Bow River 10 Street Gravel Bar

Preliminary Design Report

September 2025

02

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1 Executive Summary

This Preliminary Design Report details the findings of the Preliminary Engineering phase of the Bow River 10th Street Gravel Bar Restoration project (“the Project”).

The gravel bar at Louise Bridge expanded dramatically during the 2013 flood and has since vegetated into an emergent riparian forest (Figure 4). The bar reduces conveyance capacity through the Louise Bridge arches, increasing the risk of flooding in neighbouring communities. To mitigate this risk a review of bar removal and realignment options was conducted.

Through partnerships with the University of Ottawa and the National Research Council of Canada, detailed numerical and physical modelling of the site was conducted (Appendix D: National Research Council Canada – Physical Model Study of Gravel Bar Realignment Designs for the Bow River near Louise Bridge) and it was determined:

- Without intervention, the gravel bar will continue to grow, increasing the flood and erosion risk to the area and City infrastructure.
- A nature-based solution that realigns the gravel bar but keeps most natural gravels in the area is the most sustainable solution with the least long-term maintenance.

Based on the findings from these studies, and with guidance from the River Walk West (RWW) project team that is enhancing the public promenade along the river, a gravel bar realignment solution that mitigates the flood risk and has multiple social, recreational, and environmental benefits was developed (Figure 3). The proposed realignment is estimated to reduce water levels in the area by up to 0.5 m during a 1:100-year flood.

The most prominent recreation feature of the design is the inclusion of an adjustable recreational wave. A recreational wave was included in the design due to strong public support for this concept and because the flood mitigation project required the removal of an existing natural wave used by river recreationalists. A detailed review of the wave’s indicated that the wave is feasible and would result in significant economic and social benefits viability (Appendix H: City of Calgary 10 Street Recreational Wave Viability Report).

The adjustable wave is estimated to draw tens of thousands of river users and spectators; be an iconic location regularly featured in tourism and social media and conservatively generate approximately $2M in direct economic activity each year. The class 4 construction cost estimate for the entire project is $12M with an economic return on investment between 6 and 10 years.

The design for the Bow River 10th Street Gravel Bar project transforms the site into a comprehensive riverfront destination that balances flood mitigation with enhanced public access and recreational opportunities. The design creates a network of interconnected spaces that celebrate the river's ecological integrity while providing diverse recreational experiences that align with numerous City initiatives and goals including the Flood Resilience Plan, the Riparian Action Program, Recreation’s GamePlan, The Greater Downtown Plan, and RiverWalk West vision for the space (refer to Section 10 References).

Figure 1: Preliminary design landscape perspective: View from above

Figure 2: Preliminary design landscape perspective: View from 10th Street Bridge looking southeast

2 Acknowledgements

This Preliminary Design Report and The Project in general have only been possible due to the support and guidance from numerous organizations and individuals, including:

- The National Research Council's Ocean, Coastal and River Engineering Division and specifically Ivana Vouk, Mitch Provan, and Sean Ferguson;
- Dr. Colin Rennie and Dr. Qingcheng Yu from the University of Ottawa;
- The Alberta River Surfing Association;
- The Alberta White Water Association;
- Mary Quinlan and Jia Cheng of Project Spaces Public Development, City of Calgary;
- Carolyn Tooth and Rosanne Pinchin of Partnerships, City of Calgary;
- Katherine Hikita and Mark Schultes from the Transportation Public Delivery team, City of Calgary;
- Erica Goth and Anne Breckenridge of Climate and Environment, City of Calgary;
- Norma Ruecker and Eric Camm of Water Services, City of Calgary;
- Shawn Howery and David Storwick (Lieutenant) of Fire, City of Calgary;
- Mitch Addeson, Matt Wall, Laureen Bryant, and Jenna Cross of Parks, City of Calgary; and,
- The entire City of Calgary Riverwalk West project team.

The Design Consultant Project Team included:

- O2 Planning and Design Inc.
- Montrose Environmental Solutions Canada Inc. (previously known as Matrix Solutions)
- Surf Anywhere
- Applied Ecohydraulics
- Lifeways

3 Project Overview

3.1 Introduction

Over the past several decades a gravel bar has been forming in the Bow River under the Louise Bridge that connects 10 Street N.W. to downtown Calgary. Since the 2013 flood, the 10 Street Gravel Bar under the bridge has grown dramatically in size, increasing the flood risk to neighbouring communities. The bar's expansion has been accelerated by vegetation establishment, which anchors sediment in place and significantly reduces flow capacity through the bridge arches during high water events.

The primary purpose of this project is to mitigate flood risk while transforming necessary infrastructure improvements into a world-class community asset. Rather than simply mitigating the gravel bar flood risk, the project explores the optimal configuration that enhances river safety, ecology, and recreation for all Calgarians. The design includes a recreational wave feature that provides water sports opportunities while supporting the hydraulic requirements for effective flood mitigation.

This comprehensive approach addresses a critical infrastructure need while creating significant economic and social value through enhanced public access and recreational opportunities in the Bow River. The project transforms a flood liability into a distinctive recreational destination that positions Calgary as a leader in innovative flood management and urban river design.

The project integrates multiple technical disciplines including hydrotechnical engineering, morphology, hydraulics, ecology, and landscape architecture to develop solutions that balance flood mitigation with environmental stewardship and recreational programming. This interdisciplinary approach ensures that flood mitigation measures enhance rather than compromise the river's ecological function and long-term sustainability. Extensive physical modelling by the National Research Council of Canada and numerical modeling validate the nature-based design approach and confirm the flood mitigation benefits (Appendix D: National Research Council Canada – Physical Model Study of Gravel Bar Realignment Designs for the Bow River near Louise Bridge). For a detailed breakdown of the consultant team and discipline structure, refer to 9.3 Team Structure.

Coordination with the adjacent RiverWalk West project maximizes public investment by creating a continuous, world-class river promenade from Fort Calgary to the west end of downtown. This collaboration extends the successful river pathway improvements completed in the East Village and Eau Claire areas, establishing a unified vision for Calgary's downtown river corridor. The combined projects harmonize flood mitigation with enhanced public realm infrastructure, supporting Calgary's growth as a vibrant, resilient city that celebrates its relationship with the Bow River.

Figure 3: Preliminary Design - project areas

3.2 Problem Definition

The project site faces complex and interrelated challenges spanning flood risk, public infrastructure, recreation, safety, environmental health, and climate resilience. These multifaceted problems require comprehensive solutions that address both immediate risks and long-term sustainability.

Flood Risk

Over the past several decades, a gravel bar has been forming in the Bow River beneath the Louise Bridge, which connects 10th Street N.W. to downtown Calgary. Since the 2013 flood, the 10th Street Gravel Bar has grown dramatically due to sediment deposits, becoming increasingly covered with vegetation including mature trees that are expected to continue expanding (refer to References, Rood et. al., 2016).

This growing gravel bar creates cascading hydraulic problems that threaten both infrastructure and community safety. The sediment accumulation blocks water flow and reduces river channel capacity, leading to increased upstream water levels that risk overflowing into adjacent neighborhoods (Figure 5) and increases groundwater levels. Simultaneously, the altered flow patterns cause erosion along the opposite bank and riverbed, potentially compromising critical infrastructure including bridges, outfalls, and pathway systems.

Figure 4: Drone photograph of Louise gravel bar, facing south towards downtown Calgary. Note vast extents and large amounts of vegetation

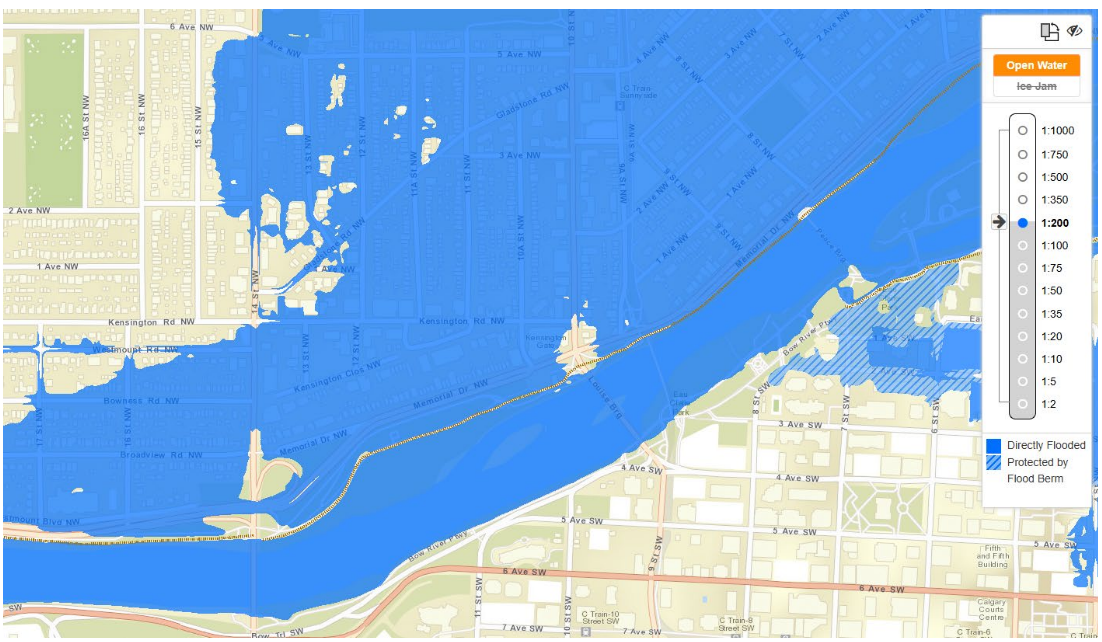


Figure 5: Flood Mapping of the areas of concern showing the level of impact during a 1:200 year flood and the barrier protecting communities from the river.

Wave Recreation and Navigation Challenges

The existing natural standing wave adjacent to the gravel bar (Figure 6) has historically served as a popular recreation feature for river surfing and kayaking. However, ongoing sediment movement has diminished this wave, reducing its recreational value and the proposed flood mitigation project would remove the natural wave completely. The existing channel configuration also creates hazardous conditions for river rafters and floaters (Figure 7), who must navigate around the gravel bar and risk becoming stranded on boulders and construction debris where the river turns beyond the bridge.

Figure 6: Photograph of the existing surf wave, including recreational users and spectators (Photo credits: Matt Gibson)

Figure 7: Photograph of the existing surf wave, including navigation around wood posts

Public River Access Limitations

The recreational challenges are directly linked to broader public access limitations that affect all Calgarians' ability to safely access and enjoy the river. The site's prime urban location adjacent to downtown and the heavily utilized regional pathway system creates significant public demand for recreational river access. However, current access options are inadequate and often unsafe. While the existing regional pathway system provides some east-west connectivity along the river, upstream of 10th Street the regional pathway is narrow and directly adjacent to Memorial Drive and Bow Trail vehicle lanes.

Most riverbank areas consist of steep, vegetated slopes accessed only through informal routes and footpaths. The site lacks dedicated infrastructure for swimming access, boat launches, waterside seating areas, or viewing platforms. There are no designated routes for walking directly adjacent to the water or safely approaching the water's edge.

The proliferation of informal trail networks creates operational inefficiencies, poor user navigation, accelerated bank erosion, and ongoing vegetation and habitat damage.

Outdated Landscape Infrastructure

Calgary's projected population growth to 1.6 million by 2029 and approximately 2 million within the next 15-20 years *(*Calgary and Region Population Outlook 2024-2029*)*, combined with extensive downtown waterfront revitalization projects along the Bow River—including the RiverWalk West, Eau Claire Promenade, Downtown Flood Barrier, and Peace Bridge—has significantly increased visitor traffic to the downtown waterfront.

From a public realm perspective, the project site fails to reflect the cultural and social significance of its strategic location adjacent to a major urban centre's downtown core. The City's Downtown Strategy emphasizes that "activating places and spaces is essential to increase downtown vibrancy and make downtown a place that people want to live, visit, and establish a business" *(*Calgary's Greater Downtown Plan, 2021*)*. Calgary requires high-quality public realm infrastructure at this site to accommodate growing pedestrian traffic and enhance economic activity by attracting businesses and investment downtown, ultimately contributing to improved quality of life and urban desirability.

Social Challenges

The site contains homeless encampments, where individuals have constructed temporary shelters using tents and tarps. Residents of encampments (Figure 8) face profound challenges with respect to their health, security, and wellbeing due to the absence of basic services such as clean water, sanitation facilities, waste management, and healthcare access. Associated environmental impacts include soil contamination, vegetation damage, and habitat disturbance. Concerns about public safety and access to shared spaces must be balanced with the fundamental recognition that encampment residents need support and kindness.

Figure 8: Existing site - homeless encampments

Habitat Degradation and Fragmentation

Accumulated habitat and vegetation degradation on the site creates substantial negative impacts on ecosystem health, contributing to habitat fragmentation, reduced biodiversity, and invasive species proliferation. Due to lack of river access points and formal trails, riparian areas and banks are trampled by informal pedestrian traffic and homeless encampments. Past historical interventions and outdated erosion mitigation works have created near vertical banks on the south slopes that are covered in invasive species (*Caragana arborescens*), negatively affecting native plant communities and overall ecological integrity.

Figure 9: Existing riverbank along the south slopes, with concrete debris and active erosion

3.3 Goals and Objectives

The primary purpose of this project is to mitigate flood risk while improving river safety, recreation, and ecology. The initiative aims to transform the site into a resilient, ecologically integrated, and community-focused destination that leverages the area's rich ecological history, cultural significance, and strategic location within Calgary's urban fabric. The project addresses historical challenges while enhancing the overall environmental and social value of the site.

Building on this foundational purpose, the project team has developed three interconnected goals, each supported by specific measurable objectives that guide implementation and success evaluation.

Goal 1: Enhance Flood Resilience

This goal focuses on reducing flood risk through nature-based channel modifications and infrastructure protection.

Flood protection infrastructure in the project area, including the under-construction Sunnyside flood barrier, were designed with water levels that did not include the long-term growth and vegetation of the gravel bar, so will be less effective over time compared to the design. Reshaping the gravel bar eliminates the predicted increased flood risk from the gravel bar vegetating and growing.

Past river interventions through this reach have impacted the sediment balance resulting in the current bar alignment. Reshaping the gravel bars to a more natural condition will mitigate flooding and minimize future gravel accumulation. The realignment will also reduce ice jam risk and enable an improved riparian corridor, pathway network, and river access.

Goal 2: Create a World-Class Waterfront Visitor Experience

The site will be transformed into a premier recreational destination that serves diverse user needs and generates a strong economic, cultural, and environmental return on investment. Objectives include creating a permanent, robust, and safe recreational river wave that provides consistent recreational wave opportunities. The project will establish safe public river access for both pedestrians and water users through dedicated infrastructure and clear wayfinding and signage.

The design will create a unique and vibrant cultural anchor that celebrates the historical and cultural context of the project site while integrating seamlessly with the RiverWalk West Master Plan. This comprehensive approach ensures the site becomes a signature destination that enhances Calgary's waterfront network and supports downtown revitalization efforts.

Goal 3: Enhance Ecological Integrity

This goal prioritizes environmental restoration and biodiversity enhancement throughout the project area. Objectives include mitigating riverbank erosion through natural and engineered solutions while addressing environmental degradation at the Landing and North Channel woodlands. The project will improve and create new fish habitats to compensate for any in-stream impacts, ensuring net positive ecological outcomes.

Riparian habitat preservation and restoration along the south bank will strengthen the ecological corridor function, while water quality improvements will support enhanced biodiversity throughout the river system. These ecological enhancements will create a resilient natural environment that provides long-term ecosystem services while supporting recreational and educational opportunities.

4 Site Context

This project covers a reach of the Bow River that is approximately 1 km long, in the vicinity of downtown Calgary. The surrounding floodplain is heavily urbanized and there are many anthropogenic factors that influence hydraulics and sediment processes within the channel and along the riverbanks including bank armouring, pedestrian pathways, outfalls, bridge piers, and bridge abutments.

4.1 Site History

Historical aerial and ground-based imagery from 1906 to 2023 shows numerous river interventions and changes, providing context as to the current state of this reach of river. Figure 10 through 14 below document many of these changes. Key observations include:

- Several mid-channel structures appeared in the 1924 imagery upstream of the Louise Bridge (Figure 10, Marker 2). These include the 1906 steel bridge, the weir structure and south sub-channel, and remnants of the 1888 Bow Marsh bridge. The Bow River was split roughly 40:60 between the south subchannel and the main channel, separated by a wooden pile wall. Logs floated into the south channel for processing at the Eau Claire sawmill. The weir also raised water levels in the south channel to supply water to the Eau Claire Hydroelectric Plant (Figure 10, Marker 1).
- An instream berm appears on the 1948 imagery upstream of 10th street. Montrose speculates that the berm was used for gravel mining to support the construction of Crowchild Trail Bridge.
- By 1948, the 1906 steel bridge and the guide structures to the south sub-channel were removed, but the wooden pile wall against the south sub-channel remained. By 1957, the weir was partially breached, and the south sub-channel was partially infilled (Figure 11). The weir was fully removed, and the sub-channel was fully infilled, by 1984 reducing the river's width by more than half.
- Portions of the river's south bank were infilled from 1948 to 1957 to construct 5th and 6th Avenue SW (Figure 11);
- Between 1957 and 1984, a gravel bar formed at the toe of the north bank. This bar has continued to stabilize and vegetate since 1984;
- By 1984 the Louise Bar was starting to form and had some vegetation. In 1997 the bar was roughly the same size as it was in 1984, perhaps with more vegetation. After the 2005 flood, the bar grew slightly downstream of the Louise Bridge but not laterally (Figure 12). After the 2013 flood, the bar grew substantially in all directions and caused flows below the 1:2-year flood to be split on either side of the bar (Figure 13; Marker 4). The 2013 flood removed most vegetation from the bar that had been present since 1984. By 2022, the bar was almost fully vegetated again, with larger extents to the post 2013 flood condition (Figure 14; Marker 8).

The overall takeaway from the historical data is that the Bow River through downtown is a heavily modified reach of the river and no longer in a natural regime. The project works described in this report will not degrade a natural system but rather restore it within an altered urbanized setting shaped by historical modifications. Appendix CAppendix C: Preliminary Hydrotechnical Design Report provides a more in-depth review of the historical aerial and ground-based images as well as outlines key changes to the river over time.

Figure 10: 1924 Historical Imagery with Key Areas of Change

Figure 11: 1957 Historical Imagery with Key Areas of Change

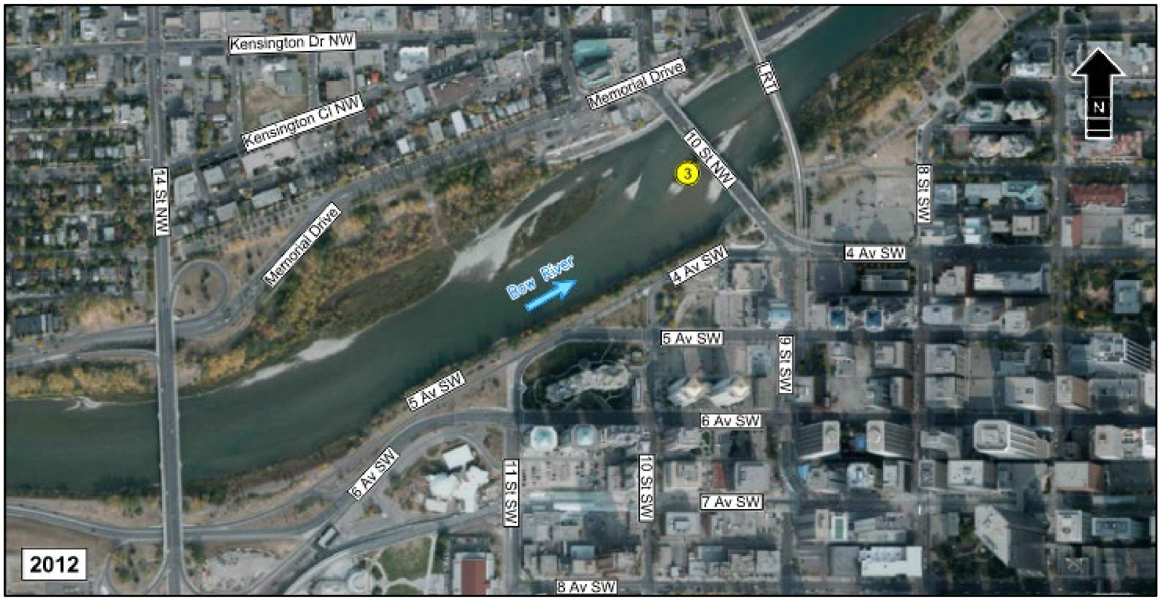


Figure 12: 2012 Imagery with Key Areas of Change

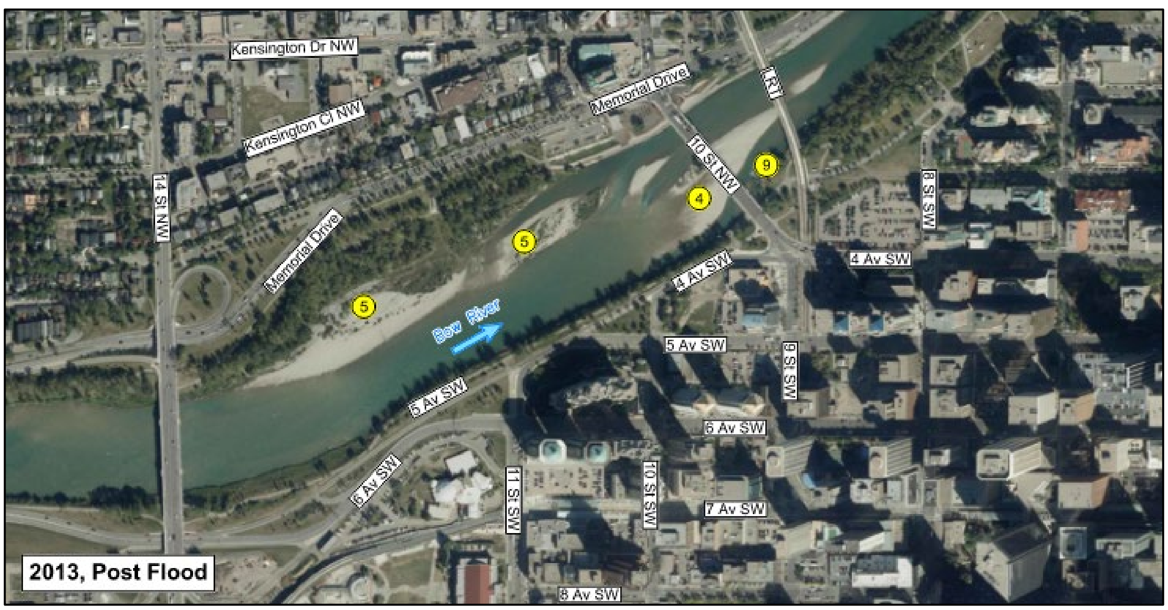


Figure 13: 2013 Post Flood Imagery with Key Areas of Change

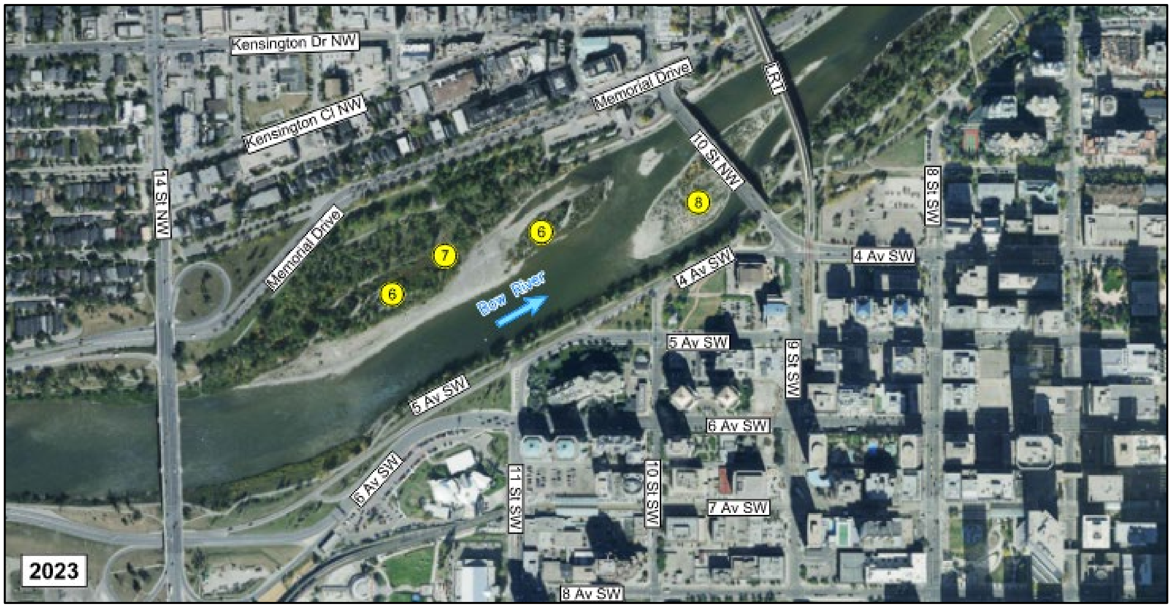


Figure 14: 2023 Imagery with Key Areas of Change

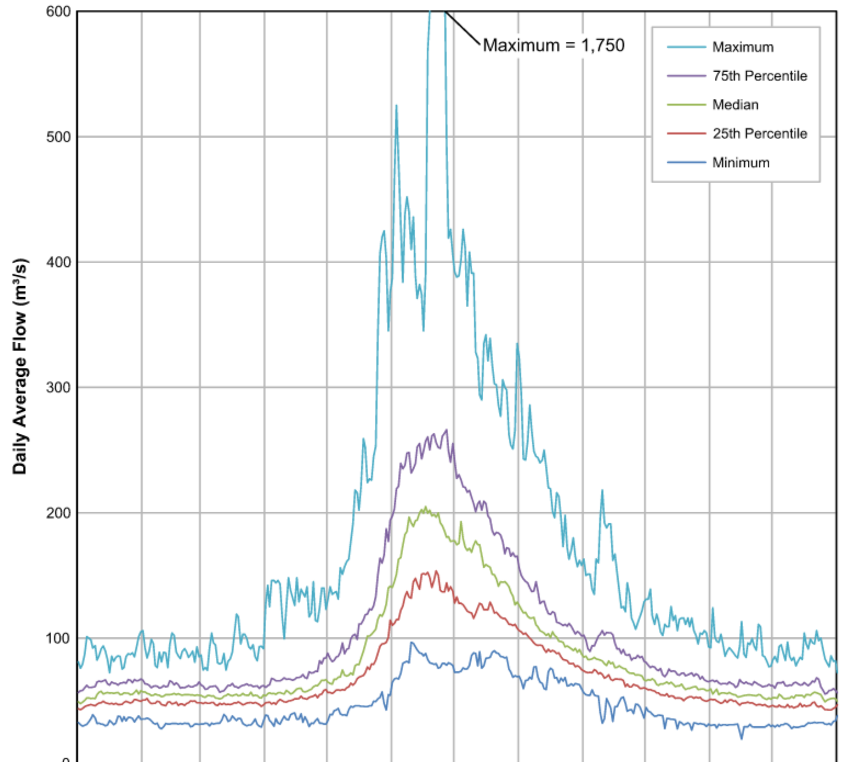
4.2 Hydrology

A detailed hydrology study for the Bow River was completed by others as part of the *Bow, Elbow, Highwood, and Sheep River Hydrology Assessment* on behalf of Alberta Environment and Parks (Golder 2020a). This report provides naturalized flow conditions from the 1:2-year to the 1:1,000-year return periods, i.e., flow conditions without any attenuation of flow from upstream reservoirs.

The annual flow hydrograph and flow statistics for the Bow River are displayed in Figure 15. More detailed hydrology is available in Appendix C: Preliminary Hydrotechnical Design Report. Important flows for consideration in this project included:

- The naturalized 1:100-year flood used for design is 2,090 m^3/s (Golder 2020a) which is the generally considered the maximum design flood in Alberta and in the City of Calgary infrastructure should withstand. This flow does not account for regulation from upstream reservoirs on the Bow and Kananaskis Rivers though also does not consider climate change impacts.
- The 1:2-year flood (401 m^3/s) was considered a reasonable flow to keep river adjacent infrastructure above such as pathways and benches to minimize disruption from normal yearly high-water events.
- The safe boating advisory flow (280 m^3/s) is generally considered the maximum flow above which boating on the Bow becomes unsafe, though it can vary depending on water temperature and clarity as well as weather conditions.
  - 250 m^3/s is considered the perennial plant vegetation trim line on The Bow in Calgary based on Rood et. al. (2016). This flow is exceeded 3% of the time on an annual basis.

- 92 m³/s is the average open water (April 1-October 31) flow rate based on Klohn, (2017). This flow rate will be used to assess fish habitat impacts and benefits from the project based on The City's fish habitat banking program.
- The 99% exceedance flow (33 m³/s) (Klohn, 2017) will be used to ensure connectivity of all side channels to ensure fish movement and water quality are maintained.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min. Monthly Flow	35.7	33.5	40.2	43.9	57.0	100.5	89.1	68.3	52.6	35.1	31.0	33.2
Mean Monthly Flow	55.9	55.8	55.2	62.9	100.2	201.1	164.3	110.8	81.8	63.8	55.8	54.5
Max. Monthly Flow	78.3	79.0	81.9	107.3	186.7	410.0	274.7	201.2	135.7	104.0	85.4	80.5
	Restricted Activity Period (Sep 15 to Apr 5)			Work Window	Restricted Activity Period (May 1 to Jul 15)			Work Window		Restricted Activity Period (Sep 15 to Apr 5)		

Figure 15: Annual Hydrographs and Monthly Flow Statistics (1955 to 2022)

4.3 Hydraulics

Due to the above noted historic interventions, the river hydraulics through this reach are comparatively simplified with the river being a fairly uniform, entrenched single channel (outside of the gravel bar) that is constrained by hardened riprap banks and bridges. At the gravel bar, a remnant side channel has formed but terminates awkwardly due to the historic land infilling downstream of tenth street.

The Provincially designated 1D HECRAS model for this reach of river was used to assess potential flood risk impacts from future changes to the bed level or increases in roughness due to vegetation. As seen on Figure 16 below, the current 1:100-year water level is within 0.34 m of the top of bank and the 1:200-year flood is well beyond it through portions of this reach. As such, the adjacent communities are at increased flood risk should the gravel bar continue to grow and vegetate into a riparian forest.

The hydraulics through this reach are also impacted by Louise Bridge (Figure 17). The same hydraulic model noted a 20% reduction in flow area through the bridge compared to upstream which resulted in a 30cm water level drop across the bridge and an increase in velocity of approximately 0.6 m/s. This backwater effect likely contributed to deposition and growth of the Louise Bar during the 2013 flooding. Based on this, increasing the flow area through the bridge, as this project proposes, will be beneficial. Further information on the channels hydraulic condition can be found in Appendix C: Preliminary Hydrotechnical Design Report.

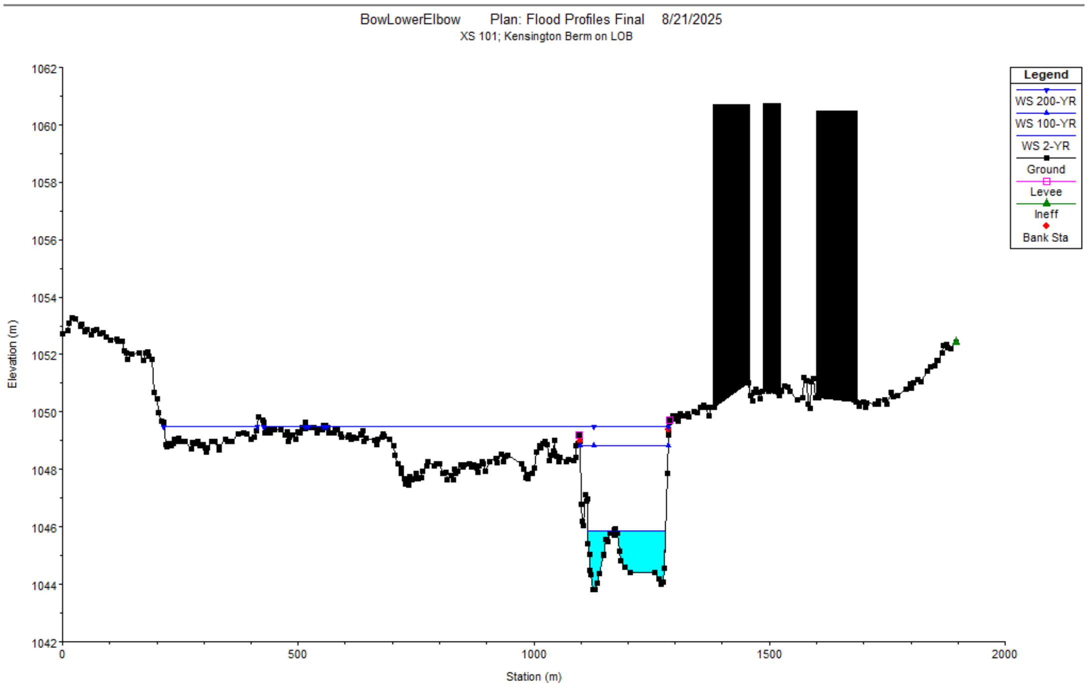


Figure 16: HECRAS cross section of reach of interest showing 1:2-year flood water level and the entrenched and simplified nature of the channel

Figure 17: 10th Street Louise Bridge 2013 flood. (Credit: J.R. Devaney).

4.4 Morphology

As noted in the site history section, The Bow River at the project site was heavily altered by human activities which have affected the river's natural morphologic regime. The large amounts of sediment deposited in the reach due to the historic intervention (Figures 12 through 16) combined with the bridges hydraulic constraints have likely contributed to the problematic growth of the Louise Bar itself.

The Calgary Rivers Morphology Study (Klohn Crippen Berger, 2017) was the first to identify the bar as a potential concern and developed a conceptual design to remove the bar completely. However, there were concerns with the resilience of this approach and whether the bar would just be reformed.

To assess the long-term impacts from the bar Dr. Colin Rennie and Dr. Qingcheng Yu of the University of Ottawa's Department of Civil Engineering completed a numerical morphodynamic modeling study evaluating three base management scenarios for the Louise Bar: bar removal, bar realignment, and a do-nothing case (Yu et al. 2022). The study was undertaken in collaboration with the River Engineering Group at the City of Calgary, and showed that for the do-nothing management case, deposition continued to occur at the tip and right side of the Louise Bar, eventually resulting in total infilling of the right side of the river (Figure 18).

The full bar removal resulted in eventual reformation of the Louise Bar (Yu et al 2022; Appendix O). The bar realignment case predicted some minor deposition at the tip of the realigned bar but overall had minimal bedform change compared to the other two cases (Figure 18). No deep scour holes or regrowth of high, elevated bars were predicted for the realignment case. The research paper discussing the modelling of these cases is provided in Appendix O.

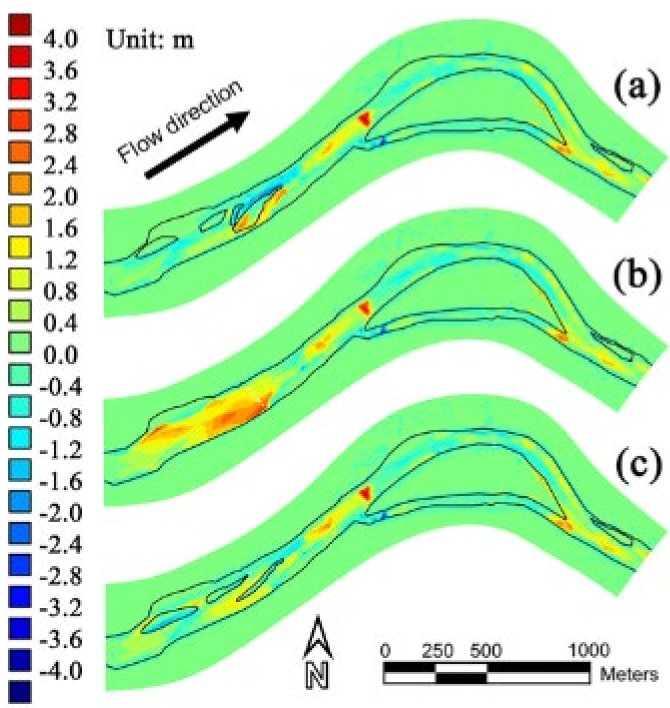


Figure 18: Cumulative deposition (red) and erosion (blue) map of different bar management plans. (a) is the do-nothing approach, (b) is the bar removal approach, and (c) is the bar realignment approach (Yu et al. 2022).

In addition to the numerical modelling by The University of Ottawa, a physical model of the reach of concern was developed by the National Research Council of Canada in partnership with the City of Calgary and the University of Ottawa (Figure 21). A 1 km reach of the Bow River was modelled at an undistorted 1:30 scale in NRC-OCRE's research laboratory in Ottawa, Ontario; the model extended from the 14th Street Bridge to just downstream of the LRT Bridge. The resulting physical modelling report is attached as Appendix D: National Research Council Canada – Physical Model Study of Gravel Bar Realignment Designs for the Bow River near Louise Bridge. Figure 19 shows the locations in the physical model where water levels were measured.

> The study confirmed the findings from the numerical modelling, that without intervention, the gravel bar is expected to continue growing, increasing the flood and erosion risk through this reach. Based on this modelling, the bar growth is expected to increase water levels through this reach by approximately 0.5 m upstream of the bridge (Figure 19,

Table 1).

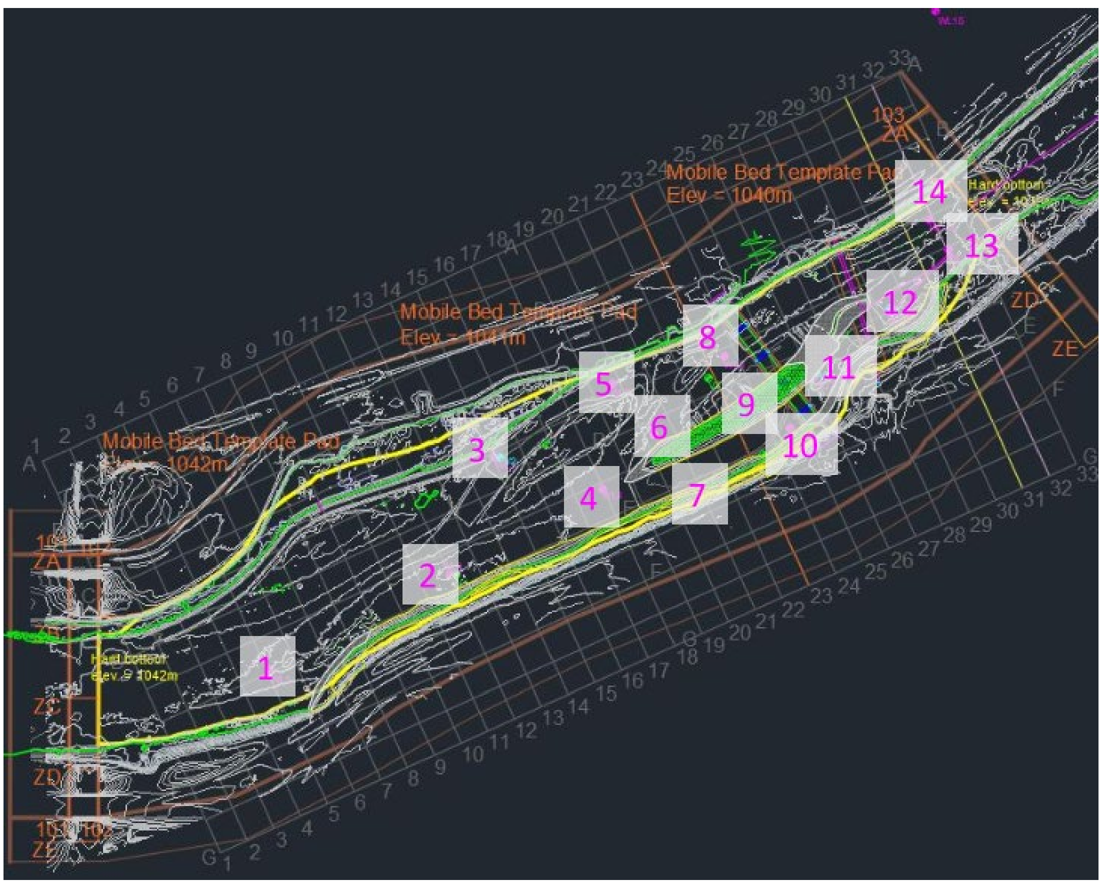


Figure 19: Water Level Measurement Locations in the Physical Model

Table 1: Water Level Increases for the "Do Nothing" Bar Management Case at the 1:100-Year Flood

Location	WL from 1D Hydraulic Model	Average WL from Physical Model	WL Increase if "Do Nothing" Approach is Used
1	1049.43	1049.93	0.5
2	1049.22	1049.68	0.46
3	1049.25	1049.25	0
4	1049.05	1049.42	0.37
5	1049.07	1048.89	-0.18
6	1049.01	1049.31	0.3
7	1049.01	1049.77	0.76
8	1048.8	1049.13	0.33
9	1048.63	1049.27	0.64
10	1048.8	1049.34	0.54
11	1048.59	1049.73	1.14
12	1048.17	1048.98	0.81
13	1047.81	1048.68	0.87
14	1047.78	1048.71	0.93

The study also noted that the gravel bar realignment option is the most sustainable solution at addressing the future flood risk. The model further demonstrated that even after consecutive 1:10, 1:35, and 1:100-year floods, the proposed bar realignment and recreational wave infrastructure would only have minimal sediment deposition and result in minor maintenance requirements, resolving a longstanding concern of including a recreational wave as part of the project.

As previously discussed, and based on our understanding of the channel's morphology, the river through this reach is no longer in a natural morphologic state. This project seeks to work with the existing morphological patterns while providing a stable, functional channel form that restores natural processes. By addressing historical constraints and enhancing sediment dynamics and bank stability, the project will improve the legacy condition of the river.

Figure 20: looking upstream at the Tenth Street Bridge and proposed channel realignment in the NRC physical model

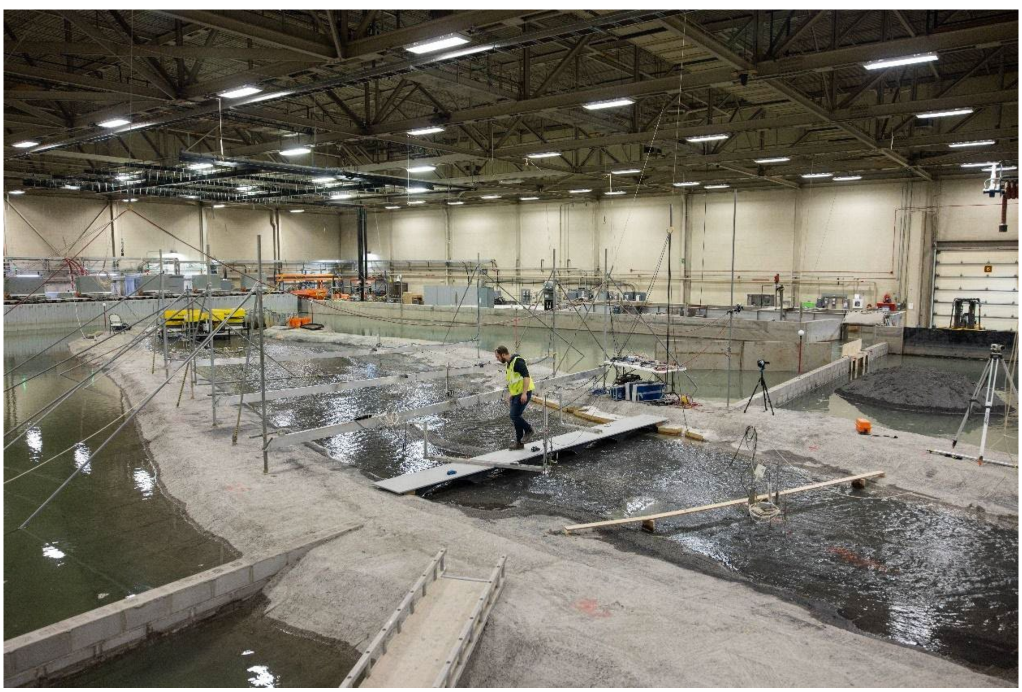


Figure 21: Physical modelling of Bow River high flow impacts on 10th Street Gravel Bar Restoration Project. Model at National Research Council Large Area Basin

4.5 Geology/Lithology

A sediment sampling program was completed as part of the *Calgary Rivers Morphology and Fish Habitat Study* (KCBL 2017). This study determined that the river substrate at the Louise Bar consists of a surface armour layer of gravels and cobbles with a D_{50} = 104 mm, and a subsurface D_{50} = 48 mm. This particle size would be mobilized during flooding, resulting in changes in the river bedform and slope.

The proposed recreational wave hydraulics rely on a relatively consistent bedform through the project reach, so to help determine the relative stability or the river bedform, historical borehole data along the Bow River was collected. The resulting lithology mapping is available in Appendix C: Preliminary Hydrotechnical Design Report. Key takeaways of the lithology mapping are as follows:

- Through the project area and in the river channel, substrates predominantly consist of gravels, underlain by clay, and then sandstone.
- In some locations in the project area the gravel substrate has been mobilized away from the underlying clay. This clay layer is generally resistant to scour and protects against bed lowering.
- Based on comparisons between LiDAR and bathymetry before and after the 2013 flood, the clay layer acts as a stable riffle. This generally prevents headcutting and channel slope changes from progressing through the project area – an important consideration for operational performance of the wave and wave channel.

4.6 Environmental Condition

Due to the large amount of historic impacts and developments through this reach, the environmental conditions through this reach are considered relatively poor. On the south bank of the river:

  - Upstream of the C-Train bridge, there is almost no riparian buffer between the River and Infrastructure such as roads/pathway and invasive caragana is prevalent along it.
  - Downstream of the C-Train bridge a reasonably healthy riparian area exists though is impacted by trail braiding and trampled slopes.

- historical erosion prevention efforts, constructed in part with waste construction material (i.e., fractured concrete slabs), limit riparian health, and are potentially dangerous.
- steep slopes and a lack of designated access points prevent easy access to the river. The lack of access points has contributed to erosion of the bank slopes as people develop their own path to the water

On the north bank of the river, and on the vegetated gravel bar at Poppy Plaza:

  - A reasonably healthy riparian area exists although extensive use by members of the public has created impromptu paths through the gravel bar. The vegetation on the bar obscures sight lines, which has the effect of enabling encampments by unhoused individuals (Figure 8).

- A semi-permanent graminoid marsh of approximately 0.2 ha exists on the Poppy Plaza bar and will need to be considered as part of the design
- extensive garbage and debris is present as a result of unlicensed dumping and camping on the vegetated gravel bar at Poppy Plaza (Figure 23Figure 23)

Within the river channel itself:

- The extensive historic instream interventions have resulted in reduced habitat complexity along this reach.
- Concrete and other construction debris has been used as erosion protection along the South Slopes and may be impacting aquatic habitat
- Poor riparian health through this reach may be impacting aquatic habitat

In general, the reach of river that runs through the project area is not optimal for public use and its current configuration allows for negative impacts to the environment and the public's enjoyment of the river. Results from the draft BIA (Appendix A: Biophysical Impact Assessment - Draft) are provided in the following sections.

Figure 22: Informal foot paths impact the health of the riparian area

Figure 23: Lack of designated trails results in disorderly conduct and garbage accumulation

4.7 Land Ownership, Management and Existing Utilities

There are three landowners and seven titled parcels that intersect or are immediately adjacent to the study area. Land ownership, encumbrances, and utility rights of way are discussed further in Appendix I: Land Ownership and Figures 28/29 below highlights the utilities located along the project site. The following points outline critical considerations and necessary coordination for the project:

- **Enmax transmission line coordination:** A 138 kV Enmax transmission line necessitates mandatory coordination with Enmax for utility clearance. Enmax is planning on decommissioning the line in 2027 and coordination of its removal may be required as part of this work.
- **Water main protection during excavation:** The 1500 mm concrete water main will require careful planning to prevent damage during any modifications of the banks or bed of the river along its alignment.
- **Stormwater infrastructure consideration:** Storm outfalls and infrastructure at the Landing, Wave Deck, and South Slopes will have to be adjusted to accommodate any proposed channel adjustments.
- **Land ownership and legal requirements:** Public Lands Act approvals are mandatory for any disturbances or structures on provincially owned lands.

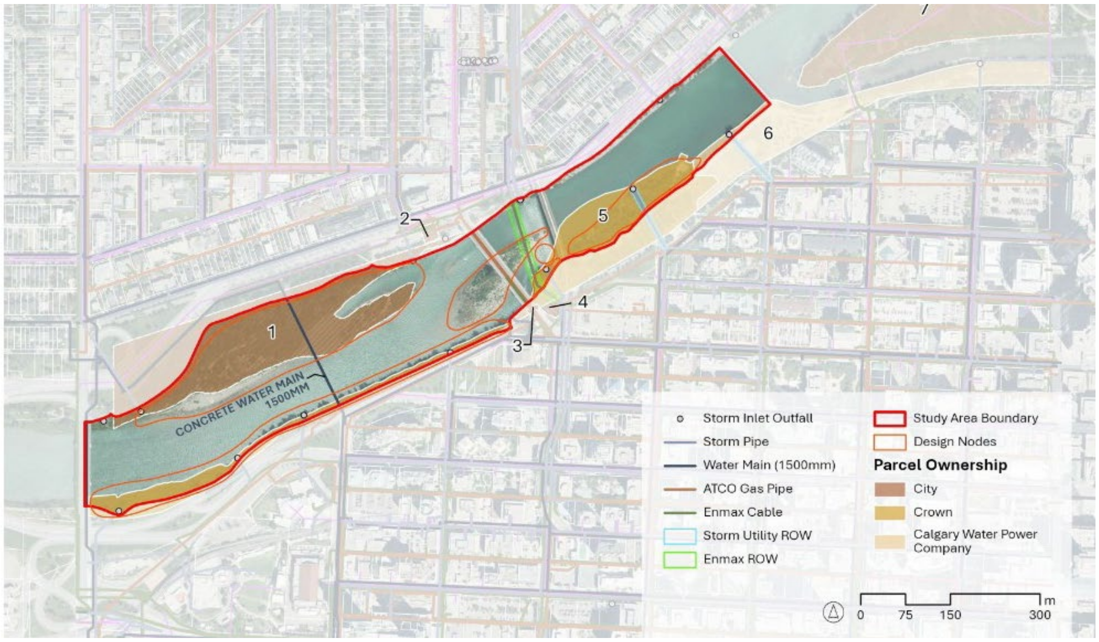


Figure 24: Utilities and Rights-of-Ways in and adjacent to the Study Area

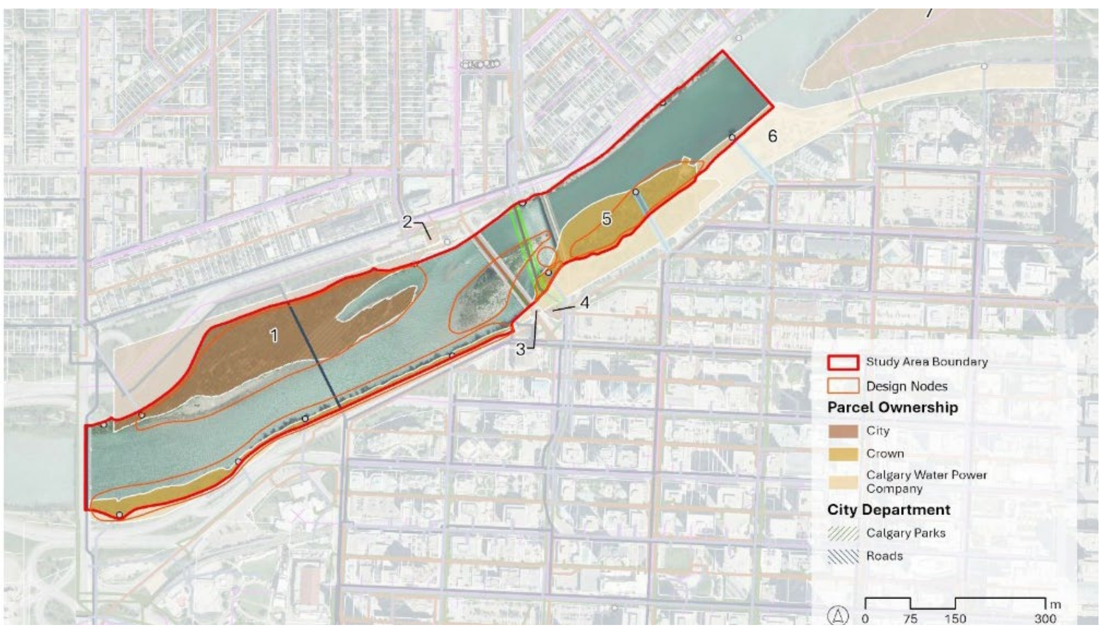


Figure 25: Land titles on file and parcel ownership in and adjacent to the Study Area

4.8 River Recreation

The project site has significant river recreation challenges and risks. The 10th Street Wave that formed from old logging pilings has degraded due to sediment deposition and is no longer usable at most flow rates.

The sharp river bend on the south side of 10th Street Bridge causes many shore impacts with summer rafters, damaging both casual rafts and risking injury. The south side of 10th Street Bridge is a desired river access point (Figure 26) for recreation watercraft launches and take-out, because it is one of the first accessible shorelines near downtown and is beside a public parking lot (Calgary Parking Authority Lot 6). There is no current adequate river access, and people scramble down a riverbank to access the river or over riprap next to fast moving water which creates risks.

Figure 26: Poor bank condition and trampled vegetation at the existing wave location

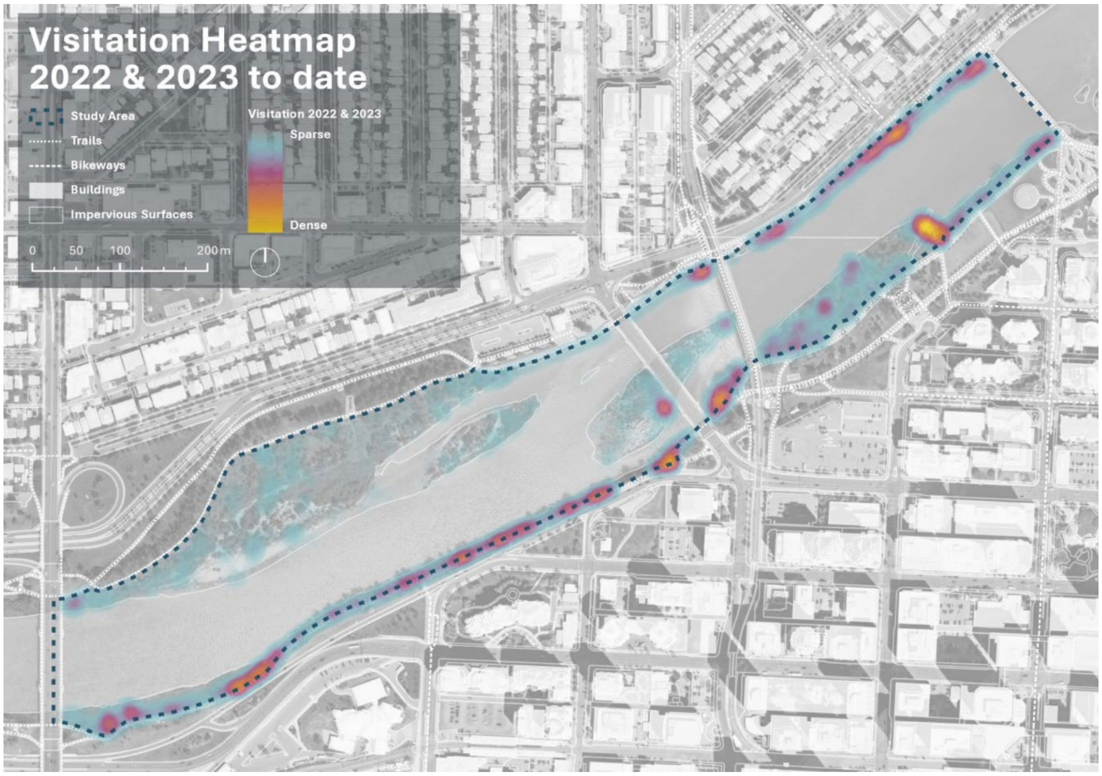


Figure 27: Visitation heat map showing the 10th Street wave location and the south slopes are high usage areas.

4.9 Community Use

The project site is integrated into Calgary's extensive multi-use pathway network, which comprises approximately 1,000 km of regional pathways in the city. The regional Bow River pathway system provides east-west connectivity along both riverbanks through the project area. However, upstream of the 10th Street Bridge, the regional pathway becomes narrow and runs directly adjacent to Memorial Drive vehicle lanes, creating safety concerns for pathway users.

Downstream of tenth street, multiple informal trails have developed into a braided pattern that fragments the landscape and contributes to environmental degradation through accelerated bank erosion and habitat disturbance.

Current public access to the river is severely limited and often unsafe. Most riverbank areas consist of steep, vegetated slopes accessed only through informal routes and unplanned footpaths. The site lacks dedicated infrastructure for safe water access, including designated swimming areas, boat launches, waterside seating areas, viewing platforms, or formal routes for approaching the water's edge.

The adjacent RiverWalk West project (currently in design phase) will create a continuous widened river promenade connecting the east and west sides of downtown Calgary along the Bow River. This project will link previous City investments, including the West Eau Claire Park and Eau Claire Promenade (completed in 2019) on the west side of downtown and the RiverWalk (completed in 2014) on the east side of downtown. These completed sections feature a 6-metre pedestrian promenade with an additional 3-metre bicycle pathway, establishing the design standard for downtown river pathway infrastructure required to support high traffic use.

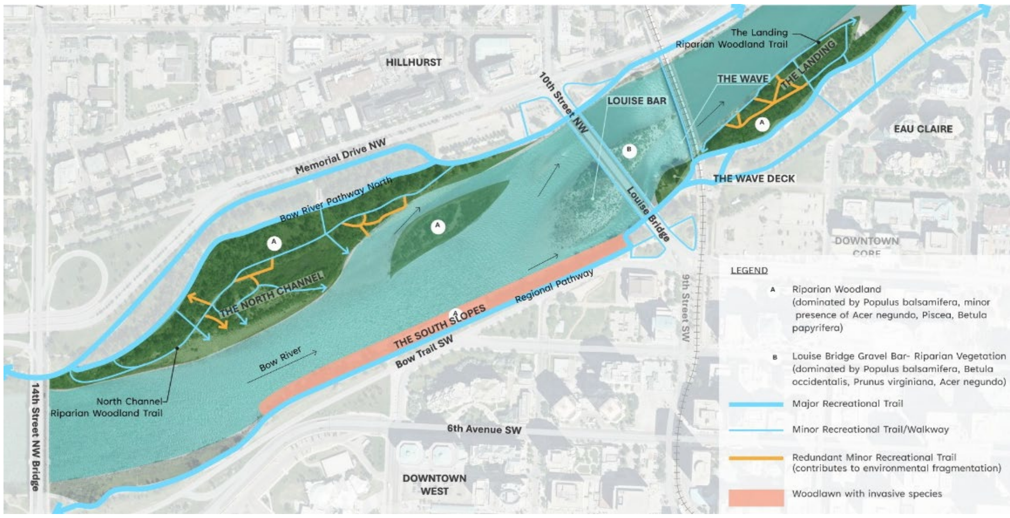


Figure 28: Trails and Natural Areas Analysis

5 Conceptual Design

A conceptual design for the lowering of the Louise Bar and Poppy Plaza Bar was completed by others as part of the Calgary Rivers Morphology and Fish Habitat Study (KCB 2017). The conceptual design was focused on reducing flood levels, and included the following key components:

- Excavation and Recontouring: Both bars would be lowered to approximately the spring (April) average water level to improve river conveyance and reduce flood levels. The armour layer (surface gravels) would be temporarily removed, underlying material excavated, and the armour replaced afterward
- Fish Habitat Features: Excavated areas would be contoured to form preferential flow paths, functioning like braided channels during low flows. A side channel will be constructed on the north side of the Poppy Plaza bar to enhance the available year-round fish habitat, with a minimum depth of 0.1 m at low flow. The side channel would include aquatic habitat features like riffles, pools, and overhead/instream cover (e.g., woody debris or boulders)
- Bank Stabilization: Erosion protection and riparian enhancements were proposed along the right bank upstream of the Louise Bridge
- Material Reuse: Excavated gravel will be reused to build habitat features or placed elsewhere in the river system. Notably the conceptual design did not discuss where or how the excavated gravels would be used
- Optional Recreation Elements: The design discussed the possibility of incorporating recreational features (e.g., maintaining or enhancing the standing wave at 10th Street)

In addition to the flood reduction design by KCBL, the Alberta River Surfing Association in partnership with Surf Anywhere developed a conceptual river wave and urban beach design report for inclusion at the Louise Bridge location (Surf Anywhere 2019). This design included the following key components:

- Hydraulically controlled wave structure(s) that can be raised or lowered to create ideal river surfing conditions across a range of flows, intended for recreational surfing, kayaking, and other water sports. The wave structure would be non-operational during high flows, at night, and in the winter
- Shoreline enhancements, riverbank access improvements, and a supporting facility on City of Calgary parkland that provides amenities for users and spectators
- Drop analysis (i.e., size of the recreational wave) for various river flows
- A discussion of the economic and cultural benefits of river waves in general, and assessment of how a river wave at the proposed location would benefit the city. This included discussion of wave operating plans and proposed ownership models

These assessments were used as a basis for the preliminary design herein.

Figure 29: Conceptual visualization from the Conceptual River Wave and Urban Beach Design Report (2019)

6 Preliminary Design

6.1 Preliminary Design Summary

The preliminary hydrotechnical design for the 10th Street Gravel Bar project evaluated existing river conditions and developed strategies that align with the overarching project goals: reducing flood risk, enhancing public access and recreation, and improving environmental conditions. The design addresses five key project nodes: the Gravel Bar, River Wave and Wave Deck, the Landing, the South Slopes, and the North Channel (Figure 30).

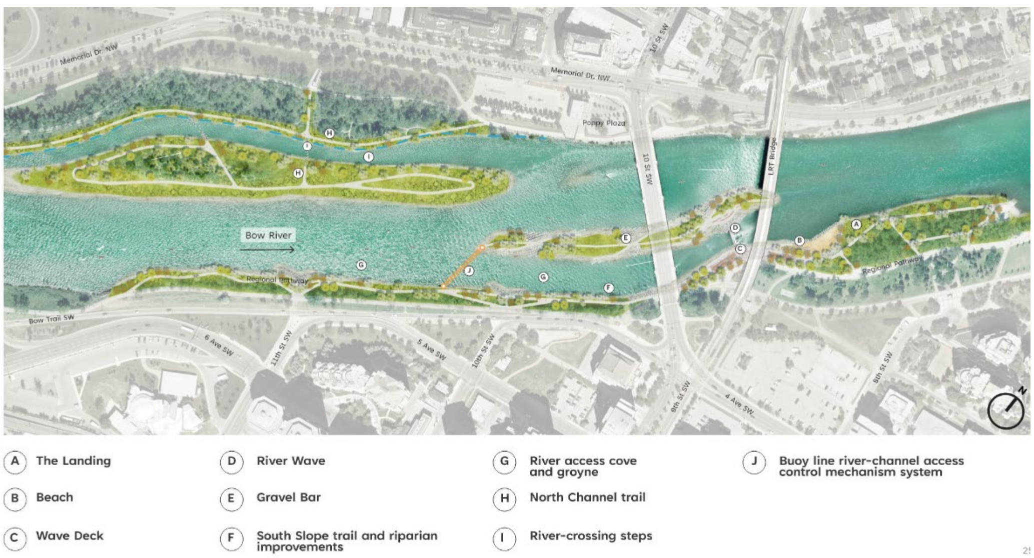


Figure 30: Preliminary Design: Overall Plan

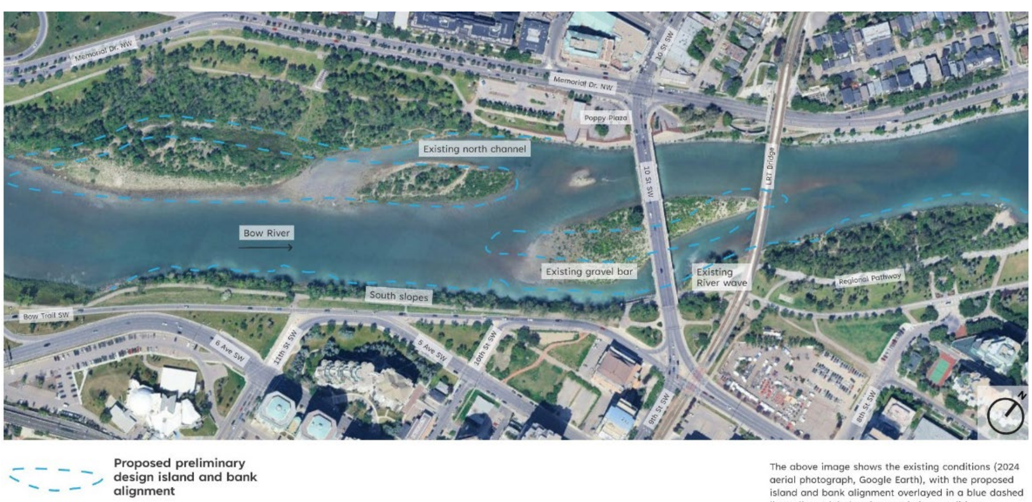


Figure 31: Existing conditions and proposed preliminary design alignment

6.2 Environmental and Ecological Inputs

Environmental assessments of the project area were completed as follows:

- 2023
  - June 16 – Rare Plant Survey
  - June 22 – Amphibian Auditory Survey
  - July 18–19 – Bat Survey
  - July 26–27 – Rare Plant, Weed, Vegetation Community, and Riparian Health Surveys
  - August 1 – Fish Habitat Assessment Survey
- 2024
  - April 24 – Snake Survey
  - May 30 – Amphibian Visual Survey

The results of these surveys were incorporated into the draft Biophysical Impact Assessment (Appendix A: Biophysical Impact Assessment - Draft) for the project, which will be finalized during the detailed design phase. The assessments were utilized to guide the design to ensure no rare plants or species at risk were impacted.

6.2.1 Riparian and Upland Vegetation

Vegetation types in the project area include riparian (deciduous and shrubby), beach/gravel bar, seasonal marsh, and disturbed communities like riprap.

Riparian forests, found along the riverbanks, are dominated by native poplars and shrubs, with a high presence of non-native herbaceous species such as caragana due to urban disturbance and-foot traffic. Shrubby riparian zones include red-osier dogwood, willow, and poplar saplings. The gravel bars support dense stands of young poplars that have germinated in the years following the 2013 flood and are expected to continue growing into a riparian forest.

A 0.2 ha semi-permanent graminoid marsh was identified in the project area along the North Channel and contains species like Sprengel's sedge and Bulrush, but no rare plant species were observed within it. This wetland will be removed as a consequence of constructing the north channel in this area and will be compensated for by contributing to the City of Calgary offsetting fund. The compensation will cost approximately $30,000. It is not practical to incorporate or recreate this marsh within the project area.

None of the four provincially rare plant species with potential to occur in the area were found during field surveys, nor were any rare ecological communities identified. Rare plant potential is considered low overall, except in the graminoid marsh, where it is medium to high though again none were observed.

Surveys recorded one prohibited noxious, 13 noxious, and 44 other non-native or potentially invasive species within the project area (Figure 32). Where the proposed project design disturbs areas with this vegetation, it will be removed and replaced with native vegetation more appropriate for the area.

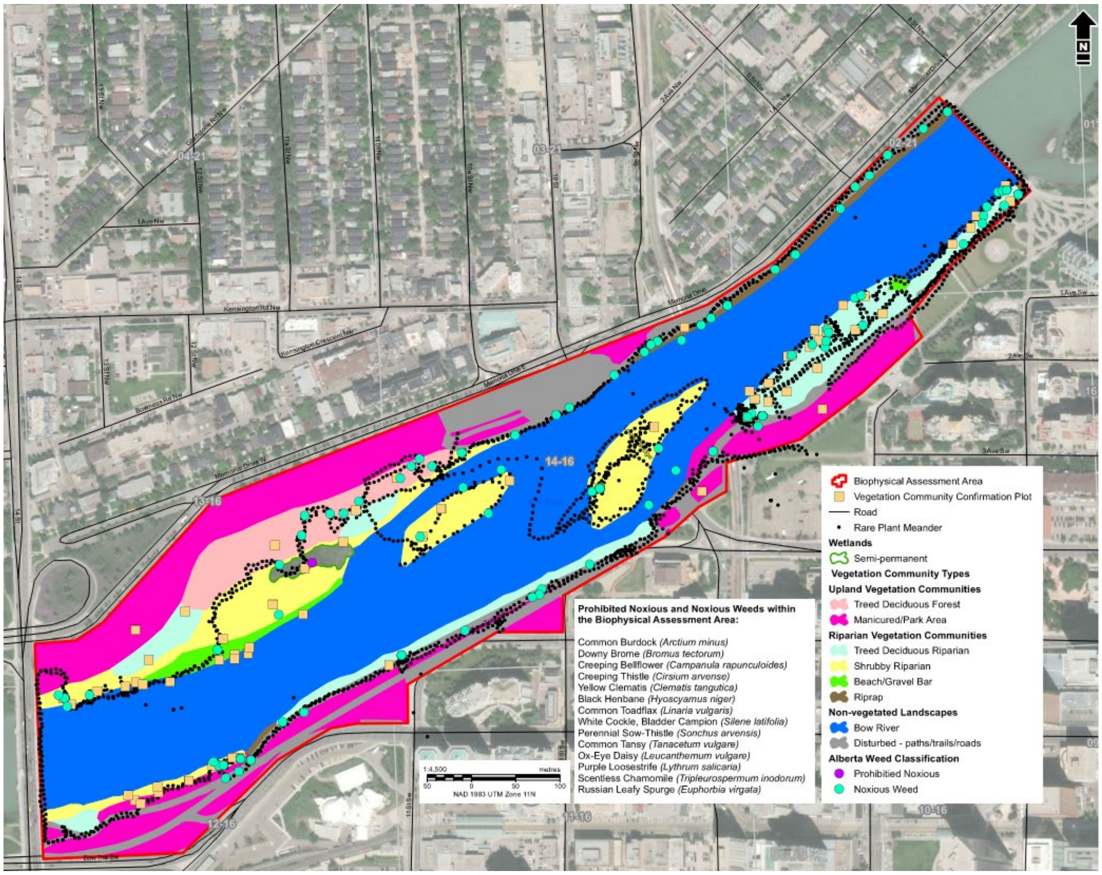


Figure 32: Vegetation Community Distribution, Survey Points, and Weed Species

Riparian health scores at the North Channel, Louise Bar, and landing area were calculated by Jason Boutet, P.Ag.; and Julia Kemper, B.Sc., Vegetation Ecologist-in-Training; based on vegetation, soil, and hydrology factors, using the *Alberta Wetland Health Assessment for Large River Systems* (Cows and Fish 2020). Riparian health in these areas was rated as "healthy, but with problems," with an overall score of 77%. Regeneration of native shrubs was strong, but invasive plant presence lowered scores in some areas, notably along the South Slopes, where there is a large amount of invasive caragana species. The assessment also noted the heavy use of the area by pedestrians and dogs and the large number of informal trails that braid through the project site.

Approximately 90 mature trees will have to be removed due to this project but will be compensated at a minimum of 3:1 through additional planting along the south slope and wave deck area using large caliper trees. The tree removals are primarily located where the north channel will be created (Figure 33). Additional information on tree impacts will be provided with the finalized Biophysical Impact Assessment (BIA).

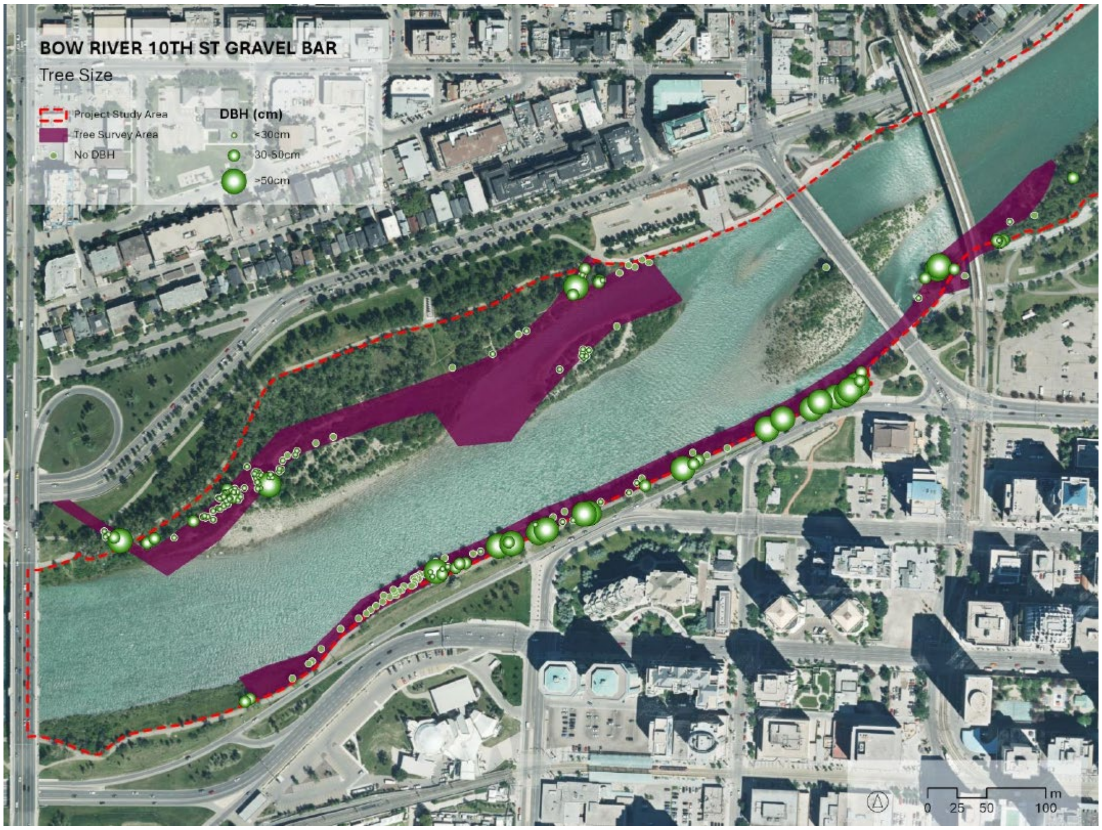


Figure 33: Existing trees that may be impacted by the project

In summary, no rare plants, rare ecological communities, or critical vegetation features were identified that would be adversely affected by the project. On the contrary, this project is expected to improve riparian health through the area, by removing the noted invasive species, providing additional riparian area for native planting, by removing braided trails, and by focusing use of the area at designated hardened trails and access points.

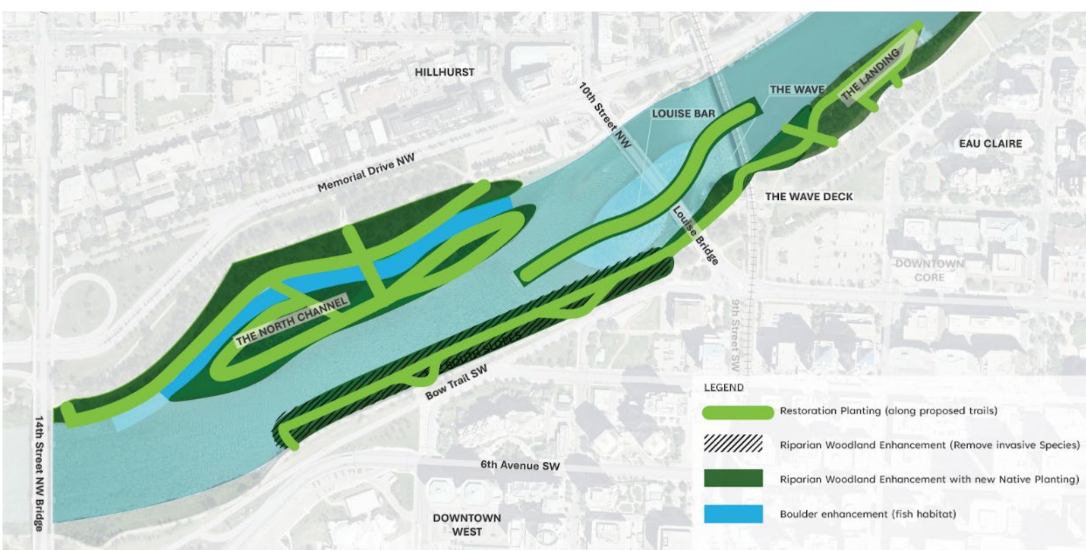


Figure 34: Environmental improvements

6.2.2 Riparian and Upland Wildlife Habitat

Considering its urban nature, a variety of wildlife species have still been observed or are expected to occur within the project area, including waterfowl and shorebirds/waterbirds (e.g., Canada goose, American wigeon, Mallard, Common merganser, etc.), raptors (e.g., Osprey), perching birds/songbirds (e.g., Yellow-bellied sapsucker, Northern flicker, Downy woodpecker, etc.), amphibians, reptiles, and various other mammals.

Seventy-three species at risk (SAR) have ranges overlapping the project area, however the presence of most of these SAR is unlikely in the project area due to its urban nature and lack of suitable habitat. No active important wildlife features, such as nests, dens, or burrows requiring regulatory setbacks, were identified during 2023 surveys. Acoustic bat surveys identified likely little brown myotis (a species at risk) travelling through the project area, but none were found physically roosting in the project area.

Raptor nesting habitat is present, but no nests were found. Amphibians and reptiles may be present but were not observed during fieldwork. Garter snakes are known in the region, but no active hibernacula were identified within the project area during the 2023 review.

Bird habitat is present throughout the project area, especially in less disturbed areas. Most species observed are common to Calgary, and no active nests were found. One SAR bird, the sora, was observed in marsh habitat near the North Channel.

Mammals are limited to urban-adapted species such as squirrels, coyotes, and deer. Seven bat species may occur, including five SAR. Acoustic surveys recorded 46 bat call files, primarily little brown myotis and long-legged myotis, near suitable roosting habitat in the Landing and North Channel. Little brown myotis is a listed species at risk.

In summary, while a range of wildlife may use the project area, no critical habitat features, or sensitive wildlife concentrations were identified during field assessments. Standard precautions and pre-construction sweeps should be sufficient to mitigate harm to wildlife during construction.

Once the project is complete, it is expected that there will be an overall general benefit to wildlife due to:

- Improved riparian habitat along the south slopes as well as the lower bench providing a wildlife corridor away from Bow Trail and closer to the river
- The reduction in braided trails and the consolidation of bank access at key designated access points.
- The creation of an Island by the North channel that will limit human access and provide a wildlife refuge
- An increase in fish habitat area and overall diversity

The only long-term concern from the project revolves around fish movement due to the wave as discussed below.

6.2.3 Fish Movement at Wave Structure

The wave structure has the potential to affect fish movement upstream when the wave is in operation due to the high velocities at the wave location. The proposed recreational channel represents approximately 1/3 of the channel flow/width and though fish would still be able to navigate upstream through the main channel, concern with fish finding the main channel to provide this passage was noted. To better understand potential impacts, Montrose reviewed literature on fish movement behavior for key species in the Bow River, including Brown Trout, Rainbow Trout, and Mountain Whitefish.

In this context, the concern is with general fish movement rather than large-scale migrations. Movement occurs within a fish's home range as it seeks food and shelter while avoiding predators. This movement follows diel (day-night) patterns that vary by species and environmental conditions. Brown Trout typically move at night or during crepuscular periods (dawn/dusk), while Rainbow Trout are more active during the day, with some peak activity at dusk. Despite individual variation, most fish move only short distances and remain within a limited home range. For context, the distance from the wave structure to the downstream tip of the realigned Louise Bar and confluence of the wave channel and main channel is about 45 m. This is long enough that fish may mill near the wave structure barrier until it is turned off for the night.

Given these considerations, it is unlikely that the wave structure will have any significant impacts to fish movement in the area as the recreational channel only impacts approximately 1/3 of the river/flow and the wave is only expected to be operated during daylight hours during the ice-free season. To confirm that the wave will be a movement barrier at all, finalized design velocities for the wave will be tested using the Fish Swim Performance Tool during detailed design.

6.3 Hydrotechnical and Civil Design

6.3.1 Hydrotechnical and Morphodynamic Design

The design was guided by a set of hydrotechnical and morphodynamic criteria including:

- Reducing 1:100-year flood levels;
- Reducing velocities (and therefore shear stresses) to minimize erosion;
- Balancing shear stresses throughout the reach to prevent excessive sedimentation or erosion at any one location;
- Ensuring stability and performance of the wave structure; and,
- Establishing low-flow connectivity for the proposed North Channel.

These criteria promote long-term channel stability and reduce reliance on ongoing dredging or maintenance. Historical and recent morphological assessments, including those by Montrose and KCBL, make it clear that the project reach has been shaped by more than a century of human interventions and sediment deposition.

Lithological mapping (Appendix X) and post-flood bathymetric surveys identified a clay layer that lies just beneath the gravel surface throughout much of the project area. This clay layer is resistant to erosion and plays a stabilizing role in the morphology of the reach. Of particular note, a riffle near the upstream tip of the Louise Bar was stable through the 2013 flood and remains in place.

To build on this inherent stability, the project design avoids full bar removal and instead reshapes and armours the realigned bar to a target geometry aligned with flow and sediment transport patterns. This approach is more resilient than routine dredging, which exposes underlying clay and often leads to rapid sediment infilling and bar reformation (Yu et al. 2022).

Appendixes C, X and X provide additional detail on the hydrotechnical and morphologic design, but in summary, the design was developed through an iterative modelling process involving numerical and physical modelling tools as follows:

- A one-dimensional HEC-RAS model was used to assess changes to flood levels and confirm the flood reduction benefits of the design.
- A two-dimensional HEC-RAS model was used to refine the Louise Bar alignment and resulting flow split, and to estimate site-specific velocities for armouring and scour protection design.
    - A target flow split of approximately 35 to 40% of the safe boating advisory flow of 280 m^3/s, i.e., up to 112 m^3/s, into the wave channel was selected to optimize wave performance while maintaining adequate conveyance in the main channel and establishing permanent flow, and therefore fish habitat, in the North Channel. Channel and bar modifications were also designed to reduce high-flow constriction, minimize excessive velocity concentrations, and create a hydraulically stable system. Approximate flow splits at various flood return periods are listed in Table 2.
- A 2D Delft3D morphodynamic model was used as an initial tool to predict sediment transport and deposition under the proposed conditions.
- A physical 1:30-scale model of the project extents was constructed and tested by The National Research Council Ocean Coastal and River Engineering (NRC-OCRE) Research Centre to confirm flood hydraulics and geomorphic response.
    - These insights informed further refinements to the digital elevation model (DEM), which was iteratively updated in HEC-RAS and further enhanced with morphodynamic modelling (Delft3D) to assess sediment transport dynamics.
    - The DEM was finalized through several rounds of collaboration between the hydrotechnical and landscape architecture teams, resulting in a design that integrates hydraulic performance with a high-quality urban riverfront.

The morphodynamic model results indicated that the proposed bar form and wave channel are likely to remain functional after a major flood, with relatively minor deposition expected in the North and Wave Channels. In contrast, scenarios involving simple dredging, such as those discussed in KCBL's prior analysis, tend to require frequent re-excavation due to the absence of morphological controls. The proposed design therefore represents a more sustainable intervention that works with the natural sediment regime rather than against it.

The numerical hydraulic models show that with the proposed design and erosion protection, local flow velocities through the project reach are not high enough to cause erosion that might cause elements of the project to fail, particularly the Louise Bar and South Slopes (Figure 37).

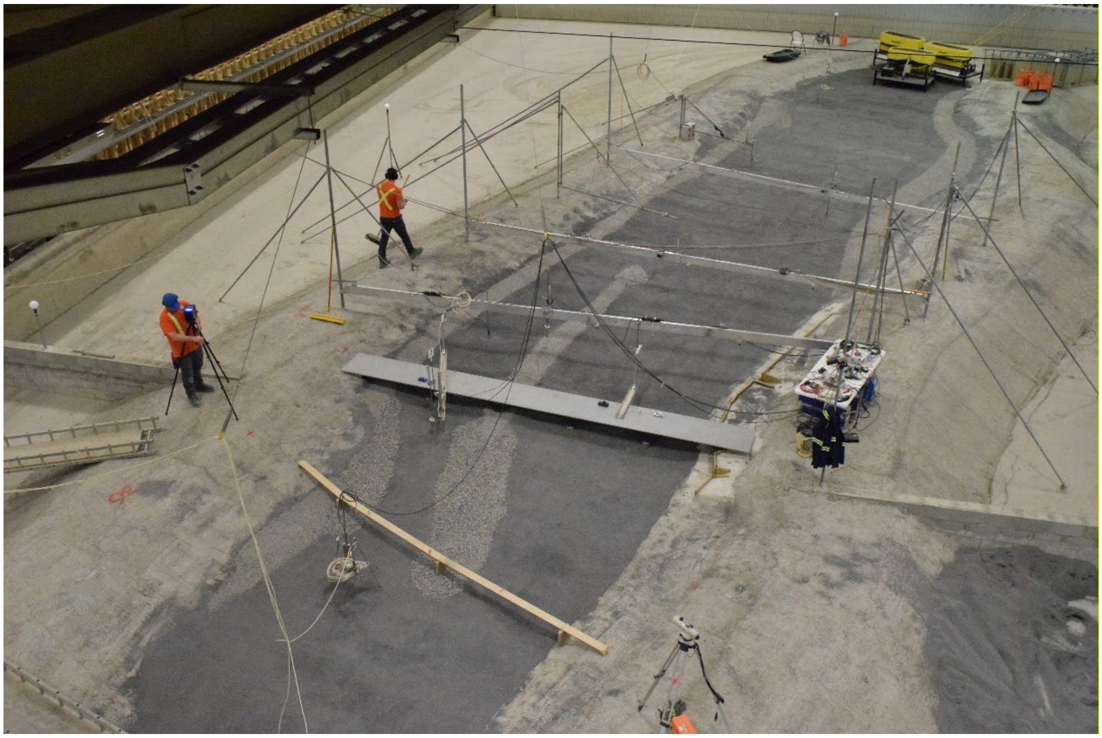


Figure 35: Physical modelling trial run setup. Proposed riprap stabilization is in place along the south slopes and the realigned gravel bar.

Figure 36: Physical modelling calibration run to calibrate the model

Table 2: Split between Main Channel and Wave Channel

Total Flow (m^3/s)	Flow in Main Channel (m^3/s)	Flow in Wave Channel (m^3/s)
280	167	113
271	161	110
173	100	73
114	64	50
57	31	26
33	16	17

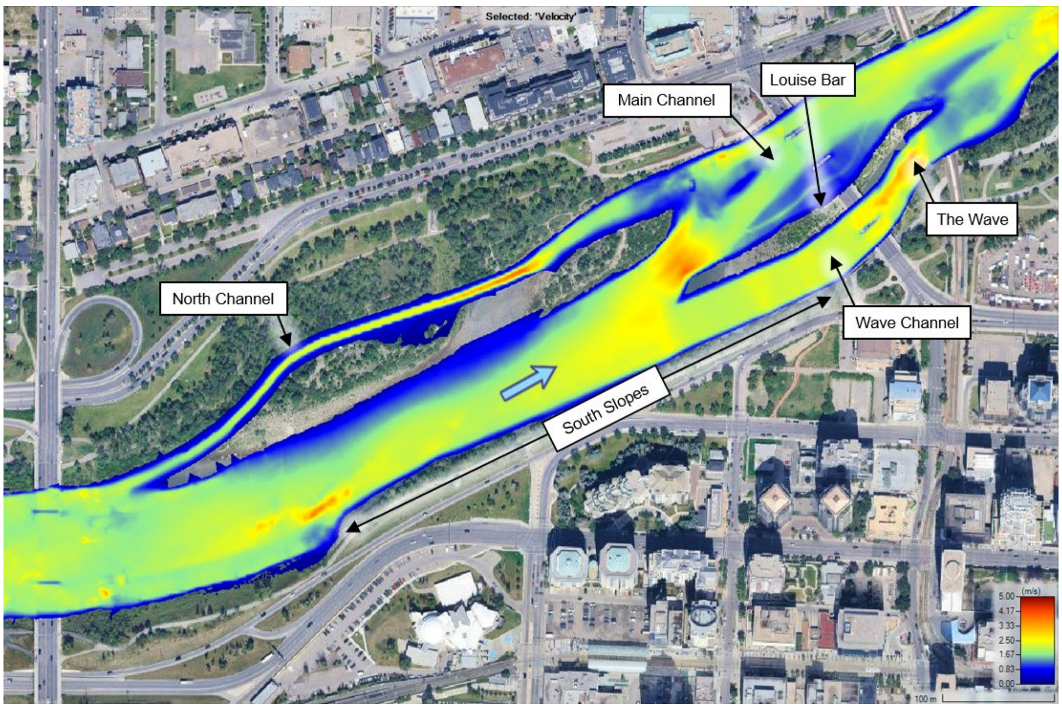


Figure 37: Modelled Velocities at the Safe Boating Advisory Flow (280 m3/s) Modelled Velocities at the Safe Boating Advisory Flow (280 m3/s)

Modelled 1:100-year flood water levels, including the effects of vegetation on the Louise Bar, show a reduction of up to 0.5 m at the Louise Bridge compared to existing conditions, with flood level reductions extending approximately 300 m upstream and tapering off downstream of the LRT bridge (Figure 37). These reductions are primarily due to improved conveyance from strategic excavation at the Louise Bar and Landing. Water levels downstream of the LRT bridge remain unchanged.

Erosion protection through the project reach will be provided primarily with angular Class 2 riprap (D_{50} = 500 mm). The riprap voids will be filled with suitable growing medium above the vegetated trim line and planted with native vegetation such that the riprap is obscured by the vegetation once it has established. Riprap below the vegetated trim line will be top-dressed with salvaged native river gravels to provide a traversable surface and minimize the “step hazard” to people and wildlife. Scour protection for the riprap will generally be accomplished by thickening the riprap revetments such that there is enough riprap available to launch and fill scour holes, rather than placing a toe apron which would narrow the channel or require excavation below the channel bed for a buried apron.

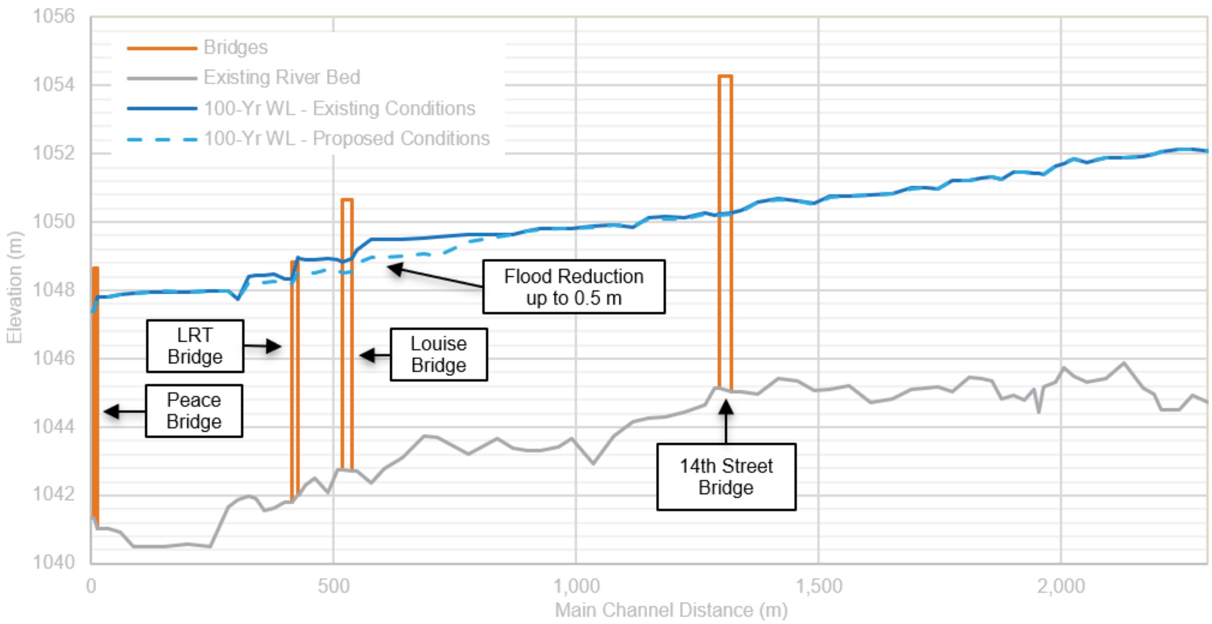


Figure 38: Water Surface Profiles from 1D Hydraulic Model (Current and Proposed Conditions)

6.3.2 Civil Design

At this stage, the civil design focuses on balancing material between the north and south sides of the river and reusing sediments from Louise Bar and the north channel to build the South Slopes. Reusing instream materials (gravels, cobbles, and sediments) forms the bulk of the earthworks and is central to the project. This approach maintains the river's sediment supply and reduces costs by limiting imported material. In general, salvaged material stays on the same side of the river: north-side material (e.g., from the north fish habitat channel) will enhance the Poppy Plaza gravel bar, while south-side material (e.g., from Louise Bar and the Landing excavation) will build the South Slopes. Figures 35 to 37 show the civil design surface developed for the project, which results in a net material balance for the project (i.e., does not require import of river gravels; riprap erosion protection import is still required).

There are a number of details for the civil design that will be refined in the detailed design phase. This includes designs for the stormwater outfalls along the south slopes (i.e., extending the outfalls through the South Slopes, or locally shaping the south slopes in the vicinity of the outfalls), and details on any adjustments to erosion and scour protection at the bridge piers.

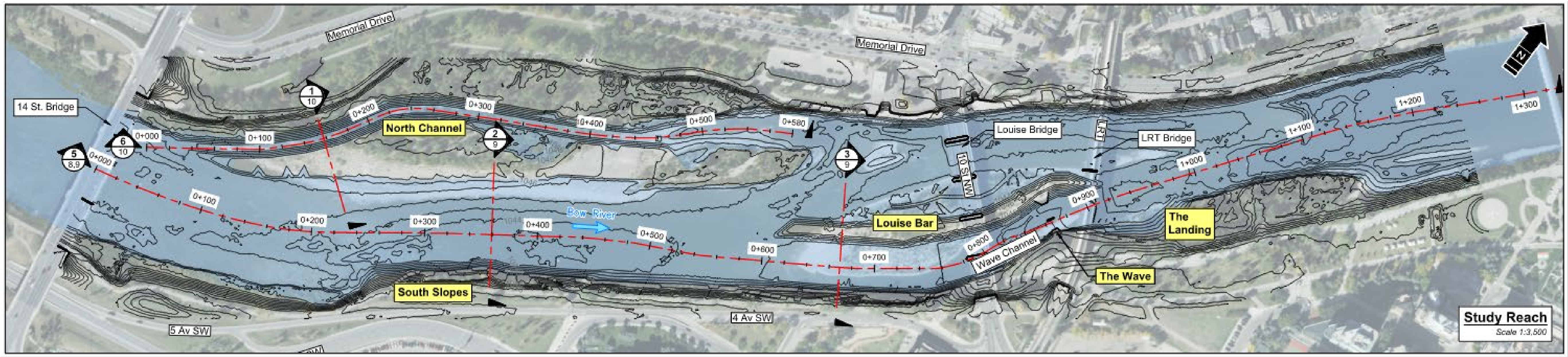


Figure 39: Civil Design – Overall Project

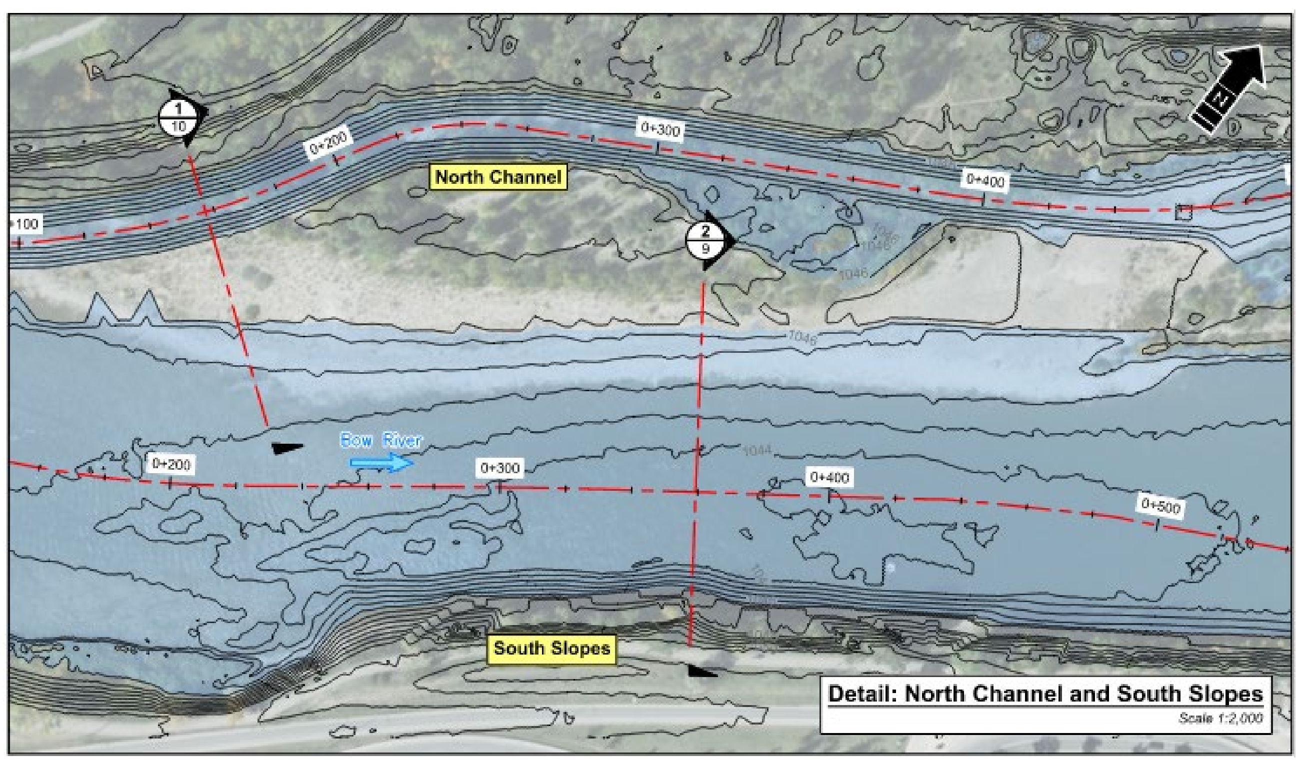


Figure 40: Civil Design – North Channel and South Slopes

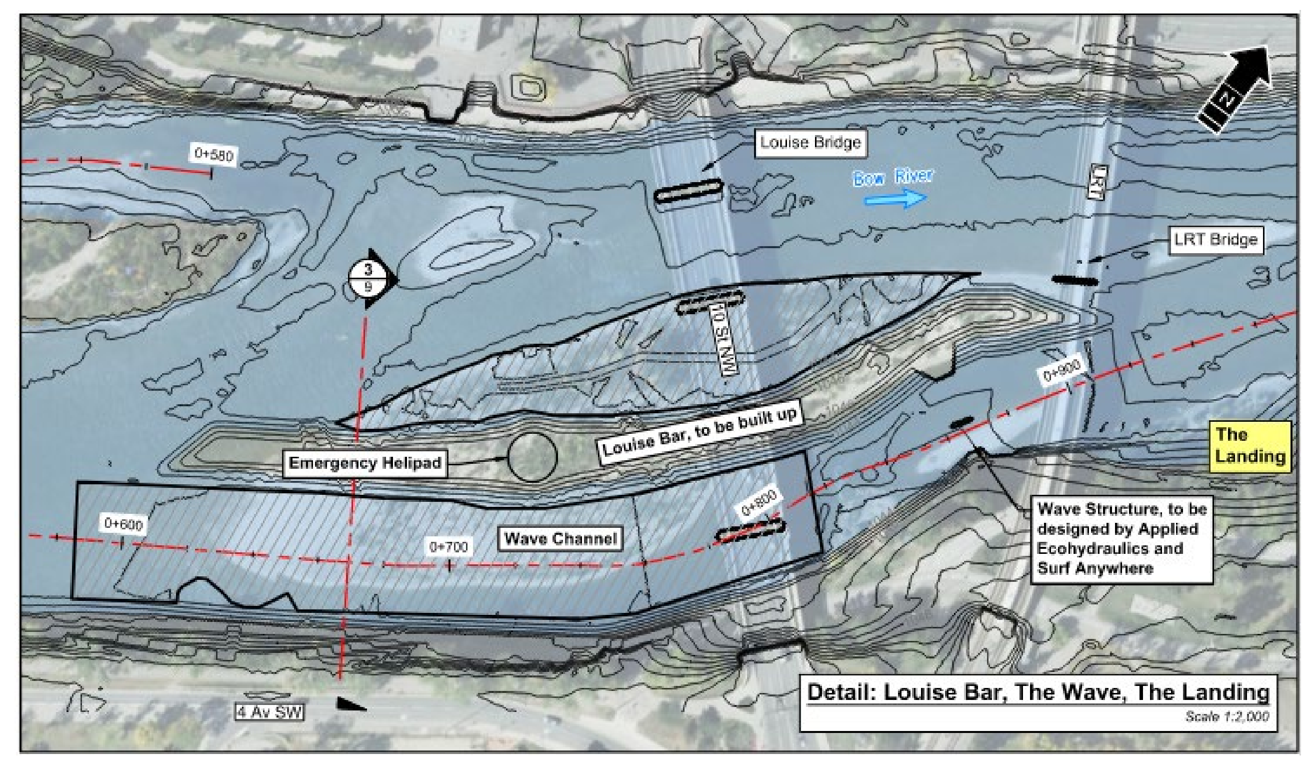


Figure 41: Civil Design – Louise Bar, the Wave, and the Landing

Select geometric design elements for the Louise Bar and South Slopes are listed in the following tables:

Table 3: Civil Design – Louise Bar

Parameter	Value	Comment
Louise Bar – Removal Elevation	Upstream 1044 m; Downstream: 1043.5 m	As per U of O conceptual design DEM for which morphodynamic modelling was completed (Yu et al. 2022). The proposed elevation is driven by flood reduction and will provide a smooth transition to the surrounding riverbed.
Louise Bar – Crest Elevation	Upstream: 1046.5 m Downstream: 1046.0 m	Bar to be about 0.5 m above the 1:2-year water level so that the wave can operate, and so vegetation can grow on the island.
Louise Bar – Length	300 m, measured at the toe of the bar	As required to provide 1.5 m of head for the wave (criteria from Applied Ecohydraulics).
Louise Bar – Top Width	4 m nominally	Minimum 4 m for constructability.
Width of Wave Channel	35 m along the channel, 25 m at the wave	Between the bar and the south bank. Width is approximate along channel and exact at the wave. 25 m width at the wave allows for multiple gate sections of varying widths. Exact number of gates and specific widths to be determined during detailed wave design.

Table 4: Civil Design – South Slopes

Criteria	Value	Comment
Minimum Top Width of Fill	4 m	As required for construction equipment
Minimum Top Elevation of Fill	1:2-year Flood, plus 0.5 m	As preferred by the City of Calgary, to minimize duration that pathway is inundated while balancing minimizing disturbance to vegetation above the 1:2-year water level
Side Slope of Fill	3H:1V	To facilitate the architectural features (e.g., pathway variation).

6.4 Fish Habitat Design

The project results in both localized habitat loss and the creation of new habitat features, with a net gain in functional fish habitat.

The Louise Bar currently occupies a large area of the riverbed that is inaccessible to fish during much of the year. By reducing the bar's size and lowering its elevation, the project restores wetted area and re-establishes fish habitat in this reach.

Some infilling will be required to construct the South Slopes and enhance the Poppy Plaza gravel bar, which will temporarily displace existing aquatic habitat. However, this impact is offset by the creation of the North Channel, which is designed to provide aquatic habitat on the north side of the river. The North Channel will increase habitat complexity, offering refuge, rearing, and foraging opportunities for a variety of fish species. Importantly, its location and alignment maintain connectivity to the mainstem, supporting fish migration through the project reach.

Habitat diversity will be further enhanced through selective placement of integrated fish habitat features along both banks. The use of vegetated riprap provides stable bank protection while contributing to fish habitat. Below the vegetated trim line, the voids between riprap stones function as overhead cover and refuge, particularly for juvenile fish. This approach has proven effective in similar Bow River projects, such as those at St. Patrick's Island, where historical snorkel surveys have confirmed high levels of fish use within riprap voids. Additional complexity will be provided through features like boulder clusters, woody vanes, and an undulating riprap toe, enhancing hydraulic variability and microhabitats across a range of flows.

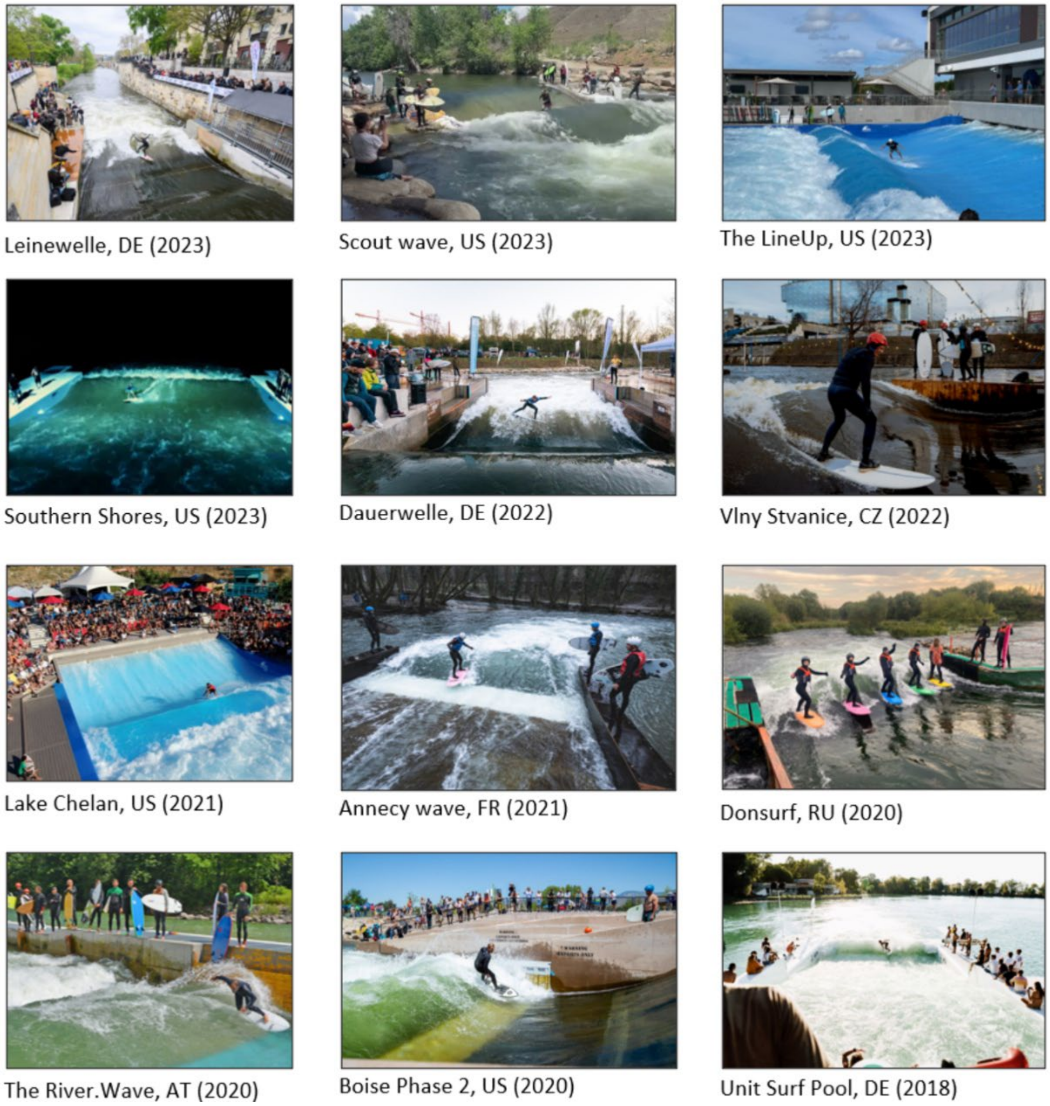
Together, these measures result in a net gain of accessible, diverse, and resilient fish habitat throughout the project area.

Table 5: Summary of Fish Habitat Changes

Location	Habitat Change (m^2)	Notes
Louise Bar Lowering (Restored Wetted Area)	8,460	Area newly wetted once bar is lowered
North Channel (New Aquatic Habitat)	7,400	For a 5 m bottom width channel with 2H:1V side slopes
South Slopes (Permanent Displacement)	-7,170	Portion below ordinary high-water mark occupied by South Slopes infill material
Poppy Plaza Bar Augmentation	-7,450	Extension of Poppy Plaza bar
Net Change	1,240	+'ve number is net increase in habitat

6.5 Wave Structure Design

The preliminary adjustable wave structure design is based on a review of more than 30 existing adjustable river waves from around the world (refer to Figure 42Figure 42 and Figure 43) as well as detailed numerical and physical modelling performed with the University of Ottawa (Appendix D: National Research Council Canada – Physical Model Study of Gravel Bar Realignment Designs for the Bow River near Louise Bridge, Figure 44). Learnings from both these sources have been integrated into the proposed design which is discussed below. Further information on the waves design can be found in Appendix E.



Leinewelle, DE (2023)
Scout wave, US (2023)
The LineUp, US (2023)
Southern Shores, US (2023)
Dauerwelle, DE (2022)
Vlny Stvanice, CZ (2022)
Lake Chelan, US (2021)
Annecy wave, FR (2021)
Donsurf, RU (2020)
The River.Wave, AT (2020)
Boise Phase 2, US (2020)
Unit Surf Pool, DE (2018)

Figure 42: Manufactured waves demonstrating economic and cultural benefits 1/2

Figure 43: Manufactured waves demonstrating economic and cultural benefits 2/2

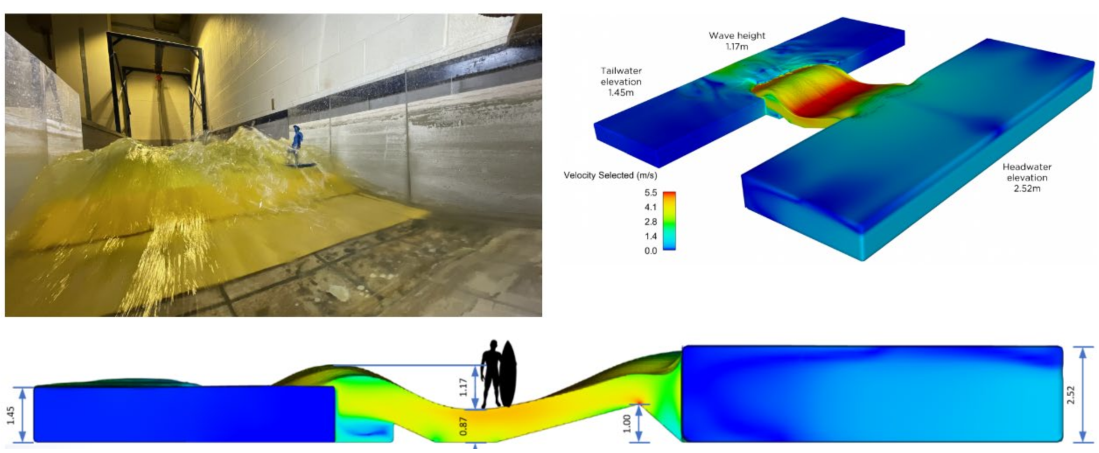


Figure 44: Physical modelling and computer modelling research of adjustable river waves provided as information for the project. Imagery created through research with the University of Ottawa. Images are from [“Flat bottom wave dimensions” by Surf Anywhere](#).

The recreational wave structure is proposed to be constructed out of a large cast in place concrete slab with concrete wingwalls. The slab will be separated into two channels 8 m wide and 12 m wide separated by a 3 m wide central pier. At the upstream end of each channel will be hinged steel plates that are raised and lowered using pneumatic air bladders (Obermeyer gates). This is the same technology that was used as part of the recently completed Springbank Dam Diversion Headworks.

Images of the proposed river gate design are provided in Figure 45 and Figure 46. The Steel gates will be fixed with a hinge at the upstream end but articulate at a central joint and be drawn upstream along its downstream edge as the gates are raised.

Raising the gates will create the necessary water elevation difference to accelerate the water such that the wave can form. On the downstream slope of the gates will be two rows of adjustable “kicker” gates that are used to force the wave to form and adjust the wave shape for different user types and skill levels. The “kicker” gates will also be pneumatically actuated and one row will be embedded into the main gate and the other downstream along the foundation to account for different tailwater elevations. The following sections describe the recreational channel design in more detail.

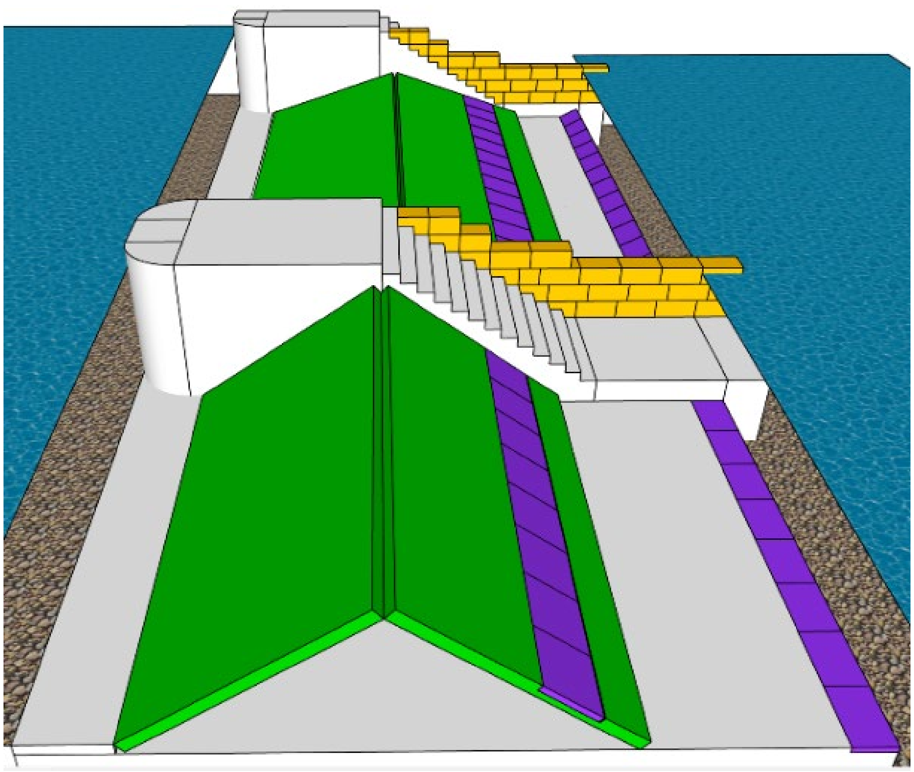


Figure 45: Regular flow 142 m3/s – Surf wave configuration showing structure

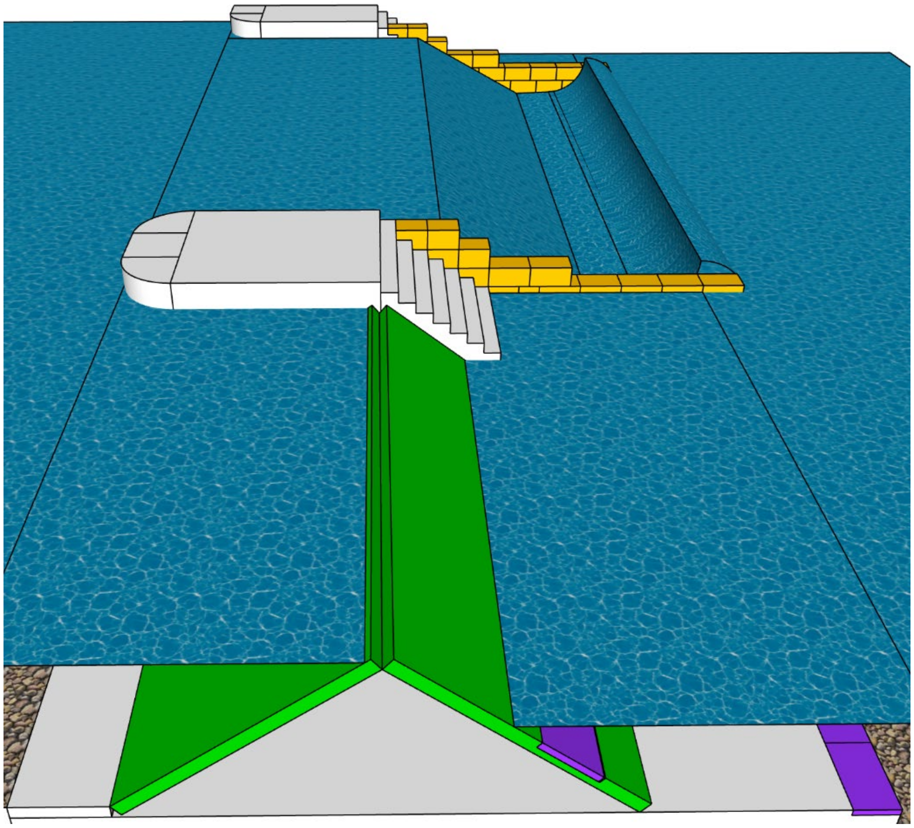


Figure 46: Regular flow 142 m3/s – Surf wave configuration showing water

6.5.1 Channel width and configuration

As discussed above, morphologic resilience of any recreational structure was critical to the efficacy of the structure. The proposed design reduces the width of the recreational channel from 35 m to 25 m at the recreational wave infrastructure which locally increases velocity limiting sediment deposition on the infrastructure itself. This constriction has no impact on flood water levels due to its low height and the fact that the gates lower themselves to the bed elevation when not in use.

The alignment of the wave structure follows the existing channel curvature and is oriented such that wave users will be deposited into a slower water pool or flushed downstream and not into the bank.

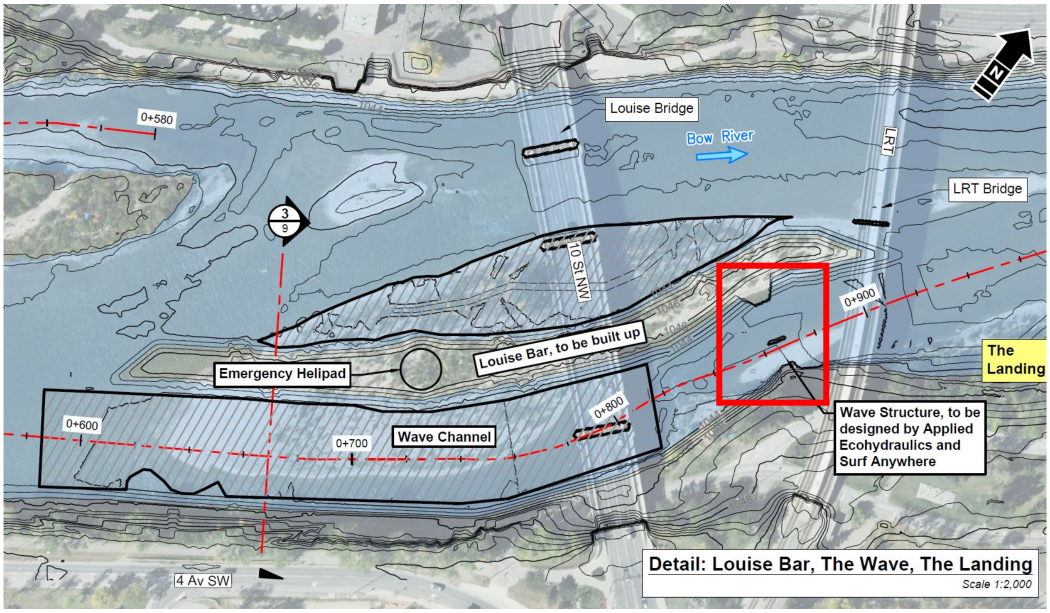


Figure 47: Adjustable wave structure channels and pier in the Site Plan and Digital Elevation Model. Rom Appendix C: Preliminary Hydrotechnical Design Report)

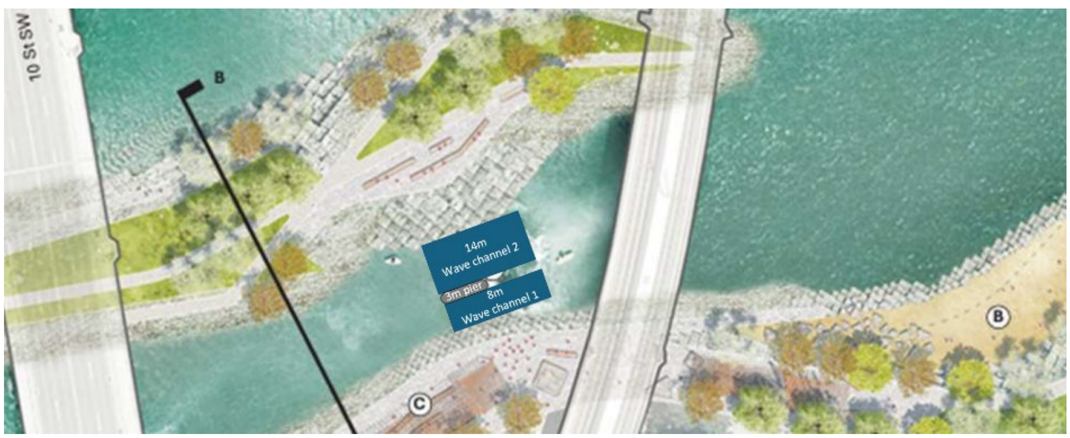


Figure 48: Adjustable wave channels over preliminary design plan drawing

The channel widths also allow the appropriate flow intensity for a recreational wave over the range of design flows. Flow Intensity is the volume of water per second per meter of width that goes through the wave channels. The ideal flow intensity for a river wave is between 2 and 7 m^3/s per meter of width based on observations of 30+ manufactured river wave around the world.

The wave is only expected to be operational during the open water season (no ice) and is meant to be operational for Bow river flows ranging from extreme low flows (the 99% exceedance flow = 33 m3/s) to the safe boating advisory flow (approximately 280 m3/s). Table 6 below shows the flow intensities, and exceedance probabilities, for the range of Bow River flows in various gate opening configurations. Figure 49 to Figure 52 show examples of waves at different flow intensities.

Table 6: Bow River Channel flow split, flow intensity over waves, and wave quality

				Channel 1	Channel 2	Channel 1 + 2
			Wave width (m)	8	14	22
% of time flow exceeded from April to Oct	**Total River Flow (m^3/s)**	**Surf channel flow (m^3/s)**	**% of flow in surf channel**	**Flow intensity (m^3/s)/m**	**Flow intensity (m^3/s)/m**	**Flow intensity (m^3/s)/m**
99%	33	16.9	51%	2.1	1.2	0.8
95%	50	22.4	45%	2.8	1.6	1.0
60%	75[1]	27	36%	3.4	1.9	1.2
40%	100[1]	36	36%	4.5	2.6	1.6
23%	142	48.4	34%	6.1	3.5	2.2
12%	180	57.6	32%	7.2	4.1	2.6
4%	280	82.6	30%	10.3	5.9	3.8

Figure 49: Scout Wave in Salida, CO, 10m wave at 1.2 m3/s per m. 12 m3/s

Figure 50: Scout Wave in Salida, CO, 10m at 2.1 m3/s per m. 21 m3/s

Figure 51: Scout Wave in Salida, CO, 10m at 3.6 m3/s per m. 36 m3/s

Figure 52: Scout Wave in Salida, CO, 10m wave at 7 m3/s per m. 70 m3/s

6.5.2 Channel and Hydraulic Profile

For wave formation, approximately 1m of water level difference is needed between upstream and downstream of the wave. This water level difference is achieved through the raising of the gates and the height needed depends on the flow and tailwater condition. For the highest design flow of 280 m^3/s, the adjustable wave structures need to have a peak elevation between 2m and 3.1m above the foundation. Raising of the gates will increase water levels upstream through the recreational channel by between 1.05m at the wave structure and 0m at the inlet of the surf channel. Figure 53 shows the water surface elevations locations and Table 7shows the maximum water surface elevation changes at different flows.

Figure 53: Map showing location of water surface elevation measurements and calculations.

Table 7: Water surface elevation changes from wave structure

Total Bow Flow	Inlet of surf wave channel elevation	End of surf wave channel elevation	Drop or Maximum water elevation increase at wave	Comment relating to wave structure max elevation
	Maximum wave headwater elevation	**Minimum wave tailwater elevation**	**Headwater - Tailwater**	
m^3/s	**m**	**m**	**m**	
33	1044.13	1043.36	0.77	
92	1044.69	1043.66	1.03	
142	1044.97	1043.92	1.05	1044.97 is the min max wave structure elevation for the 14m channel. Will block the 14m channel at 142 m^3/s total Bow flow.
190	1045.14	1044.15	0.99	
240	1045.31	1044.38	0.93	
280	1045.44	1044.56	0.88	1045.44 is the min max wave structure elevation for the 8m channel. Will block the 8m channel at 280 m^3/s total Bow flow.

These water levels and elevations will be confirmed in detailed design using a Computational Fluid Dynamics (CFD) Model. The CFD model will also confirm structural loading on the wave such that it can be designed to withstand uplift, hydrostatic and momentum forces as necessary.

6.5.3 Wave Hydraulics and Shaping

The recreational wave will not only have to function under a range of flows, but it will also have to accommodate a range of user types and skill levels. Shaping of the wave will be done through the use of independently moving kickers and adjustable channel walls.

Figures 54 to Figure 57 from the Kayak Wave Research Report (Surf Anywhere, 2021) show different wave types that can be created using both independent kickers and adjustable wing walls.

Figure 54: Example of a bowl wave

Figure 55: Example of an oblique wave

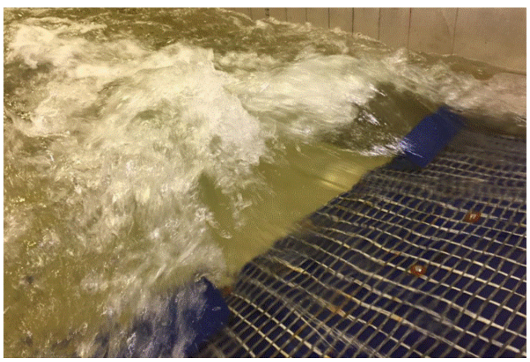


Figure 56: Example of a kayak wave

Figure 57: Example of a perpendicular wave

Figure 58: Adjustable wall at Boise, USA

6.5.4 Social and Economic Benefits of Recreational Waves

The social and economic benefits of a recreational wave at this location were originally noted by ARSA (2019) and were reviewed by the City as part of a feasibility study (Appendix H: City of Calgary 10 Street Recreational Wave Viability Report). The report confirmed direct economic benefits of approximately $2M/year are expected and suggested numerous indirect benefits were likely.

The report also reviewed the safety record of recreational waves and noted that the sport is on par with other outdoor sports such as skiing and hiking in regard to risk. The wave also has the potential to generally improve river safety by being an education node integrated into the broader river front landscape as discussed in the following sections:

6.6 Landscape Design

The design for the Bow River 10th Street Gravel Bar project transforms the site into a comprehensive riverfront destination that balances flood mitigation with enhanced public access and recreational opportunities. With the reshaped Gravel Bar as the foundational design move, the project creates a network of interconnected spaces that celebrate the river's ecological integrity while providing diverse recreational experiences for users of all abilities.

The recreation design is organized around four integrated strategies, of which the middle two relate to landscape and recreation:

1. Reshaping the gravel bar island and channel creates hydraulic conditions necessary for recreational features while improving flood capacity.
2. Making the river a destination through anchor program elements including the recreational wave, wave deck, and enhanced riparian woodlands.
3. Creating safe recreational river access through designated points that replace informal access routes with engineered solutions.
4. Enhancing ecological integrity by integrating recreation infrastructure with habitat restoration efforts.

The primary recreation components center on the reshaped Gravel Bar and engineered recreational wave, which provides opportunities for kayaking, river surfing, and water sports. The reshaped Gravel Bar creates opportunities to complement the recreational wave with an adjacent Wave Deck with viewing platforms and gathering spaces (Figure 59). The Landing and Beach area serves as a naturalized cobble and gravel beach that functions as the primary egress point for wave users while providing accessible waterfront recreation including sunbathing, picnicking, and informal water access.

An enhanced trail network consolidates and formalizes the existing trail system, eliminating redundant informal pathways while creating coherent connections to the regional Bow River pathway system through new North Channel Trail, South Slope Trail, and improved linkages to existing infrastructure. Strategically located river access infrastructure provides safe entry to the river and the reshaped Gravel Bar through engineered features including stepped river access, accessible ramps, and river access coves with integrated erosion protection.

The recreation design strengthens connections to adjacent developments, particularly the RiverWalk West project, creating a continuous public promenade along the downtown river corridor. The design addresses current deficiencies in public access while providing infrastructure capable of accommodating high-density usage during peak recreational periods. Viewing areas, gathering spaces, and interpretive opportunities throughout the site support both active recreation and environmental education, allowing visitors to engage with the river's history, ecology, and cultural significance. The design balances programmed recreational activities with flexible spaces that can accommodate spontaneous use and community events.

For more details on the recreation design and landscape architecture, refer to Appendix F: Preliminary Landscape Architecture Design Report.

Figure 59: Preliminary design landscape perspective: View from the 10th St Bridge looking northeast

6.6.1 Cultural Considerations

Within the project area of the proposed wave deck is an illuminated architectural light sentinel which will require relocation or removal as part of construction. The City's Cultural Landscape Team has been informed of this without significant concern and will provide guidance through detailed design on the preferred option.

6.6.2 Archeological Considerations

The project team submitted a Historic Resources Application in June 2023 per the provincial Historical Resources Act (HRA) requirements. Conditional Historical Resources Act approval was granted in September 2023, on the understanding that a Historical Resources Impact Assessment for archaeological resources in the form of a monitoring program will be conducted.

Components of the development that lie along riverbank areas that were associated with the historic City of Calgary Water Works Pumping Station and archaeological site EgPm-354 may contain archeological deposits. As a result, a program of archaeological construction monitoring is required for three project areas: The South Slopes, The Wave Deck and The Landing**.**

No further archaeological investigation is required for the project components identified as The North Channel, Louise Bar, or The Wave.

6.6.3 Indigenous Considerations

The Riverwalk West project team is leading Indigenous engagement and considerations throughout their project space which this project team will learn from and build upon in detailed design. In addition, the project will learn from the Calgary River Valleys Plan’s extensive Indigenous engagement including:

- Calgary’s river valleys contain deep histories of meaning, significance and use that span millennia
- The need to engage with Indigenous peoples (Treaty 7 Nations, Otipemisiwak Métis, and Urban Indigenous peoples and communities) about rivers and river-based projects through a relationship-focused approach
- Ecological protection and the health of specific plants with cultural significance to Indigenous peoples
- River and land access for hunting, fishing, foraging, cultural and spiritual activities, and more

Indigenous engagement is required to identify if any traditional use sites exist in the project area. Indigenous consultation is anticipated as part of both the Provincial and Federal regulatory process. The project team is excited to complete these engagements and integrate any learnings or guidance into the design where possible.

6.7 Habitat Restoration

The Habitat Restoration Approach (refer to Appendix B: Habitat Restoration Approach) outlines a comprehensive strategy to repair, stabilize, and restore degraded riparian areas within the project boundary using nature-based solutions and native plant communities. The restoration plan addresses current ecological challenges including invasive species dominance (particularly caragana), informal trail networks causing bank erosion, homeless encampments creating habitat disturbance, and poor riparian health conditions rated as "unhealthy" by Alberta Riparian Habitat Management Society assessments. Riparian health in these areas was rated as “healthy, but with problems,” with an overall score of 77% using the *Alberta Wetland Health Assessment for Large River Systems* (Cows and Fish 2020) (refer to Section 6.2 Environmental and Ecological Inputs). The approach utilizes reference models based on four native community types appropriate for the Foothills Fescue Natural Subregion: Aspen/Red-Osier Dogwood for upland south-facing sites, White Spruce/Common Horsetail for upland north-facing slopes, Balsam Poplar/Red-Osier Dogwood for riparian areas, and Sandbar Willow for gravel bar environments.

The restoration strategy establishes two primary goals: improving bank stability and resiliency through bioengineering techniques and native woody vegetation with deep root systems and restoring ecosystem functioning through 100% native species plantings with structural diversity to support wildlife habitat. Implementation will include pre-construction invasive species removal, locally-sourced seed collection and propagation, strategic placement of hardened access points to eliminate informal trails, and comprehensive establishment care including irrigation, beaver protection, and three-year maintenance programs. Success will be measured using Cows and

Fish riparian health parameters including floodplain accessibility, riverbank root mass protection, canopy cover targets, and invasive species control, with adaptive management approaches guided by annual monitoring and photomonitoring protocols to ensure long-term ecological integrity and habitat connectivity within Calgary's broader Bow River corridor.

7 Constructability

This project has several constructability aspects to be considered, including site access, laydown areas, material management, water isolation, and regulatory construction windows.

7.1 Sediment Reuse Strategy

A central objective of the project is to reuse river sediments excavated on site rather than import material. This strategy maintains the Bow River's sediment balance, avoids disrupting upstream or downstream supply, and reduces both costs and environmental footprint. Material salvaged from excavation areas is strategically relocated to project features, keeping material on the same side of the river wherever possible to minimize haul distances and preserve geomorphic continuity. Table X outlines the approximate cut/fill balance between different project nodes.

Key applications of this strategy include:

- **River Sediment Salvaging:** Gravels and cobbles will be salvaged from the North Channel, the north and south banks of the Louise Bar, and the south bank east of the Sunnyside C-Train Bridge.
- **River Sediment Placement:** Salvaged sediments will be placed on the Poppy Plaza bar, in the central Louise Bar, and along the South Slopes. This reuse both supports construction needs and helps maintain natural sediment processes, while also improving discharge capacity and managing erosion.
- **River Wave Gravel Beach:** Salvaged gravels will be placed along the south bank east of the Sunnyside C-Train Bridge to form a stable, naturalistic gravel beach at the River Wave.
- **North Channel Habitat Enhancement:** Excavation of the North Channel will diversify aquatic habitat, creating shallow riffles, pools, and runs suitable for rearing and fall spawning, while also providing refuge during high flows. These features will increase habitat complexity and quality and will be further specified during the detailed design phase.
- **Recreational Trail Development:** Salvaged gravel placed on the South Slopes will also support construction of a new recreational trail, connecting the Regional Trail and the Landing Trail.

Table 8: Approximate Cut/Fill Sediment and Riprap Volumes

Area / Node	River Gravels Generated (from Cut; m³)[1]	River Gravels Used (for Fill; m³)[1]	Riprap (m³)[2]	Net Balance (Generated + / Used –)
River South				
Louise Bar – Remove Gravel Bar	12,000	0	0	12,000
Louise Bar – Dividing Wall	0	9,000	5,800	-3,200
South Slopes	0	12,500	3,700	-8,800
The Landing	3,000	0	0	3,000
South Subtotal	15,000	21,500	9,500	3,000
River North				
North Channel	7,600	0	500	8,100
Poppy Plaza Island	0	7,600	0	-7,600
North Subtotal	7,600	7,600	500	500
Project Total	**22,600**	**29,100**	**10,000**	**3,500**

(1) These cut/fill categories represent the river sediments to be excavated and salvaged, excluding any riprap placed. Shortfalls in fill on the south side of the river are offset by the imported riprap.
(2) To estimate the riprap fill quantity, the expected riprap protection area was multiplied by the expected thickness.

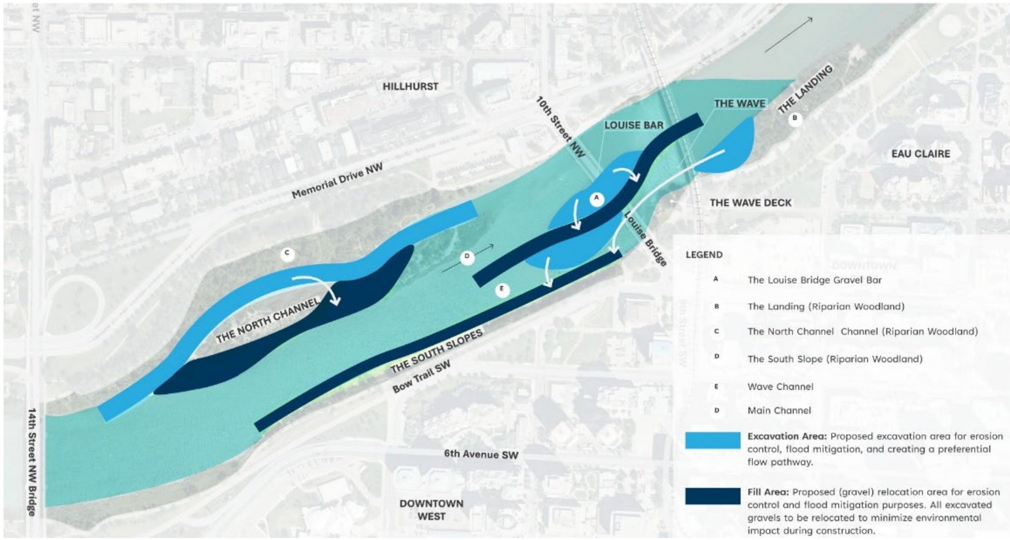


Figure 60: Preliminary design Bow River channel reconfiguration

7.2 Care of Water

Construction of the wave and associated instream works will require isolating portions of the river to provide dry and safe working conditions. The most practical method is the installation of sheet pile cofferdams around active work areas, including the wave structure footprint and gravel bar reshaping zones. Cofferdam elevations must be set high enough to prevent overtopping under typical flow conditions, with contingency planning for unexpected high flows.

Isolation works will be actively managed throughout construction. Key considerations include monitoring river stage, seepage, and turbidity, as well as managing sediment release and minimizing effects on fish and fish habitat. Seasonal risks such as ice loading and variable flows must also be accounted for in the design and monitoring of the cofferdams.

To reduce exposure to spring freshet and high-flow events, critical instream construction (i.e., the wave foundations and moveable components) should be completed within a single open-water season where possible. Construction phasing must also comply with the Bow River restricted activity periods (May 1 to July 15 and September 16 to April 5), limiting instream work windows from April 6 to 30 and July 16 to September 15 annually. Note that construction works within a flow isolated area can be completed during any time of year, as those areas are not considered in stream once the isolation is established.

7.3 Site Access and Logistics

Construction site access and logistics to the project site presents challenges due to the operational aspects of working in a constrained urban environment with traffic coordination, staging areas, material movement, and utility coordination. The Louise Bridge features reversible lanes that accommodate higher traffic into downtown during morning hours and outbound traffic during afternoon commutes, requiring careful coordination of construction timing to minimize disruption. South side access through downtown presents additional complexity, as the westbound 5th Avenue SW Connector provides limited routing flexibility for construction vehicles needing to access different areas of the project site. Large delivery trucks and equipment will need to plan routes carefully to avoid prohibited left turns and navigate the constrained downtown street grid.

The design approach must be structured to create an effective framework for construction, requiring the City and project team to identify and evaluate construction approaches, staging, and schedule issues in more detail. Since the project relies on relocating excavated gravels from the Louise Bar to construct the South Slopes, an effective staging plan is essential to minimize material handling and ensure efficient placement. City-owned property, such as parking lots on the south bank of the river, could serve as potential staging areas, while pathway rerouting will likely be required on both sides of the river. To manage traffic challenges, any necessary lane closures on Memorial Drive and the Louise Bridge should be scheduled outside of peak reversible lane operations (6:30-9:30 AM and 3:30-6:30 PM) and coordinated with the City's Traffic Management Centre to maintain emergency vehicle access.

7.4 Phasing

Regulatory considerations with respect to timing of instream work include:

- Restricted Activity Periods (RAPs) on the Bow River through Calgary are May 1 to July 15 and September 16 to April 5. Instream work ideally occurs in the working windows from April 6 to 30 and July 16 to September 15.
- Winter work should ideally remain out of the river or within fully isolated areas (e.g., with temporary cofferdams constructed of sheet piles, dewatered to work in the dry).
- Recommendations from a Qualified Aquatic Environmental Professional (QAES) will be required for execution of the instream components of the project.

Considering the RAPs, construction will need to be phased to minimize the instream impact to aquatic life. A feasible construction phasing approach is as follows:

Phase 1: Pre-Construction and Mobilization (Before March)

- Complete pre-construction submittals, staging setup, and access preparation (subject to regulatory approvals and land agreements).
- Begin off-site fabrication of wave structure components.
- No instream work may occur before April 6.

Phase 2: South Side and Gravel Bar Works (Summer 1; July 16 to September 15, Year 1)

- Deploy a south-side crew to reshape the Louise Bar and construct the South Slopes within the two-month summer fish window. Install sheet-pile cofferdam at upstream end of Louise Bar such that the recreational channel is dry.
- Upstream of the Louise Bar, conduct works in the wet with turbidity curtains and fish deterrence measures.
- Salvage and relocate sediments from the Louise Bar either directly to their reuse locations or to temporary storage.
- Maintain isolation of the recreational channel during this phase.

Phase 3: Wave Structure Construction (Winter, Year 1 to 2)

- With sheet pile cofferdams in place, construct the surf wave foundations and gate structures in dewatered conditions.
- Install electrical and hydraulic systems.
- Complete the wave structure within a single winter season to avoid multi-year exposure to freshet risk.

Phase 4: North Channel Construction (Summer 1 or 2; July 16 to September 15, Year 1 or 2)

- Excavate and shape the North Channel to provide a permanent side channel and fish habitat.
- Place salvaged sediments to achieve material balance and integrate fish habitat features (boulder clusters, woody vanes, undulating riprap).
- Complete connection to the mainstem near the end of the instream window.

Phase 5: Cofferdam Removal, Final Connections, and Commissioning (Spring Window; April 6 to 30, Year 3 if required)

- Complete inlet and outlet tie-ins to the wave structure and North Channel under dry conditions.
- Test and commission wave operations.
- Remove sheet pile cofferdams and temporary isolation works.

Phase 6: Upland Works and Site Finishing (Summer to Fall, Years 2 to 3)

- Construct recreational trail connections, gathering areas, wave deck, and viewing platforms.
- Complete signage, landscaping, and erosion protection.
- These works are primarily upland and may proceed outside of instream windows.

7.5 Cost Estimate

The total project cost is estimated at just under $12 million CAD. For a detailed breakdown, refer to Appendix G: Cost Estimate.

The largest project cost is the river wave structure at around $6.0 million. The river wave adjustable structure consists of two wave channels, measuring 8 meters and 14 meters in width, respectively. It includes a foundation and pier system, pneumatically adjustable slope, slope kickers, and foundation kickers. More details on the cost of the wave structure are provided in the next section.

Earthworks and hardscape are also significant costs at $2.6 million and $2.4 million respectively. Earthworks include the in-stream work to re-shape the gravel bar by placing riprap armour, as well as topsoil. Hardscape cost includes flood-resilient stone steps, and the flagstone paving for the wave deck.

Category	**Estimated Cost**	**%**
General Conditions	$450,000.00	4%
Demolition & Site Protection	$253,043.10	2%
Earthworks	$2,579,361.10	22%
Hardscape	$2,383,716.31	20%
Site Furnishings, Signage, Site Features	$167,551.79	1%
Softscape	$109,016.84	1%
Lighting	$45,000.00	0%
Wave Structure	$6,000,000.00	50%
Total	**$ 11,987,689.14***	**100%**

* Based on a Class 4 cost estimate, accuracy varies in the range of -30% to +50%.

7.6 Regulatory Considerations

The following provides a brief overview of the main regulatory approvals that will be required for this project to move forward and a brief description of the implications of a recreational wave:

Fisheries and Oceans Canada (DFO) – Fisheries Act: The project will be assessed both with the wave active and inactive using the City's Habitat Suitability Index (HSI) Model which was developed in partnership with The Province and DFO after the 2013 flood to assess impacts from City flood restoration projects. The overall project is expected to result in a net increase in fish habitat and does not significantly affect fish movement so no significant concerns from DFO are expected.

Government of Alberta – Public Lands Act: The project will be constructed on the "Bed and Shore" of the river which is provincially stewarded land. As such, a "License of Occupation" from The Province will be required. Licenses of occupation are also required for other City Infrastructure built in the river such as Stormwater Outfalls and Bridges. As other recreational facilities have been allowed to be constructed on public lands (Harvie Passage, Kananaskis Wave) it is not expected that there will be significant concern.

Government of Alberta – Water Act: The Water Act is primarily concerned about water quality and flood impacts. As the project will not impact water quality in the long term and will use best management practices during construction, no water quality concerns should arise. From a flood mitigation perspective, the project will reduce water levels through this reach of river and most importantly will mitigate flood risk in the long term by addressing the problematic gravel bar. The surf wave would not be activated during flood flows and as such will not impact water levels.

Transport Canada – Navigable Water Act: As previously discussed, the river will be split into two channels with approximately 2/3 of the flow being directed into the north (navigable) channel are un-impacted by the proposed project and will remain available for safe navigation through this reach of river. Provided that appropriate navigation signage is included in the project, it is not expected that Transport Canada will have significant concerns with the project.

7.7 Risk and Uncertainty Considerations

Development of the proposed wave structure at 10th Street is subject to a range of risks and uncertainties that may influence design feasibility, permitting, and construction. Key considerations include:

- **Regulatory Approvals**: The project requires multiple regulatory reviews and approvals, including federal (DFO), provincial (AEP), and municipal permits. Uncertainty exists regarding regulator interpretation of project impacts on fish habitat, navigation, and flood levels, which may affect approval timelines and conditions.
- **Construction Timing and Windows**: In-stream construction is constrained to short seasonal work windows to avoid fish spawning and migration periods. Delays in permitting or contracting could compress schedules and reduce available time to complete work within the allowable Restricted Activity Period (RAP).

- **Hydrologic and Hydraulic Variability**: The project is sensitive to river flows, both during construction and over the long term. Unexpected high flows or floods during construction could damage partially completed works, while long-term variability in seasonal flow regimes could affect wave performance and maintenance requirements.
- **Wildlife and Environmental Considerations**: The project footprint is within an active aquatic and riparian ecosystem. The potential presence of species at risk, migratory birds, or sensitive habitat could require design refinements or additional mitigation measures that affect project scope, cost, or timing.
- **Historical Resources**: The Bow River corridor has historical and cultural significance. Archaeological or heritage resource discoveries during construction could halt or delay work until appropriate assessments and mitigations are completed.
- **Geotechnical and Bedrock Conditions**: Subsurface conditions, including potential shallow bedrock or variable alluvium, present uncertainty for excavation and structure foundation design. Adverse conditions may necessitate design modifications, specialized equipment, or additional construction effort.
- **Public Safety and Recreation Use**: The wave structure will be integrated into a high-use recreational area. Risks include managing public access during construction, ensuring post-construction safety of the wave feature, and addressing potential conflicts with other river users.

Collectively, these risks have been or will be addressed through a combination of conservative design assumptions, adaptive management, targeted field investigations, and proactive engagement with regulators and stakeholders.

8 Project Value

8.1 Flood and Erosion Mitigation Benefits

KCBL (2017) performed a TBL analysis on a gravel bar removal project at this location and determined that it reduced flood risk by over $30M over a 27 yr time period which was the assumed lifespan of the project. This concept design did not include any kind of recreational wave and the estimated construction costs were $4.9M. When the other TBL factors were included, the project had an overall Benefit/Cost ratio of 3.9. However, the project did not account for the Sunnyside Flood Barrier Project which would protect the northern communities from overland flood risk up to a 1:100 year flood assuming no further gravel bar growth.

The KCBL analysis was done prior to the Sunnyside Flood Barrier Project and so there was concern that the flood mitigation benefits would no longer be correct. The City reassessed the flood mitigation benefits of the project compared to the do nothing scenario and determined that significant benefits still remained due to groundwater impacts, potential stormwater system backflow impacts, and for floods higher than

1:100 due to the expected gravel bars continued growth as noted in the above sections.

8.2 Economic Benefits

The economic benefits from the adjustable wave are well described by Surf Anywhere in Appendix E: and were validated by Appendix H: City of Calgary 10 Street Recreational Wave Viability Report. A summary of these benefits follows.

Global wave tourism is valued at $60 billion a year (Economic Impacts of River Waves, Neil Egsgard, Surf Anywhere, October 2023) and numerous studies have documented the economic benefits of natural recreational waves (refer to References 4,5,6,12). The greatest validation of recreational wave value are the numerous private pumped wave facilities being built every year that charge around $100CAD per wave session (Economic Impacts of River Waves, Neil Egsgard, Surf Anywhere, October 2023).

Based on these documented values and a conservatively estimated usage numbers, The proposed adjustable wave is estimated to generate $1.7M annually in economic activity from wave users alone (Figure 61 below). Substantial additional economic impacts will come from creating a vibrant cultural anchor on the western edge of downtown. The projected return on investment is 4 years for the $6M wave portion of the construction costs.

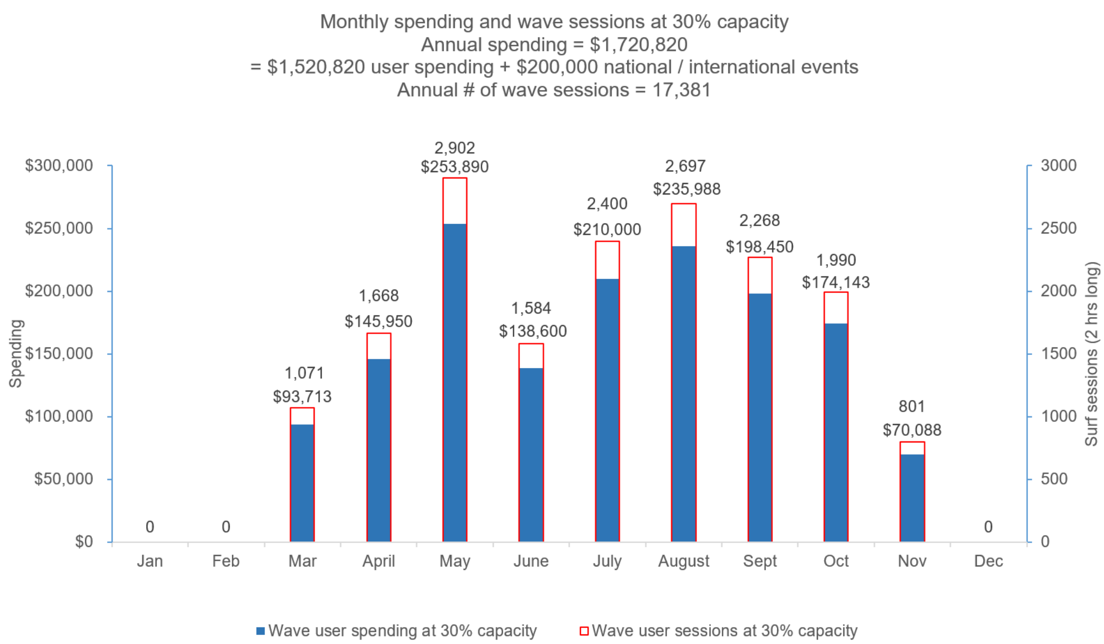


Figure 61: Monthly wave spending and sessions at 30% of expected capacity.

8.3 Recreational Benefits

The project creates a comprehensive outdoor recreation destination that serves both active water sport participants and those seeking more traditional riverside leisure activities.

The project creates Canada's first adjustable recreational standing wave for river surfing and whitewater kayaking, providing both beginner and advanced wave conditions. This supports the growing river recreation communities including the Alberta Whitewater Association and Alberta River Surfing Association. Since surfing became an Olympic sport in 2020, the wave will help train future Canadian Olympic athletes. Surf kayaking and freestyle kayaking, though not yet Olympic sports, have global competitions in which Canada participates. The facility will also enable Calgary Events to hold world-class surfing events, benefiting from increased area usage.

Beyond the wave itself, the project creates extensive outdoor recreational opportunities for spectators, pedestrians, and visitors who may not directly use the wave but benefit from the enhanced riverside environment. Passive recreation opportunities include picnicking, nature observation, wading, fishing, or simply connecting with the water (through new safe access points). Enhanced pathway systems connect to the regional pathway system, creating improved opportunities for walking, cycling, and jogging along the riverbank.

8.4 Placemaking Benefits

The project transforms urban waterfront activation by creating a safe, vibrant urban waterfront that connects people to the Bow River and transforms an underutilized area into a destination. The recreational wave, south slopes, and landing nodes present a unique opportunity to develop national-class public realm improvements that will be a major driver of tourism and cultural activities in Calgary. This includes activation of a cultural hub and gathering space, with similar river surfing waves in Munich, Germany and Bend, Oregon seeing over 100,000 visits by users and spectators per year (Economic Contributions of Bend Park and Recreation District: Benefits and Impacts Report, EcoNorthwest, for Bend Oregon Park and Recreation District, November 2017). From a tourism and economic development perspective, the national-class recreational infrastructure will attract visitors, support the emerging river recreation tourism market, and create a unique urban amenity that differentiates Calgary.

Calgary’s Greater Downtown Plan specifically aims to create "a vibrant city centre people enjoy 24/7, with a balanced mix of residential, office, retail, entertainment, tourism and culture" (Calgary’s Greater Downtown Plan: Roadmap to reinvention, The City of Calgary. 2021). The project directly supports three critical elements of this transformation strategy:

1. It activates public spaces in the underutilized west end of downtown, addressing the strategy's emphasis on "activating places and spaces" to increase vibrancy. The City has identified that activating places and spaces is essential to increase downtown vibrancy and make downtown a place that people want to live, visit, and establish a business. The recreational wave and enhanced riverfront create exactly this type of activation – a unique cultural and recreational destination that operates year-round and will be a major driver of tourism and cultural activities in Calgary. This includes activation of a cultural hub and gathering space, with similar river surfing waves in Munich,

Germany and Bend, Oregon seeing over 100,000 visits by users and spectators per year.

2. The project enhances the pedestrian experience and public realm quality, which urban planning experts identify as essential for downtown success. Downtown revitalization requires improving the public realm to enhance the pedestrian experience and connecting the places where people already are. The project's enhanced pathways, river access points, seating areas, and recreational facilities create the type of street-level amenities and public spaces that transform downtown into a livable community.

3. The project supports the tourism and entertainment component of the mixed-use vision by creating a distinctive cultural attraction that differentiates Calgary from other cities. The Downtown Strategy emphasizes the need for "a more balanced mix of residential, office, retail, entertainment, tourism, and culture" to shift "from vacancy to vibrancy." As Canada's first adjustable recreational wave, the project provides a unique entertainment and tourism asset that complements other major cultural investments like the Arts Commons Transformation and BMO Centre expansion, creating a network of attractions that extend the downtown experience beyond traditional business hours and throughout all seasons.

Using the original KCBL (2017) TBL screening tool, the project with both the Sunnyside barrier in place and the estimated economic benefits from the recreational wave included was reassessed and determined to have a benefit/cost ration of 6.3 indicating that the project is still a high value project to move forward.

9 Conclusion and Next Steps

9.1 Conclusion

This Preliminary Design Report demonstrates a feasible and integrated approach, bringing together complex technical requirements for flood mitigation and wave creation with essential ecological restoration and public realm enhancements. The proposed design components, including the reshaped Louise Bar, the adjustable wave structure, the Landing, the South Slope stabilization, and the North Channel, work synergistically to achieve the project’s diverse goals.

Ultimately, the Bow River 10th Street Gravel Bar project, as advanced through this preliminary design, holds significant potential to transform this vital section of Calgary’s riverfront. By successfully integrating flood resilience measures with enhanced ecological functions and vibrant, accessible public spaces, the project is poised to deliver lasting benefits to the community, bolstering the city’s resilience and reinforcing the Bow River’s role as a cherished natural and recreational asset.

9.2 Next Steps

This comprehensive Preliminary Design Report provides the necessary foundation and justification to proceed to Detailed Design. This subsequent phase will involve refining the engineering specifications for all components, finalizing material selections for durability and aesthetic integration, preparing detailed construction drawings and documents, advancing regulatory approvals (including those under the Public Lands Act), and confirming utility coordination requirements (such as with Enmax). The detailed design process will build directly upon the analyses, recommendations, and strategies established within this document.

Continued collaboration with stakeholders, including government agencies, environmental groups, recreational organizations, and Indigenous communities, will remain essential during Detailed Design to ensure the final plan reflects shared values and objectives, as guided by the project's principles. Attention to construction sequencing, adaptive management strategies for ecological components, and ongoing maintenance considerations for structures like the wave gates will also be critical elements refined in the next phase.

The project map diagram (right) outlines the Preliminary Design stages, associated team responsibility and the schematic design process stage. Next steps include looking at a phased Detail Design and Construction Plan to ensure that the project is sequentially developed and constructed to ensure the best project outcomes.

The following outlines the stages that occur after Preliminary Design once Detailed Design starts.

1. **Detail Design + Permit Application**
    - Development of final design documentation
    - Development and submission of permit applications
    - Coordination with City and additional authorities for approvals
2. **Tender Process**
    - Procurement and selection of contractors through the tendering process
    - Construction mobilization and site preparation for construction activities
3. **Construction**
    - Site Preparation and Infrastructure Improvements
        - Initial excavation and material placement for bar and slope stabilization.
        - Construction of foundational public access points and erosion control measures.
    - Wave and Channel Development
        - Installation of wave gates and hydraulic controls.
        - Creation of fish habitat features and enhancement of ecological connectivity.
    - Public Realm and Recreational Space Completion
        - Development of the wave deck, gathering spaces, and viewing platforms.
        - Finalization of pedestrian pathways, signage, and landscaping.
4. **Monitoring and Adaptive Management**
    - Ongoing monitoring to assess ecological health and project performance.
    - Adaptive management strategies to address evolving site conditions and restoration needs.

- Implementation of maintenance measures as necessary to ensure long-term project success.

9.3 Team Structure

The consultant project team included:

O2
Project Management & Integration
Ecological Planning and Design
Visualization & Mapping Concise Reporting

Montrose Environmental Solutions Canada
Hydrotechnical Analysis & Regulatory Lead
Biology Aquatics & Fish Habitat; Regulatory Lead

Surf Anywhere
Surf Wave Design Input

Applied Ecohydraulics
Surf Wave Hydraulics
Sediment Management

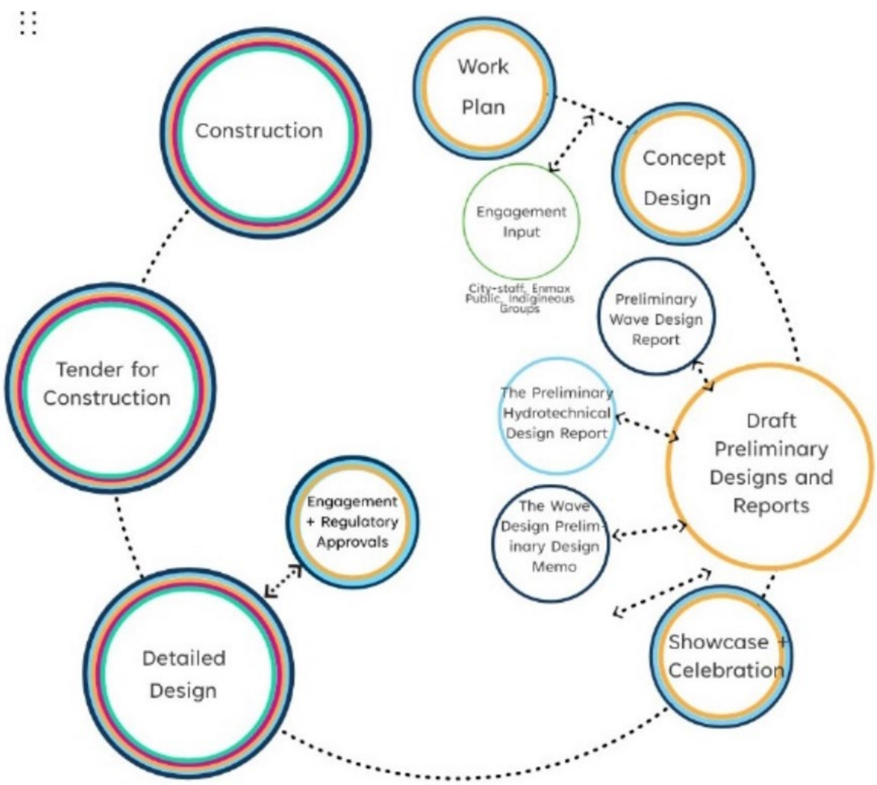
Harmony Walkers
Indigenous Engagement

Lifeways
Historical Resources & Archaelogy

Ratio Structural Engineering
Structural Engineering

Taylor Geotechnical
Geotechnical

The consultant contributions to deliverables are demonstrated below:



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11 Report Authorization

This project summary report is approved. This report has been prepared for exclusive use by The City of Calgary and should not be relied upon by any other party without due consideration and authorization. For detailed engineering and technical documentation, refer to the Appendix reports.

SIGNATURE	September 16, 2025 DATE

Matt Williams, AALA, CSLA,

Principal, Landscape Architect, O2

12 Appendices

12.1 Appendix A: Biophysical Impact Assessment - Draft

12.2 Appendix B: Habitat Restoration Approach – Draft

12.3 Appendix C: Preliminary Hydrotechnical Design Report

12.4 Appendix D: National Research Council Canada – Physical Model Study of Gravel Bar Realignment Designs for the Bow River near Louise Bridge

12.5 Appendix E: Adjustable Waves Preliminary Design Report

12.6 Appendix F: Preliminary Landscape Architecture Design Report

12.7 Appendix G: Cost Estimate

12.8 Appendix H: City of Calgary 10 Street Recreational Wave Viability Report

12.9 Appendix I: Land Ownership and Utilities Memo

12.10 Appendix J: Existing Use Memo

12.11 Appendix K: Tree Survey Memo

12.12 Appendix L: Literature Review Memo