Penticton – A Place to Stay Forever

Master Plan
Penticton Creek Restoration

ACKNOWLEDGEMENTS

The Committee Members would like to thank the City of Penticton for contributing resources and leadership to this initiative and pursuing the outcomes to revitalize Penticton Creek. In turn, the foresight, commitment and knowledge of the Committee Members and Consultants is critical to the success of the monumental task of reviving Penticton Creek. The City of Penticton extends their gratitude to all individuals representing these organizations and looks forward to bringing the Master Plan to fruition.

City of Penticton

Committee Members:

Downtown Penticton Association

Department of Fisheries and Oceans

Freshwater Fisheries Society of BC

Landowner Representative

MFLNRO: Fish and Wildlife Division

MFLNRO: Water Stewardship Division

Okanagan Nation Alliance

Penticton Fly Fishers' Association

Penticton Indian Band

South Okanagan-Similkameen Conservation Program

Consultants:

Mould Engineering

Newbury Hydraulics

Matthews Environmental Consulting

4 Seasons Heritage Consulting

Prepared By:

Mould Engineering ♦ 567 Lawrence Avenue, Kelowna, BC V1Y 6L8 ♦ Tel: 250-868-2072 ♦ Fax: 250-868-2078 ♦ e-mail: mouldeng@h2o6engineering.com

TABLE OF CONTENTS

INTRODUCTION	4
PLANNING PROCESS	7
DESIGN FLOOD	12
EVALUATING THE INFRASTRUCTURE	14
FISHERIES HABITAT ASSESSMENT	18
CULTURAL & HERITAGE INVENTORY MAPPING	19
CREEK REVITALIZATION	22
PROJECT PRIORITY LIST	40
PRELIMINARY COST ESTIMATES	40
FUNDING STRATEGY	41
RECOMMENDATIONS	42
REFERENCES	44
TABLE OF ANNEXES	46

FIGURES

Figure 1: Penticton Creek Watershed 13
Figure 2: Maximum Daily Gumbel Distribution Plot 13
Figure 3: The Alluvial Fan of Penticton Creek 14
Figure 4: Profile of Lower Penticton Creek 14
Figure 5: Risk of Structure Failure 16
Figure 6: Proportion of Observed Kokanee Spawners in Different Areas of Penticton Creek (Askey, 2016) 18
Figure 7: Existing Conditions for Several Reach 4 Flows 19
Figure 8: Proposed Conditions for Several Reach 4 Flows 23
Figure 9: Type A Structure Replacement where Adequate Freeboard 23
Figure 10: Type B Structure Replacement where Inadequate Freeboard 23

TABLES

Table 1: Penticton Creek Flow Data & Information Used 12
Table 2: Q200 Determination 13
Table 3: Velocities During 4 cms Flow 18
Table 4: Existing Habitat Characteristics (excerpt from Matthews, 2016) 18
Table 5: Summary of Cultural Heritage Values Identified 19
Table 6: Flood and Fisheries Prioritization 40
Table 7: Summary of Preliminary Cost Estimates (in 2016 dollars) 41

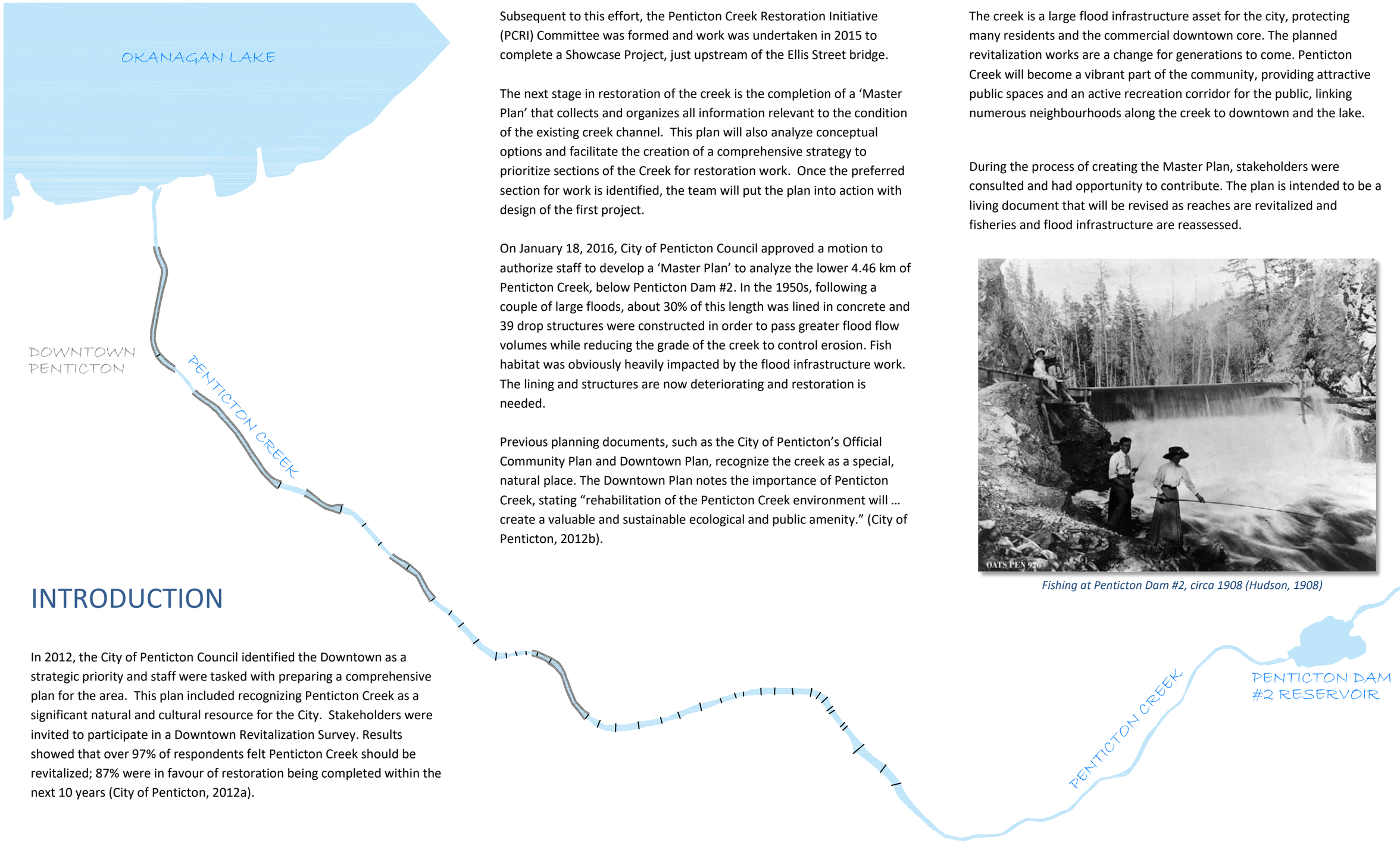
PENTICTON CREEK DOCUMENT TRACKING

***Left**: Structure #9, 2016 (facing NE)* ***Right**: Failed Structure #9 after a cold winter and spring freshet, 2017 (facing SW)*

The creek is actively changing over time and as a result, the Penticton Creek Restoration Master Plan is intended to be an active document. As the infrastructure ages, it will deteriorate at an exponential rate; an example of such failure is shown in the photos above.

Future inspections, studies and restoration designs will be completed before the next update of the Master Plan and should be tracked to ensure readers of the Plan have the most up to date information. As such documents are produced, they will be listed in the table below.

Date	*Document Name*	*Author*
Nov. 2017	2017 Erosion & Deposition Inspection Report	Mould Engineering
Dec. 2017	Master Plan - Penticton Creek Restoration	Mould Engineering



INTRODUCTION

In 2012, the City of Penticton Council identified the Downtown as a strategic priority and staff were tasked with preparing a comprehensive plan for the area. This plan included recognizing Penticton Creek as a significant natural and cultural resource for the City. Stakeholders were invited to participate in a Downtown Revitalization Survey. Results showed that over 97% of respondents felt Penticton Creek should be revitalized; 87% were in favour of restoration being completed within the next 10 years (City of Penticton, 2012a).

Subsequent to this effort, the Penticton Creek Restoration Initiative (PCRI) Committee was formed and work was undertaken in 2015 to complete a Showcase Project, just upstream of the Ellis Street bridge.

The next stage in restoration of the creek is the completion of a 'Master Plan' that collects and organizes all information relevant to the condition of the existing creek channel. This plan will also analyze conceptual options and facilitate the creation of a comprehensive strategy to prioritize sections of the Creek for restoration work. Once the preferred section for work is identified, the team will put the plan into action with design of the first project.

On January 18, 2016, City of Penticton Council approved a motion to authorize staff to develop a 'Master Plan' to analyze the lower 4.46 km of Penticton Creek, below Penticton Dam #2. In the 1950s, following a couple of large floods, about 30% of this length was lined in concrete and 39 drop structures were constructed in order to pass greater flood flow volumes while reducing the grade of the creek to control erosion. Fish habitat was obviously heavily impacted by the flood infrastructure work. The lining and structures are now deteriorating and restoration is needed.

Previous planning documents, such as the City of Penticton's Official Community Plan and Downtown Plan, recognize the creek as a special, natural place. The Downtown Plan notes the importance of Penticton Creek, stating "rehabilitation of the Penticton Creek environment will … create a valuable and sustainable ecological and public amenity." (City of Penticton, 2012b).

The creek is a large flood infrastructure asset for the city, protecting many residents and the commercial downtown core. The planned revitalization works are a change for generations to come. Penticton Creek will become a vibrant part of the community, providing attractive public spaces and an active recreation corridor for the public, linking numerous neighbourhoods along the creek to downtown and the lake.

During the process of creating the Master Plan, stakeholders were consulted and had opportunity to contribute. The plan is intended to be a living document that will be revised as reaches are revitalized and fisheries and flood infrastructure are reassessed.

Fishing at Penticton Dam #2, circa 1908 (Hudson, 1908)

BACKGROUND

Penticton Creek is perched on a large alluvial fan, deposited in the valley by post-glacial inflows from the Monashee Mountains (Roed & Fulton, 2011). The creek was significantly modified in the late 1940s/early 1950s in order to protect the City from flooding. Following severe flooding in the Okanagan in 1942, the two senior governments were pressured to implement measures to reduce inundation. A joint federal and provincial study was released in 1946 which recommended major diking, channelization, and storage solutions in the Valley. Another devastating flood in 1948 was the catalyst to begin work. Flood protection included channelizing many sections of the creek, and in the lower reaches a concrete lining was installed (see photo below). Channelizing narrowed the creek from an estimated 1-in-2 year bankfull width of approximately 16 m to 6 m. In effect, the stream channel became a massive infrastructure project, similar to a major road artery, conducting water, rather than vehicles.

Analysis of 1938 air photos show an additional creek length of approximately 220 metres. This is not a significant difference and it is not obvious that long oxbows have been cut off from the creek. It seems that most changes resulted in elimination of floodplains and creating a single channel, rather than allowing the creek to braid. This was considered when creating conceptual designs for renaturalizing the creek. Maintaining the flood capacity and stability of the channel while enhancing its biological and scenic characteristics presents significant challenges for Penticton Creek.

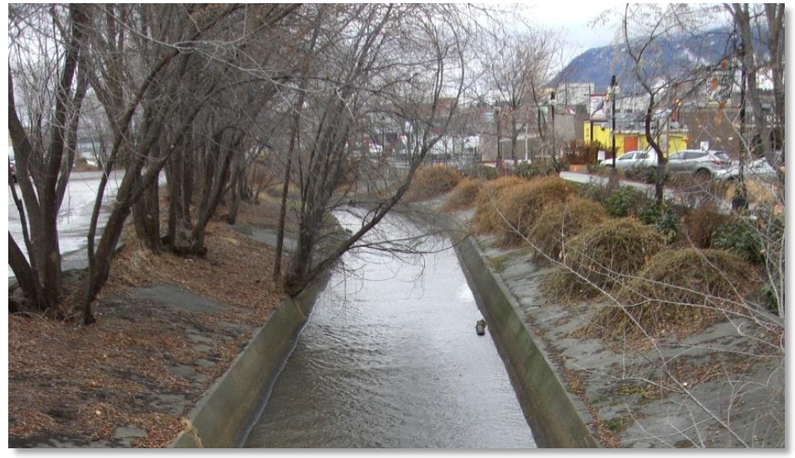
Today, after 65+ years of service, the concrete lining and drop structures are showing their age, deteriorating in many locations to the point that native material is being exposed. The City has had to complete emergency repair works in the past. In addition, there has been interest in restoring the creek channel in order to improve both fish habitat and appearance, particularly through the downtown area of the City.

Attempts at restoration date back to the early 2000s, when the Penticton Flyfishers Society planned improvements to the fisheries aspects of the creek. Work at the time included the placement of concrete parking curbs on the creek bottom, with the intent of increasing water depths to help fish migration. The Penticton Flyfishers Society also maintains two spawning beds and works with the Province to manage a Kokanee hatchery. Currently, there is minimal habitat for fish in the lower reaches and the concrete lining and drop structures are significant barriers to upstream reaches that have habitat potential.

With renewed interest in restoring the channel, the PCRI Committee was formed to oversee the renaturalization of the creek, from Lake Okanagan to Penticton Dam #2. Fisheries representatives and supporting funding organizations played a significant role in backing the Showcase Project (2015), which is proving to be a successful revitalization initiative.

Flooding damage at Van Horne St. & Nanaimo Ave. (Source Unknown, 1942)

Construction of concrete lining. (Source Unknown)



Penticton Creek below Ellis St. bridge (looking upstream)

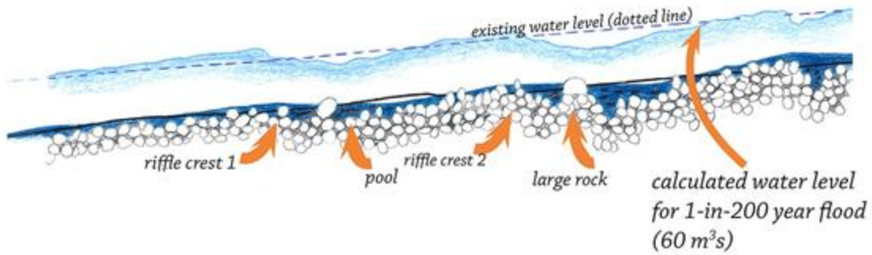
SHOWCASE PROJECT

An 83-metre long demonstration section of creek was constructed in 2015. The concrete lining was removed, the channel bottom widened from 6 metres to 8 metres, and river cobble installed to create pools and riffles. Riffles are common to natural water courses and are "shallow, high-velocity sections of stream that provide important areas for fish food production, rearing and migration." (City of Penticton, 2015b)

The widened channel maintains flood levels similar to the concrete-lined channel while providing habitat and easier passage for migrating fish. It is expected that other aquatic species will develop with time, and a more natural appearance will occur. Vegetation will mature and bedload with woody debris will move in and out of the project, based on the magnitude of spring freshet and storm events.

Prior to construction, the Restoration Committee discussed the creek history, design flows, improvement options as well as preferred location and communication. A design brief was prepared based on these meetings, approvals were obtained and a construction window was identified. The project was completed by Okanagan Valley contractors, consultants and volunteers utilizing local materials.

As the project involved reconstruction of the entire channel bed, it was necessary to dewater and relocate all fish prior to construction. Once the environmental tasks were completed, installation of the containment dams and diversion pipe took place. Construction challenges included: limited site access, availability of large river rock, complexity of constructing low head pools and riffles with large material, and a short work window. Commissioning began on September 1st with water being slowly introduced into the newly constructed creek channel. Removal of the creek diversion works and final grading occurred the following day. Once the upstream and downstream fish fences were removed, migrating fish immediately began to explore and pass through the new surroundings.



Profile view of the Showcase design (City of Penticton, 2015b)

Responses to the project from members of the public and professionals alike have been positive. There were numerous positive comments about fish passage and the new look and sound of the Creek. The results "exceeded expectations" for some, and the ongoing monitoring results are encouraging. Electrofishing of the Showcase on August 24, 2016 resulted in one salmonid per 16 m^2, compared to one salmonid per 360 m^2 before the restoration. The detailed fish count on August 24, 2016 included fifteen rainbow trout, six eastern brook trout and thirty-eight longnose dace within 332 m^2.

The Ellis Street Bridge and the adjacent walkway have become popular viewing locations and site tours for interested organization have occurred. Stakeholders and funding partners were numerous and are shown on the project signage.





PLANNING PROCESS

COHESION WITH OTHER PLANS

The Master Plan for Penticton Creek should be cohesive with other planning documents and consider previous recommendations. Two previous documents that discuss Penticton Creek are the City of Penticton's Official Community Plan and the Downtown Plan.

The Official Community Plan (Bylaw 2002-20), was released in 2002, and designates Penticton Creek as part of a sensitive wetland and riparian habitat in Penticton. The plan wishes to heighten awareness about the sensitivity of this area and therefore, requires an Environmentally Sensitive Development Permit for work around the creek. It also recognizes the flood areas adjacent to Penticton Creek as having flood hazard potential. The plan is supportive of efforts to naturalize the creek and enhance fish habitat and states it will "maintain base water flows and encourage the retention of trees and other natural vegetation along the banks of creeks and watercourses that traverse through Penticton." (City of Penticton, 2002). According to the plan, there is public support for developing a greenway pedestrian corridor along the creek that will help connect all areas of the city with trails. Currently, there is no public path between Forestbrook Drive and Eckhardt Avenue.

The Downtown Plan was also supportive of naturalizing and restoring Penticton Creek, "with the aim of restoring fish habitat through stream bed reconfiguration and/or naturalization." The funding strategy for this work includes funding from the provincial and federal governments, considering partnerships with other stakeholders such as First Nations groups, naturalists and community groups, grants, and considering adding the work "as a park project to the DCC program and utilize those specific DCCs to subsidize project costs." (City of Penticton, 2012). The plan would also like to see additional pedestrian bridges constructed in the downtown area, specifically at the corner of Backstreet Boulevard adjacent to the Kokanee/En Tee Teuk salmon sculpture. By rehabilitating the creek and providing access to the east side of the creek, the plan hopes to increase pedestrian activity along Ellis Street.

GOALS, OBJECTIVES & CHALLENGES

The overall goal of creating a Master Plan for Penticton Creek is to create a feasible, multi-stage plan that encompasses restoration of the creek while reflecting multi-stakeholder values. The Master Plan will aim to:

- **Restore fish habitat:** Returning Penticton Creek to a more natural state will benefit Kokanee and Rainbow trout and other riparian wildlife. This improves the creek's aesthetic and social values, and supports recovery of Okanagan Lake fish stocks and associated recreational fishery activities, thus contributing to the economy.
- **Provide flood protection:** Penticton has a history of high creek flows that have overtopped the banks and flooded areas of Downtown. Flood protection infrastructure needs to be designed to meet current standards and provide a high-level of protection to private property.
- **Fix failing infrastructure:** Existing channel works have been eroding for some time, and this can cause sudden maintenance issues and considerable unplanned expenses for City Operations.

Restoration of the creek to the original channel and cross-section would be an ideal situation, but not practical because of the extreme cost of purchasing private property as well as the large-scale earthmoving task needed to carve-out the original creek width capable of passing a large flood. Similar effects can be obtained by introducing pools, riffles, and other habitat features that can be supported by the hydraulics.

Specific objectives are to:

- Document a clear understanding of the current channel flow capacity, state of deterioration of flood control works and risk of failure/flood through the length of Penticton Creek from Penticton Dam #2 to Okanagan Lake.
- Improve the stream's capacity to support wild fish populations and enhance wildlife habitat, as fish and wildlife populations are a mere shadow of what they once were.
- Improve the aesthetic and recreational value of the creek corridor for the public.

A separate objective is to prepare detailed design documents for improvements to the next section of creek, for construction to proceed during the 2017 fisheries window.

Challenges are many, more than typical creek or river projects, due to the urban setting of Penticton Creek. This Master Plan outlines the vision and concepts for most reaches, with a couple reaches requiring further analysis. Additional details and discussion will also occur at the final design stage.

Challenges include:

- Obtaining the desired clearance between high water level and bridge girders;
- Achieving freeboard standards without creating dikes;
- Public awareness to flood protection needs;
- Narrow corridor due to private and public property;
- Vegetation, both from flood prevention and riparian aspects;
- Achieving stakeholder visions within constraints of the low and high flow hydraulics;
- Funding, not only for construction but also for monitoring and adaptive management;
- Preserving areas of cultural and heritage value; as well as
- A short construction window.

COMMUNICATIONS PLAN

A comprehensive communications strategy is needed in order to develop a Penticton Creek Master Plan that successfully recognizes and obtains the support of the numerous stakeholders involved. Also, a collaborative approach is being used with members of the Restoration Committee involved in the data collection and presentation stages; so communication is important. There are three distinct stages regarding communications for this project: Preparation of the Master Plan, Public Consultation, and Phase 1 Construction.

Goals and Objectives

For all three Stages of Communication, key objectives are:

1. Be open and transparent about what is planned for Penticton Creek
2. Be inclusive of stakeholders directly and indirectly affected by the project
3. Explain technical information using plain language
4. Translate technical drawings into artistic renderings when needed
5. Recognize funding partners
6. Educate the public on the value of a healthy Penticton Creek
7. Foster Creek stewards amongst creek-side property owners
8. Garner public support for the Project
9. Celebrate the success of the Penticton Creek Restoration Committee.

Project Steering Committee & Stakeholders Involved

As stated in the Introduction, the preparation of the Master Plan was under the direction of the Penticton Creek Restoration Initiative Committee. Members of the Committee can be seen in Annex B. The stakeholders involved in the plan include:

- City of Penticton Mayor, Council, and Staff;
- Penticton Indian Band (PIB) Chief and Council;
- Okanagan Nation Alliance (ONA);
- Provincial and Federal regulatory authorities;
- The Penticton Creek Restoration Committee;
- Funding agency representatives;
- Adjacent property owners;
- Penticton Flyfishers;
- Freshwater Fisheries;
- South Okanagan-Similkameen Conservation Program;
- School District No School District No 67 (Okanagan Skaha);
- École Entre Lacs;
- Downtown Penticton Association; and the
- General Public;

Communications Sensitivities

In 1942, water overflowed the banks of Penticton Creek creating a large flood that had a significant impact on private property (homes and downtown businesses). In response, Government and Council of the 1950s took several steps to protect private property, including physical flood control measures like concrete lining, drop structures, berms, and the channelized creek banks.

Failure or changes to these works results in several sensitivities that must be considered today:

- **Fear of Flooding:**
  Long-term residents and their children may recall the flood and visual change to the creek when the channel works were constructed. More recent residents recall the high water levels of 2006 and 2008 and may be concerned about changes to the flood protection infrastructure.
- **Fish Habitat:**
  Natural spawning grounds, habitat areas, and the ability for fish to migrate up Penticton Creek were all impacted when it was channelized. The negative impact on the fishery reduces the economic contribution to local communities.
- **Maintenance Challenges:**
  The concrete channel lining and drop structures are two components of the infrastructure that are eroding badly and causing maintenance challenges. City Operations must complete sudden repairs to Penticton Creek as erosion happens. This unplanned work can be expensive, and does not address the root problems with a channelized creek.
- **Private Property Flood Protection Awareness:**
  To protect the community, M-178, M-185 & M-195 Plans were approved by Council between 1950-1970 to define the corridor for flood protection measures. These plans appear as a notation on Title for private property along the creek; however, as properties changed hands over the years, awareness of the notation and/or the importance of preserving the areas included within the three plans may not be as obvious to current owners. This results in encroachments found throughout the length of the study corridor.
- **Publicly-Owned Land:**
  The City of Penticton owns numerous parcels along the creek; School District No. 67 also owns a parcel. The community may be impacted by changes and desire input regarding use of the public parcels.
- **Vegetation:**
  Trees have grown and infilled along the creek banks as well as within the wetted concrete channel sections. Vegetation removal can be a sensitive issue, as it affects the environment, sight lines, shade, etc. Deadfall trees can also become a hazard during high-flow events.
- **Construction:**
  Activities related to construction such as site access, noise, dust, traffic, parking, etc. all need to be considered.

Public Relations Methods

Methods used to communicate with the public include:

- News Releases to radio and TV;
- Web Presence;
- Site Signage;
- Contact Person(s).

Communication Dynamics

The landowners spanning the 4.5 km corridor range from: commercial businesses in the downtown core; residential homeowners upstream of the showcase project; and semi-natural areas, some of which is owned by the City. These three landowner groups, along with other stakeholders, will need different information as the Master Plan and construction projects take shape.

One of ten panels prepared to present the Master Plan to the public (City of Penticton, 2017)

Public Engagement At a Glance…

10+ News articles	**70+** Conversations with residents	**40+** Attended a walking tour
779+ Reviewed email	**10,000** Received newsletter	**14** Day display

Public Consultation

After a comprehensive process to create a draft of the Master Plan, the document was presented to various stakeholders, including:

- Penticton City Council;
- Penticton Indian Band and related organizations;
- The general public, via the media (paper, website, etc.) and the Penticton Community Market.

The presentations to the City of Penticton Council and Penticton Indian Band Chief and Council included providing details of Master Plan objectives, methodology and the results and conclusions from the research undertaken. Following these presentations, the Plan was also summarized into ten panels, called the Penticton Creek Master Plan Story, which was available to view on the website. The first Story panel is shown to the left. The public was then invited to view the draft Plan and leave feedback on the City's 'Shape Your City' website. .

In September 2017, an event named 'Something Fishy' was planned to promote the Master Plan, inform the public, and request feedback. There were two parts to the event: an informative display of the Story panels and a walking tour along the creek. The panels were displayed at the Penticton Community Market where PCRI Committee members were available to discuss the Master Plan with the public. Over 70 conversations with residents took place and over 30 chose to provide comments.

The walking tour began at temporary fish fences, which had been installed near Okanagan Lake Park. The public could watch volunteers who were conducting a fish count of kokanee. The tour then walked along the creek approximately 400 m to Ellis Street bridge, where participants could view the 2015 Restoration Showcase project. Over 40 people attended the walking tour.

The Penticton Creek Master Plan Story panels were displayed at the Penticton Community Centre for two weeks after the Community Market event. In addition, a writeup on the Master Plan was highlighted in the monthly City newsletter, which is mailed out with resident's electrical bills.

Public Feedback

The feedback from the public was very positive and supportive of the Master Plan and restoration of Penticton Creek.

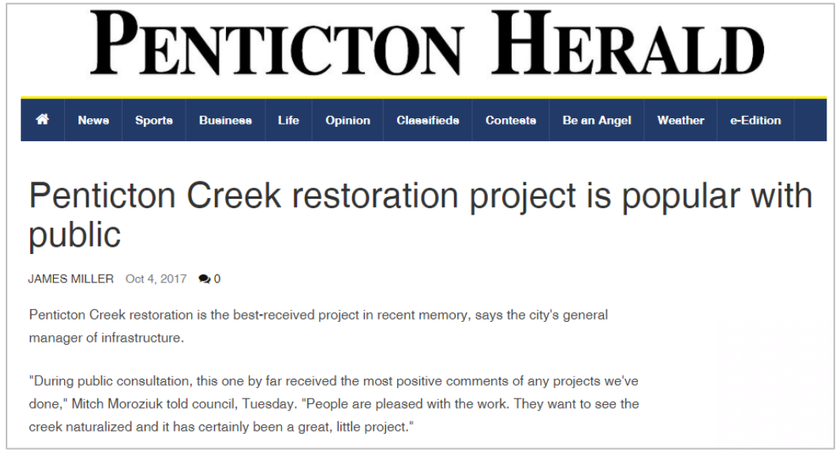
The following are some verbatim comments from the public:

- Very important for us to do.
- Anything to bring back the fish.
- Good for future generations.
- Making it natural is an excellent idea.
- Well planned.
- Excellent! Engineers and staff should be commended.
- Prioritize this project.
- I support it going forward, it is a mess.
- Spend more money on the creek and less on Downtown phase 3.

The following are a summary of suggestions or concerns from the public:

- Look at eliminating public access under the bridges
- Maintain public access trail and fill in missing pieces
- Specific property concerns
- Work on the reaches downstream of the Showcase first, to improve aesthetics and provide an asset for the fish

These comments and suggestions have been discussed by the Penticton Creek Restoration Initiative (PCRI) committee and in general, will be addressed on a project-by-project basis. The desire to see improvements downstream of the Showcase (Reaches 1, 2a and 2b) emphasis the recommendation of the Master Plan that additional study is needed to select a final design for these reaches.



PENTICTON HERALD

News Sports Business Life Opinion Classifieds Contests Be an Angel Weather e-Edition

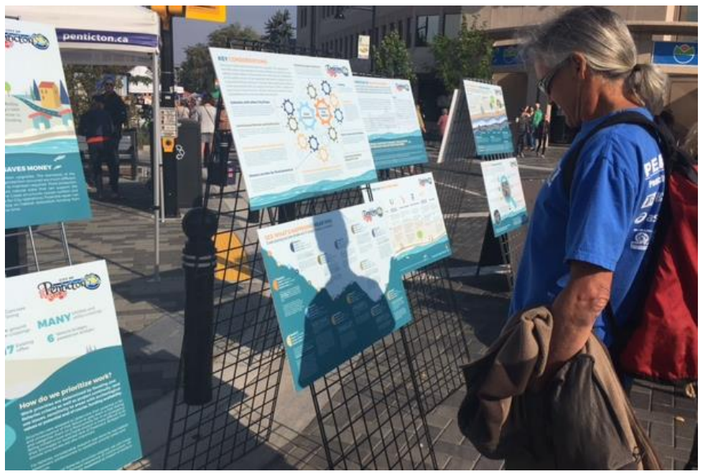
Penticton Creek restoration project is popular with public

JAMES MILLER Oct 4, 2017 0

Penticton Creek restoration is the best-received project in recent memory, says the city's general manager of infrastructure.

"During public consultation, this one by far received the most positive comments of any projects we've done," Mitch Moroziuk told council, Tuesday. "People are pleased with the work. They want to see the creek naturalized and it has certainly been a great, little project."

Public Response to Penticton Creek Restoration (James Miller, 2017)



Left and Centre: *PCRI Committee members interact with the public at a Penticton Farmer's Market event*

Right*: Paul Askey (Freshwater Fisheries BC and PCRI Committee member) hosts a restoration walking tour*

DESIGN FLOOD

Prior to preparing restoration concepts, and in order to ensure that modifications do not restrict the flood capacity of the channel, the magnitude of a 1-in-200 year flood event needed to be determined. This flow, also known as the Q_{200}, has a 0.5% Annual Exceedance Probability, or a one in two hundred chance of being exceeded in any year. In addition, there are two values of Q_{200} flow that need to be established: the maximum instantaneous flow and the maximum annual daily flow, which is an average of the flows recorded on the highest flow day of the year. It is important to consider both of these floods because there are different freeboard requirements for each, which is discussed in the Hydraulic Analysis section.

The process of determining these flood values began with assembling and analyzing known creek flow data and historic information available, which is summarized in Table 1. It is noted that the flood of 1942 was estimated to have been an instantaneous value of 48 cms (cubic metres per second) and so the concrete channel constructed in the late 1940's was designed to pass 51 cms. Once the data and information was correlated to a creek discharge, a statistical analysis was performed as well as a Gumbel distribution plot was created. A Gumbel plot is one method of using known recorded flows to extrapolate to a possible flood event. A total of 37 data points make up the current plot, which is shown in Figure 2.

From the Gumbel Distribution, the maximum annual daily Q_{200} flow is estimated to be 40 cms. This value is increased by 20% to account for climate change (recommended by the Association of Professional Engineers and Geoscientists of BC when data is limited), and a further 25% "peaking" factor is added to estimate the maximum instantaneous discharge. The resulting recommended Q_{200} maximum instantaneous discharge is then estimated to be 60 cms, as shown in Table 2. The channel must be capable of passing this design flood value, which has been discussed at length by the Committee.

Table 1: Penticton Creek Flow Data & Information Used

DATA SOURCE	YEAR(S)
Joint Board of Engineers, Okanagan Flood Control Report (1946)	1942
Water Survey of Canada Gauging Station 08NM118 (currently inactive)	1950 – 1971
City of Penticton Water Treatment Plant records	1997 – 2016
Dean Environmental – data from the Campbell Mtn. diversion	1998 & 1999
*Photos/newspaper articles re: flow over the Penticton Dam #2 spillway	1948, 1990, 2006 & 2008
*Photos of flow in concrete channel below the Ellis Street bridge	2002 & 2006
*A computer model of Penticton Creek, created using the U.S. Army Corps. of Engineers Hydraulic River Modeling program (*HEC-RAS*), was used to estimate stream discharge based on photographic evidence.	

PENTICTON, B.C., CANADA, THURSDAY, MAY 28, 1942

FLOOD WATERS RECEDE

Spectacular Inundation Brings Worst Disaster In Penticton's History

Fund Opened

What is to be the future of Penticton's citizens who have been "washed out" remains to be seen. Local authorities have been prompt in seeking aid from both B.C. and federal governments, the Red Cross has set up a depot, friends and neighbors have given some succor, offers have gone into the municipal hall to care for those who have lost a roof over their heads.

Further later details of plans are reported elsewhere.

Yet meanwhile there are pressing needs for many. There is many a family that could use, will indeed badly need, funds as well as helping hands and kind offers of other types of aid.

With is in mind, the Herald announces that it will be glad to receive and acknowledge donations from all parts of this general district, or from farther afield, to the end that some sort of a fund may be commenced. Such a move has been taken with the knowledge and approval of the Hon. R. L. Maitland, acting premier of the province, and of Reeve R. J. McDougall, of this community.

Local Red Cross Ready To Aid Flood Victims

Flood Sidelights

WATER GOUGES A $5,000 CRATER

Converging Streams Rip Up 4,000 Yards Of Dirt Rear Of Lincoln Hotel

At Lakeshore drive and Main street, near the Lincoln hotel, the roaring torrent of muddy water pouring down Main street and Martin street gouged out 4,000 yards of dirt and rock and left the C. P. R. railway tracks leading to the barge wharf and to the Penticton Co-op hanging in mid air. An early estimate of the damage caused by this washout was $5,000.

Some idea of the volume of water pounding down Main and Martin streets on Tuesday morning can be gathered from the fact that at the Hub bowling alleys two pumps were installed to keep the waters from

Local Citizens Relieved As Torrent Subsides — Possible Quarter Million Dollar Damage To Business, Residential Areas — Swollen Mountain Streams Cause Penticton And Ellis Creeks To Overflow

Latest report before the Herald went to press, from Municipal Superintendent A. G. Pearson, was that the level of water going over the intake spillway was 3 feet 3 inches. This is about the "normal". At the last meeting of the council, in fact, before the flood occurred, a similar reading was recorded. On Wednesday at noon the level was 3 feet. It had dropped six inches by midnight last night, was down to 2 feet 4 inches at 6 o'clock this morning, was down another inch by noon today. Some indication of the flood proportions can be gathered from the fact that the peak at 2 o'clock Monday afternoon was a level of 5 feet 6 inches, and this was going over the entire dam for its entire width. The spillway, through which the water is now passing, is only a portion of the dam in its centre and tapers somewhat toward the bottom. The decrease, in short, is even sharper than the above figures might indicate to one not familiar with the location. Those who do not clearly realize the picture should also take note that the above figures apply only to the intake fairly close to the city where the irrigation and domestic water are picked up in normal conditions. There is no reference to the large Penticton dams, much farther removed, where, at latest reports, the water level has dropped sharply, is continuing down. These were never "topped". Other press reports to the contrary, they never broke. The only fracture was last Saturday night in the Ellis Creek No. 4 dam, the results of which never touched the general urban section.

Newspaper page from May 28, 1942

Flooding on Front Street (Stocks, 1928)

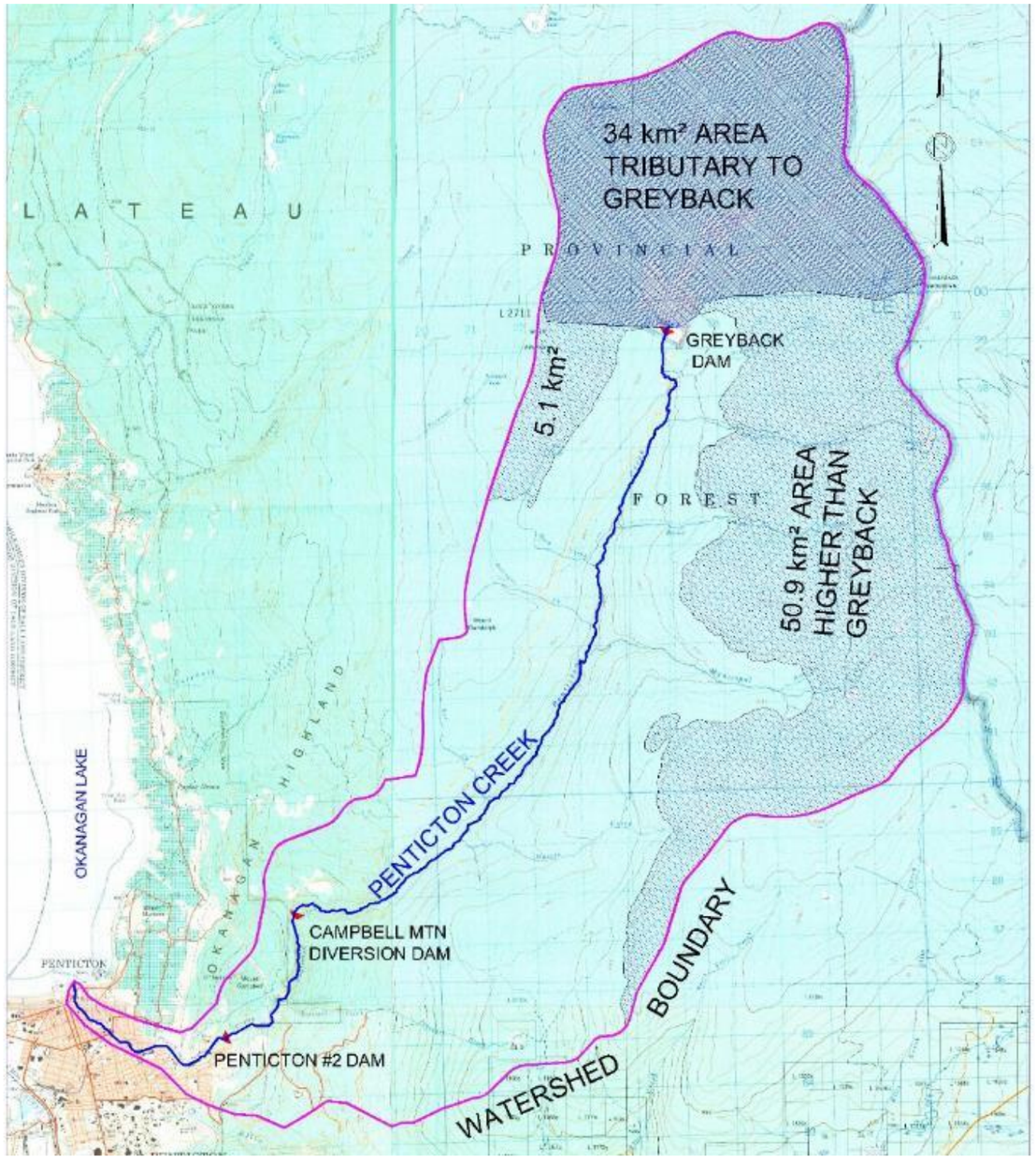


Figure 1: Penticton Creek Watershed

It is important to note, that the majority of the data recorded from the Water Survey of Canada Gauging Station does not incorporate the large attenuating effect of the Greyback Reservoir (Greyback), which acts on a considerable portion of the upper Penticton Creek watershed. As seen in Figure 1, approximately 38% of the upper watershed is tributary to Greyback. Since the construction of the dam in 1967, Greyback has significantly reduced the magnitude and timing of the runoff peak entering Penticton Creek.

Since 1969, there have been 21 years where Greyback did not spill. The City of Penticton's Water Treatment Plant data (available since 1997) shows that the peak creek runoff was almost always recorded before Greyback filled and spilled; the only exceptions occurred in 1999 and 2012.

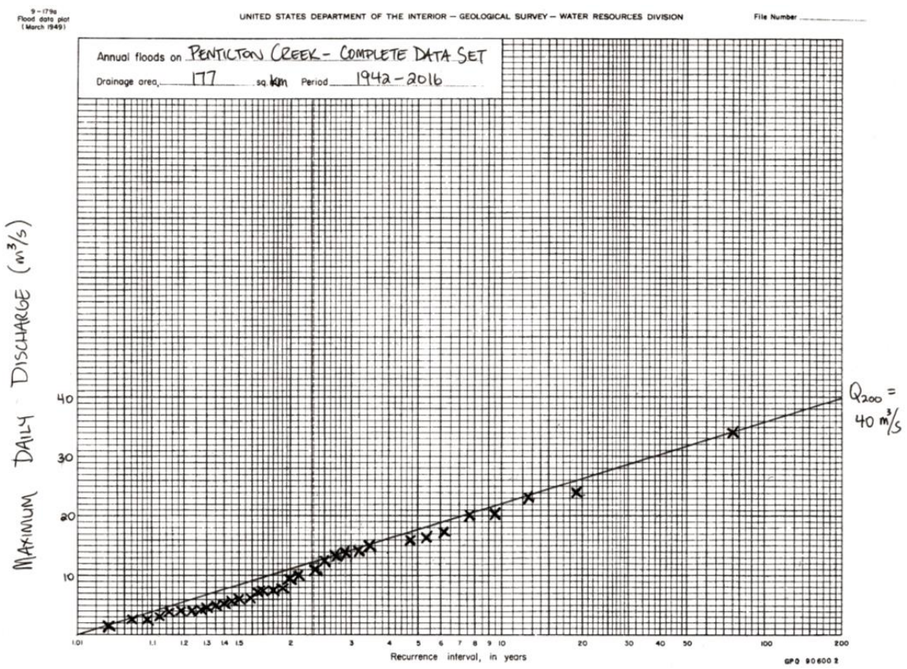


Figure 2: Maximum Daily Gumbel Distribution Plot

Table 2: Q200 Determination

Historical info./data/photo review = 40 cms (maximum daily) Add 20% for climate change = 48 cms (maximum daily) **Recommended Maximum Daily Q_{200} = 48 cms**
Recommended Maximum Daily Q_{200} = 48 cms Add 25% for peaking factor = 60 cms (maximum instantaneous) **Recommended Maximum Instantaneous Q_{200} = 60 cms**

EVALUATING THE INFRASTRUCTURE

The existing infrastructure was analyzed and inventoried during numerous site visits between March and June, 2016. A high-level survey was completed by the City of Penticton in the spring and summer of 2016. This data is needed to inform planning and conceptual design decisions. In the future, as detailed design of each reach begins, a more in depth survey will be completed.

The infrastructure identified includes numerous drop structures, pedestrian bridges, vehicular bridges, above ground utility crossings, storm system outlets, and concrete lining. Analysis resulted in division of the creek into sections and reaches, based on criteria including channel lining, land use on either side of the creek, water surface width, entrenchment depth, and slope between drop structures. Drawings and cross sections of the existing creek are shown in Annex H. A plan view and pictures of Reaches 1 – 3 can be found on pages 20 and 21.

SECTIONS

Three sections were classified based on their slope and bank lining, as can be seen in the profile opposite and the photos on the following page.

Section 1 is approximately 2.1 km long, beginning at Lake Okanagan and ending just upstream of Forestbrook Drive bridge. The section includes Reaches 1 to 10 and is mostly concrete lined, with minimal resting for fish. The overall average slope through this section is 2.1%.

Section 2 is 1.1 km long and extends from just upstream of Forestbrook Drive bridge to a geographical creek pinch point, created naturally and tightened by Penticton Avenue. This section includes Reaches 11 and 12 and is a mostly natural bottom, stepped channel with drop structures and pools. The overall average slope is approximately 3.0%.

Section 3 consists of Reach 13 and begins at the pinch point of the creek and ends at Penticton Dam #2. This section is just under 1.3 km long and has an average overall slope of 3.0%. The channel is a natural run, with constant gradient and no drop structures.

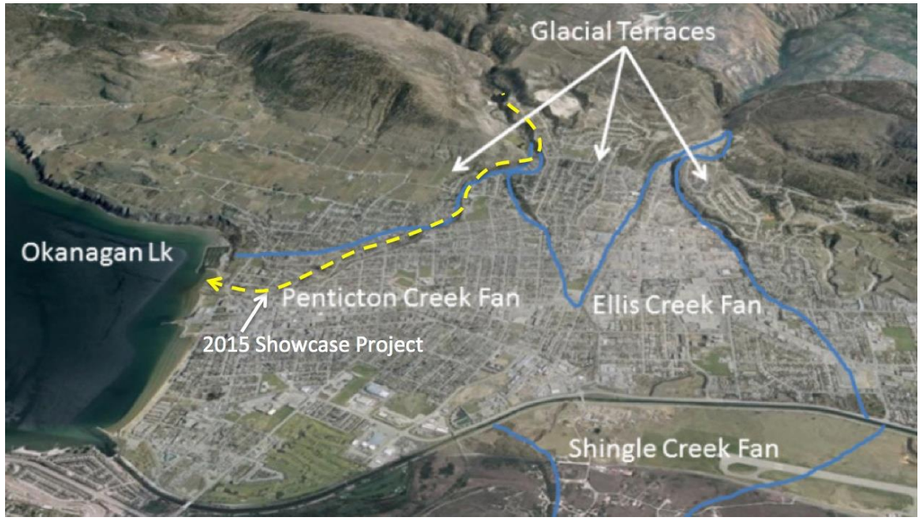


Figure 4: The Alluvial Fan of Penticton Creek

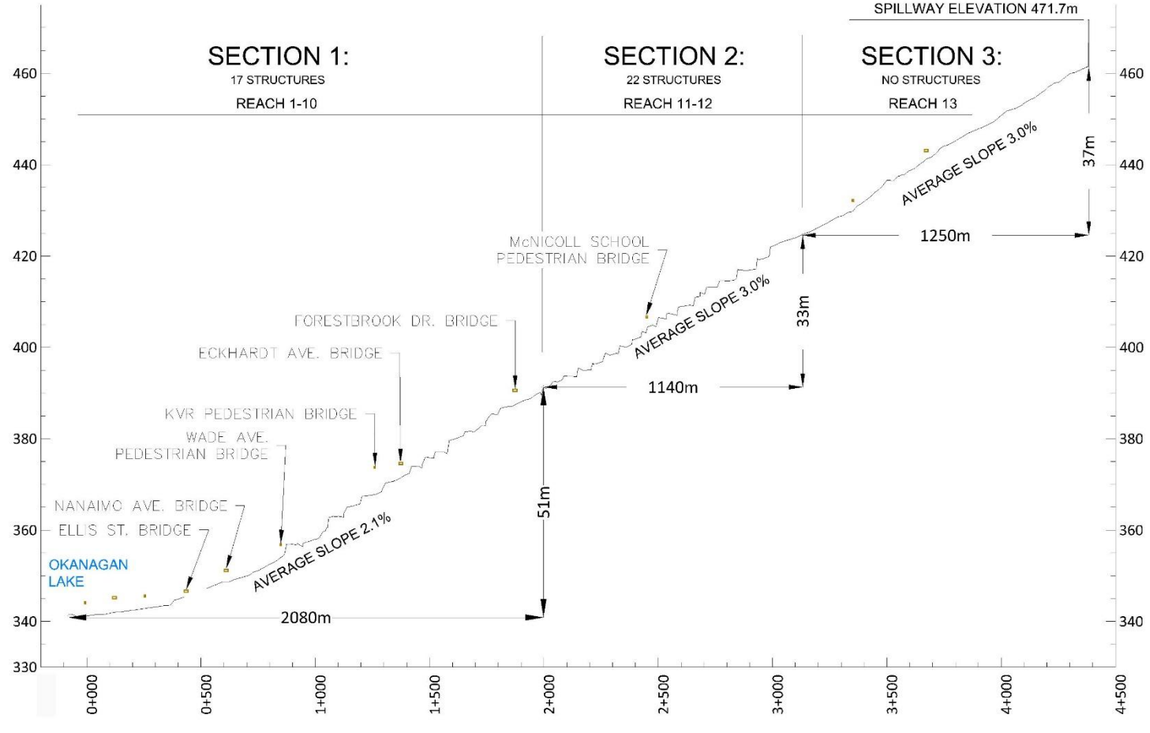


Figure 3: Profile of Lower Penticton Creek

Reaches & Subreaches

Thirteen reaches were identified based on their existing channel slope, lining type (channel bottom and bank), number of structures, ability to widen, and land use on either side of the creek. It was found that the channel slope between drop structures varied significantly, ranging from 0.0% to 3.3%. A table of reach descriptions is shown in Annex C. Reach boundaries are shown in plan and profile views in Annex H.

For restoration purposes, possible constructible length in a work window was considered and many of the longer reaches were subdivided, and shorter reaches combined to make projects of roughly 200 m each. This resulted in a total of 20 sub-reaches. In some cases, a natural feature, such as the Penticton Avenue pinchpoint, or a bridge, create clear boundaries between sub-reaches.

Lining

The lining of Penticton Creek includes reinforced formed and non-formed concrete, riprap, and natural channel materials. For reaches lined in concrete, deterioration and holes in the lining was noted. In many non-formed sections, wire reinforcing mesh is visible where the concrete has failed. Reaches that are lined with rock or natural materials were analyzed to determine the stable rock size required as bank protection. This is dependent on the slope and depth of water in each reach. In some sections, such as Reach 13, the existing rock size is not large enough to be stable, which results in channel downgrading.

The lining was rated according to the potential to fail and the consequence of said failure. These two ratings were then converted into a risk rating, which was used as part of the project prioritization process to minimize flood risks. The lining ratings and flood periodization list can be found in Annex F.

Section 1 – Concrete Lined

Section 2 – Stepped Channel

Section 3 – Natural Run

Drop Structures and Riffles

A total of 39 drop structures were documented on Penticton Creek. These were a combination of three types: concrete, wood crib, and riprap structures, as shown below. Many of these structures are visibly deteriorating and some have already failed.

Similarly to creek lining, the structures were rated according to their potential to fail and the consequence of said failure. These two ratings were then converted into a risk rating, which was used to categorize reaches into a flood priority list. The four categories of risk are low, moderate, high, and very high, as seen in Figure 5.

In addition to the drop structures, 17 existing riffles were identified. Some appear to be created by hand, perhaps annually, to develop deeper swimming holes. Since these riffles can be easily altered, by nearby residents or spring freshet, they were not given risk ratings.

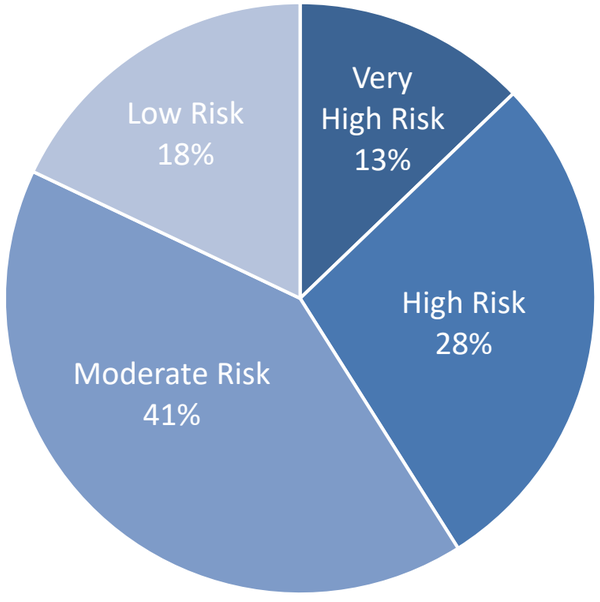


Figure 5: Risk of Structure Failure

Bridges and Utility Crossings

There are currently six vehicular bridges (Front Street, Ellis Street, Nanaimo Avenue, Eckhardt Avenue, Forestbrook Drive, and Penticton Avenue) and six pedestrian bridges (Art Gallery, Ellis Street, Wade Avenue, KVR, McNicoll School, and Bridgewater Development) over Penticton Creek. These bridges are important infrastructure, providing access for day-to-day traffic, emergency vehicles, pedestrians and cyclists and supporting utilities across the creek. The existing clearance between the Q_{200} instantaneous and maximum daily flows is discussed further in the Existing Bridge Clearance section and shown in Annex F.

Two aboveground sewer crossings and an aboveground gas main were noted. In addition, there are many utilities attached to bridge crossings, utility crossings under the creek, and storm mains that empty into the creek. These will require further exploration in the detailed design stage of future projects.

Drop Structure with Riprap Apron

Drop Structure with Concrete Crest and Apron

Wood Crib Drop Structure with Rock and Concrete

HYDRAULIC ANALYSIS

Using the survey of the creek, a HEC-RAS hydraulic analysis was computed for the Q_{200} instantaneous flood (60 cms) and maximum daily flood (48 cms) to determine bank locations that lacked freeboard or bridges that lacked clearance.

Freeboard and Clearance Standards

In order to determine existing deficiencies along Penticton Creek, applicable guidelines were adopted. Although most the creek does not have dikes, the *Dike Design and Construction Guide: Best Management Practices for British Columbia* can be used to maintain and/or reduce the risk of flooding.

The guide suggests *"[t]he standard for river dike crest elevation is the higher of 1 in 200 year instantaneous flow plus 0.3 m freeboard, or the 1 in 200 year maximum daily flow plus 0.6 m freeboard*." (BC Ministry of Water, Land and Air Protection, 2003)

For bridges over the creek, the guide states *"the underside of a bridge shall have a minimum clearance of 1.5 m above the higher of the calculated peak instantaneous 1:200 year level or flood level of record, or higher as required for ice or debris passage; If demonstrated to be uneconomic or not feasible, clearance requirements may be varied if there is an acceptable debris/ice management program in effect or determination of acceptable risk of blockage. Under no circumstances will the underside of a bridge be lower than the higher of 0.3 m above the peak instantaneous 1 in 200 year level or 0.6 m above the 1 in 200 year mean daily flow."* (BC Ministry of Water, Land and Air Protection, 2003)

Existing Freeboard Analysis

Many locations that have less than the minimum freeboard targets were identified. Several of these coincide with the crest of a drop structure and will be addressed when the drop structure is replaced. Other locations that lack freeboard will require the banks to be raised or the creek lowered. A table showing the locations that lack bank freeboard can be seen in Annex F. The approximate stations, as well as which side of the creek lacks freeboard and a description of the areas are given.

The topographical survey conducted was suitable for a Master Plan level, however, it was not extensive enough to determine if there are berms or areas that should be considered as dikes. A preliminary review indicates Reaches 10b and 11c/d, and possibly other reaches, need further investigation.

Existing Bridge Clearance Analysis

When analyzed using HEC-RAS, many of the bridges were found to have less than 1.5 metres of clearance. At higher water levels, woody debris can catch on the girders, leading to removal requirements. Therefore, a debris management program is recommended for Penticton Creek. Once in place, the governing bridge clearance requirement is 0.6 m above the Q_{200} maximum daily flow (48 cms) for all twelve bridges. The resulting clearances between the underside of the bridge girders and the water level can be seen in Annex F. Two bridges were found to have 1.5 metres of clearance or more and four bridges have between 0.6 metres and 1.5 metres of clearance, which are considered acceptable. The remaining six bridges are deficient and two of these have no clearance. As can be seen in the photo below, the cross-sectional area narrows at Forestbrook Drive bridge, which is common at most of the bridges on Penticton Creek.

Channel Narrowing at Forestbrook Drive bridge

The options for improving bridge clearance are to increase the cross-sectional area beneath the bridge by widening or deepening the channel. Alternatively, bridge replacement, or removal could be considered. The recommendations for each deficient bridge are discussed in the Revitalization section.

Sediment Transportation

The lower portion of Penticton Creek is located on an alluvial fan created by deposition of sedimentary materials. The sediments are the result of stream erosion in the upland mountainous areas. Erosion usually occurs during peak spring flows and eroded material is then deposited when the stream reaches the lower gradient channel in the alluvial fan. Sedimentation in natural channels reduces capacity and eventually results in overtopping; however, as previously described, Penticton Creek is far from natural conditions.

A number of factors unique to Penticton Creek come into play that alter the natural processes. Firstly, the source of deposition material from the upper watershed is very limited due to the Penticton #2 Dam. The dam is located just upstream from the channelized section and any eroded material coming down the creek settles out in the large reservoir created by the dam.

Secondly, the 39 drop structures have flattened the grade of the creek, reducing water velocities and sediment transport potential. The channel banks are generally only a couple of metres high, so potential landslide areas that could create a large sediment source are limited. There is one high bank north of the creek and just downstream of the new Bridgewater development, however it is comprised of bedrock. Only Structures #38 & #39 show evidence of significant deposition after 65 years of operation.

Thirdly, since construction of the Greyback Mountain Dam, the additional storage volume reduces downstream peak flows and consequently reduces erosion potential.

During the detailed design stage, a HEC-RAS analysis would be completed to determine if the freeboard is adequate, should the pools be filled in.

FISHERIES HABITAT ASSESSMENT

The *Penticton Creek Fish and Riparian Habitat Assessment and Preliminary Restoration Recommendations Report* (Matthews, 2016) was produced to inform the PCRI Committee of the existing condition of fish and riparian habitat in each reach and to suggest potential restoration options. The target species for Penticton Creek are Kokanee, Rainbow Trout and Longnose Dace. This Master Plan does not include consideration of anadromous species due to the current fish barrier at Okanagan Lake, but completed and future restoration works on Penticton Creek may also benefit Sockeye, Chinook and Steelhead in the eventuality that fish passage is provided. The existing habitat limitations, contributions and quality ratings excerpt from Matthews' report is outlined in Table 3.

Matthews' notes that in the past, "Penticton Creek was an important producer of kokanee and a unique adfluvial rainbow trout population for Okanagan Lake." (Matthews, 2016). After the channelization and lining of Penticton Creek, very few fish return to the creek for spawning and rearing.

Table 3: Velocities During 4 cms Flow

Reach	Station	Velocity (m/s)
1	0+050	0.5
2a	0+250	2.0
2b	0+370	3.7
3a	0+550	1.9
3b	0+825	2.3
4	0+920	0.6
5	1+010	3.8
6	1+170	1.2
7	1+370	2.4

In general, the greatest habitat limitation for fish are the migration barriers. These include structures with large elevation differences, and concrete lined sections with high velocities and no resting areas. Table 4 shows various velocities, calculated during an average May flow (4 cms). The stations were arbitrarily selected and may not represent the whole reach. Aside from Reach 2b (Structure #1 at 0+370), these stations do not represent velocities on a structure, as there are fish ladders located at Structures #2 through #10.

As can be seen in Figure 6, only a small portion of kokanee can swim to the spawning bed in Reach 4. Within the areas of creek that are accessible by fish, natural habitat areas for spawning and rearing are lacking.

Penticton Dam #2 prevents the natural augmentation of spawning gravels into the lower reaches. This has led to the addition of spawning gravels into Reaches 4 and 6 by the Penticton Flyfishers Club. These spawning beds have been somewhat successful; however, large flat spawning beds are not typically found in unaltered creeks. The future designs for Penticton Creek will attempt to mimic natural creeks and let the spring freshets dictate where the spawning gravels will end up.

Currently, there are no fish flow requirement for Penticton Creek from the Ministry of Forest, Lands and Natural Resources. The current low flow target for the creek is set by the City of Penticton and is based on maintaining a minimum of 20 Mld, or 0.23 cms throughout the year. It is recommended that a flow management strategy be developed for Penticton Creek, to establish a flow for future designs.

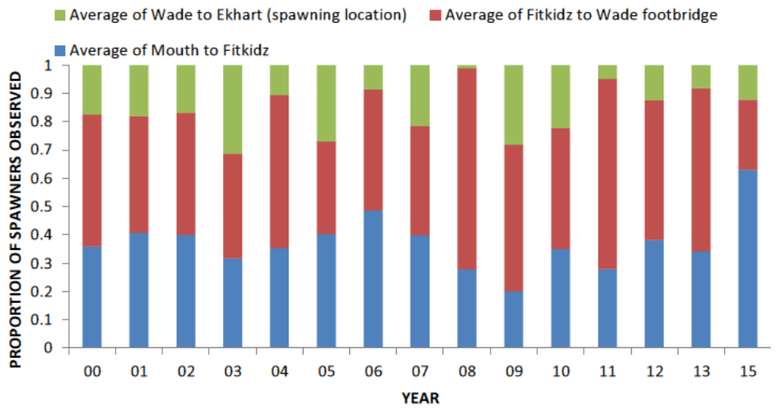


Figure 6: Proportion of Observed Kokanee Spawners in Different Areas of Penticton Creek (Askey, 2016)

Table 4: Existing Habitat Characteristics (excerpt from Matthews, 2016)

Reach	Habitat Limitations	Habitat Contributions	Habitat Quality Rating
1	No spawning; low quality rearing due to low gradient	No migration limitations	**Low+**
2	Concrete lined; All habitat types – no sp./rearing; low value migration and riparian; Structure #1 major migration obstacle	Minimal –no barriers but substantial migration obstacles	**Low-**
3	All habitat types – Structure #2 migration obstacle	Minimal; migration /rearing values in Showcase Project	**Low-** [1]
4	Access from lower reaches;	Spawning within artificial gravel platform – requires annual cleaning/gravel additions; some area specific rearing	**Mod-**
5	All habitat types – Structure #3 migration obstacle	Minimal	**Low-**
6	Access from lower reaches; barrier at weir structures	Area specific rearing	**Low+**
7	All habitat types	Minimal	**Low-**
8	Migration, spawning	Rearing and Riparian	**Low+** [2]
9	Spawning	Migration and some rearing	**Mod-**
10	All habitat types	Minimal	**Low-**
11	Migration, spawning	Rearing, riparian	**Low+** [2]
12	Migration, spawning	Rearing, riparian	**Low+** [2]
13	Spawning	Migration, rearing, riparian	**Mod-** [3]

[1] Does not include Showcase Project
[2] Would be significantly higher if no intra and inter migration issues
[3] Values currently limited to resident populations due to downstream barriers

In order to assess the quality of existing habitats, and create design targets for the future, preferred depth and velocities for a number of species were established. As mentioned above, the target species for Penticton Creek are Kokanee, Rainbow Trout and Longnose Dace; however, there are other species present in the Okanagan Basin. The design hydraulic and habitat characteristics that are beneficial for Rainbow Trout and Kokanee have been considered and also apply to other species, should they become present in Penticton Creek. Annex D compiles a wide variety of fish habitat preferences gathered across the United States and coastal BC. The range of habitat preferences for the target Penticton Creek species are based on Interior BC Habitat Suitability Indexes recommended by Paul Askey (Freshwater Fisheries Society of BC) and Ron Ptolemy (BC Ministry of Environment). These indices provide a likelihood that fish will be found at specific velocities and depths. The Committee decided to use the 0.50 percentile as the desired target.

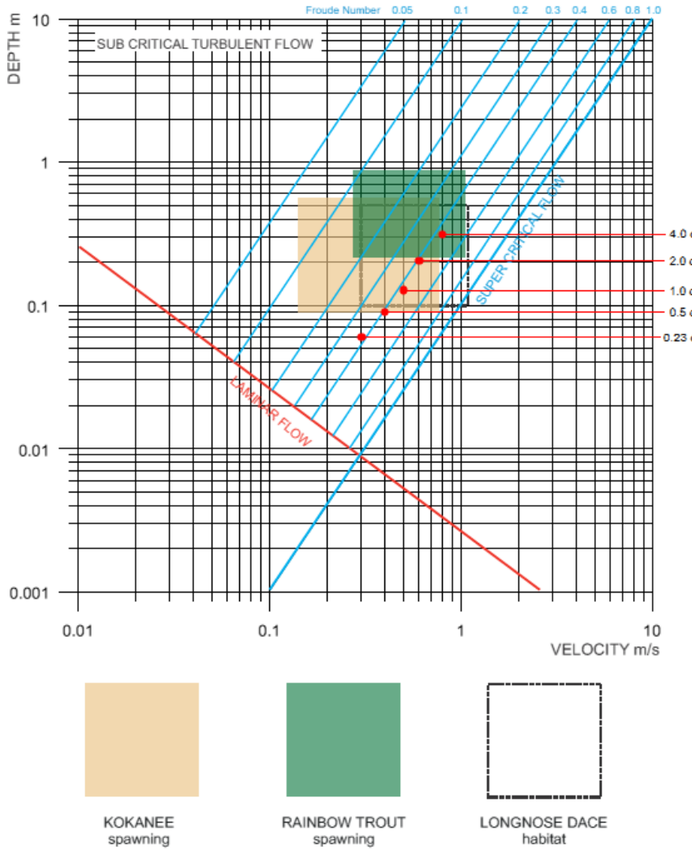


Figure 7: Existing Conditions for Several Reach 4 Flows

The values for the target Penticton Creek species are shown on a velocity vs. depth plot, provided by Dr. Bob Newbury. Figure 7 shows the existing Reach 4 spawning bed data as an example. At the lowest flow of 0.23 cms, which is typical for 8 to 10 months of the year, the current cross section of Reach 4 is not ideal for spawning. The current width results in lower depths than the targets.

CULTURAL AND HERITAGE INVENTORY MAPPING

A Cultural and Heritage Inventory Mapping (CHIM) assessment was carried out by 4 Seasons Heritage Consulting and Penticton Indian Band in July, 2016. The purpose was to complete a high-level survey to identify cultural heritage items of value to the Syilx people. The findings can be seen in Table 5.

Areas of 'Archaeological Potential' are "observed to have intact sediments, large trees indicating intactness of original landform or potential buried original landform." (4 Seasons Heritage Consulting & PIB, 2016) Where artifacts were found, the area was categorized as an 'Archaeological Site.' The description of features found in each reach are outlined on pages 24 to 39 and the specific details can be found in the CHIM report.

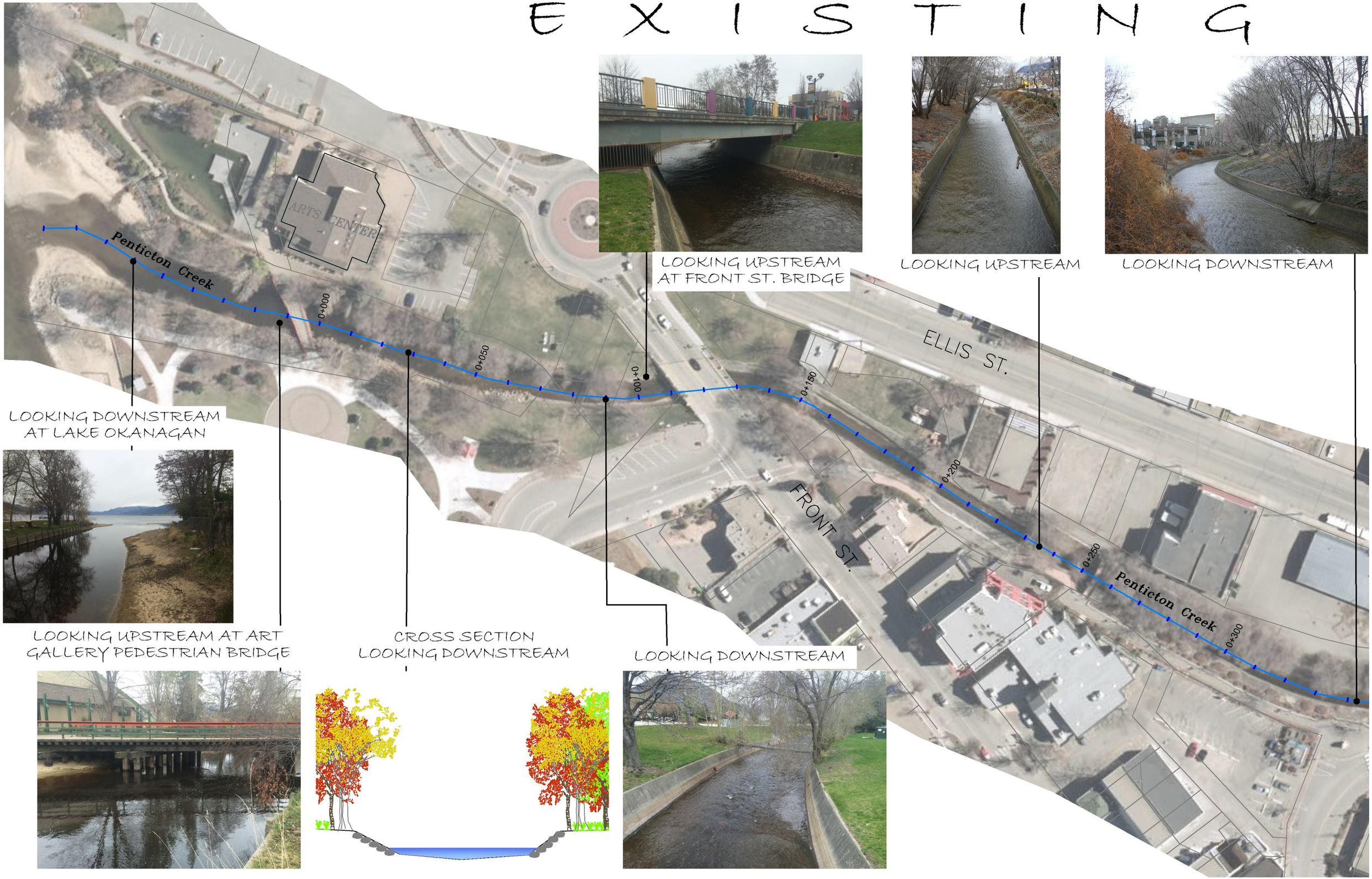
It is noted that any work around the archaeological sites requires a *Heritage Conservation Act* (HCA) Archaeological Impact Assessment and a Site Alteration Permit before construction, which may include provisions for monitoring or data recovery. Two heritage resources were found which require further investigation: a petroform (stone fishing weir or swimming area) and a culturally modified tree. These require an HCA permit to determine if they predate 1846; if so, they are automatically protected by legislation.

The report recommends applying for an annual HCA blanket permit for the entire creek which would assist with any potential land altering work. This would cover locations of archaeological potential; although these areas do not require a permit to perform work, construction could be held up if any archaeological items were found. A second recommendation is that an archaeological and/or cultural heritage resource management strategy guide be developed. This would include communications protocols for things like a chance finds procedure. Another recommendation is that HCA permitted testing of landforms' archaeological potential be undertaken in advance of development activities.

Table 5: Summary of Cultural Heritage Values Identified

Cultural Heritage Feature	Number Identified
Archaeological Potential	18
Archaeological Potential (area)	4
Archaeological Site	2
Cut and Fill	2
Deer	2
Fortis Pipeline Crossing	1
Limited Potential	7
Plant Communities or Plants of Significance	9
Culturally Modified Tree	2
Petroform (stone fishing weir or swimming area)	1
Remnant Wetland	1
Spawning Gravels	1
Vesicular Basalt	4
Natural/Limited	1
TOTAL	**55**

EXISTING



LOOKING DOWNSTREAM AT LAKE OKANAGAN

LOOKING UPSTREAM AT ART GALLERY PEDESTRIAN BRIDGE

LOOKING UPSTREAM AT FRONT ST. BRIDGE

CROSS SECTION LOOKING DOWNSTREAM

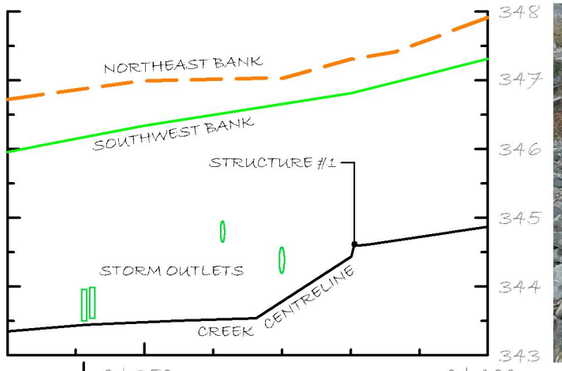
LOOKING UPSTREAM

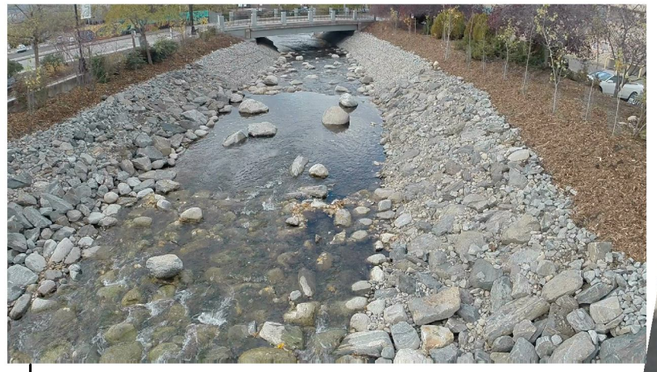
LOOKING DOWNSTREAM

LOOKING DOWNSTREAM

CONDITION

STRUCTURE #1





SHOWCASE, LOOKING DOWNSTREAM

LOOKING UPSTREAM

SHOWCASE, LOOKING DOWNSTREAM

LOOKING UPSTREAM AT NANAIMO BRIDGE

LOOKING UPSTREAM

CREEK REVITALIZATION

The Penticton Creek revitalization plan is a hybrid between natural stream characteristics and the present man-made channel. This is due to the fact that natural gravel bed streams of this size are less than one metre deep and more than 16 metres wide. In addition, floodplain widths in the range of 100 metres wide conduct flood flows that are greater than the median annual flood. In contrast, the man-made channel excavated in the 1940's is less than half the width and three times deeper. Without floodplains, it contains all of the flood flows and passes them as efficiently as possible in a narrow smooth canal.

Consequently, natural stream features to create fish habitats must be ruggedly designed to withstand the full range of flood flows. The habitat features to be added include gravel spawning areas for kokanee and rainbow trout, overwintering habitats for juvenile rainbow trout and suitable runs and pools to maintain a permanent population of longnose dace. Some reaches are better suited to adding natural features while others require re-configuring to allow for fish passage and minimum flow depths.

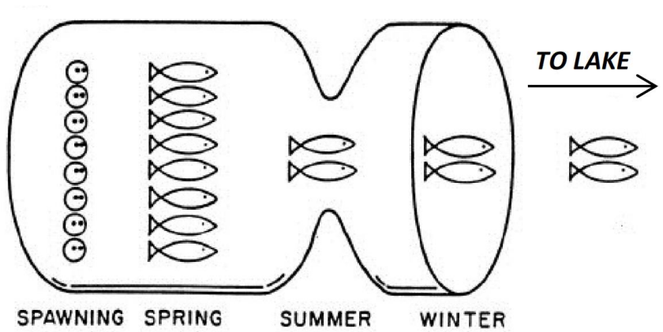
Generally where structures are deficient in freeboard, work needs to be done upstream of the crest, as discussed in the Structure Replacement section on the next page. Some of these structures fall on a reach boundary. When this occurs, project lengths may need to be adjusted and therefore, will not match the existing reach boundaries. Bank freeboard and bridge clearance deficiencies will be addressed using designs that meet the *Dike Design and Construction Guide: Best Management Practices for British Columbia.*

In general, the restoration options for the creek were limited, due to the many challenges. There is some opportunity for creative designs in Reaches 1 and 2, where there is room for expansion (Reach 1) and commercial land use (Reach 2). The Showcase design is proposed for residential areas where the creek corridor is narrow and the concrete is failing, in Reaches 3a, 7, and 10. A very long riffle and pool design is needed to overcome large structures, such as in Reaches 3b, 5 and 12. Reaches 4, 6 and 8 have room to incorporate more fisheries features, such as meandering low flow channels, woody debris and deeper pools. The restoration for Reach 9 includes creating a fish passable channel, as the current creek is very steep with high velocities. Some deficiencies that need to be addressed exist in the remaining reaches (11, 12 and 13) but in general, the proposed work will not considerably alter the creek.

Other work to address deficiencies include replacing all structures with riffle and pool sequences, increasing bank freeboard, increasing bridge clearance, removing concrete lining and increasing rock lining size to be stable.

FISHERIES DESIGN TARGETS

The conceptual designs and prioritization of each reach from the fisheries perspective is expected to change over time, as restoration is completed and the amount of spawning, rearing and migration changes. It is important that each stage of the fisheries lifecycle is represented in the creek, as to not create bottlenecks. The guiding principles for reach design and prioritization from a fisheries perspective can be found in Annex E.



Potential Population Bottlenecks that Limit Production of Juvenile Migrants to the Lake (Askey, 2016)

The Committee indicated that where possible, reducing the amount of maintenance required was preferred. As stated in the Sediment Transport section, Penticton Creek does not have a natural supply of gravel. The committee has discussed augmentation of spawning gravels and was in favor of adding gravels at key locations that could be distributed through the system during spring freshet events. However, small gravels may not be stable in many areas during large spring freshets. Measures such as implementing floodplains can reduce the frequency of spawning gravel maintenance.

Formal spawning side channels are not preferred by the Committee as work is needed to ensure flows are divided properly and entrances do not get blocked. Small islands in the creek are acceptable, but it is understood that they will be left to Mother Nature and may change over time. Other features that can be included to increase habitat diversity include deeper pools, woody debris, meanders, back eddies, alcoves and pockets of spawning gravel.

Gravels trapped behind natural woody debris in the Showcase (Askey, 2016)

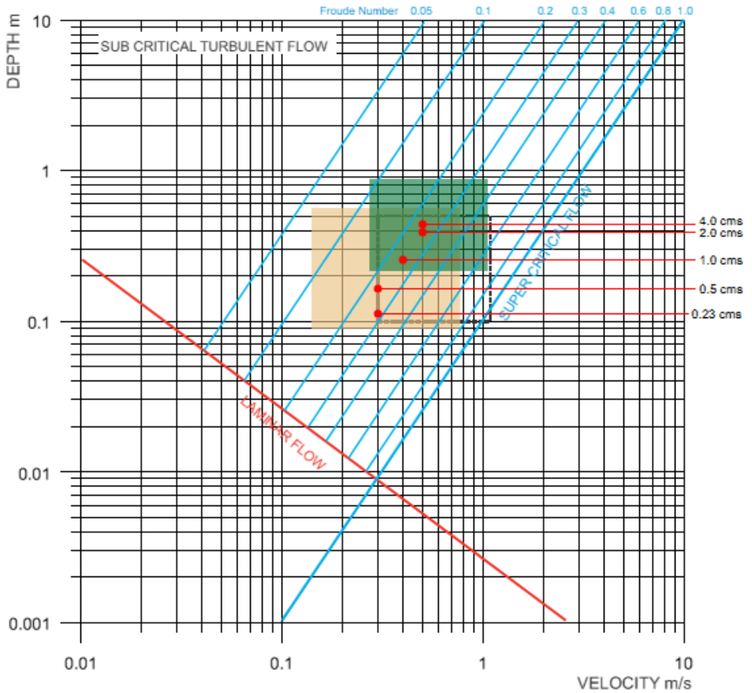


Figure 8: Proposed Conditions for Several Reach 4 Flows

Until a low flow management strategy is developed, designs will use 0.23 cms as the low flow in Penticton Creek. As discussed in the Existing Habitat Assessment section, future designs should target the depths and velocities established by the Habitat Suitability Index curves. Using the example of Reach 4, the proposed design (which is discussed on page 30) will increase depths, resulting in much more suitable habitat for spawning. Figure 8 shows the results of this.

Structure Replacement

When replacing drop structures, the specific design will depend on the freeboard at the drop structure crest.

The first structure replacement design (Type A) should be used for drop structures with adequate freeboard. For this type of design, the drop structure can be replaced with a riffle that has a crest in the same location as the existing crest. Depending on the height of the structure, a single or multiple pool/riffle scheme can be used.

When there is inadequate freeboard at the crest, the drop structure should be replaced by a riffle and pool sequence set further upstream than the existing crest (Type B).

In either case, detailed survey and HEC-RAS analysis will be needed to confirm freeboard issues exist and ensure that the proposed design resolves all problems.

Revitalization Options

The following pages provide a brief description of the existing and proposed conditions within the thirteen reaches.

Land use on either side of the creek was a considerable factor in determining what restoration options were possible. Development includes park, commercial, residential, and public roads and walkways; some areas are more heavily developed than others, with road right-of-way and structures narrowing the creek corridor. Between 1948 and 1973, a series of five City of Penticton bylaws (929, 952, 1057, 2848 & 3008) were enacted related to the channelization of the creek. These bylaws outline three plans; the M-178, M-185 and M-195 plans which establish a creek corridor where flood infrastructure was constructed.

Further, much of the property adjacent to the channel has seen additional development and the City has constructed a linear walkway along the majority of the study length. This limits the available corridor to approximately 20 m wide, significantly less than required for natural conditions.

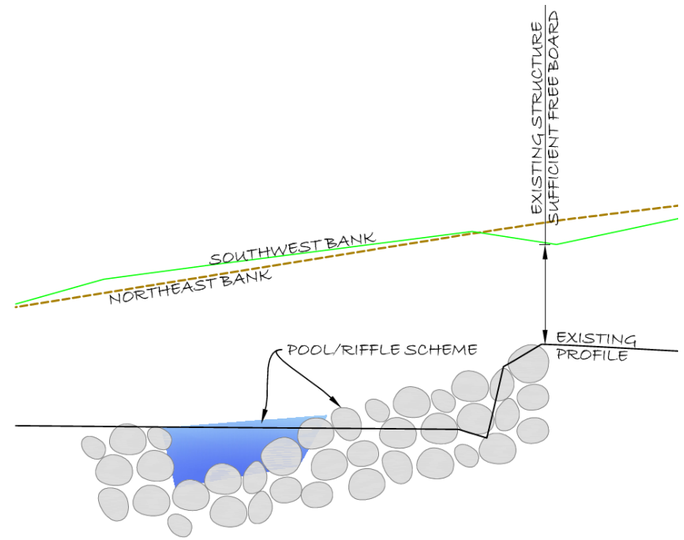


Figure 9: Type A Structure Replacement where Adequate Freeboard

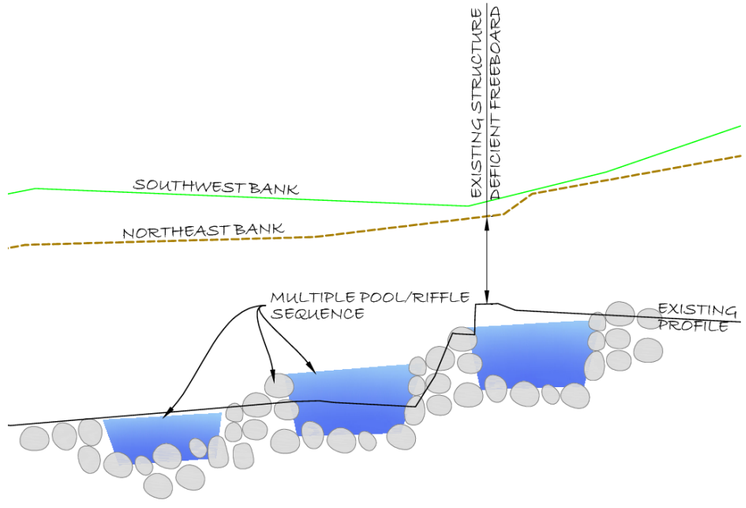


Figure 10: Type B Structure Replacement where Inadequate Freeboard

REACH 1

Existing Conditions

Length: 150 metres

Average Width: 11 metres

Average Slope: 0.0%

Existing Habitat Quality Rating: Low+

Reach 1 is located at the mouth of Penticton Creek and extends from Okanagan Lake to the beginning of the concrete lining below Front Street bridge. The channel bottom is natural and the bank material ranges from sandy banks to riprap armoring. This reach is currently fish passable.

The property on both sides of the creek are owned by the City of Penticton and are currently utilized as public space. The Art Gallery and Penticton-Ikeda Japanese Garden is located to the east of the creek while the Okanagan Lake Park is located to the west.

Mouth of Penticton Creek at Lake Okanagan

Upstream of the Art Gallery Pedestrian Bridge

A large alder stump was identified as a marker of archaeological potential. Thule reeds were also found on the banks and are considered valuable to the Syilx people.

There is considerable variation in bank armoring and some of the smaller sized material will be unstable at higher flows. The short retaining wall on the west side of the creek is currently failing and the Art Gallery pedestrian bridge does not have the required clearance at high flows.

The Okanagan Lake level has considerable influence on the creek flows and elevations in this reach. The full pool elevation (342.48 m) often backwaters the creek to the Front Street bridge. As a result, some variations of lake level and creek flow result in a standing wave and a lack of bank freeboard at multiple locations.

REACH 1

Proposed Revitalization

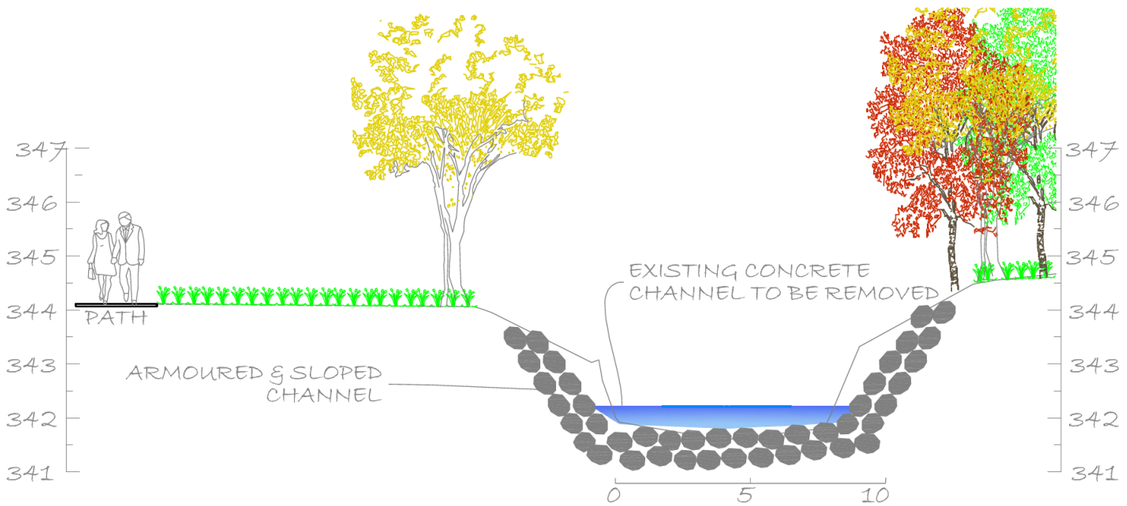
The proposed restoration of Reach 1 includes the lower 45 metres of Reach 2, so that the Front Street bridge becomes the boundary. This short length immediately downstream of the bridge has many of the characteristics of Reach 1, including the ability to expand the creek width due to adjacent City owned properties.

Many options were explored for this Reach, resulting in two potential designs. Further development of these designs is needed in order to refine the cost estimates and allow an option to be selected. In addition, as other projects are completed, the type of habitat desired, such as spawning or rearing, may change. Both potential options include the relocation of the aboveground sanitary sewer crossing to Front Street bridge and include the replacement of the Art Gallery pedestrian bridge, as it does not meet the clearance standards.

The first option includes removing the concrete lining immediately downstream of Front Street bridge, and replacing the bank material with riprap. The existing bank slopes will be altered, creating a slightly wider top-of-bank to top-of-bank width; however, this option does not significantly expand the creek footprint.

In areas with small diameter bank material, rock size will be increased to ensure stability during high flows. Bank heights will also be increased to ensure minimum freeboard standards are met. This option is more cost effective; however, it does not significantly improve the quality of fish habitat.

The second possible option takes advantage of the City owned property on either side of the creek and widens the floodplain in order to create a braided creek with gravel deposition areas. In addition, the creek bottom could be elevated to reduce backwatering of the reach by Okanagan Lake during spawning seasons. The plan view of this option can be seen in Annex A.



A potential revitalization option within the existing footprint

The new elevated creek profile will be stabilized with several riffles, including one at the creek mouth, and above and below Front Street bridge, to ensure the bed will not downgrade

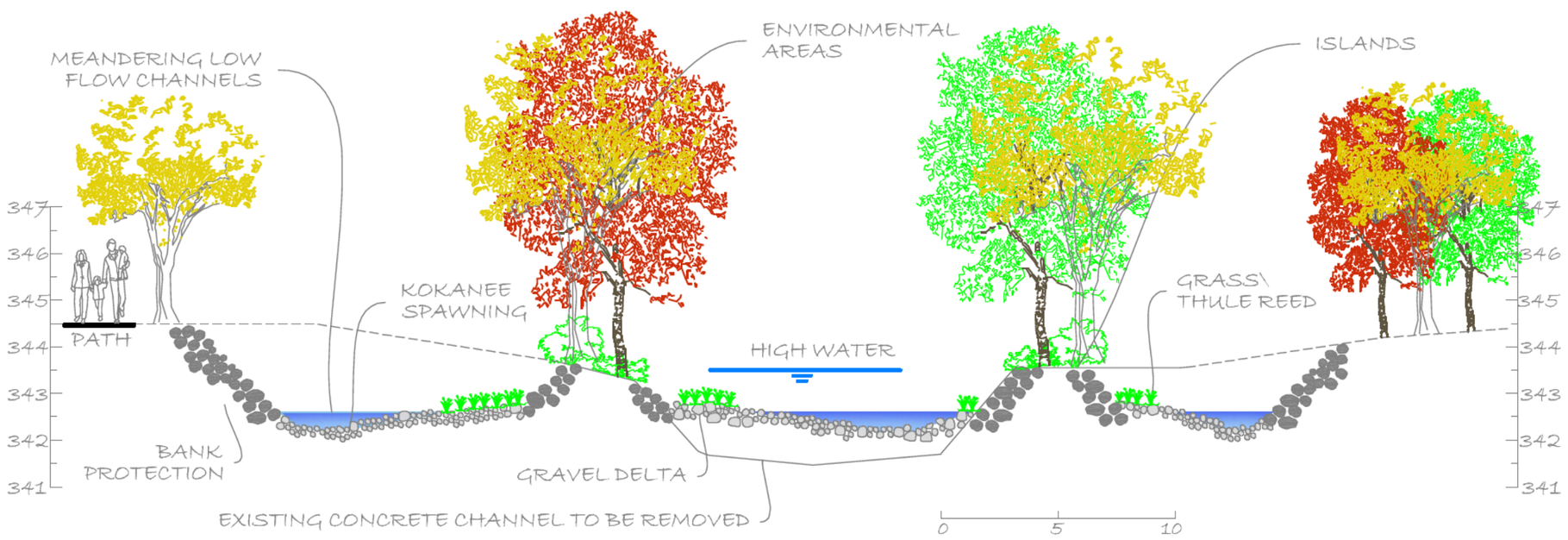
The existing path on the west side of the creek can remain in its current location. On the east side of the creek, utilities, including water, storm, electrical and communications infrastructure, will require relocation. The width of riparian area on the east side of the creek could be expanded with additional vegetation planted.

This option would create a unique feature in the downtown core that contrasts the urban landscape upstream and highlights the creek, rather than simply creating a necessary flood corridor.

This option would leave the existing bank vegetation as islands in the creek with three low flow channels. The lower gradient of the creek bottom and additional width will create optimal depths and velocities for potential spawning. The gravel delta will be able to retain much of the smaller material during spring freshets, due to the wide floodplain and lower water depths.

As part of the expanded floodplain option, a ramp could be installed for collecting the accumulated gravels that will be reintroduced into the system at a higher elevation. A sedimentation management strategy is discussed in the Recommendations section on page 42 and 43.

.



A potential restoration option with an expanded floodplain

REACH 2

Existing Condition

Length: 350 metres

Average Width: 6 metres

Average Slope: 0.7%

Existing Habitat Quality Rating: Low-

Restoration Sub-Reaches: 2a & 2b

Structure(s): #1

Looking upstream at Structure #1

Reach 2 is the narrowest, and most urban, section of creek with an average bottom width of 6 metres. The entire reach is concrete lined and differs from the other lined reaches as the concrete was formed, and is generally in better condition than the reaches that were not formed (Reaches 3, 5, 7 and 10). However, there are still many holes in the lining. As can be seen in the existing photos, vegetation including shrubs and trees are growing through the concrete lining. There is a lack of freeboard along the right hand side of the creek, upstream of Front Street bridge.

The concrete liner itself is a deterrent to fish attempting to migrate upstream, as it provides no resting places. The Penticton Flyfishers have placed concrete curbs in this reach to add depth; however, the estimated percentage of kokanee passing Reach 2 is approximately 60% (Askey, 2016). The first major barrier to migration up Penticton Creek is Structure #1, pictured on the left. There is no fish ladder and the calculated velocity of 3.7 m/s during a typical spring flow (see Table 3) is a complete barrier to rainbow trout. (Askey, 2016)

The creek corridor through this reach is very restricted, with commercial land uses on each side. There are some City owned properties which may provide opportunities for a slight width expansion. The Ellis Street pedestrian and vehicular bridges have adequate clearance. However, the cross sectional area narrows under Front Street bridge and therefore, there is a lack of clearance.

Several areas of archaeological potential were identified in the CHIM report. These are associated with a well-defined landform and will require monitoring when work is done in this reach.

Formed concrete lining, facing upstream

REACH 2

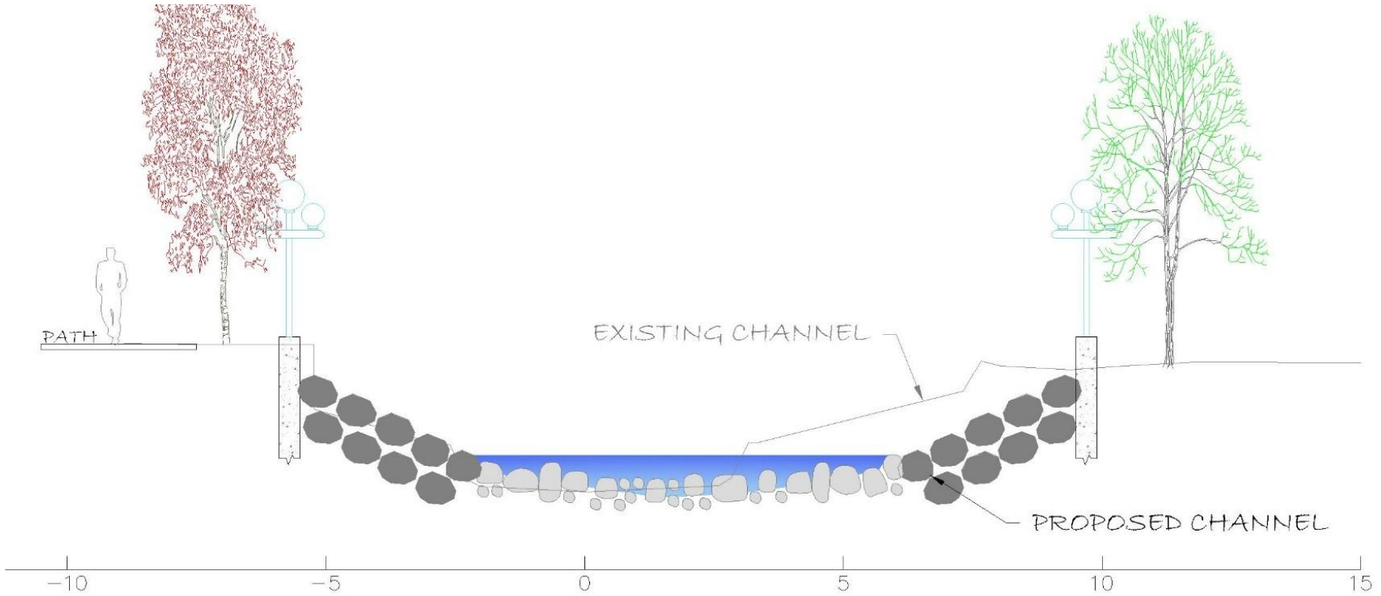
Proposed Revitalization

The proposed restoration of Reach 2 excludes the lower 45 m of creek, below Front Street bridge, and the remainder is divided into sub-reaches 2a and 2b. As with Reach 1, many options were explored for this reach, and two potential designs were identified. The overall proposed design will be very similar for both sub reaches. Some additional features can be incorporated into local areas where there may be additional width. Additional development of both options is needed to inform the Committee so that they can make a decision in this reach.

Due to the narrow creek right-of-way and inability to widen, the design through this reach must incorporate 'smooth' bank materials (with low 'n' values) to pass the Q_{200} flood. Therefore, both designs incorporate retaining walls with a natural creek bottom, while keeping the existing pathway to the west of the creek. Although there is an existing low retaining wall on the west side of the creek, it is not suitable as a structural wall to protect from flooding. Therefore, the existing wall and concrete lining will be removed and a new retaining wall with an appropriate foundation will be built.

Both options include removing the concrete under Front Street bridge and widening the cross sectional area to increase the clearance. Since both options include creek widening, the Ellis Street pedestrian bridge will need to be replaced with a longer span. No work is currently required at the Ellis Street vehicular bridge as the concrete is in reasonable condition but it could be replaced in the future.

The first potential option is a simpler design that incorporates rock banks; however, concrete retaining walls are still needed to ensure that the minimum freeboard requirements are met. This option creates a low flow channel with small riffles to assist in migration. A series of riffles will be needed to replace Structure #1, in Reach 2b.



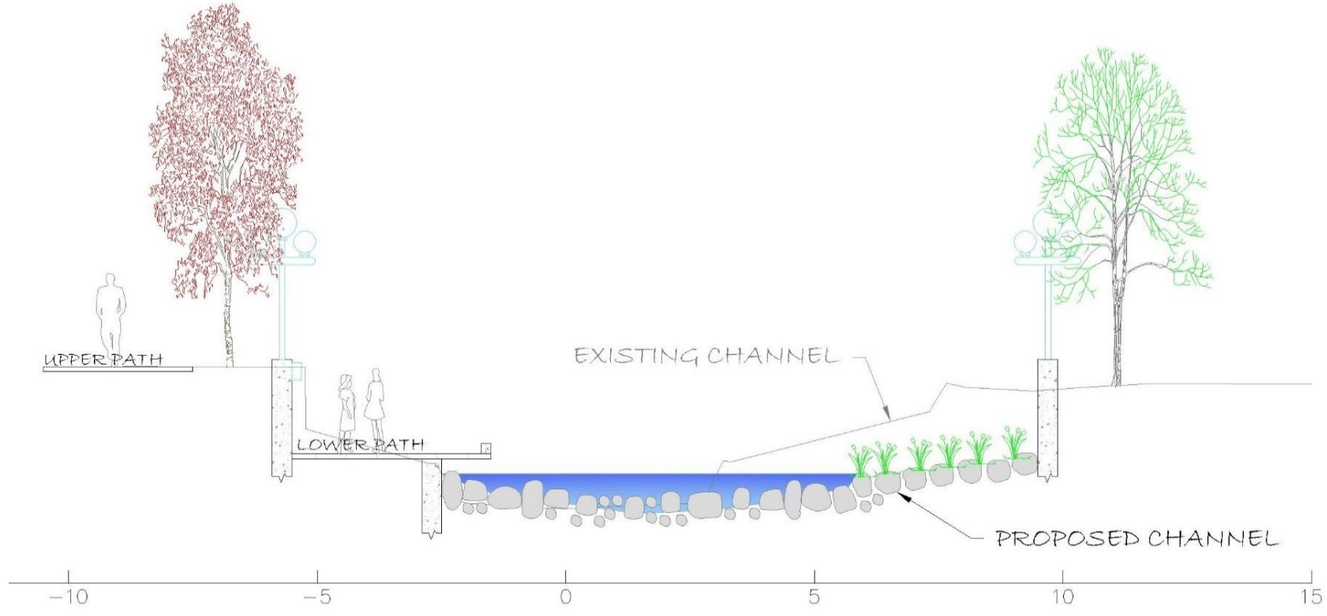
A potential restoration option with no pedestrian access to creek

The corner just below Ellis Street bridge has some additional width and opportunity for unique design features. A gravel bar could be incorporated into the inside corner, creating a small side channel. A riffle would be built to regulate the flows around the island. The higher spring freshet flows would naturally rearrange the gravel each year. Deeper pools could also be incorporated on the outside of the corner. A cross section of this can be seen on the Conceptual Design plan in Annex A.

Another feature that could be incorporated is a waterfall, on the inside corner. The sound of the waterfall is attractive to fish and the location would encourage fish to use the small side channel. The feature could be gravity fed by a pipe, with an inlet in a pool upstream.

The second option is an urban design that fits within the context of the downtown Penticton area. The land use on either side of this reach is commercial and provides a contrast to the rest of the more residential and natural areas along the creek. The creek bottom would be similar to the previous option, with small riffles to assist with migration. The proposed design includes a lower path for pedestrians on the west side of the creek. The access for this walkway would be provided by a ramp. Amphitheater style seating could be incorporated along the creek in areas where there is additional width. A cross section of this can be seen in the Conceptual Design plan in Annex A.

A low flow channel that will meander within the width of the retaining walls will provide some fisheries diversity. In addition, the path could be cantilevered over the creek to provide shade. At higher flows the lower path will need to be closed to the public.



A potential urban restoration option with lower path

REACH 3

Existing Condition

Length: 455 metres

Average Width: 7 metres

Average Slope: 2.1%

Existing Habitat Quality Rating: Low- (excl. Showcase)

Sub-Reaches: Showcase, 3a & 3b

Structure(s): #2

Reach 3 is narrow, concrete lined section of creek that includes Structure #2, the tallest structure measuring 2.7 m in height. The concrete lining is deteriorating, exposing a wire mesh in many locations. Approximately every 10 metres, a cutoff beam spans the creek. These beams measure approximately 0.4 metres wide and over one metre deep, and are presumed to have been constructed to add stability to the creek and prevent downgrading.

Looking upstream From Nanaimo Avenue Bridge

Looking upstream at Structure #2, From Wade Avenue Pedestrian Bridge

The land use on either side of the creek is mostly residential, with some City owned property and adjacent road right of ways. The path on the west side of the creek is continuous, except for a 45 metre gap where pedestrians must walk along an alley, just south of Nanaimo.

The Wade Avenue pedestrian bridge has adequate clearance. However, there is a lack of clearance at Nanaimo Avenue bridge and a lack of freeboard at two bank locations, and at the crest of Structure #2. The risk rating of Structure #2 is very high due to the height and current condition of the structure. The failing apron has created large holes where the material behind the structure can be seen.

Similar to Reach 2, there is no resting for fish in this Reach and concrete curbs are currently used to assist in migration. There is a fish ladder at Structure #2 but the success rate of fish trying to pass this barrier is very low.

The CHIM report identified two areas of archaeological potential, located between the Nanaimo and Wade Avenue bridges.

REACH 3

Reach 3 consists of the 2015 Restoration Showcase project (80 metres) and sub-reaches 3a and 3b. Due to the length of creek needed to overcome Structure #2, a separate design is needed for each sub-reach.

Sub-Reach 3a Proposed Revitalization

The restoration of Reach 3a will be a continuation of the 2015 Showcase design, including riffles and pools, to replace the failing concrete lining. The design will widen the creek on the east side, to accommodate the rock banks that will be rougher than the current concrete lining. Where the banks are required to be higher than natural ground, a 3 metre wide berm will be constructed to protect public and private land.

The design will include additional diversity for fish, such as sharp narrowing and widening of the creek. This will create back eddies and possible locations where gravel could accumulate.

Although there are no clearance deficiencies at the Wade Avenue pedestrian bridge, a longer span will be needed to accommodate any widening of the creek in this area. Also, the Nanaimo Avenue bridge is near the end of its life span and is currently lacking clearance. Any work to increase clearance by changing the channel or abutments would be costly. Consideration could be given to replacing the existing bridge with a pedestrian bridge, to ensure access and mobility is not reduced for cyclists and pedestrians. The area east of the creek could become a public green space and planted for riparian depth, while ensuring the alley between Abbott and Van Horne remains accessible. A conceptual plan of this area is shown in Annex A.

Looking upstream at the 2015 Restoration Showcase

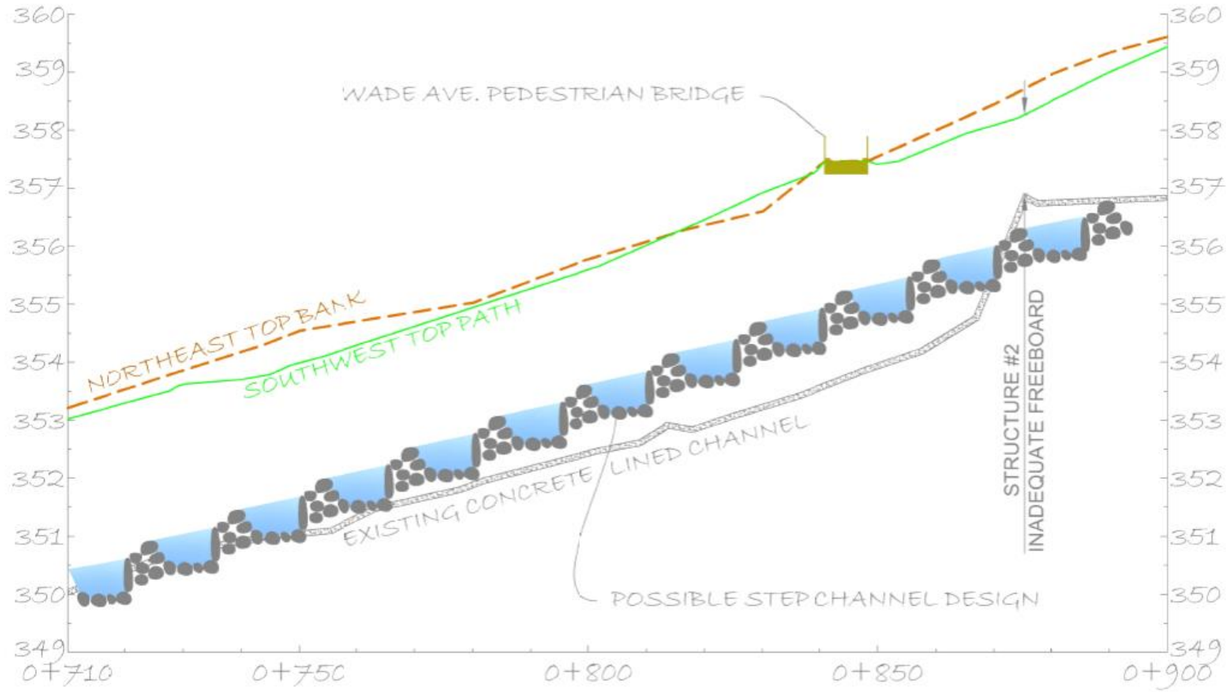
Sub-Reach 3b Proposed Revitalization

In order to replace Structure #2 and create a channel that is fish passable, the restoration design for Reach 3b will create a series of riffles and pools for approximately 180 metres. The overall slope of the design will be steeper than the existing channel, therefore taking advantage of the additional freeboard downstream of the structure. By raising the creek profile, the bottom width will increase, creating better habitat conditions for fish.

Because there is a lack of freeboard at the current structure crest, the crest of the top riffle will be located approximately 15 metres upstream, in the existing Reach 4. The viewing area just above the crest on the east side of the creek will be removed and a replacement viewing feature could be considered.

Each riffle and pool sequence will be approximately 15 m long, with an overall slope of approximately 3.6%. The maximum slope of each riffle will be 7% with a pool depth of approximately 0.4 metres.

There is a pinchpoint, located downstream of the Wade Avenue pedestrian bridge, which will require some creek widening. Thus, the bridge will need to be replaced with a longer structure, but could be installed again in another location.



A profile view of the possible Reach 3b design to replace Structure #2

REACH 4

Existing Condition

Length: 75 metres

Average Width: 14.5 metres

Average Slope: 0.4%

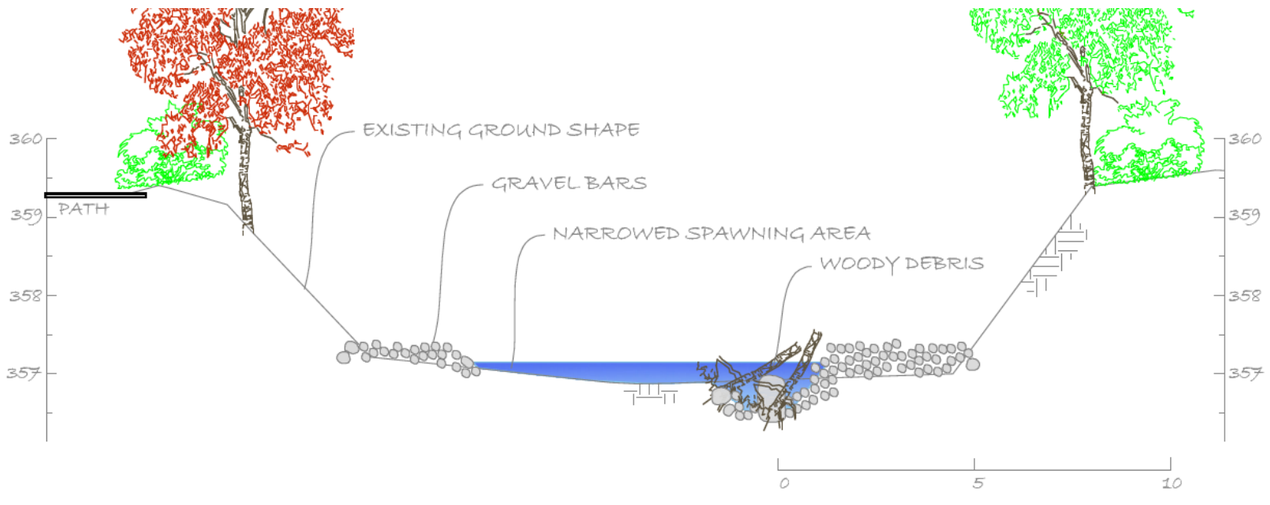
Existing Habitat Quality Rating: Mod-

Reach 4 is a wider, flat reach that is currently used as an artificial spawning bed by the Penticton Flyfishers Club. The channel banks and bottom are not lined, and are artificially augmented with gravels after a large freshet event. The creek bottom is very flat and combined with the width, creates a very low depth of water. Parking curbs are placed across the crest of Structure #2 to create greater depths for spawning.

The only flood deficiency in this reach is at the crest of Structure #2, as mentioned in the Reach 3b writeup. There are no structures or lining. The CHIM report observed limited archaeological potential in Reach 4.

Looking upstream at Reach 4

There are some grasses and shrubs located within the low flow channel and a narrow riparian area of trees, located higher up the banks.



A proposed cross section with a narrowed low flow channel

REACH 4

Proposed Revitalization

This reach has been used as a spawning bed, with small material augmented due to the lack of natural gravels in the channel. In order to create a maintenance free channel that retained small gravels during annual floods, a 40 metre floodplain would need to be created, which is unrealistic given the land use around this reach.

One possible design widened the creek to the east, creating a small floodplan; however, this would not produce a noticable difference in the amound of gravel retained and the design would eliminate the established riparian area.

Therefore, the proposed design would create a narrower low flow channel, within the existing banks, that would provide additional water depth and a more natural channel shape. This channel could meander and include woody debris and larger rocks to improve habitat diversity. Rather than creating a designated spawning bed in Reach 4, more natural pockets of spawning areas were desired by the PCRI Committee. The low flow channel is designed to create preferred spawning depths and velocities. Gravel augmentation will still be required in this area, as the overall channel width will not change. The lower Reach 4 boundary will need to be revised, as the replacement of Structure #2 will move the crest upstream approximately 15 metres.

Any restoration created in Reach 4 will be difficult to maintain unless an energy dissipating riffle is built between Reaches 4 and 5. The channel in Reach 5 is steep and narrow and most of the hydraulic energy will be directed down the center of Reach 4 if this feature is not built. Therefore, Reaches 4 and 5 should be constructed together, as one project.

REACH 5

Existing Condition

Length: 110 metres

Average Width: 10.5 metres

Average Slope: 3.3%

Existing Habitat Quality Rating: Low-

Structure(s): #3

Reach 5 is the steepest and most entrenched section of creek, with bank heights up to 5.6 metres. The entire reach is narrow and concrete lined, with a pinch point and aboveground sewer crossing just below Structure #3 at the upper end. There are some City of Penticton properties on the east side of the creek which could accommodate some width expansion. The west side of the creek is lined by a walkway and Government Street.

The flood infrastructure deficiencies in this reach include the lining and Structure #3. The lining is deteriorating with many holes showing mesh lining and growing vegetation. Structure #3 is the second tallest drop structure in the creek, measuring 2.3 metres. There are many holes in the apron and woody debris was observed caught on the structure and lining below.

The channel below Structure #3 is a fish barrier due to the creek velocity and smooth concrete lining, lacking resting places. Structure #3 does have a fish ladder; however, it is understood that it is rarely utilized by migrating fish due to the numerous downstream barriers.

Limited archaeological potential was observed in Reach 5, as it has already been heavily impacted.

Looking upstream at the aboveground sewer crossing and Structure #3

Looking downstream from the crest of Structure #3, during spring freshet

REACH 5

Proposed Revitalization

The proposed design for Reach 5 is the same riffle and pool design as proposed for Reach 3b. The height of Structure #3 requires raising the creek bed throughout the entire reach to create a fish passable channel. As the centreline profile is raised, extra width is created; however, additional widening is recommended on the east side to remove the pinchpoint. Because there is adequate freeboard at the crest of Structure #3, the crest of the new riffle design can be located at the same elevation and location as the existing crest.

Widening of the creek at the pinch point will require the relocation or replacement of the 200 mm sanitary sewer crossing, which runs east to west over the creek. There are numerous options for the sewer and Investigation will be necessary to determine the preferred design.

As discussed in Reach 4, a riffle is needed to dissipate the energy at the lower end of Reach 5. This riffle will spread the water from the narrow chute across a wider surface area in Reach 4 and incorporate large rocks to dissipate the scour energy.

REACH 6

Existing Condition

Length: 190 metres

Average Width: 12 metres

Average Slope: 0.8%

Existing Habitat Quality Rating: Low+

Structure(s): #4 and #5

Reach 6 is a wider reach with a natural bottom and low grade. The grade is broken up with Structures #4 and #5 and a few rock riffles. The area above Structure #2 has similar characteristics to Reach 4 and has been augmented with gravels by the Penticton Flyfishers in the past. However, the use of this artificial spawning area is low due to the downstream migration barriers.

Reach 6 is bounded by road right-of-way on both sides: Pickering Street to the east, and Government Street to the west. The walkway continues along the west side of the creek through this reach. There is a viewing area just upstream of the crest of Structure #3 on the west side.

Some shrubs and small trees line the channel, overhanging the water. Larger trees exist at the top of the banks, with no impact on the water during low flows.

A vesicular basalt cobble and a remnant landform retaining archaeological potential were found in Reach 6. These items should be avoided or collected during restoration work.

Looking upstream from Structure #2

Looking upstream at the concrete crest and apron of Structure #4

REACH 6

Proposed Revitalization

Because there are no freeboard or lining deficiencies, most the restoration work in Reach 6 will be to remove and replace the concrete structures. Each will be replaced with a fish passable, single riffle of approximately 8% slope. These riffles will have a larger footprint than the existing structures, as the slope will be much lower than the concrete apron.

When Structure #3 is replaced, just downstream of Reach 6, the viewing area will be removed. During the detailed design stage of this reach, consideration could be given to incorporating a replacement viewing space in another location.

Pockets of spawning gravel can be added to the upstream side of the riffles. Because the upstream face of the riffles will have a negative slope, some spawning gravel will be retained but the gravel will be unstable during high flow freshet years. Reach 6 has the width and freeboard to incorporate other diverse habitat features, such as woody debris or deeper pools.

REACH 7

Existing Condition

Length: 170 metres

Average Width: 7.5 metres

Average Slope: 1.9%

Existing Habitat Quality Rating: Low-

Structure(s): #6 and #7

Reach 7 is another concrete lined section of channel. It is in similar condition to Reach 3, with vegetation growing through holes in the concrete and wire mesh exposed. The reach has two structures and one riffle, and includes the KVR pedestrian bridge and Eckhardt Avenue bridge. Both structures are equipped with fish ladders.

The creek is surrounded by City of Penticton property and road right of way in this reach. The walkway on the west side of the creek follows Government Street and moves away from the creek near Eckhardt Avenue. This is the lowest reach where the pathway is not continuous. Pedestrians and cyclists could continue along Ontario Street but they would share the road with vehicles as there is no separated walkway.

There is a lack of freeboard in the area around the crest of Structure #7, on the west side of the creek. Both the KVR pedestrian bridge and Eckhardt Avenue bridge have adequate freeboard compared to the adopted standard. However, the bridge at Eckhardt Avenue is considered a major transportation route for the City and work should be done to increase the existing clearance.

Limited archaeological potential was observed in Reach 7, as it has already been heavily impacted.

Looking upstream at Structure #6, from the KVR pedestrian bridge

Looking downstream at Eckhardt Avenue bridge

REACH 7

Proposed Revitalization

The work to improve Reach 7 will be very similar to the Showcase Restoration Design, completed in Reach 3 in 2015, with the exception of the structure replacements. The concrete lining will be removed and between the structures, a series of pools and riffles will be created with the same overall existing grade. This will assist in fish migration and create diverse habitat. The replacement of each structure will be three smaller, steeper riffles. The footprint for these replacements will be about 60 metres each; therefore, the Showcase design will be incorporated into the remaining 50 metres of this reach.

The Showcase design is an example of what could be done in Reach 7

The redesign of Structure #7 will move the crest further upstream, to increase freeboard (see Figure 7: Type A replacement). If a freeboard issue still exists, the banks must be heightened on the east side of the creek. To increase the clearance under Eckhardt Avenue bridge to a target of 1.5 metres, the concrete banks under the bridge should be removed as they restrict the cross-sectional area. The KVR pedestrian bridge does not require any work at this time.

REACH 8

Existing Condition

Length: 265 metres

Average Width: 17.5 metres

Average Slope: 0.6%

Existing Habitat Quality Rating: Low+

Structure(s): #8 to #11

Looking upstream at creek braiding in Reach 8

Reach #8 is the most natural lower reach, with a wide cross section and a small floodplain. The slope is quite flat between structures and the rock size of the banks is stable during high flows. Some braiding has created a vegetated island, as seen above.

Reach 8 includes four structures, one of which has already failed and attracted public attention during floods in 2006. As mentioned in the Reach 7 write-up, there is a lack of freeboard at the crest of Structure #7, which is on the border of the two reaches. Work to replace the structure will extend into Reach 8. Structure #10 is the last structure that has a fish ladder, and also has a lack of freeboard around the crest.

The land use around Reach 8 includes some residential properties, City owned land, and Ontario Street. Once Ontario Street veers away from the creek, there is no public walkway along the water. The Official Community Plan identified the Penticton Creek Trail as a pathway that should be a construction priority and future designs should incorporate this.

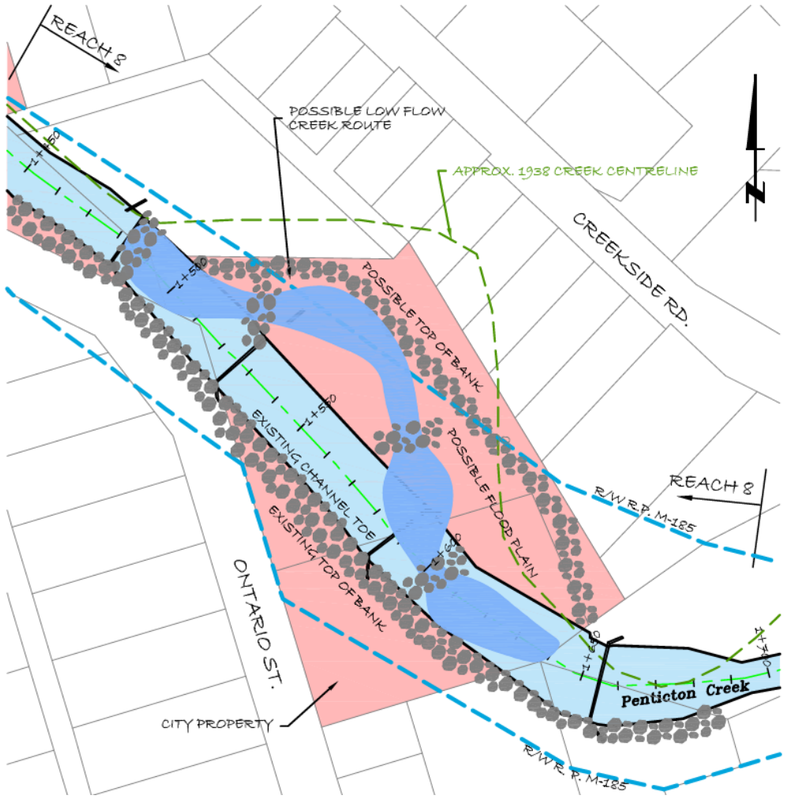
A number of plant communities, areas of archaeological potential, and an archaeological site were identified in the CHIM report. It is recommended that the site be reported and investigated, prior to any restoration work.

REACH 8

Proposed Revitalization

This reach is one of the few opportunities to create a wide floodplain, due to the land owned by the City of Penticton adjacent to the creek. A meandering low flow channel with preferred spawning depths and velocities could be created with enhanced features like woody debris and deep pools, to diversify the creek. The additional floodplain width will reduce water depths during spring freshet, making small spawning gravels more stable. The lower boundary with Reach 7 will likely be changed to accommodate the replacement of Structure #7. In addition, some work may be needed to increase bank heights on the right side of the reach, above the structure.

In order to make the reach fish passable, each structure will be replaced by a single riffle of approximately 8% slope that spans the entire width of the floodplain.



Plan view of an expanded floodplain and meandering low flow channel

The cost estimate for this reach does not include the installation of a public walkway along the creek, but this is an addition that should be considered when at the design stage. The City of Penticton's GIS mapping shows a proposed multi use trail along the west side of the creek.

REACH 9

Existing Condition

Length: 75 metres

Average Width: 8 metres

Average Slope: 2.8%

Existing Habitat Quality Rating: Mod-

Structure(s): #12 to #14

Reach 9 is a short and steep section of channel that has been repaired with riprapped banks by the City in the past. The structures in this reach have already failed and no longer have an impact on the water surface, although the concrete wingwalls still exist. The west side of the creek is bounded by a retaining wall for the parking areas of adjacent apartment buildings. On the east side, there are residence set slightly further back. The creek runs through private property for the entirety of this reach and within the M-185 Plan.

During the maximum daily and instantaneous flood flows, the slope and depth of water cause the size of the riprap to be unstable. There are no freeboard issues and no bridges in this reach.

Although most of Reach 9 has limited archaeological potential due to land altering impacts, the eastern portion of a Reach 8 remnant landform overlaps into this reach.

Looking upstream at Reach 9

A failed concrete structure in Reach 9

REACH 9

Proposed Revitalization

Due to the migration issues downstream of Reach 9, it is suggested that any upper restoration focus on flood infrastructure issues. As projects are completed that allow fish to travel to Reach 8 and the Master Plan is updated, future conceptual designs could be developed for Reaches 9 to 13. Any work done to remove concrete and replace structures in the meantime will be completed with fish migration in mind.

The restoration of Reach 9 will address the flood deficiencies by stabilizing the riprap and creating riffle and pool sequences to overcome the large elevation change. In addition, it is proposed that Reach 9 be widened to shift from a narrow channel to the broader floodplain of Reach 8. This will create an energy transition to ensure that a center torrent from Reach 9 will not destroy the works below.

REACH 10

Existing Condition

Length: 240 metres

Average Width: 7 metres

Average Slope: 1.7%

Existing Habitat Quality Rating: Low-

Sub-Reaches: 10a & 10b

Structures: #15 to #17

Looking upstream from Forestbrook Drive bridge

Reach 10 is very similar to the conditions seen in Reaches 3 and 7. The channel is narrow and concrete lined, with very low quality fish habitat. The land use around this reach is mostly residential, with some City owned properties adjacent to the creek. As with Reaches 8 and 9, the north part of Reach 10 is lacking a pedestrian and cyclist trail. The paved trail picks up again south of Forestbrook Drive bridge, on the west side of the creek.

The walkway between Forestbrook Drive and Kensington Street appears to be a dike, but detailed survey was not picked up in this area. This should be investigated to ensure dike standards are met. There are no freeboard issues in this Reach; however, the concrete lining is deteriorating with many visible holes.The existing clearance under Forestbrook Drive bridge meets the adopted guideline.

A remnant landform was identified as an area of archaeological potential to the south of Forestbrook Drive bridge on the western bank of the creek.

A concrete lining hole with visible mesh

REACH 10

Proposed Revitalization

The concrete in this reach will be removed and it is proposed to use the Showcase Restoration design. The riffles and pools will provide a fish passable reach, with increased habitat quality for fish. There is limited potential to retain pockets of gravel, as in the original Showcase project. Due to the narrow corridor, it is unlikely that additional features could be built in Reach 10.

It is proposed that there will be no change under Forestbrook Drive bridge and the concrete liner will remain. However, it should be inspected at the time of work.

Each structure will be replaced with two to three riffles.

Proposed riffle and pool design for Reach 10

REACH 11

Existing Condition

Length: 800 metres

Average Width: 16.5 metres

Average Slope: 0.8%

Existing Habitat Quality Rating: Low+

Sub-Reaches: 11a, 11b, 11c & 11d

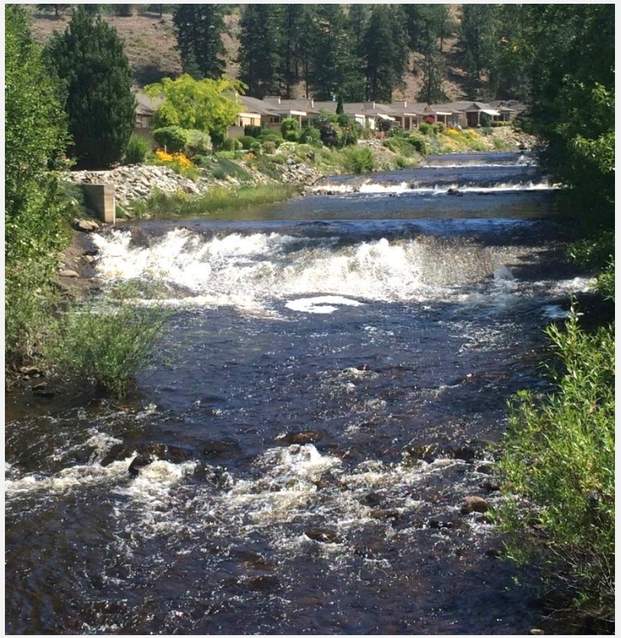
Structures: #18 to #36

Reach 11 has eighteen structures, which is nearly half of the total number of structures on the creek. Some of these structures have already failed and have no impact on the water surface. The concrete crest has been removed for several, while the crest is still visible for others. In some cases, the concrete aprons of the structures have failed and the City has repair them with riprap aprons. Home owners along the creek reported noticing deterioration of a couple structures in the last five years.

There is a lack of freeboard at the crest of five different structures, and a lack of clearance under the McNicoll pedestrian bridge. In addition, the size of the rock lining the banks is unstable at flood flows.

The land use in this reach is mostly residential on the north side, with a large amount of City owned land on the south side. The paved path on the west side continues throughout the entirety of this reach and is well used by residents, visitors, and students in the area.

Numerous cultural heritage features were identified in this area, mostly along the south side of the creek. These include “discreet areas retaining archaeological potential, vesicular basalt, fish spawning gravels, well established vegetation throughout with a significant establishment of Thule and one fairly large area of kinnikinnick.” (4 Seasons Heritage Consulting & PIB, 2016).



Looking upstream from the McNicoll pedestrian bridge

View of McNicoll pedestrian bridge and Structure #26 from downstream

REACH 11

Proposed Revitalization

The main restoration of Reach 11 will be to remove the concrete and wood crib structures and wing walls and replace them with single or multiple riffles, depending on the height of the structure. This will address the freeboard deficiencies.

McNicoll pedestrian bridge is located just above Structure #26, as seen in the photo to the left. One proposed option is that the structure be replaced with a riffle and moved upstream, to increase the area under the bridge to gain adequate clearance. Several other design options were discussed and further investigation will be needed during the detailed design phase.

In the future, there is opportunity to expand the floodplain on the south side of this reach, and to incorporate meanders or side channels to create a high level of rearing diversity. It appears that some areas on the south side may at a lower elevation than the path. Investigation should be done to determine if this should be considered a dike and upgraded to dike standards.

REACH 12

Existing Condition

Length: 400 metres

Average Width: 20 metres

Average Slope: 0.8%

Existing Habitat Quality Rating: Low+

Sub-Reaches:12a & 12b

Structures: #37 to #39

View of a structure, looking upstream

Reach 12 is a very wide, more natural section of the creek. There is some braiding and catchment of cobble deposition from upstream.

Water flowing under the concrete apron of Structure #36

Reach 12 is bounded by private property and City owned property on the north side, and Penticton Avenue on the south side. Near the top of the reach, the banks on the north side are quite steep and create a pinchpoint.

Reach 12 has three very large structures that are visibly failing and deterioration was seen during the preparation of the Master Plan. In addition, there is a lack of freeboard on the outside corner of the creek, near the pinchpoint of Penticton Avenue. This is on the border of Reaches 12 and 13, where there is currently a log boom.

There were three significant plant communities identified, as well as numerous trails on the north bank that have continued use by community members. A Fortis pipeline also exists in this area and future design will need to take these into consideration.

REACH 12

Proposed Revitalization

It is proposed that each of the three large concrete structures will be replaced with a single riffle with a slope of 8%, which will be quite long due to the height of the structures (over 2 metres tall).

At the upper end of Reach 12, creek improvements, such as widening, are needed increase the freeboard available. This area is currently quite confined, due to the proximity to Penticton Avenue on the south side and steep banks to the north side.

Once restoration projects have been completed and barriers to fish migration no longer exist, there is the potential to create a wide floodplain in Reach 12. This would reduce water depths during flood flows, stabilizing spawning gravels so they would not need artificial augmentation. A meandering channel, or side channel could be created. Conceptual designs were not developed in detail as the current fish populations cannot access Reach 12. However, this is an option that could be explored in future updates to the Master Plan.

REACH 13

Existing Condition

Length: 1180 metres

Average Width: 9 metres

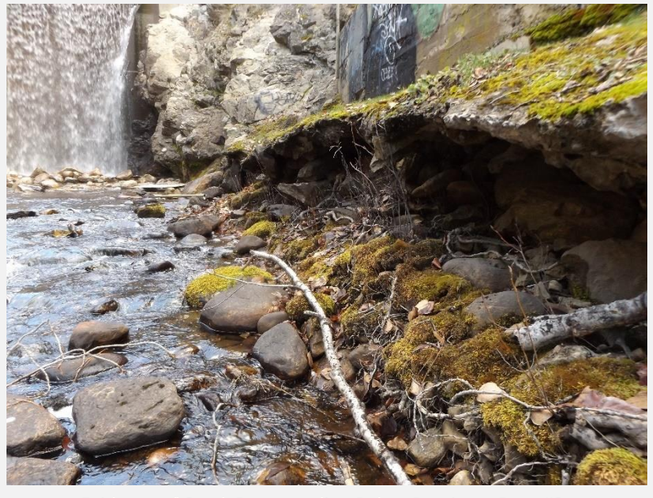
Average Slope: 3.0%

Existing Habitat Quality Rating: Mod-

Sub-Reaches:13a, 13b & 13c

Reach 13 has no structures and has a consistently steep slope with a natural bottom and banks. The reach is lined with Penticton Avenue to the south and mostly residential areas to the north. The walkway along the south side continues past the end of Penticton Avenue, beside the water treatment plant, and ends around 80 metres downstream of Penticton Dam #2.

The natural rock in this area is too small to be stable at flood flows. Evidence of downgrading can be seen in areas where concrete was poured and is now not supported by the soils. The lack of freeboard discussed in Reach 12 continues into the lower part of Reach 13, along the outside corner. There are also two additional locations lacking bank freeboard. There is a lack of clearance at both the Bridgewater pedestrian bridge to the new development on the north side of the creek, and the Penticton Avenue bridge.



Evidence of Creek Downgrading Below Penticton Dam #2

Many cultural heritage values were found in this reach, despite land altering activities. A wetland, well established petroform (swimming hole), a blazed cottonwood tree, large boulder, trail marker tree and large pine were identified in this area. These items should be avoided during restoration activities.

Looking upstream at Reach 13

REACH 13

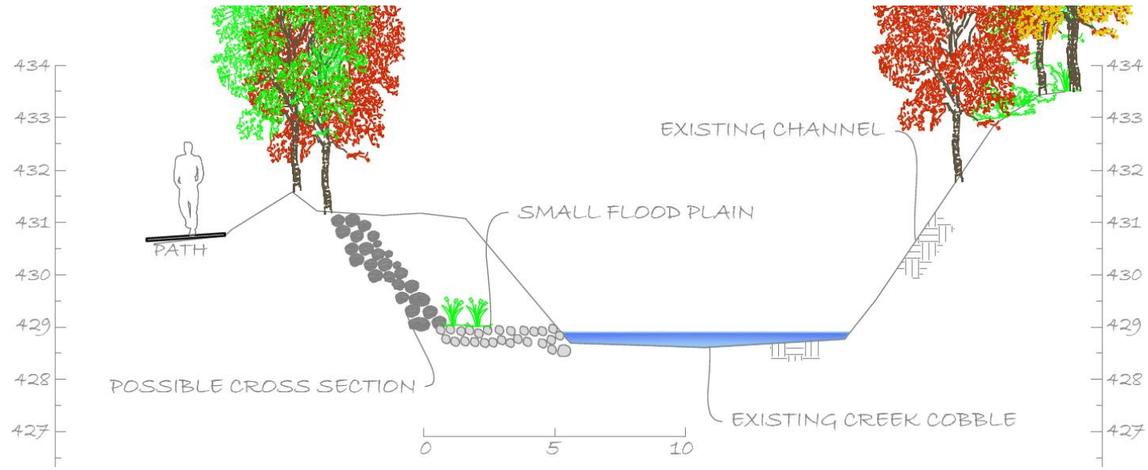
Proposed Revitalization

As discussed in Reach 12, widening should be undertaken at the Penticton Avenue corner to increase freeboard and prevent flooding. Additional areas lacking freeboard were found and should be addressed by increasing bank heights.

In order to create a stable channel lining, a widened floodplain is proposed for the south side of the creek. This widening will not affect the original channel bottom. Where widening is not possible due to the proximity of the path or road, larger riprap will be placed to ensure the channel is stable. Small riffles can also be added to stabilize the rock. It is expected that large river rock will be found when working on this reach, which is a valuable resource that can be used in flatter reaches where the stable rock size is smaller.

The cross-sectional area under both bridges will need to be increased to address the clearance issues. For the Bridgewater pedestrian bridge, channel improvements include widening or deepening under the bridge. There is room for channel modifications under the Penticton Avenue bridge as the headwalls are considerably wider than the creek.

As noted with the other upper reaches, restoration work for fisheries in Reach 13 will be most beneficial once migration barriers are addressed.



Proposed floodplain widening on the south side of the creek

PROJECT PRIORITY LIST

The prioritization of projects was completed, according to flooding and fisheries criteria. The individual lists were then grouped into five priority categories. This allows for some flexibility in selecting projects, due to land use issues, funding availability, conflict with cultural and heritage areas of archaeological potential, or continuity with other projects.

The **flood priorities list** was originally created using the following guiding principles:

1. In an emergency, failing infrastructure and bank erosion is more difficult to fix than localized lack of freeboard or woody debris blockages. Bridges and traffic flow are also very important, specifically bridges that represent the only entrance/exit for an area. Therefore, flood priorities are ordered as follows:
    - Drop structure failure
    - Lack of bridge clearance
    - Lining failure
    - Lack of bank freeboard
2. Perception, as public want to know their life and property are protected by flood infrastructure that is being maintained.
3. Continuity between projects.
4. River rock requirements, as it is becoming a valuable resource needed for restoration.

Table 6 shows the latest flood priority list, which was updated following the 2017 Spring Erosion & Deposition inspection. The changes made are a result of increased weighting for damage caused by smaller, more frequent events (i.e. 1:10 to 1:20 year events), rather than heavily weighted to a large 1:200 year event. The Master Plan is an active document, and priorities will change as flood events occur.

The documents considered to create the **fisheries priority list** were:

- *Quantitative benchmarks to inform Penticton Creek restoration priorities* (Askey, 2016); and
- *Penticton Creek Fish and Riparian Habitat Assessment and Preliminary Restoration Findings* (Matthews, 2016).

In addition, the fisheries representatives from the Committee have provided the guiding principles for the fisheries prioritization, as seen in Annex E. In general, fisheries input recommends that reaches be restored in a bottom-to-top order, rather than restoring upper reaches that fish may not be able to migrate to for some time. As projects are completed and fisheries response data is collected, the priority list (Table 6) will likely change, to adapt to population bottlenecks that may occur.

Table 6: Flood and Fisheries Prioritization (updated Nov. 2017)

Priority	Flood Priorities	Fisheries Priorities
1	**Reach 3b*** Reach 4 + 5 Reach 3a Reach 13a	Reach 2b Reach 2a **Reach 3b***
2	Reach 11c Reach 11d Reach 12a Reach 12b	Reach 3a Reach 1** Reach 4 + 5
3	**Reach 6*** **Reach 7*** Reach 11b Reach 11a	**Reach 6*** **Reach 7*** Reach 8 Reach 9 + 10a Reach 10b
4	Reach 9 + 10a Reach 8 Reach 13c Reach 10b	Reach 11a Reach 11b Reach 11c Reach 11d
5	Reach 13b Reach 2b Reach 2a Reach 1	Reach 12a Reach 12b Reach 13a Reach 13b Reach 13c

* These reaches indicate where flood and fisheries priorities align.

** The relatively high fisheries prioritization of Reach 1 in the table is based on a specific restoration option (expanded floodplain), which significantly increases the available Kokanee spawning habitat from the current state. However, the reach is currently passable to fish, has limited potential value to Rainbow Trout, and thus other restoration options completed upstream could diminish the relative value of Kokanee spawning habitat in this reach (details in Askey, 2016).

PRELIMINARY COST ESTIMATES

Preliminary Class C cost estimates were prepared for each reach of the creek. The Association of Professional Engineers and Geoscientists of BC (APEGBC) and Consulting Engineers of BC (CEBC) state that Class C cost estimates are “prepared with limited site information and based on probable conditions affecting the project.” The Class C estimate is to be prepared within 25% to 40% of the final cost and is “used for program planning, to establish a more specific definition of client needs and to obtain preliminary project approval.” (CEBC & APEGBC, 2009)

The estimates include:

- Construction;
- Environmental monitoring;
- Cultural & heritage monitoring;
- Engineering;
- Administration;
- Construction management; and
- Contingencies

For Reaches 1, 2a and 2b, a single option was selected in order to present a cost estimate. The option selected for estimation in each reach was the more extensive and costly of the options. The cost estimates for all subreaches are presented in 2016 dollars in Table 7 on the next page.

The estimates do not include costs related to transition lengths, that may vary due to sequencing of reach improvements. In many cases, there is an impact on hydraulics, aesthetics and cost when an upstream reach is revitalized before a lower reach. Other exclusions from the cost estimates include land purchases/easements and creating additional paths/crossings, as recommended in the City of Penticton’s Official Community Plan and Downtown Plan.

The site surveys and drawings in this report, which the cost estimates are based on, are conceptual in nature and not intended to be used for construction. The breakdown of each cost estimate can be found in Annex G.

Table 7: Summary of Preliminary Cost Estimates (in 2016 dollars)

Reach	Preliminary Cost Estimate
Reach 1 (Expanded Floodplain Option)	$2,200,000
Reach 2a (Urban Option)	$2,300,000
Reach 2b (Urban Option)	$2,350,000
Reach 3a Lower	$630,000
Reach 3a Upper	$1,350,000
Reach 3b	$2,000,000
Reach 4	$250,000
Reach 5	$1,650,000
Reach 6	$700,000
Reach 7	$1,450,000
Reach 8	$1,950,000
Reach 9	$750,000
Reach 10a	$850,000
Reach 10b	$1,300,000
Reach 11a	$850,000
Reach 11b	$1,500,000
Reach 11c	$1,800,000
Reach 11d	$1,800,000
Reach 12a	$950,000
Reach 12b	$600,000
Reach 13a	$550,000
Reach 13b	$650,000
Reach 13a	$550,000
TOTAL	**$28,980,000**

FUNDING STRATEGY

Costs for each reach of Penticton Creek have been estimated, with the Committee, advisors and consultants assessing and determining priorities for infrastructure risk and fisheries benefits. A separate Implementation Strategy is intended to provide a detailed plan that explicitly outlines the timeline, cost, and funding sources for each of the prioritized reaches to be restored, and contingency funds for any emergency works required in between proactive projects. The costs of restoring the failing infrastructure and improving fisheries values within Penticton Creek are too large for a single agency or source of funding so a program of diverse funding options needs to be sought.

Penticton Creek provides significant ecological services to the City of Penticton. In recognition of this, the City will incorporate the role the creek plays in receiving and safely conducting storm flows through the community as it finalizes an update of the Storm Water Master Plan. The City is also engaging a consultant in 2017 to create a Storm Water Utility Rate Structure to charge for the provision of Storm Water services. The City will examine the possibility of adding a portion of Penticton Creek restoration costs into the rate structure as part of the project.

The City also recently unveiled a Capital Asset Management Study outlining an infrastructure deficit of up to $175 Million dollars. This reflects the value of infrastructure that has passed its expected useful life, but is still providing service to the community. The concrete flood protection works in Penticton Creek was not considered part of the infrastructure assessed within this study. It is difficult to consider the creek as an asset within the context of regular infrastructure that includes for example, roads, pipes and buildings. However in the future, staff will look at amending the Asset Management Investment Plan to create a new category of asset, “natural features” that will include creeks and waterfront/foreshore and other important ecosystems that provide ecological services to the community. Recognition of the importance and function of Penticton Creek in these documents will allow the City of Penticton to consider Penticton Creek restoration needs when budgeting in the future.

The City of Penticton and supportive partner organizations will undertake the following fundraising activities to meet the goals of each of the priority areas over the life of the project:

- **Outside grant and Foundation Funds**: The City of Penticton will take advantage of any provincial/federal funding available, and will write grants directly, and partner with stewardship and non-profit organizations, to access private and government foundations and granting bodies for fisheries habitat restoration and flood protection, emergency management and infrastructure works.

- **Reserve Establishment and Contributions**: The City of Penticton could establish a Reserve to retain all the funds for Penticton Creek that are garnered from various sources. Then, the City of Penticton could create an annual reserve contribution for Penticton Creek restoration and maintenance that would provide an anchor source of funding with which to address emergency works, and leverage outside funds and grants. This is a recommendation the Committee will make to Council.

- **Public Donations**: This project is important to the citizens of Penticton. Establishing an endowment fund for Penticton Creek restoration would allow for private donations and private sector sponsorships. The City of Penticton is able to establish an endowment itself, partner with a local conservation group, or work with a community foundation. Municipalities can accept donations from the public through traditional financial contributions, as well as through estate planning in the form of publicly traded securities, estate gifts, and life insurance benefits. The City of Penticton or partner organization can provide individuals and private companies charitable tax receipts for donations.

- **South Okanagan Conservation Fund**: The City of Penticton is a participating local government in this regional fund established in December of 2016 to undertake “activities, projects and works that will include water, environment, wildlife, land, habitat conservation efforts to protect natural areas within the participating areas of the RDOS”. The conservation fund will redistribute requisitioned dollars through an application-based process. The first application intake is planned for September 2017.

- **Property Tax Incentives**: The Community Charter allows municipalities to provide tax incentives or exemptions for landowners who steward, conserve or donate land, or an eligible interest or right in land that is ecologically important. The Committee recommends that the City of Penticton explore options for tax incentive programs and additional conservation and stewardship tools that would enable and encourage landowners to maintain the natural value of creek and riparian habitat.

RECOMMENDATIONS

The Committee has efficiently utilized funds available to accomplish as much as possible. However, during the process of developing the Penticton Creek Master Plan, several items have been identified regarding the planning and future construction aspects that require additional attention.

Planning:

1. It is recommended that an Implementation Strategy be developed, to determine the timeline and funding sources for each restoration reach, as well as identify the source of contingency funds for emergency works required between projects.

2. While the Official Community Plan and Downtown Plan have been considered during preparation of the Master Plan, additional creek crossings and linear pathways mentioned in these documents have not been incorporated. If these features are still desired and the costs not incorporated elsewhere, consideration should be given to adding them to the Master Plan.

3. For future planning, cost estimating and design purposes, it would be useful to complete additional topographic surveying to establish a practical boundary defining past flood works (berms, etc.), within the M-178/185/195 Plan, where the City has authority to use the land for changes along the creek.

4. Future development approvals should restrict building within Registered Plans M-178/185/195 or any other flood easements. A riparian buffer zone should also be considered for developing properties adjacent to the creek.

5. The City of Penticton should plan to secure key properties along the creek for future restoration purposes.

6. The Cultural and Heritage Inventory Mapping report recommends applying for an annual Heritage Conservation Act blanket permit, as well as testing of landforms to determine their archaeological potential prior to revitalization activities.

7. Establishing the Environmental Flow Needs for the creek and creating low and seasonal flow management strategies would be beneficial for the fisheries and habitat design aspects.

8. A vegetation and debris/ice management program needs to be developed to minimize flooding risks related to bridge clearances, creek freeboard and channel flood capacity, while respecting the benefits of vegetation in and around the creek. This could include a high flow management strategy.

9. It is recommended that the drop structures be labelled in the field, so that they can be referenced with the Master Plan and identified when conducting inspections.

10. Before the revitalization design of Reaches 1 and 2 can begin, additional study is needed in order to select a final plan that can be developed into construction drawings. The Master Plan currently outlines two options for each reach.

11. Guidelines should be developed to direct the addition and removal of spawning gravel throughout the creek. The document should include which flow events would trigger the augmentation of gravel and the methods and locations where these deposits should be removed.

12. Erosion and degradation of the Penticton Creek infrastructure will be impacted the greatest by large freshet events or freezing temperatures that break up the concrete lining and drop structures. Therefore, thorough inspections and a review of priorities are recommended following freshets greater than 20 cms and temperatures lower than -15°C.

13. Applying for a water license on Penticton Creek to cover the revitalization works outlined in the Master Plan would be beneficial and address the requirement for multiple approval applications for Section 11 of the Water Sustainability Act (Changes In and About a Stream).

14. It is recommended that the Master Plan be updated on a 10-year interval.

15. It is recommended that a fisheries monitoring program be implemented to collect data regarding fish habitat suitability, quantify numbers and migration limits. Additional information is needed to better understand the limiting factors of fish production and monitor how this changes as creek improvements are made.

16. It is recommended that Penticton Creek's role in conveying storm water through the city be recognized in an update of the Storm Water Master Plan, with a portion of the restoration costs included in the rate structure of the plan.

17. It is recommended that a "natural features" asset category be incorporated into the Capital Asset Management Investment Plan to allow the City to consider Penticton Creek restoration needs when budgeting in the future. Consideration could also be given to supporting costs from the Parks' DCC program, as mentioned in the Downtown Plan.

18. The City of Penticton and supportive partner organizations should undertake fundraising activities to meet the goals of the Master Plan, including: writing grant applications; establishing a reserve to contribute and retain funds; establishing an endowment fund for public donations and sponsorships; applying to the South Okanagan Conservation Fund; and providing property tax incentives for landowners.

19. It is recommended that the City of Penticton engage in public consultation to provide City Council, Penticton Indian Band and related organizations, and residents with information regarding the Master Plan as well as the priority of upcoming projects.

Construction:

1. The PCRI Committee has selected Lower Reach 3A as the priority project for 2018. Landowner discussions, site survey and design details were completed in 2017 and the PCRI Committee is working on obtaining final provincial approvals.

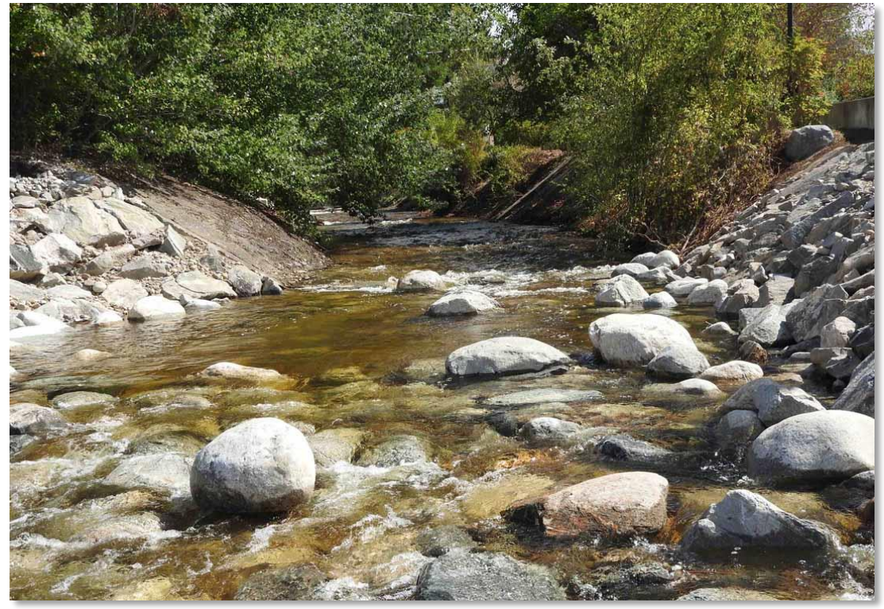
2. It is recommended that the City purchase the creek diversion pipe as it is costly and common to the majority of projects. Pipe of this size and type is not typically available to the contractors within the 'Notice to Proceed' time frame allotted and as a result, creates an immediate project delay.

3. Drop structure replacement projects in wider sections of the creek utilize a temporary bailey bridge to accommodate construction, which the City may also consider purchasing.

4. Large river rock is becoming harder to find and therefore a valuable resource. It would be cost effective to source, and perhaps stockpile, river rock closer to site during slower construction seasons.

5. Due to the short instream work window and high cost of construction delays, it is recommended that a strategy be developed to address the possibility of funding items of Cultural and Heritage value.

6. Projects will vary in size, but it is recommended that a minimum of 12 months be allotted for the land owner notifications, detailed survey, design, review, approvals, and construction tendering process. This would also help address riparian and nesting issues.



REFERENCES

4 Seasons Heritage Consulting & Penticton Indian Band (PIB) (2016). *Letter Report: Results of the Penticton Indian Band and 4 Seasons Heritage Consulting, Cultural Heritage Inventory Mapping (CHIM) of Penticton Creek, July 27 – 29, 2016*.

Askey, P. (2016). *Quantitative benchmarks to inform Penticton Creek restoration priorities (A document prepared for the Penticton Creek Restoration Committee).*

Bell, M.C. (1990). *Fisheries Handbook of Engineering Requirements and Biological Criteria*. US Army Corps of Engineers, North Pacific Division.

Bovee, K.D. (1978). *Probability of Use Criteria for the Family Salmonidae*. Instream Flow Information Paper No. 4. US Fish and Wildlife Service.

British Columbia Ministry of Water, Land and Air Protection, Flood Hazard Management Section, Environmental Protection Division (2003). *Dike design and construction guide: Best Management Practices for British Columbia*. Retrieved from: http://www.env.gov.bc.ca/wsd/public_safety/flood/pdfs_word/dike_des_cons_guide_july-2011.pdf

Consulting Engineers of British Columbia (CEBC) & Association of Professional Engineers and Geoscientists of BC (APEGBC) (2009). *Budget Guidelines for Consulting Engineering Services.* Retrieved from: https://www.apeg.bc.ca/getmedia/c31c2f50-83fe-4cc2-83a6-f3d9f81c6905/APEGBC-Budget-Guidelines-for-Consulting-Engineering-Services.pdf.aspx

City of Penticton (2002). *Official Community Plan Bylaw No. 2002-20*. Retrieved from: http://www.penticton.ca/assets/City~Hall/Bylaws/Land~Use/Bylaw%202002-20-OCP-%20current%20to%20March%202014.pdf

City of Penticton (2012a). *Downtown Revitalization – 200 Block Nearly Complete*. Retrieved from: http://www.penticton.ca/EN/main/community/vibrant-penticton/our-downtown.html

City of Penticton (2012b). *City of Penticton Downtown Plan*. Retrieved from: http://www.penticton.ca/assets/Community/Documents/COP%20-%20Downtown%20Plan%20(Proposed%20Document)%20Reduced.pdf

City of Penticton (2015a). *Penticton Creek Showcase Project Complete.* Retrieved from: http://www.penticton.ca/EN/meta/city-news/news-archives/2015_Archives/penticton-creek-showcase-project-complete.html

City of Penticton (2015b). *Downtown Revitalization | Penticton Creek.* Retrieved from: http://www.penticton.ca/EN/main/community/vibrant-penticton/our-downtown/penticton-creek.html

City of Penticton (2017). *Shape Your City | Penticton Creek.* Retrieved from: https://www.shapeyourcitypenticton.ca/penticton-creek

Edwards, E.A., Li, H. and Schreck, C.B. (1983). *Habitat Suitability Index Models: Longnose Dace*. US Fish and Wildlife Service.

Hudson, G.H.E. (Photographer) (1908). *Fishing at Penticton Dam* [Digital Image]. Retrieved from: http://www.oldphotos.ca/archivos/record.php?collectionID=2&recordID=1310246526

Long (Alex) K. and Rivard-Sirois, C. (2010). *Aquatic monitoring of the Okanagan River restoration initiative post construction 2009*. Okanagan Nation Alliance.

Matthews, S. (2016). *Penticton Creek Fish and Riparian Habitat Assessment and Preliminary Restoration Findings (A Document Prepared for the Penticton Creek Restoration Committee).*

Miller, James (2017). *Penticton Creek restoration is popular with public*. The Penticton Herald. Retrieved from: http://www.pentictonherald.ca/news/article_58b8d22e-a96a-11e7-b586-e79815d6e41a.html

Ptolemy, R. (2016). *HSI Curves*. Personal Communication with Paul Askey. Excel file attached to email dated July 26, 2016. Rivers Biologist/Instream Flow Specialist, Fisheries and Aquatic Conservation Science Ecosystems Protection & Sustainability Branch, Ministry of Environment.

Raleigh, R.F., Hickman, T., Solomon, R.C., and Nelson, P.C. (1984). *Habitat Suitability Information: Rainbow Trout*. US Fish and wildlife Service.

Roed, M.A. & Fulton, R. (2011). *Okanagan Geology South*.

Stocks, L. (Photographer) (1942). *Creek Flood, Penticton, B.C* [Digital Image]. Retrieved from: http://www.oldphotos.ca/archivos/record.php?collectionID=2&recordID=811198168

Slaney, P.A. and Zaldokas, D. (1997). *Fish Habitat Rehabilitation Procedures*. BC Ministry of Environment, Lands and Parks. Vancouver.

TABLE OF ANNEXES

ANNEX A REACHES 1 – 3 CONCEPTUAL DESIGN OPTION

ANNEX B PCRI COMMITTEE ORGANIZATIONAL CHART

ANNEX C REACH DESCRIPTIONS

ANNEX D FISHERIES DESIGN TARGETS

ANNEX E GUIDING PRINCIPLES FOR FISHERIES ASPECTS

ANNEX F EXISTING INFRASTRUCTURE DEFICIENCIES AND RATIONALIZATION OF FLOOD PRIORITIZATION

ANNEX G DETAILED COST ESTIMATES

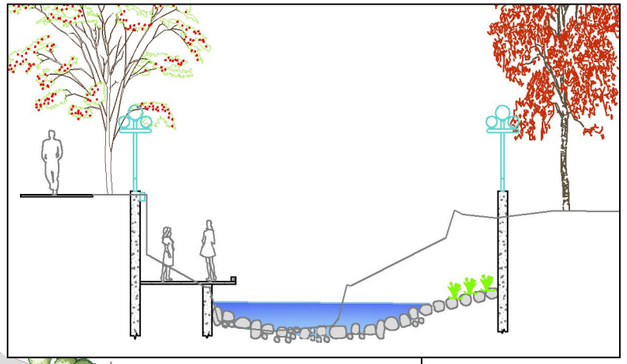
ANNEX H DRAWINGS

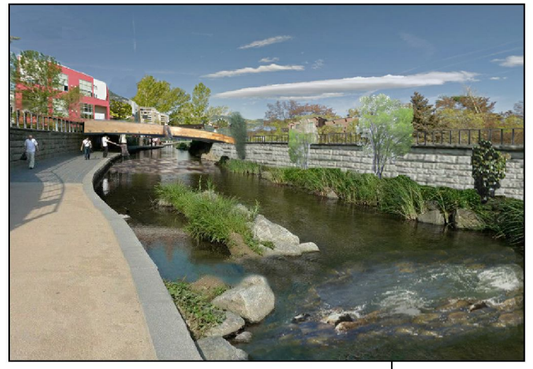
ANNEX A: REACHES 1 – 3 CONCEPTUAL DESIGN OPTION

CONCEPTUAL

ROCK RIFFLE

RIPARIAN BREADTH





LOWER WALKWAY/FLOOD CORRIDOR

ARTS CENTER

Penticton Creek

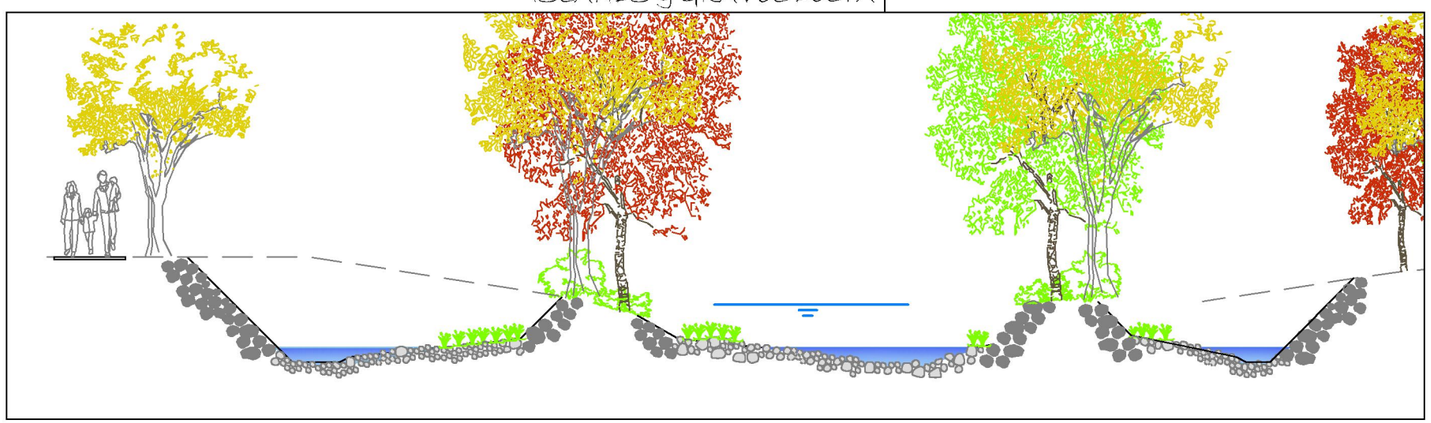
ELLIS ST.

FRONT ST.

Penticton Creek

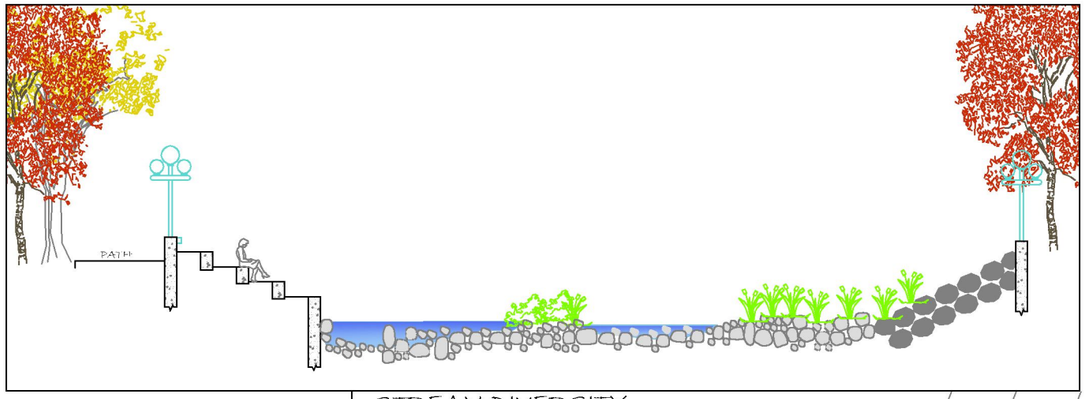
NEW PEDESTRIAN BRIDGE

ISLANDS & GRAVEL DELTA



WATERFALL

DESIGN OPTION



STREAM DIVERSITY

ABBOTT ST.

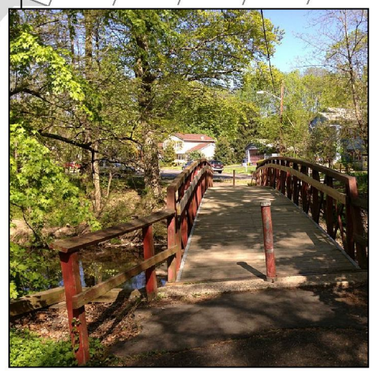
BRAID ST.

VAN HORNE ST.

NANAIMO AVE. E

ELLIS ST.

BUS BARN

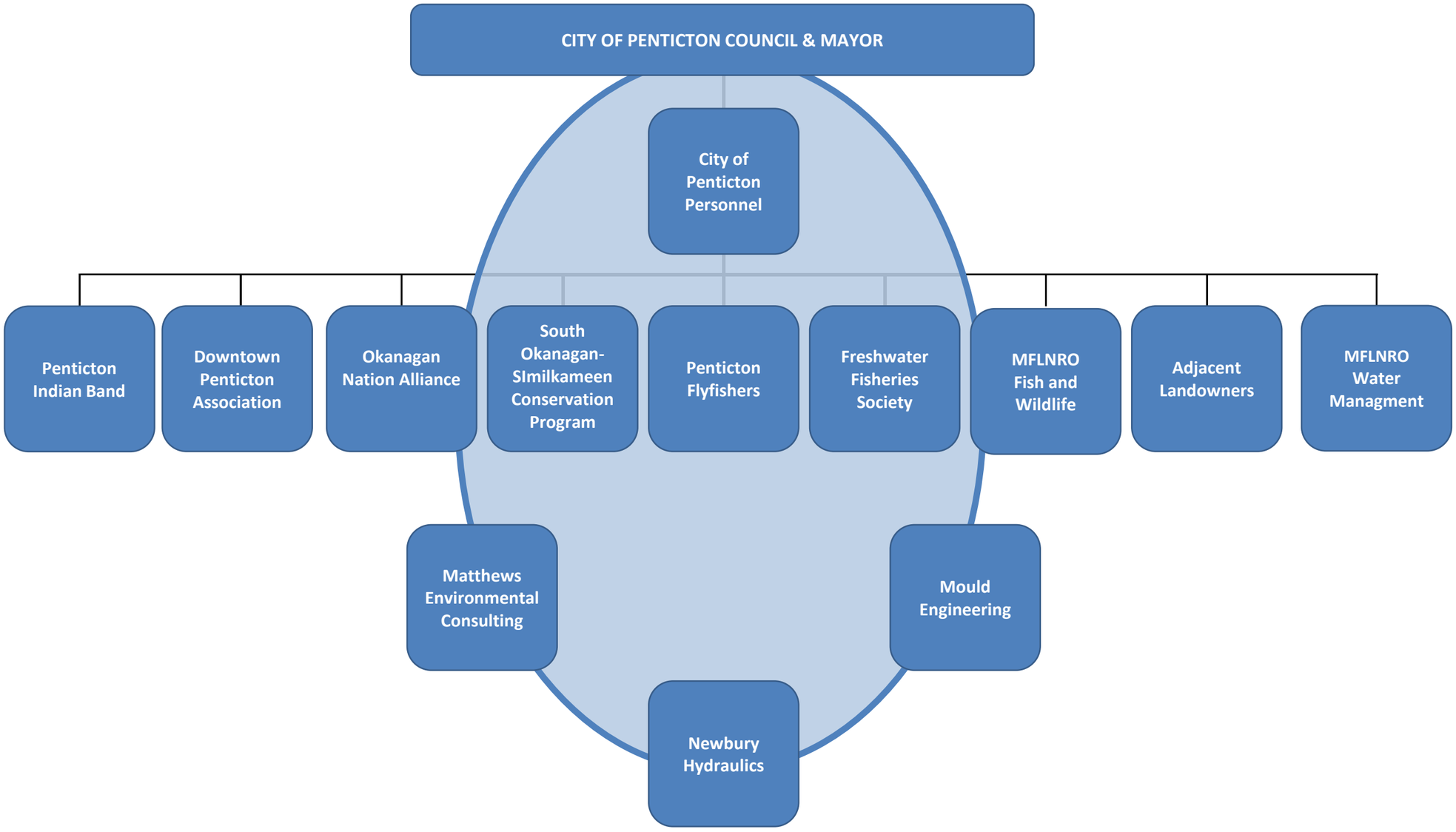


POSSIBLE PEDESTRIAN BRIDGE
& RESTORATION AT NANAIMO AVE.

CREEK SIDE SEATING

2015 SHOWCASE PROJECT

ANNEX B: PCRI COMMITTEE ORGANIZATIONAL CHART



ANNEX C: REACH DESCRIPTIONS

Penticton Creek Reach Descriptions												
Section Number	Reach #	Sta. Start	Sta. End	Length (m)	Creek Channel Lining	Land Use		Typ. Water Surface Width* (m)	Entrenched Depth (m)		Channel Slope Between Structures	Vegetation Impact	Comments
						North	South		Min.	Max.			
1	1	0-080	0+070	150	Natural channel bottom, deposition area, riprap sides	Art Gallery	Park	11	1.8	2.6	0.0%	-Some grasses located below top of bank -Trees located along top of bank -No impact on water during low flow conditions	-Impacted by lake levels, high meets low velocity -Potential standing wave scenario -Very public -Deposition area, substrates are affected by lake
	2	0+070	0+420	350	Formed concrete channel, likely reinforced	Commercial/ Urban	Commercial/ Urban	6	2.2	3.1	0.7%	-Some trees/shrubs located in concrete channel, mostly along upper banks -Vegetation breaking up concrete -Generally no impact on water during low flow conditions	-Includes Structure #1 -Very structurally sound, no holes/cracks -Apron of shotcrete/asphalt, width: -Structurally formed, flatter slope
	3	0+420	0+875	455	Concrete w/reinforced grid	Residential	Residential	7	1.8	3.3	2.1%	-Shrubs and small trees located along edge of low flow -Vegetation restricting flow in various locations	-Includes Structure #2 -Includes Showcase section
	4	0+875	0+950	75	Natural channel	Road	Road	14.5	1.2	3.9	0.4%	-Some small trees located within low flow -Grasses and larger trees located below top of bank provide stabilization	
	5	0+950	1+060	110	Concrete w/reinforced grid	Road	Road	10.5	3.9	5.6	3.3%	-Trees located below top of bank, no impact on low flow -Vegetation breaking up concrete	-Includes Structure #3
	6	1+060	1+250	190	Natural channel	Road	Road	12	1.4	3.1	0.8%	-Few small trees and shrubs located within low flow -Grasses and larger trees located below top of bank provide stabilization	-Includes Structures #4 and 5
	7	1+250	1+420	170	Concrete w/reinforced grid	Road	Road	7.5	1.3	5	1.9%	-Some shrubs and small trees located at edge of low flow, overhanging water -Larger trees located at top of bank, no impact at low flow	-Includes Structures #6 and 7 -No linear path along upper third of reach (east of KVR bridge)
	8	1+420	1+685	265	Natural bottom, sides lined from Structures #7 to #8	City Owned	City Owned	17.5	1.2	3.3	0.6%	-Some shrubs and trees located at edge of low flow, restricting flow -Small trees in creek flow, located on island around Sta. 1+625	-Includes Structures #8 - 11 -Most natural section, some braiding -Riffle #11 blown out -No linear path
	9	1+685	1+760	75	Rip rapped channel	Residential	Residential	8	1.8	3.4	2.8%	-Some shrubs located in riprap -Trees located above riprap banks -Vegetation has no impact on low flow	-Includes Structures #12 - 14 -No linear path
	10	1+760	2+000	240	Concrete w/reinforced grid	Residential	Residential	7	1.2	2.6	1.7%	-Some large trees located within concrete banks -Vegetation breaking up concrete	-Includes Structures #15 - 17 -No linear path along lower reach (west of Forestbrook)
2	11	2+000	2+800	800	Natural channel	Residential	Schools/City	16.5	1.6	3.1	0.8%	-Many shrubs and small trees located in and along edge of low flow -Vegetation restricting flow -Larger trees located below top of bank	-Includes Structures #18 - 36 -Backyards may be below dyke on south side
	12	2+800	3+200	400	Natural channel, some riprap	Landscape	Road	20	1.2	2.7	0.8%	-Many grasses and shrubs located in and along edge of low flow -Some trees located along edge of low flow -Vegetation restricting flow	-Includes Structures #37 - 39 -Most natural section (like Reach 8) -Some braiding, catchment of cobble deposition -Artificially narrowed floodplain
3	13	3+200	4+382	1180	Natural channel	Residential	Road/ Treatment Plant	9	1.2	3.9	3.0%	-Trees located below top of bank -Shrubs located along edge of low flow, minimal restrictions	-Larger cobble than Section 9 -Also narrower and steeper

ANNEX D: FISHERIES DESIGN TARGETS

Species	Age	Depth (m)	Velocity (m/s)	Substrate*	Spawning Season	Habitat	Reference
Kokanee	spawning	0.07 – 0.22	0.09 – 0.38	gravel, small cobble<5 cm*	August - November	riffles	Bovee (1978)
		0.06 min.	0.15 – 0.91				Slaney (1997)
		0.09 – 0.54	0.15 – 0.78				Ptolemy (2016)
Rainbow Trout	spawning	0.20 – 1.50	0.35 – 0.91	coarse gravel cobble <10 cm	March - June	runs, riffles & persistent pools >1.5 m	Raleigh et al. (1984)
		0.18 min.	0.48 – 0.91	6 – 52 mm			Slaney (1997)
		0.22 – 0.87	0.28 – 1.04				Ptolemy (2016)
	adults	>1.50					Raleigh et al. (1984)
Longnose Dace	spawning	0.10 – 1.05	0.20 – 0.90	gravel, cobble & small rock	June – July	clean cobble, rock cover	Edwards et al. (1983)
		0.10 – 0.50	0.30 – 1.10				Ptolemy (2016)
Sockeye	spawning	0.15 – 0.30	0.20 – 0.80	coarse gravel, cobble*	August- November	riffles and runs	Long (2010)
		0.15 min.	0.21 – 1.07				Slaney (1997)
Fast-water Insects		0.08 – 1.50	0.35 – 1.52	gravel, cobble, boulder		pools, riffles, runs	Waters (1975)

* Slaney 1997 substrate size 13 – 102 mm not species specific (Bell 1990).

ANNEX E: GUIDING PRINCIPLES FOR FISHERIES ASPECTS

The guiding principles for selecting fisheries priorities and restoration design was compiled and provided by members of the PCRI Committee, representing Penticton Indian Band, Okanagan Nation Alliance, Freshwater Fisheries of BC, Penticton Flyfishers and Matthews Consulting:

- *The PCRI Committee will play the lead role in fish and riparian habitat restoration planning and implementation.*
- *Ecosystem based approach that focuses on needs of Rainbow Trout and Kokanee, but incorporates requirements of other aquatic and riparian species*
- *Restoration designs will utilize a diversity of natural features and materials to maximize habitat quality and complexity.*
- *Integrate the seasonal diversity of environmental flow needs (as opposed to simple minimum flow requirements) into fish habitat designs.*
- *Identify and prioritize all areas (of any size) where a broader vision of stream naturalization and ecosystem function could be met (channel widening, restoration of historical meanders, natural features – deep pools, alcoves, woody debris, etc.).*
- *In restricted areas, aim to maximize habitat values within flood protection constraints, recognizing any level of naturalization is a step forward and the cumulative effects from this approach are large.*
- *A science based prioritization of fisheries restoration is an iterative process that must examine quantitative benchmarks for life-stage specific habitat needs of the target species (depending on the current state of the stream).*
- *Effectiveness monitoring and adaptive management are key components of the long-term restoration process.*
- *Prioritization of near term projects must alleviate fish population bottlenecks (such as lower reach migration limitations), however, there must also be action to immediately protect upstream areas that achieve a longer-term vision as fish are able to move upstream.*
- *Aim to minimize restoration maintenance requirements (e.g. artificial side channels), but plan for potentially unavoidable, inherent maintenance (e.g. dams cutting off all natural gravel supply).*
- *Outreach and communications will be an integral component of future restoration planning to facilitate a higher level of awareness and support*

FISHERIES PRIORITIZATION

An initial fisheries prioritization list was created using a bottom-to-top approach. Using the fisheries design targets and guiding principles, some adjustments were made, as seen in the table below.

Priority	Fisheries Priorities
1	Reach 2b Reach 2a Reach 3b
2	Reach 3a Reach 1** Reach 4 + 5
3	Reach 6 Reach 7 Reach 8 Reach 9 + 10a Reach 10b
4	Reach 11a Reach 11b Reach 11c Reach 11d
5	Reach 12a Reach 12b Reach 13a Reach 13b Reach 13c

** The relatively high fisheries prioritization of Reach 1 in the table is based on a specific restoration option (expanded floodplain), which significantly increases the available Kokanee spawning habitat from the current state. However, the reach is currently passable to fish, has limited potential value to Rainbow Trout, and thus other restoration options completed upstream could diminish the relative value of Kokanee spawning habitat in this reach (details in Askey, 2016).

ANNEX F: EXISTING INFRASTRUCTURE DEFICIENCIES AND RATIONALIZATION OF FLOOD PRIORITIZATION

BRIDGE CLEARANCE

Table of Bridge Clearances at 48 cms

Sub-Reach	Bridge	Clearance to Bottom Girder (m)
1	Art Gallery Pedestrian Bridge	-0.2
2a	Front Street Bridge	0.4
2a	Ellis Street Pedestrian Bridge	0.9
3	Ellis Street Bridge	0.8
3a	Nanaimo Avenue Bridge	0.1
3b	Wade Avenue Bridge	1.6
7	KVR Pedestrian Bridge	2.7
7	Eckhardt Avenue Bridge	1.0
10b	Forestbrook Drive Bridge	0.9
11c	McNicoll School Pedestrian Bridge	0.1
13a	Bridgewater Pedestrian Bridge	0.5
13b	Penticton Avenue Bridge	-0.4

Note: Bridge clearances were analyzed using the maximum daily flow (48 cms) and the instantaneous flow (60 cms) and compared to the standard clearances of 0.6 metres and 0.3 metres respectively. The maximum daily flow (48 cms) governed for all bridges, and is shown in the table above.

BANK FREEBOARD

Table of Locations Lacking Bank Freeboard

Sub-Reach	Approximate Stations	Affected Side of the Creek	Description
1	0-015 to 0+55	Both	Area between Front Street bridge and the Art Gallery
2a	0+130 TO 0+210	Right	Area just upstream of Front Street
3a	0+540 to 0+580	Both	Area between Showcase and Nanaimo Avenue bridge
3a	Around 0+620	Left	Area just upstream of Nanaimo Avenue bridge
3b	Around 0+875	Both	Crest of Structure #2
7	Around 1+420	Right	Crest of Structure #7
8	1+525 to 1+590	Right	Crest and area downstream of Structure #10
11b	Around 2+270	Right	Crest of Structure #22
11c	Around 2+540	Both	Crest of Structure #28
11d	2+710 to 2+770	Left	Crest and area between Structures #33 to 35
12b/13a	3+060 to 3+240	Left	Area around the Penticton Avenue pinchpoint
13a	Around 3+425	Right	Area approx. 80 m upstream of Bridgewater pedestrian bridge
13a	Around 3+455	Left	Area approx. 110 m upstream of Bridgewater pedestrian bridge

Note: Bank freeboard was analyzed using the maximum daily flow (48 cms) and the instantaneous flow (60 cms) and compared to the standard freeboard of 0.6 metres and 0.3 metres respectively. The maximum daily flow (48 cms) governed for all banks, and is shown in the table above.

STRUCTURES

Each drop structure was rated according to their 'Potential to Fail' and 'Consequence of Failure.' These ratings were then used to find a structure risk rating.

Drop Structure Potential to Fail

Potential to Fail	Definition
Low	Quality concrete with no signs of surface defects. Structure is competent with no undermining, etc. Includes structures with no effect on water surface.
Moderate	Low to moderate signs of surface defects. Low potential for rock movement (riprap structure).
High	Portions of the structure have failed. Moderate potential for rock movement (riprap structure).
Very High	Large portions of the crest and apron are in the process of failing. High potential for rock movement (riprap structure).

Drop Structure Consequence of Failure

Consequence of Failure	Definition
None	Failure of structure will have no impact.
Low	Structure is below 1.0 metres in height and would produce minimal amount of bedload. Minimal bank erosion potential.
Moderate	Structure is 1. to 2.0 metres in height. Minimal/unstable adjacent bank protection, possible bank erosion.
High	Structure is greater than 2 metres in height. Bedload created by failure could be significant. Probable bank erosion.

Drop Structure Risk Rating

Consequence of Structural Failure	Potential for Structural Failure: Low	Moderate	High	Very High
None	Low			
Low		Moderate		
Moderate			High	
High				Very High

Table of Drop Structure Descriptions and Rating

Structure Number	Station	Notes	Marking on Wingwall	Height of Structure (m)	Length of Structure (m)	Potential for Structural Failure	Consequence of Failure	Risk
1	0+380	-Concrete sill and apron, no large concrete failure -Some concrete curbs placed on structure	N/A	1.1	16	Low	Moderate	**Moderate**
2	0+874	-Concrete apron and sill with concrete curbs at crest, concrete fish ladder (north) -Holes in apron along sill -Woody debris on structure	35	2.7	9	Very High	High	**Very High**
3	1+059	-High concrete structure with parking curbs at crest, concrete fish ladder (south side) -Holes visible in apron -Woody debris caught on structure and in fish ladder	34	2.3	6	High	High	**Very High**
4	1+137	-Concrete sill and apron with holes at crest, concrete fish ladder (north side) -Apron failed at toe of structure -Some woody debris -Hydraulic jump occurring at high flows	33	2.0	16	High	Moderate	**High**
5	1+204	-Steeper structure with concrete sill and apron, concrete fish ladder (south side) -Apron in decent condition, failed at toe	32	1.7	9	Moderate	Moderate	**Moderate**
6	1+307	-Concrete sill and apron, concrete fish ladder (south side) -Some holes in lining above structure -Apron failed at toe	31	1.9	17	Moderate	Moderate	**Moderate**
7	1+420	-Concrete sill and apron, concrete fish ladder (north side) -Apron failed at toe	30	1.6	10	Low	Moderate	**Moderate**

Structure Number	Station	Notes	Marking on Wingwall	Height of Structure (m)	Length of Structure (m)	Potential for Structural Failure	Consequence of Failure	Risk
8	1+481	-Concrete sill and apron, concrete fish ladder (south side) -Apron failed at toe -Cracks and holes visible halfway up the apron	29	2.0	13	Moderate	Moderate	**Moderate**
9	1+525	-Short structure, concrete sill and apron, concrete fish ladder (south side) -Apron failed at toe and sill	28	1.1	6	Moderate	Moderate	**Moderate**
10	1+586	-Concrete apron and sill, metal fish ladder (south side) -Apron failed at toe, concrete visually in poor condition	27	2.0	10	Moderate	Moderate	**Moderate**
11	1+655	-Concrete sill with broken concrete apron -Large sections of concrete resting below structure, creating drops -Rip-Rap along bank above structure	26	0.7	7	High	Low	**Moderate**
12	1+677	-Structure's failed weir no longer has an effect on water surface	25	No effect	0	Low	None	**Low**
13	1+711	-Structure's failed weir no longer has an effect on water surface	24	No effect	0	Low	None	**Low**
14	1+735	-Structure's failed weir no longer has an effect on water surface	23	No effect	0	Low	None	**Low**
15	1+770	-Smaller structure -Concrete apron in good condition	22	0.8	0	Low	Low	**Low**
16	1+810	-Longer structure with two smooth drops -Concrete apron in good condition, some hydraulic jump created at toe	21	1.4	13	Low	Moderate	**Moderate**
17	1+999	-Concrete sill and apron with toe drains, no obvious failures	20	1.2	9	Low	Moderate	**Moderate**
18	2+040	-Crest gone, replaced with river rock -Rock structure on north side failed, high velocity flow along the north bank	19	0.8	10	Very High	Moderate	**High**
19	2+086	-Crest with riprap apron, no undermining visible	18	0.9	6	Very High	Low	**High**
20	2+150	-Concrete sill and apron -Flow fairly calm above structure -Concrete visibly in decent condition	17	1.3	8	Moderate	Moderate	**Moderate**
21	2+215	-Concrete sill and apron -Wood deflector on far side -South side of apron failed, rip rap added	16	1.0	8	High	Moderate	**High**
22	2+257	-Wood crib stepped structure, large sections missing and apron gone -Multiple drops with long pool above structure	15	1.4	10	High	Moderate	**High**
23	2+333	-Wood crib stepped structure, half failed structure -Woody debris hung up on riprap, boil created on north side	14	1.2	9	High	Moderate	**High**
24	2+389	-Concrete sill and apron -Some apron failure, large hydraulic jump off apron itself -Creek narrows above and below structure -High wing wall on north side	13	1.1	4	Moderate	Moderate	**Moderate**
25	2+430	-Concrete sill and apron -Some apron failure on south side and at toe of structure	12	1.3	6	High	Moderate	**High**

Structure Number	Station	Notes	Marking on Wingwall	Height of Structure (m)	Length of Structure (m)	Potential for Structural Failure	Consequence of Failure	Risk
26	2+453	-Hole in apron on south side, bottom of apron eroded on north side -Landscape wall base failing on the north side under the pedestrian bridge	11	0.9	5	Moderate	Moderate	**Moderate**
27	2+502	-Concrete sill and apron -Some apron failure near top, bottom still fairly level -Slower approach velocity on south side	10	1.6	11	Low	Moderate	**Moderate**
28	2+540	-Concrete sill and apron -Apron has failed, bottom portion missing -Boil at the toe of structure	9	1.0	5	High	Low	**Moderate**
29	2+589	-South half of apron has failed, replaced with riprap -Apron levels out at bottom creating different tailwater, large hydraulic jump	8	1.1	7	Very High	Moderate	**High**
30	2+640	-Structure's failed weir no longer has an effect on water surface -North wingwall not visible	7	No effect	0	Low	None	**Low**
31	2+662	-Wood with rock backing -Lots of woody debris -Retaining structure instead of wingwall	N/A	1.8	8	Very High	Moderate	**High**
32	2+685	-Concrete sill with eroded apron -Wingwall not visible, path lowered between Str. 32 and 33 -Slightly wider, straight drop off structure	6	0.8	2	High	Low	**Moderate**
33	2+712	-Wood crib drop structure, about 10m upstream is concrete sill -Riprap apron, woody debris caught on apron -Retaining structure instead of wingwall	N/A	1.2	9	Very High	Moderate	**High**
34	2+723	-Structure's failed weir no longer has an effect on water surface -South wingwall is downstream of north wingwall -South properties behind dyke may be below high water levels	5	No effect	0	Low	None	**Low**
35	2+769	-Riprap apron-Calmer approach water-Less slope and potential for scouring-Retaining structure instead of wingwall	N/A	1.4	11	Very High	Moderate	**High**
36	2+784	-Structure's failed weir no longer has an effect on water surface	4	No effect	0	Low	None	**Low**
37	2+849	-Concrete sill and apron -Most bedload behind structure with longer pool above structure -Some apron failure, problems undermining at toe	3	2.2	12	High	High	**Very High**
38	2+935	-Concrete sill and apron -Potential for undermining at bottom of apron -Minimal concrete failure on south upper apron -Fines behind structure, more bedload than Str. #39 -Woody debris caught on structure	2	2.3	6	High	High	**Very High**
39	2+989	-Concrete sill and apron -Some material behind structure, not a lot of fines -Minor apron failure behind crest	1	2.1	4	High	High	**Very High**

REACH LINING

The lining of each reach was rated according to their 'Potential for Bank Erosion' and 'Consequence of Bank Erosion.' These ratings were then used to find a lining Risk rating.

Potential for Bank Erosion

Potential to Fail	Definition
Low	Bank well armoured with riprap/concrete with little signs of surface defects.
Moderate	Low to moderate signs of surface defects in concrete/rock bank protection. Cutoff walls in bank prevent erosion. Small hydraulic capacity to move material.
High	Portions of concrete/rock bank protection is missing. Portions of the bank will erode. Moderate hydraulic capacity to move material.
Very High	Large portions of the bank will erode. Inadequately sized bank protection. High hydraulic capacity to move material.

Consequence of Bank Erosion

Consequence of Failure	Definition
None	Failure of bank protection will have no impact.
Low	Failure of bank protection could result in minimal bank erosion.
Moderate	Failure of bank protection could result in bank erosion affecting adjacent property and deposition downstream.
High	Failure of bank protection could result in significant damage to adjacent properties and deposition downstream.

Lining Risk Rating

Consequence of Bank Erosion	Potential for Bank Erosion: Low	Moderate	High	Very High
None	Low			
Low		Moderate		
Moderate			High	
High				Very High

Table of Reach Ratings

Reach Number	Creek Channel Material	Potential for Bank Erosion	Consequence of Bank Erosion	Risk
1	Natural, sandy bottom	Moderate	Low	**Moderate**
2	Formed concrete channel, likely reinforced	Low	High	**Moderate**
3	Concrete w/reinforced grid and cutoff beams	Moderate	High	**High**
4	Natural channel material	Low	Low	**Low**
5	Concrete w/reinforced grid	Moderate	Moderate	**Moderate**
6	Natural channel material	Moderate	Low	**Moderate**
7	Concrete w/reinforced grid	Moderate	Moderate	**Moderate**

Reach Number	Creek Channel Material	Potential for Bank Erosion	Consequence of Bank Erosion	Risk
8	Natural bottom, sides lined from Structures #7 to #8	Low	Low	**Low**
9	Rip rapped channel	High	Moderate	**High**
10	Concrete w/reinforced grid	Low	High	**Moderate**
11	Natural channel material	Moderate	High	**High**
12	Natural channel material	Low	Low	**Low**
13	Natural channel material	High	Moderate	**High**

FLOOD PRIORITIZATION

Using the deficiencies from the bridge clearance and bank freeboard analysis, and the risk ratings from the structures and reach lining, the following flood infrastructure priority list was created. As stated in the report, the weightings for each category of infrastructure were developed with City of Penticton engineering staff and were used to create a preliminary list. Some adjustments were made for public perception, continuity between projects, and materials requirements.

1. **Reach 3b (incl. Structure 2, Wade Avenue pedestrian bridge)**
   - Very tall, failing structure
   - Large volume of bedload behind structure
   - Failing concrete lining
   - Lack of freeboard at structure crest

2. **Reach 4 + 5 (incl. Structure 3)**
   - Very tall, failing structure
   - Large volume of bedload behind structure
   - Failing concrete lining

3. **Reach 3a (incl. Nanaimo Avenue bridge)**
   - Lack of clearance under bridge
   - Failing concrete lining
   - Localized lack of freeboard

4. **Reach 13a (incl. Bridgewater pedestrian bridge)**
   - Actively eroding outside corners (unstable rock lining)
   - Important watermains along Penticton Ave
   - Widening of creek could produce rock material for other reaches
   - Localized lack of freeboard in some locations

5. **Reach 11c (incl. Structures 26 to 29, McNicoll pedestrian bridge)**
   - Lack of clearance under bridge
   - Failing riprap and concrete structures
   - Potential for bank erosion (unstable rock lining)
   - Localized lack of freeboard at some structure crests

6. **Reach 11d (incl. Structures 30 to 36)**
   - Provides continuity from Reach 11c
   - Failing riprap and concrete structures
   - Potential for bank erosion (unstable rock lining)
   - Localized lack of freeboard at some structure crests

7. **Reach 12a (incl. Structures 37 to 39)**
   - Tall failing concrete structures
   - Stable rock lining

8. **Reach 12b**
   - Provides continuity from Reach 12a
   - Potential for bank erosion (unstable rock lining)

9. **Reach 6 (incl. Structures 4 and 5)**
   - Failing concrete structures
   - Stable rock lining

10. **Reach 7 (incl. Structures 6 and 7, Eckhardt Avenue bridge and KVR pedestrian bridge)**
    - Failing concrete lining
    - Lack of freeboard at structure crest
    - Provides continuity from Reach 6

11. **Reach 11b (incl. Structures 21 to 25)**
    - Failing riprap and concrete structures
    - Provides continuity with Reach 11a
    - Potential for bank erosion (unstable rock lining)

12. **Reach 11a (incl. Structures 18 to 20)**
    - Failing riprap and concrete structures
    - Potential for bank erosion (unstable rock lining)

13. **Reach 9 + 10a (incl. Structures 12 to 16)**
    - Potential for bank erosion (unstable rock lining)
    - Failing concrete lining

14. **Reach 8 (incl. Structures 8 to 11)**
    - Lack of freeboard at structure crest
    - Stable rock lining

15. **Reach 13c**
    - Potential for bank erosion (unstable rock lining)
    - Widening of creek could produce rock material for other reaches

16. **Reach 10b (incl. Structure 17 and Forestbrook Drive bridge)**
    - Failing concrete lining
    - Failing apron at toe of Structure #17 is top end of concrete lining

17. **Reach 13b (incl. Penticton Avenue bridge)**
    - Lack of clearance under stable bridge
    - Not actively eroding banks, although some downgrading
    - Widening of creek could produce rock material for other reaches

18. **Reach 2b (incl. Structure 1, Ellis Street Bridge)**
    - Formed concrete lining deteriorating more slowly
    - No freeboard issues
    - No undermining at structure

19. **Reach 2a (incl. Front Street bridge and Ellis Street pedestrian bridge)**
    - Formed concrete lining deteriorating more slowly
    - Lack of clearance under bridge

20. **Reach 1 (incl. Art Gallery bridge)**
    - Lack of clearance under bridge
    - Few areas of localized lack of freeboard
    - Stable rock lining
    - No structures

ANNEX G: DETAILED COST ESTIMATES

Reach 1

Construction Subtotal	$	1,430,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	490,000
Contingencies	$	220,000
	$	2,200,000

Reach 2a

Construction Subtotal	$	1,490,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	510,000
Contingencies	$	230,000
	$	2,300,000

Reach 2b

Construction Subtotal	$	1,520,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	520,000
Contingencies	$	240,000
	$	2,350,000

Reach 3a – Lower

Construction Subtotal	$	400,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	10,000
Engineering, Admin. & Project Mgmt.	$	140,000
Contingencies	$	60,000
	$	630,000

Reach 3a – Upper

Construction Subtotal	$	820,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	310,000
Contingencies	$	160,000
	$	1,350,000

Reach 3b

Construction Subtotal	$	1,270,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	40,000
Engineering, Admin. & Project Mgmt.	$	450,000
Contingencies	$	200,000
	$	2,000,000

Reach 4

Construction Subtotal	$	100,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	70,000
Contingencies	$	40,000
	$	250,000

Reach 5

Construction Subtotal	$	930,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	500,000
Contingencies	$	160,000
	$	1,650,000

Reach 6

Construction Subtotal	$	360,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	200,000
Contingencies	$	100,000
	$	700,000

Reach 7

Construction Subtotal	$	890,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	340,000
Contingencies	$	150,000
	$	1,450,000

Reach 8

Construction Subtotal	$	1,270,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	440,000
Contingencies	$	180,000
	$	1,950,000

Reach 9

Construction Subtotal	$	410,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	230,000
Contingencies	$	70,000
	$	750,000

Reach 10a

Construction Subtotal	$	450,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	250,000
Contingencies	$	100,000
	$	850,000

Reach 10b

Construction Subtotal	$	790,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	300,000
Contingencies	$	140,000
	$	1,300,000

Reach 11a

Construction Subtotal	$	450,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	250,000
Contingencies	$	110,000
	$	850,000

Reach 11b

Construction Subtotal	$	940,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	330,000
Contingencies	$	170,000
	$	1,500,000

Reach 11c

Construction Subtotal	$	1,150,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	400,000
Contingencies	$	180,000
	$	1,800,000

Reach 11d

Construction Subtotal	$	1,160,000
Environmental Subtotal	$	40,000
Cultural & Heritage Subtotal	$	30,000
Engineering, Admin. & Project Mgmt.	$	410,000
Contingencies	$	160,000
	$	1,800,000

Reach 12a

Construction Subtotal	$	500,000
Environmental Subtotal	$	30,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	280,000
Contingencies	$	120,000
	$	950,000

Reach 12b

Construction Subtotal	$	320,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	180,000
Contingencies	$	60,000
	$	600,000

Reach 13a

Construction Subtotal	$	290,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	170,000
Contingencies	$	50,000
	$	550,000

Reach 13b

Construction Subtotal	$	330,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	190,000
Contingencies	$	90,000
	$	650,000

Reach 13c

Construction Subtotal	$	280,000
Environmental Subtotal	$	20,000
Cultural & Heritage Subtotal	$	20,000
Engineering, Admin. & Project Mgmt.	$	160,000
Contingencies	$	70,000
	$	550,000