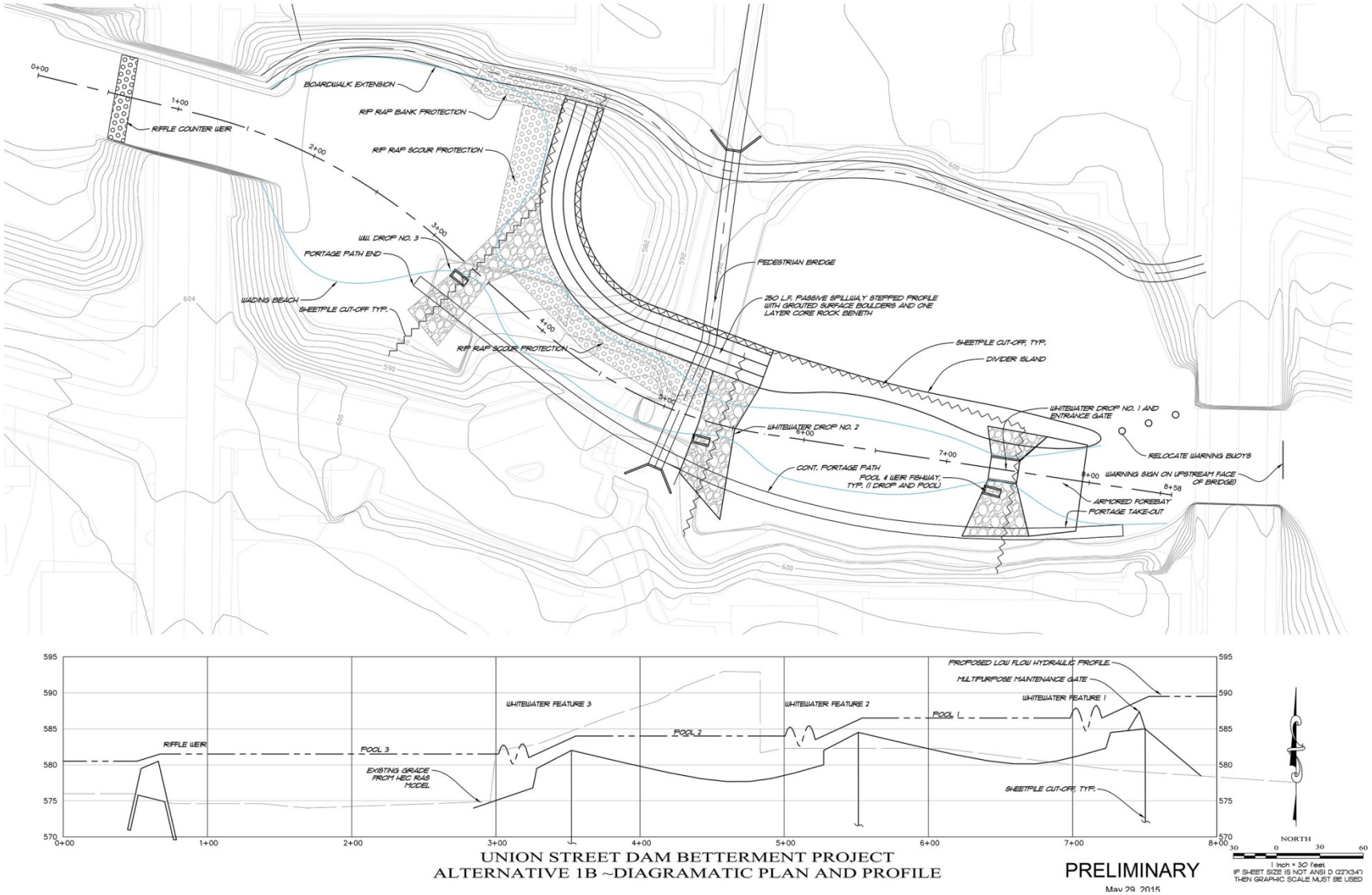


Figure 14 Alternative 1B, Refinement of Alternative 1

Budget Estimate

Because of its apparent simplicity, Alternative 1B is the recommended project and was selected for budget analysis. For comparison, we also analyzed Alternative 1A, and found to be nearly identical in cost to Alternative 1B. The City provided current local unit costs for materials commonly used in dams: concrete, quarried rock, rip rap, glacial boulders, etc. Costs of rock and concrete in particular, were found to be significantly higher than in other US markets.

The budget costs presented below assume that the project is to be constructed in next 12 months, without escalation. Also excluded are:

- Lands acquisition, easements, and damage to private property
- Boardwalk on the north side of river
- Buildings
- Utility relocation

	Base Estimate	GC's, Bonds, Mobil.	AE design/permitting	Contingency	Project Budget
		15%	25%	25%	(Rounded)
Alt 1B Passive Spillway and Dam	$ 1,260,000	$ 189,000	$ 362,250	$ 452,813	$ 2,300,000
Whitewater Channel	$ 2,520,000	$ 378,000	$ 724,500	$ 905,625	$ 4,500,000
Park Improvements	$ 440,000	$ 66,000	$ 126,500	$ 158,125	$ 800,000
Total	***$ 4,220,000***	***$ 633,000***	***$ 1,213,250***	***$ 1,516,563***	***$ 7,600,000***
Alt 1 Rehab Primary Spillway	$ 1,280,000	$ 192,000	$ 368,000	$ 460,000	$ 2,300,000
(not recommended)					

Figure 15 Summary of Cost Analysis

Limitations

Cost estimates are our opinions of probable costs. Cost estimates are made on the basis of our experience and represent our best judgment. We have no control over cost of labor, materials, equipment, contractor's methods, or bidding or market conditions. Therefore, we do not guarantee that proposals, bids, or actual construction costs will not vary from estimates of project costs, construction, and / or operation and maintenance costs presented. In addition, a large portion of the project cost lies in dewatering and water control. These costs are the least predictable because they are wholly the responsibility of the contractor. We therefore treat these costs as lump sum allowances. Unfavorable market conditions where three or fewer bids are tendered, may also negatively affect costs.

Union Dam Betterment May, 2015	Unit	Unit $	Quan.	Cost	Notes
Alternative 1B Passive Spillway					
Sheetpile cut-off, dam crest to divider island	SF	30	8100	$ 243,000	30' deep x270'
Sheetpile cut-off, downstream toe of dam, (incl ww drop 3)	SF	30	6780	$ 203,400	30' deep x 226
Toe scour protection d.s. spillway (in river)	CY	85	607	$ 51,567	1820 sf plan area x 3' deep rip rap
Toe scour protection d.s. spillway (adjacent to ww course)	CY	85	1300	$ 110,500	3900 sf plan area x 3' deep face boulders
Bank rip rap d.s. dam river right	CY	85	482	$ 40,942	1445 sf plan area x 3' deep rip rap
Conc dam cap and overhang and lip	CY	350	178	$ 62,222	200lfx 4' widex 6' tall
Grouted glacial rock spillway facing	CY	350	574	$ 200,926	6200 sf x 2.5' thick
grouted core rock 1 layer 2' rock under face rock	CY	210	459	$ 96,444	same plan area as facing
Conc demolition of fishladder	CY	32	60	$ 1,920	dispose on site as struct fill
Conc demolition of secondary spillway	Lump	30000	1	$ 30,000	dispose on site as struct fill
Conc demolition of primary spillway and stop logs	Lump	10000	1	$ 10,000	to el. 86 dispose on site as struct fill
excavate earthern dam and use on site	CY	1296	5	$ 6,481	to el. 86, use as struct fill
demolish sheet pile walls + recycle	SF	5	12000	$ 60,000	assumes salvage 600 lf x 20
Dewatering and water control	Lump	100000	1	$ 100,000	
Loose rock counterweir	CY	65	256	$ 16,611	115sf x section x 60'
Site restoration	Lump	1	25000	$ 25,000	
Subtotal to Summary				**$ 1,259,014**	
Whitewater Channel and Divider Island					
Automated maintenance gate w controls	SF	500	80	$ 40,000	16x5
Sill and abutments for gate	CY	800	27	$ 21,600	37 Sfcross section x 20' long
Demolish condo docks	Lump	10000	1	$ 10,000	
Mass earthwork cut and haul off	CY	0		$ -	none-use on site
Glacial boulder bank protection and fabric	CY	265	481	$ 127,593	325 lf x 20'wide, 2' deep
Overexcavation for bank protection	CY			$ -	(none)--place rip rap over ex grade
river cobble liner for channel	CY	65	852	$ 55,370	23000 sf plan area 1' thick
rip rap liner of forebay 2' thick	CY	85	185	$ 15,741	2500 sf plan area 2' thick
Grouted rock for sills single layer	CY	365	2567	$ 936,833	7700 sf plan area
Warning, directional signs on Cass Street bridge	Allowance, e	4000	1	$ 4,000	
Canoe takeout-put in	Allowance, e	6000	2	$ 12,000	
Buoys--relocate existing	Lump	1000	1	$ 1,000	
Sheetpile cut-off, divider island and entrance feature	SF	30	8550	$ 256,500	30' deep x 285'
Sheetpile cut-off, intermediate cut off at drop no. 2	SF	30	3960	$ 118,800	30' deep x 132'
Qarried rock fill of divider island	CY	152	3407	$ 517,926	400sf x section x 230' long
planting pockets	Ea	2000	0	$ -	not included
Portage path	CY	375	185	$ 69,444	500 lf x 8' wide w 2' turn down 1' thick, all
Fill import	CY	83	3407	$ 282,815	rip rap fill under pool no 1 400 sf x section X 230 l.f.
Pool and weir fishways	CY	800	20	$ 16,000	1 drop and pool at each ww feature
Dewatering	Lump	30000	1	$ 30,000	some included in the dam project
Subtotal to Summary				**$ 2,515,622**	
Landscape and Site improvents					
Pedestrian bridge	SF	130	2300	$ 299,000	10' wide, 230' long
Bridge abutments	CY	600	80	$ 48,000	4 abutments about 20 cy ea
Landscaping and site furnishings	Acre	60000	1.5	$ 90,000	
Boardwalk	SF	0	0	$ -	Not in project
Subtotal to Summary				**$ 437,000**	
Alternative 1 Rehabilitate Primary Spillway Gates	Unit	Unit $	Quan.	Cost	Notes
Conc vert walls, heavy reinf (6 ea.)	CY	800	92	$ 73,333	(6) walls 18" thick x34'long x sloped profile, 275 sf in elevation
Conc floor	CY	800	113	$ 90,667	34' long x 1.5 thick x60'wide
Obermeyer gates	SF	500	570	$ 284,813	10.5 long x 10.75' tall 5 each
Stop logs (for inspection and maint. only)	SF	35	550	$ 19,250	heavy timber?
Walkway grating	SF	50	900	$ 45,000	15X60
Bar racks	SF	35	1313	$ 45,938	25'x10.5 w x5
Guard railing	LF	35	90	$ 3,150	
Demolition	lump	10000	1	$ 10,000	remove slide gates, actuators bar racks
Dewatering and water control	lump	50000	1	$ 50,000	
Toe drain	lump	60000	1	$ 60,000	(STS, 2008 report)
100 lf passive stepped spillway as in alt 1B	LF	6000	100	$ 600,000	rounded cost from Alt 1B
Subtotal to Summary				**$ 1,282,150**	

Figure 16 Detail of Cost Analysis

Appendixes

1. Flood Discharge Request Record
2. PowerPoint April 23, 2015

Flood Discharge Request Record 20150144

6/1/2015

Discharge Information

Watercourse:	BOARDMAN RIVER		
Location:	Union Street Dam	Drainage Area:	275.47 mi^2
Basin Name:	09 - Boardman	Contributing Area:	213.52 mi^2
County:	Grand Traverse	Tn/Rng/Sec:	27N11W/03
Township:	City of Traverse City	Latitude:	44.761667
Quad Name:	Traverse City SE	Longitude:	-85.621667
Quad ID:	K20SE		
Requested By:	Jim Pawloski (DEQ-LWM)	Received Date:	3/31/2015
Request Type:	Dam	Issued Date:	4/1/2015
File Number:	20150144	Reference Number:	h-99263

Discharge Frequencies:		Volume Frequencies:	
10%:	1200 cfs		
2%:	1700 cfs		
1%:	1800 cfs	1%:	
0.5%:	2000 cfs	0.5%:	
0.2%:	2400 cfs		

Access to the Flood Flow Database is provided as a service to allow you to check the status of your flood flow requests or to view discharges from previous requests for preliminary design purposes. The discharges values are only valid for the original requestor and for one year after the original request date. To obtain discharge information from the Hydrologic Studies Program, a flood flow discharge request form may be submitted electronically to the DEQ. A written or email response to your request will be returned to you and must accompany your permit application.

UNION STREET DAM BETTERMENT PROJECT

City of Traverse City, Michigan

April 23, 2015

McLaughlin Whitewater
design group

Project Purpose

1. Improved Recreation and Access
   a) Whitewater Bypass Through Dam
   b) Improved Fishing Opportunities
   c) Enhanced Park Atmosphere (seating, viewing, recreation activity areas)
2. Enhanced Fish Habitat/Facilities
   a) Downstream Fish Passage
   b) Upstream Fish Passage (Jumping fish only)
   c) Effective Lamprey Exclusion
3. Accomplishes Needed Dam Repairs/Upgrades
   a) New passive spillway (200 year event)
   b) Eliminates manual gates
   c) Enhanced lake level control
4. Coordinated With Water Main Relocation

Whitewater can be part in town's image

LEDGER-ENQUIRER SUNDAY, FEBRUARY 22, 2009

TRAVEL

THE MILE HIGH CITY

Denver has a lot to offer for frugal travelers

By Catherine Tsai
Associated Press

DENVER

Denver and the Rocky Mountains are tailor-made for frugal vacations. Scenic campsites, decent fishing, hunting, rock climbing, rafting and hiking are all within an hour's drive.

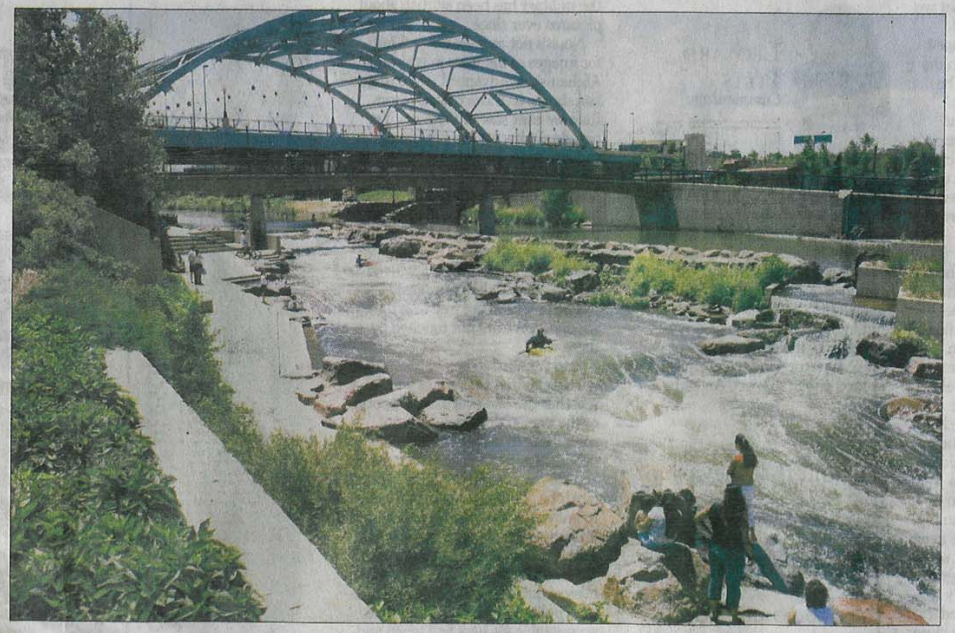
And depending on the time of year, you can find free skiing, hotel rooms at deeply discounted prices, and breaks on meals at the Mile High City's finest dining establishments.

Getting around

City buses run between Denver International Airport and downtown for $10 each way, $18 roundtrip, with discounts for senior citizens and students up to the 12th grade.

Generally, bus fare around town is $2 per trip, and day passes are $6; http://rtd-denver.com/.

Downtown, you can easily get by with a little stamina, good walking shoes and a free shuttle that runs up and down the 16th Street Mall from the gold-domed state Capitol to Union Station in the hip Lower Downtown neighborhood known as LoDo.



ED ANDRIESKI The Associated Press

Park goers watch from the banks of the Platte River at Confluence Park in Denver as a couple of kayakers make their way through the white water. Denver has more than 200 parks, rivers and trail areas, public golf courses and recreation centers.

Sloan Lake northwest of downtown hosts an annual Colorado Dragon Boat Festival: Teams of paddlers from across the nation race to the beat of drums in celebration of a centuries-old Chinese tradition.

STATE CAPITOL: Climb to the gold-covered dome for a 360-degree view of Denver and

U.S. MINT: Tours of the U.S. Mint are offered free from 8 a.m. to 2 p.m. weekdays, excluding federal holidays. Reservations are required.

DENVER ART MUSEUM: True, adult general-admission tickets are usually $10 for Colorado residents or $13 for everyone else. But on the

RUBY HILL RAIL YARD: Weather permitting, the Denver Parks and Recreation Department has been erecting rails in Ruby Hill Park for snowboarders and skiers to practice their tricks for free on what was traditionally a neighborhood sled hill.

field are just $4 apiece, unless you're age 12 and younger or age 55 and older, in which case you can get one for $1.

After the game, visit the nearby El Chapultepec jazz club. The seats are weathered, space around the bar gets crowded, and the food is best left for after you're well on the

Food and drink

Carts along the 16th Street Mall offer fare like hot dogs, paninis, burritos and barbecue.

McCormick's Fish House & Bar, 1659 Wazee St., attached to The Oxford Hotel downtown, has a happy hour every day from 4 p.m. to 6 p.m. (and another happy hour later at night) with items like a half-pound cheeseburger and fries for $1.95. Even ahi burgers are less than $5. And here's a special many locals don't know: If there's fresh snow hitting the ground, you can get an Irish coffee for $1. The Walnut Room, 3131 Walnut St., offers Pabst Blue Ribbon for 50 cents after 9 p.m. Wednesdays.

During Denver Restaurant Week, Feb. 21-27, you can find meals for two at fine-dining spots like Mizuna, Vesta Dipping Grill and Elway's for $52.80, a nod to the city's elevation at 5,280 feet above sea level. Tax and gratuity are extra. This year, nearly 200 restaurants are participating.

Where to stay

Generally, rooms are cheaper farther from the downtown core. But avoid the hostels. Splurge on a hotel.

If you happen to be in town in the weeks before Christmas, December can be slow for convention business, so several Denver hotels in recent years have signed on to offer rates of $52.80 during the early winter holidays. This is your cue to call The Oxford Hotel, a big

Economic Impact of Whitewater

Confluence Park,
South Platte River
Denver Colorado

- Before (1966):

Today: centerpiece for sports stadiums, amusement park, residences, and "walkable" retail

Confluence Area, Denver Return on Investment

Project Funding

• Public	$ 55 m
• Private/Corporate	15 m
Cost to Date	$ 70 m

Private Investment

• Coors Field	$ 220 m
• Pepsi Center	175 m
• Invesco Field	350 m
• R.E.I.	35 m
• Six Flags Elitch Gardens	110 m
• Aquarium, Children's Museum	120 m
• Residential Development	3 billion
Investment to Date	$ 4 billion

Source: South Platte River Greenway Central Platte Valley Investment Summary (10/06)

Anatomy of a Whitewater Park

- **Man-made rapids**
- **Whitewater play spots**
- **Continuous river-edge trail (portage / fishing access)**
- **Shoreline viewing**

Whitewater Trends – Youth Activity

Whitewater Trends – Kayak Play Spot

Retentive wave or "hole"

Whitewater Trends River Surfing

Green Waves ~ Adjustable Waves

River Events

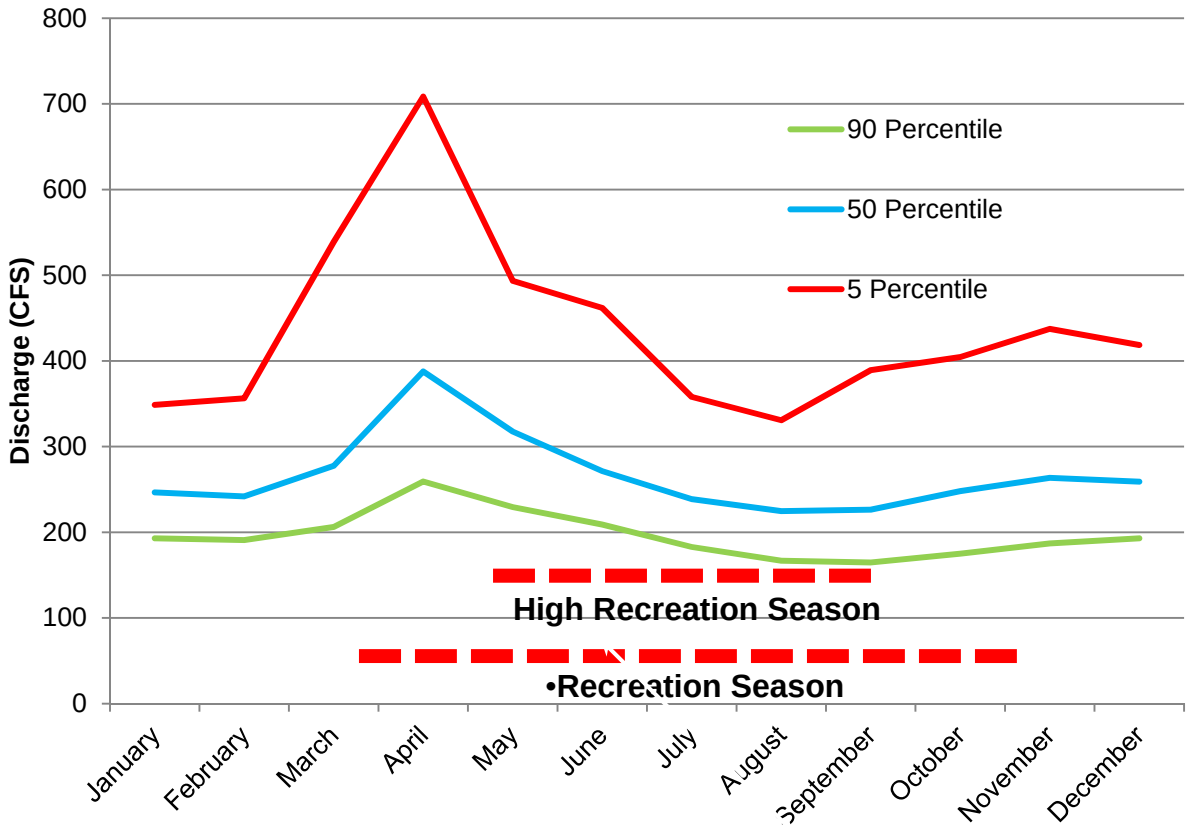
Existing Dam Operation - Hydraulics

1. FEMA modeling assumes all stop logs are removed during 100-yr and greater events
2. Results in minimal headwater increase that has to be accommodated with the proposed design
3. No easy active management (i.e. stop log removal) at this time
4. There are growing concerns that upstream dam removal will cause greater fluctuations in lake water levels

Whitewater Fundamentals

- **Flow**
- **Drop**
- **Access / Location (economic development)**

Boardman River Hydrology

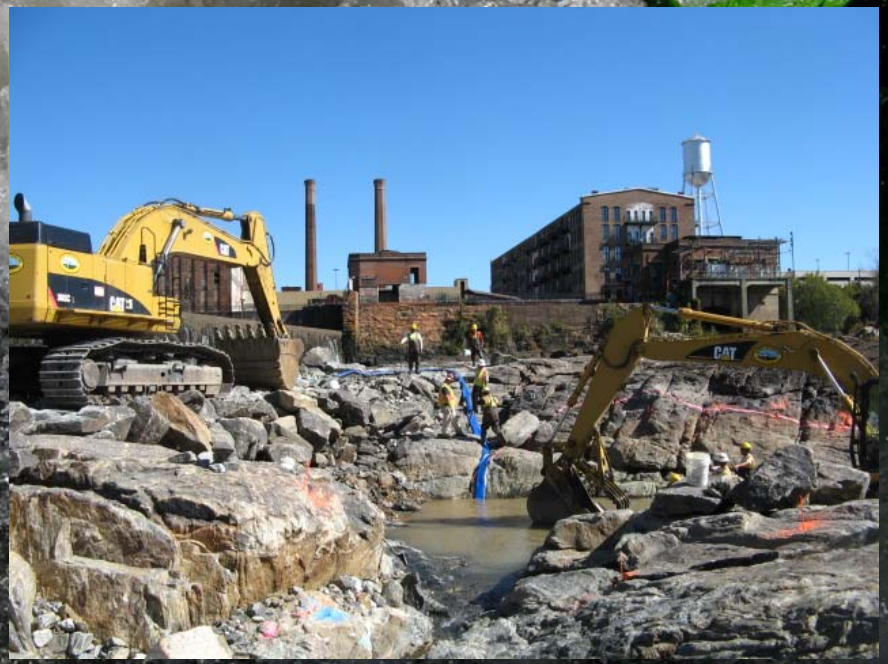


USGS Mayfield Gage x 151% (1997-2014) and Browns Bridge Gage x 195% (1952-1987)

Available Drop – 6.5 – 7.5 feet

Importance of Access

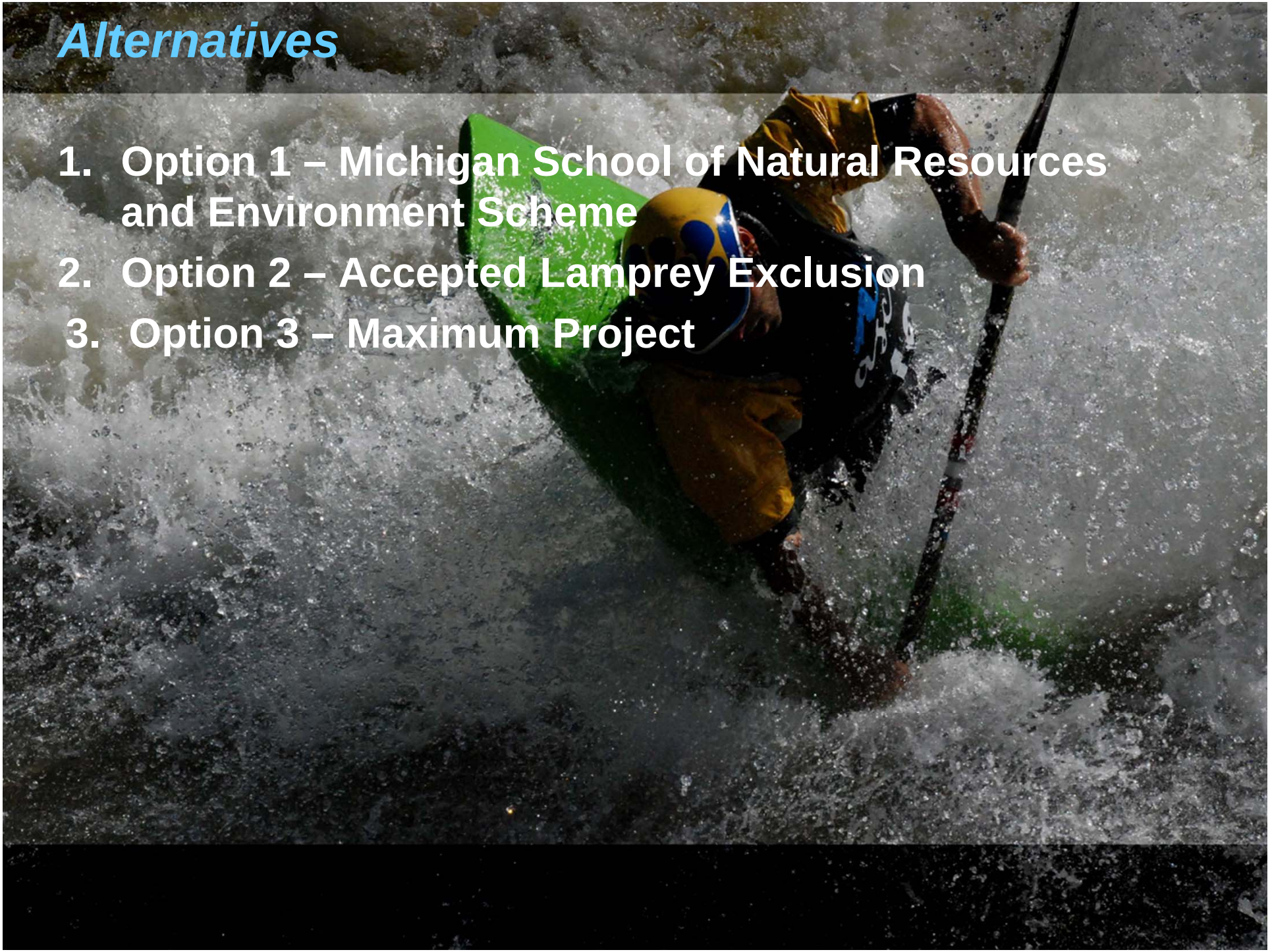
- Construction and constructability
- Self rescue
- Assisted rescue



Rock Terracing

Rock Terracing

A Re-visioned Dam



Alternatives

1. Option 1 – Michigan School of Natural Resources and Environment Scheme
2. Option 2 – Accepted Lamprey Exclusion
3. Option 3 – Maximum Project

Option 1 University of Michigan Scheme

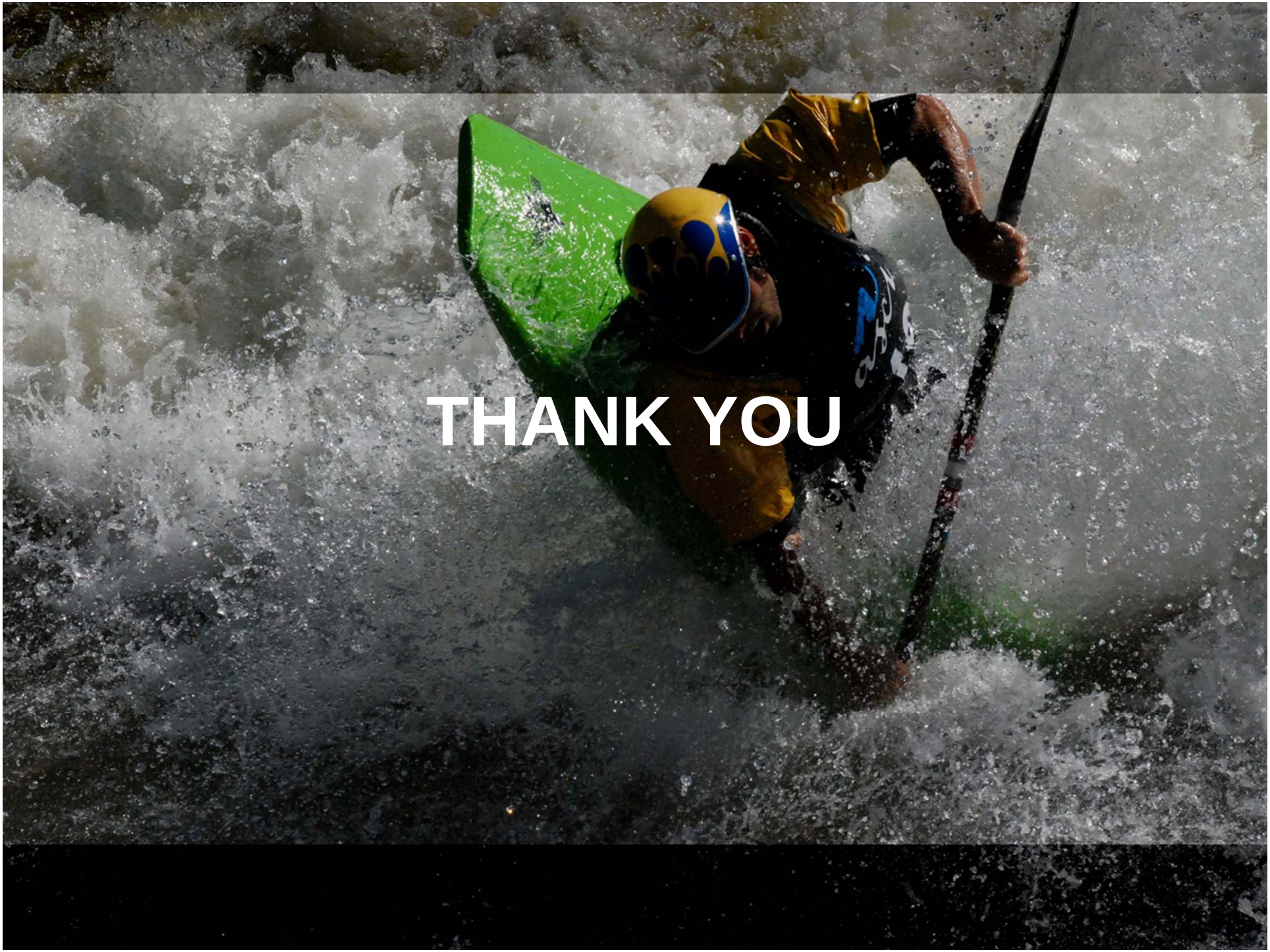
1. Reuse exist dam outlet with improvements/automation
2. Extends upstream – adjacent to private residential property
3. Lamprey exclusion relocated to upstream drop
4. Modulating upstream drop can provides periods of higher recreational flows
5. Lateral passive spillway
6. WW Drop as Lamprey velocity barrier
7. Minimal river park area adjacent to WW park
8. Retaining walls needed

Option 2 – Accepted Lamprey Exclusion

1. Long semicircle weir combines with active gate to maintain upstream water surface
2. Standard plunge-type lamprey barrier ~ overhanging lip and 18” drop
3. Significant park development downstream of dam and adjacent to WW park
4. Depends on active spillway to maintain desirable hydraulics at lamprey barrier

Option 3 – Maximum Project

1. **Modulates upstream lake elevation and passes up to 500 cfs down main channel**
2. **Passive spillway capable of passing 1,000 cfs during 200-yr event**
3. **Active spillway gate to provide additional lake level modulation (above 500 cfs)**
4. **Private impacts primarily on non-residential side of river**


THANK YOU