City of Kingston
Third Crossing of the Cataraqui River

Volume 1 - Preliminary Design Summary Report

Final Report: June 2017

JLR File No.: 27143

PARSONS · dtah · J.L.Richards ENGINEERS · ARCHITECTS · PLANNERS · Golder Associates · CSW

SIGNATURE PAGE

The following main report as well as the specialist reports and drawings located in the Appendices of this report meet the professional service requirements of the City of Kingston Request for Proposal No. EN-2015-08, dated October 7, 2015, for Preliminary Design for the Third Crossing of the Cataraqui River:

Wes D. P. Paetkau, MCIP, RPP
Assistant Project Manager
J.L. Richards & Associates Limited

Steve Saxton, P.Eng.
Senior Civil Engineer
J.L. Richards & Associates Limited

Jack Ajrab, M.Sc., P.Eng.
Senior Bridge Engineer
Parsons Inc.

Mark Langridge, OAA, MRAIC, LEED® AP BD+C
Senior Bridge Architect
dtah

Lee Jablonski, P.Eng., LEED® AP
Senior Transportation Engineer
J.L. Richards & Associates Limited

Michael Snow, M.A.Sc., P.Eng.
Senior Geotechnical Engineer
Golder Associates Ltd.

Berend Jan Velderman, P.Geo, M.Sc., QPESA, QPRA
Senior Geo-Environmental Scientist
Golder Associates Ltd.

Gwendolyn Weeks, H.B.Sc.Env
Senior Ecologist
Golder Associates Ltd.

Martha Lush, BLA, CSLA, OALA, LEED® AP
Senior Landscape Architect
CSW Landscape Architects Limited

REVIEWED BY:

Philip D. Reeve, P.Eng.
Executive Director & Chief Municipal Engineer
J.L. Richards & Associates Limited

Marcel A. Delph, P.Eng.
Ottawa Area Manager
Parsons Inc.

NOTICE TO READER

The following main report highlights key points of the detailed specialist reports only; for complete information as well as limitations, it is necessary for the reader to examine the complete report, including the information contained in the discipline reports and drawings located in the Appendices of this report.

The following main report and the Appendices of this report are in process of being reviewed by Parks Canada and other Expert Federal Authorities in support of the Federal Environmental Impact Assessment framework, pursuant to Section 67 of the Canadian Environmental Assessment Act. As such, the following main report and the Appendices of this report, as of the date noted herein, have neither been endorsed nor approved by Parks Canada and other Expert Federal Authorities.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF DRAWINGS

LIST OF APPENDICES

EXECUTIVE SUMMARY

1. Project Background

The City of Kingston (City) has retained a Project Team co-led by J.L. Richards & Associates Limited (JLR) and Parsons Inc. to undertake the Preliminary Design (pre-design) and Federal Environmental Impact Assessment (EIA) of the Third Crossing of the Cataraqui River (project). The bridge corridor forms part of the Rideau Canal (Canal), a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site, National Historic Site, Canadian Heritage River and Federally regulated navigable waterway.

The current project is pursuant to an Ontario Municipal Class Environmental Assessment (Class EA), which was engaged in 2009. The Class EA proceeded as a Schedule 'C' Class EA as per the Ontario Municipal Class EA process. As the riverbed is owned by the Federal Government, the Class EA was also in process of addressing the Federal EA framework, until Federal changes to the Canadian Environmental Assessment Act (CEAA) in 2012 suspended this requirement.

The Class EA determined that the LaSalle Causeway was operating at capacity, and that travel volumes would continue to increase, based on urban growth and related travel volume demand forecasts done at the time. If this problem was left unaddressed, the increasing travel volumes would cause local traffic to divert north to use the Highway 401 crossing, thereby leading to further out-of-way travel, additional delays and potential local-regional traffic conflicts on Highway 401.

The Class EA proceeded in two stages. Stage 1 focused on evaluating the need for additional transportation capacity across the Cataraqui River, and the assessment of the following alternative solutions:

1. **Retain the status quo or 'do nothing':** This option was not viable since the LaSalle Causeway is operating at capacity and is expected to experience increased congestion during peak traffic periods as population and employment growth continues.

2. **Increase the capacity of the LaSalle Causeway:** A series of Transportation Demand Management and Transportation Systems Management strategies along the LaSalle Causeway-Highway 2 corridor were seen as a viable interim solution only (and subject to future traffic monitoring by the City).

3. **Increase the capacity of Highway 401 from Montreal Street to Highway 15:** This option was not viable, given the primary role of Highway 401 as an inter-city freeway; the trip demand patterns of vehicles that favour crossing the Cataraqui River via the LaSalle Causeway; and the related out-of-way travel and additional delays that would result from diverting local traffic 6 kilometres (km) north.

4. **Implement a new crossing at a location between the LaSalle Causeway and Highway 401 by either a tunnel or bridge:** The tunnel option was not viable due to extensive technical constraints and environmental impacts as well as prohibitive capital costs. Thus, based on an assessment of nine possible river crossing options, the preferred solution was a bridge crossing linking John Counter Boulevard and Gore Road. This mid-central location provides improved transportation network connectivity through the City, and also offers opportunities to enhance the City's historic association with the Canal.

Stage 2 completed the Class EA by focusing on three bridge design concepts, shoreland road and landscape designs, mitigation measures, capital and maintenance costs and the Environmental Study Report (ESR). The ESR recommended the Arch With V-Piers design concept, based on the following overall aesthetic expression for the bridge that focuses on the use of contemporary geometry, materials and detailing that will stand the test of time, but also enable the bridge to 'age gracefully':

1. The double V-piers reduce in-water effects and their slender, open look minimizes visual impacts.

2. The 150 metre (m) pier-to-pier distance of the arch span provides unencumbered through-navigation for the Canal's navigable channel and adjacent rowing lanes.

3. The arch over the navigable channel and adjacent rowing lanes highlights the bridge as a 21^{st} Century 'gateway' to-from the Canal and the City's Inner Harbour to the south.

4. The bridge has an s-curve alignment which reduces noise and visual effects and provides a softer landscape for abutting residential lands on the east shore; and provides gradually shifting view perspectives for bridge users as they navigate the s-curve.

5. The bridge clearance above the water accommodates existing topographic conditions on both shorelines and exceeds the 6.7 m vertical by 15 m horizontal Federally regulated navigable clearance requirement for the Canal.

The recommended bridge deck cross-section in the ESR comprised the following main features:

1. A 4-lane vehicular roadway, complete with median. It should be noted that the ESR confirmed a staged approach could also work (involving a 2-lane or 3-lane bridge for vehicular traffic) with a substructure that could accommodate widening the bridge deck to 4 lanes in the future (subject to future traffic monitoring by the City).
2. A 3.6 m wide multi-use trail on the south side of the bridge for active transportation.
3. 1.5 m wide commuter cycling lanes for westbound and eastbound travel.
4. A barrier separating the multi-use trail and commuter cycling lane on the south side of the bridge.
5. A series of observation look-out/interpretive areas provided along the south side of the bridge.

The bridge deck features extended on-shore, with:

1. Multi-use trail linkages to improve active transportation network connectivity north and south of the bridge.
2. Extensive landscaping and observation look-out/interpretive areas provided near-shore.
3. Signalized intersections at John Counter Boulevard-Montreal Street; Gore Road-Point St. Mark Drive-Gore Road Library entrance; and Gore Road-Highway 15.
4. A two-way stop sign controlled intersection at John Counter Boulevard-Ascot Lane.
5. Associated turning lanes at the intersections noted above.

The ESR identified dredging a channel for construction barge access as the preferred solution to facilitate in-water bridge construction, based on the following:

1. The excavated channel could introduce a different habitat to a marine environment that is currently dominated by Milfoil, a type of submerged vegetation.
2. Dredging would reduce capital costs in comparison to the temporary work bridge option, which was also assessed during the Class EA.
3. Dredging could accommodate a potential east-west watermain within the excavated channel, which was being planned by Utilities Kingston (UK) during the Class EA.
4. Dredging would require only one in-water disturbance and one related set of mitigation measures as part of its installation, since it was anticipated that the excavated channel would not be backfilled in order to accommodate the UK watermain.

The ESR identified the following preliminary opinion of probable capital and maintenance costs for the various bridge deck scenarios (in 2011 dollars and excluding applicable taxes):

1. The preliminary opinion of probable capital cost was:
   a) $121 million (M) for the 2-lane bridge.
   b) $179M for the 3-lane bridge (4-lane substructure).
   c) $196M for the 4-lane bridge.
2. The preliminary opinion of probable maintenance cost was up to $4,000 per lane km.

The ESR identified a series of potential environmental interactions associated with the 100-plus year design life cycle of the bridge, from construction through to operations and decommissioning. The following two tools were recommended in the ESR for the City to prepare and implement during future project phases to mitigate potential adverse environmental effects:

1. A Cultural-Natural Heritage Protection Plan (C-NHPP), which would include best management practices, including the extensive mitigation and enhancement measures recommended in the ESR.
2. A Community Action Plan (CAP) that would establish protocols for use by the City for notifying the general public of any service interruptions and addressing public issues arising

from bridge construction activities as well as the subsequent use and maintenance of the bridge.

The Class EA was approved in 2013 by the Province of Ontario, signifying that the project could proceed to the implementation phase. As such, the current project represents the next phase in the City's Action Plan, which outlines the process needed to advance the project to 'shovel-ready' status.

2. Public and Stakeholder Consultation

Decision making and consultation activities during the current project phase have been facilitated by the following committees:

1. A Senior Management Committee to oversee the overall project direction.
2. A Technical Advisory Committee comprised of City staff, Project Team members as well as various Provincial and Federal government departments to provide technical guidance and act as a sounding board for technical decision making.
3. A First Nations Consultation Sub-Committee to facilitate consultations with First Nations communities having an interest in the project as well as associated government agencies.
4. A Public Engagement Committee to provide guidance and input for public consultation activities.

In addition, a comprehensive consultation plan has been implemented to facilitate meaningful input from the public and various agencies. Public consultation has been facilitated through:

1. Maintaining an up-to-date project website.
2. Preparing regular project updates through various social media platforms.
3. Facilitating three Public Open Houses to provide information on the background to the project; the progress of the pre-design work, and the draft project findings and recommendations.
4. Engaging in consultations on specific project issues with City staff and other stakeholders, including:

City of Kingston

a) Utilities Kingston
b) Public Works
c) Parks and Recreation
d) Kingston Transit
e) Kingston Hydro
f) Accessibility Advisory Committee

Other Stakeholders

a) Parks Canada
b) Infrastructure Ontario
c) Cataraqui Region Conservation Authority
d) Hydro One
e) Cogeco Cable Canada Inc.
f) Kington Rowing Club

3. Design Evolution and Innovation

The proposed design and construction of the bridge has evolved since the Class EA phase. As highlighted in the sections that follow, this is due to updated transportation analyses; more in-depth fieldwork activities; optimizations of various bridge design elements; additional stakeholder consultations; potential environmental impacts; and capital cost considerations.

3.1 Bridge and Approach Roadway Components

The proposed width of the bridge deck is 16.5 m consisting of:

1. Two lanes for vehicular traffic in response to the recommendation in the recent Kingston Transportation Master Plan update. Based on the current design speed [70 kilometres per hour (km/hr)] and future posted speed (60 (km/hr) on the bridge, the width of each lane is 3.5 m. There is also a 2 m wide shoulder adjacent to each vehicular traffic lane to assist with snow clearing and other maintenance activities and accommodate commuter cyclists.
2. A 4 m wide multi-use pathway on the south side of the bridge deck to provide for active transportation and look-out / interpretive areas. At the arch, the width of the multi-use pathway increases to 9.5 m to provide a look-out / interpretive area over the navigation channel and adjacent rowing lanes.
3. Three 0.5 m wide barriers for public safety: on the north side of the bridge (1); separating the roadway and the multi-use pathway (2); and on the south side of the bridge (3).

The bridge will have a 225 millimetre (mm) thick reinforced concrete deck with waterproofing and 80 mm of asphalt on the wearing surface. Four (possibly five) haunched in plan plate girders will support the reinforced concrete deck. The plate girders can either be curved to match the horizontal alignment or kinked to simplify fabrication. The girders will be supported by a combination of diaphragms, cross-frames and lateral bracing to provide lateral stability during construction and for live load sharing.

There will be two storm sewer pipes under the bridge deck, one along the north barrier and one along the barrier separating the roadway and the multi-use pathway. These storm sewer pipes, which will run from each side of the arch, will drain stormwater off the bridge into stormwater management facilities on either shore, adjacent to the approach roadways.

The proposed horizontal alignment of the bridge maintains the s-curve for reasons cited in the Class EA. But the s-curve has been modified to consist of two large radii horizontal curves, which will preclude the need for costly superelevation (banking) on the bridge.

The proposed vertical profile of the bridge was also refined since the Class EA. Firstly, the crest will be centered on the arch span with the low points located off the bridge. This will not only make the arch the focal point of the bridge, it will also better facilitate stormwater management and optimize the number of deck drains needed on the bridge. Secondly, the vertical profile will be lowered by 2.8 m at the crest, which will reduce capital costs in response to lower pier heights and reduced embankment fill requirements on the approaches.

The initial preferred pier design consisted of two separate concrete V-piers with two tie beams. The V-piers were to be supported by a large pier cap at the base of the pier, from which several large diameter caissons would be drilled into bedrock. Though the pier cap would increase the ice loading potential pushing against the pier, of the V-pier design options assessed, this initial design was deemed simplest to construct, more economical and structurally viable, and it provided a more open and transparent design. As noted later, the pier design was revisited in response to bridge constructability, capital cost and environmental mitigation considerations.

The proposed arch will be paired outward tilting tied arches. Each arch will have 18 multi-strand cables connected to the transverse floorbeams, which will support the bridge deck. The proposed arch top chord is shaped with parallel cross struts between the arch chords and parallel hangers.

The abutments will be reinforced concrete with a spread footing founded on an engineered granular backfill pad. Both abutments will have conventional concrete wingwalls.

The design of the approach roadways has not changed significantly since the Class EA. However, the John Counter Boulevard-Ascot Lane intersection has been designed to accommodate future signalization, should it be required based on traffic monitoring by the City. In addition, the roadway lighting will be contemporary and elegant in appearance with accent lighting that highlights key bridge corridor components in a subtle, yet aesthetically pleasing effect at night.

The proposed Cultural-Natural Heritage Protection and Enhancement Plan (C-NHPEP) as part of this current project phase advances the best management practices and design measures recommended during the Class EA to further protect, restore and enhance the cultural and natural heritage landscape within the bridge corridor both during and after construction. Focusing on post-construction design measures and consistent with the Class EA:

1. The on-shore look-out / interpretive areas and active travel / commuter cycling provisions will be carried forward.

2. The surrounding lands and shorelines will be extensively restored and enhanced using native plant materials to create both a natural and parkway setting. Furthermore, should water access via the east side of the project corridor be preferred by the Contractor during the construction phase, the associated water dockage provisions could be transformed post-construction into a permanent boat launch facility, subject to further review and consideration by those authorities having jurisdiction.

3. On-land wildlife micro-habitats such as bat and duck boxes, turtle nesting areas and snake hibernacula will be provided.

4. In recognition of the impact area from the permanent bridge on the structure and function of the Greater Cataraqui Marsh Provincially Significant Wetland (PSW), the C-NHPEP also includes provisions for wetland rehabilitation of the near-shore area on the west side of the bridge corridor. These provisions include the installation of habitat enhancements (e.g. reptile basking structures, submerged and emergent logs) and in-water re-vegetation using dominant wetland species.

The proposed CAP similarly establishes a community outreach framework for the City to use both during and after bridge construction for notifying the public (e.g. about upcoming service interruptions); educating the public (e.g. about monitoring activities in support of in-water and on-shore restoration works); and addressing public issues (e.g. through a Bridge Liaison Officer).

3.2 Bridge Constructability and Related Impact Considerations

The Class EA context in which dredging was recommended as the preferred in-water bridge construction option has also subsequently evolved, as highlighted below:

1. UK confirmed an alternative route for the proposed watermain that was originally intended to be located within the dredged channel.

2. Based on more in-depth fieldwork activities, the composition of the dredgeate could lead to severe suspension and sloughing of in-river sediment during construction; and changes in sediment dynamics and increased turbidity in the water column after construction.

3. Critical outcomes from specific consultations with Parks Canada during the current project phase yielded the following:

   a) The context of the bridge corridor within the Greater Cataraqui Marsh PSW ecosystem, particularly its role as a coastal wetland, and its status as one of Parks Canada's larger protected heritage areas.

   b) The proposed 4.3 hectare (ha) impact area from the dredging option, which is significantly larger than the proposed 0.6 ha impact area from the temporary work bridge option.

   c) The lower risk concerning the potential long-term effects from the temporary work bridge option on the Cataraqui River substrate, vegetation, habitat and water quality.

Based on the above considerations as well as extensive bridge constructability assessments by the Project Team in consultation with City staff, the current project is recommending the temporary work bridge as the preferred in-water bridge construction option. The temporary work bridge will be approximately 11 m wide, and supported on piles every 10 to 12 m. It will be advanced incrementally in conjunction with the construction of the permanent bridge from shore to the navigation channel on both sides. Localized excavation of the riverbed will still be required, but only at the v-pier locations which, as noted later, are being carried forward to frame the arch span as the focal point of the bridge. As such, the overall impact footprint will be significantly minimized.

It would take up to three months to remove the temporary work bridge following construction of the permanent bridge. The temporary piles could either be removed completely or cut below the top of the riverbed and left in place.

3.3 Pier Design Innovation

Based on the preferred V-pier design, main arch span and bridge deck configuration, and temporary work bridge option, a Schedule 'C' capital cost estimate was prepared. Relative to the cost estimates prepared during the Class EA, these current project components, in conjunction with consumer price index increases to present day, resulted in significant escalations to anticipated capital costs.

In response, the Project Team designed an innovative pier alternative. While the V-piers would remain to frame the arch span as the focal point of the bridge, the remaining piers would consist of 16 inverted U-frame piers with an outside face angle that both matches and gradually increases in height toward the tilted arch span.

Upon review with City and Parks Canada staff, this alternative was considered a 'triple win', in that:

1. The temporary work bridge is preferred over the dredged channel from an environmental impact and protection perspective with regards to construction methodology (first win).

2. Although the span arrangement would increase from 14-to-19-spans, the overall environmental footprint from the U-frame piers would still be lower compared to the initial V-pier design. This alternative pier design, in conjunction with the temporary work bridge, also yields a more reasonable cost estimate that is commensurate with the City's current financial resources (second win).

3. From functional and aesthetic perspectives, the functionality of the bridge would not be compromised due to the alternative pier design, and the bridge deck features would be retained to enhance user experiences along the Canal; and aesthetically, the inverted U-frame piers would still provide a cohesive overall rhythm towards the arch span as the focal point of the bridge (third win).

The alternative pier design has been advanced as the preferred structural arrangement for the current project. As such, the bridge will be supported on 92 conventional pot bearings, 88 for the plate girder approach spans up to the arch and 4 for the arch itself. To minimize maintenance and operation costs and increase durability, the bridge will have only four expansion joints. To the east of the arch, the expansion joints will be strip seal joints; to the west of the arch, the expansion joints will be multi-cell modular joints.

The U-frame piers will consist of two 1800 mm diameter caissons rock socketed into the bedrock with a steel liner. The V-piers at the arch will be supported on eight 2100 mm caissons with a footing. With the high ice loading that can develop on the arch pier footing, a pier nosing will be installed on the ends of the footings to break-up the ice.

3.4 Supplemental Innovation Considerations

Key additional innovative features which were evaluated during the current project phase include:

1. Flexibility in the design of the superstructure to allow different erection methods for the arch and the approach spans, depending on the means and methods of the Contractor.
2. Bridge Service Life considerations which focus on the overall life cycle of the bridge so that the initial design ensures optimized performance and related operations / maintenance / rehabilitation costs, and which can include:
   a) Designing the arch components from completely sealed components to enhance the long term life and durability of the structure.
   b) Structural health monitoring system (SHMS) provisions, such as but not limited to a weather station; permanent displacement survey prisms; displacement sensors; Global Positioning System (GPS) sensors; accelerometers; and leak detection systems.
   c) A hanger system comprised of multi-strand cables and anchorages with adjustment nuts, which would enable quick and easy adjustment (and replacement) of the cable forces throughout the life of the bridge.
   d) The use for stainless steel / galvanized and GFRP reinforcing steel rather than carbon steel in areas prone to high corrosion.
   e) Employing a four coat system and the potential metalizing of the arch components.
   f) The use of LED light fixtures to reduce energy consumption, and optimize associated maintenance and replacement costs.
   g) The use of sustainable de-icing and anti-icing systems.

4. Property Impacts

Property considerations are necessary in three locations with respect to the bridge and approach roadways: the east approach (on land); the bridge span (over water); and the west approach (on land).

The east side of the bridge corridor utilizes an unopened road allowance at the west end of Gore Road (north of the Point St. Mark neighbourhood) and the City-owned Gore Road Library property at the northwest corner of Highway 15 and Gore Road. All east side lands required for the construction and operation of the approach roadway, active transportation provisions and landscape works, embankment leading to the bridge abutment, bridge footprint and stormwater management areas will be contained within City-owned property.

The Cataraqui River bed is owned by the Federal government and managed by Parks Canada. As such, it will be necessary to recognize the footprint of the bridge both within and over the river as well as the construction and operation of the bridge through a future land lease and construction agreement(s) with Parks Canada.

The west side of the bridge corridor predominantly uses an existing unopened road allowance at the west end of John Counter Boulevard. The City has already purchased the former Music Marina property on the north side of the road allowance near-shore, up to the River Park Subdivision. This property will partially accommodate construction staging and laydown area requirements as well as future stormwater management provisions. Additional lands will also be required:

1. On the south side of the road allowance to accommodate construction staging and laydown areas, the re-located John Counter-Boulevard-Ascot Lane intersection as well as active transportation and landscape works.

2. At the John Counter Boulevard-Montreal Street intersection for widening John Counter Boulevard to accommodate eastbound turning and through lanes.

5. Permitting Status and Expectations

Parks Canada is responsible on behalf of the Federal government for managing and protecting the Canal as a National Historic Site and Canadian Heritage River. Parks Canada is also responsible on behalf of the UNESCO World Heritage Committee for protecting the Canal as a UNESCO World Heritage Site.

Following the acceptance of the ESR by the Province in 2013, the Parks Canada 'Directive on Impact Assessment' was prepared in 2015. It outlines the legislative and policy requirements and accountabilities for the assessment of impacts of proposed projects within Parks Canada protected heritage places, which includes the Canal. In keeping with its mandated priorities, Parks Canada's Environmental Impact Assessment (EIA) process examines how a project may lead to adverse effects on natural and cultural resources, specifically:

1. Adverse effects to characteristics of the environment important to key visitor experience.
2. Adverse effects to health and socio-economic conditions of First Nations and non-First Nations communities.
3. Adverse effects to First Nations communities' current use of lands and resources for traditional purposes.

The continuation of the Federal EIA process is part of the scope of this current project phase. Given the nature of the bridge project and the sensitivity of the project area, Parks Canada has determined that the Detailed Impact Analysis (DIA) framework is to be used for the Federal EIA. The DIA is the most comprehensive level of assessment, intended for complex projects that require applied analysis of project interactions with valued components that may affect a particularly sensitive environmental setting or threaten one or more sensitive valued components. The City and Project Team are currently working with Parks Canada on achieving an agreement-in-principle regarding the DIA as part of this current project phase.

Following the formal approval of the DIA during the future final design phase, the City will be required to enter into an agreement with the Government of Canada (represented by Parks Canada) to ultimately proceed to construct and subsequently operate the bridge for the duration of its life cycle, pursuant to the Federal Real Property and Federal Immovables Act. Approvals from the Cataraqui Region Conservation Authority (CRCA) would also be required for the construction work, pursuant to its role in administering Ontario Regulation 148/06: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses.

In addition, there are also a number of permits and approvals that will be required from various regulatory authorities in support of the design work as it proceeds from the current project phase to the final design phase. Such approvals are related to various non-passive fieldwork activities in support of the design work, which could also include authorizations pursuant to:

1. The Endangered Species Act.
2. The Permit To Take Water requirements under the Ontario Water Resources Act.
3. Ontario Regulation 148/06.

6. Anticipated Construction Schedule

Construction of the bridge could include different techniques for its various components depending on the means and methods of the Contractor. It is estimated that the construction duration for bridge and road approaches will be three years. Best management practices and mitigation measures will be in place to either reduce or eliminate the potential negative effects of specific project construction activities on the surrounding natural and cultural heritage environment.

7. Cost Estimate and Cost Escalation Considerations

The Class EA identified the preliminary opinion of probable capital cost of a 2-lane bridge (in 2011 dollars and excluding applicable taxes) at $121M. For the current project phase, estimated capital costs were updated as the refinements to the bridge design and constructability program advanced.

As referenced earlier, the Schedule 'C' capital cost estimate prepared in support of the initial bridge design and preferred temporary work bridge construction option resulted in a significant escalation to anticipated capital project costs, in the range of $200M (in 2017 dollars), as shown in **Figure 1**.

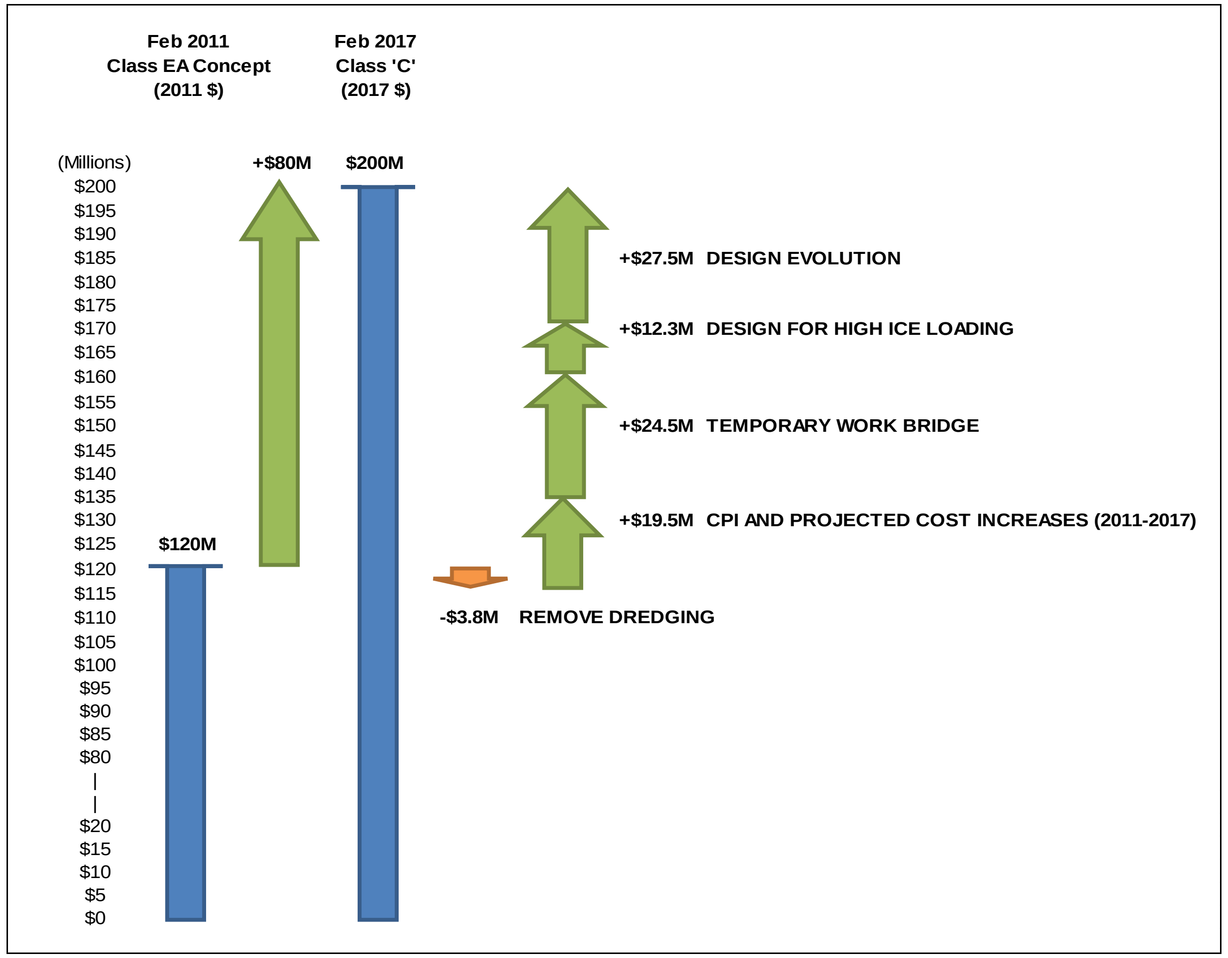


Figure 1 – Capital Cost Escalation Considerations

As also referenced earlier, the refined pier design has offered an opportunity for a 'triple win', focusing on reduced environmental impacts; retained aesthetic design and user experience considerations; and reduced capital project costs. Regarding the latter, and as shown in **Table 1**, the Class 'B' cost estimate prepared for the refined design and temporary work bridge construction option shows a capital project cost (in 2017 dollars and excluding applicable taxes) of $161M, a $40M decrease compared to the Schedule 'C' capital cost estimate for the initial design.

Table 1: Class 'B' Cost Estimate	
Sub-Total for Structure Construction	$106,500,000
Sub-Total for Construction of Bridge Approaches	$11,500,000
Sub-Total for Landscaping	$3,400,000
Sub-Total for Construction Costs	**$121,400,000**
Mobilization (3%)	$3,600,000
Engineering and Contract Administration (12.5%)	$15,200,000
Quality Management (3.0%, 2.5% Structural)	$3,100,000
Contingency (15%, 10% Landscape)	$18,000,000
Total Estimated Construction Cost	**$161,300,000**

Proportionate costs relative to construction costs (75%) and indirect costs (25%) are shown in **Figure 2**.

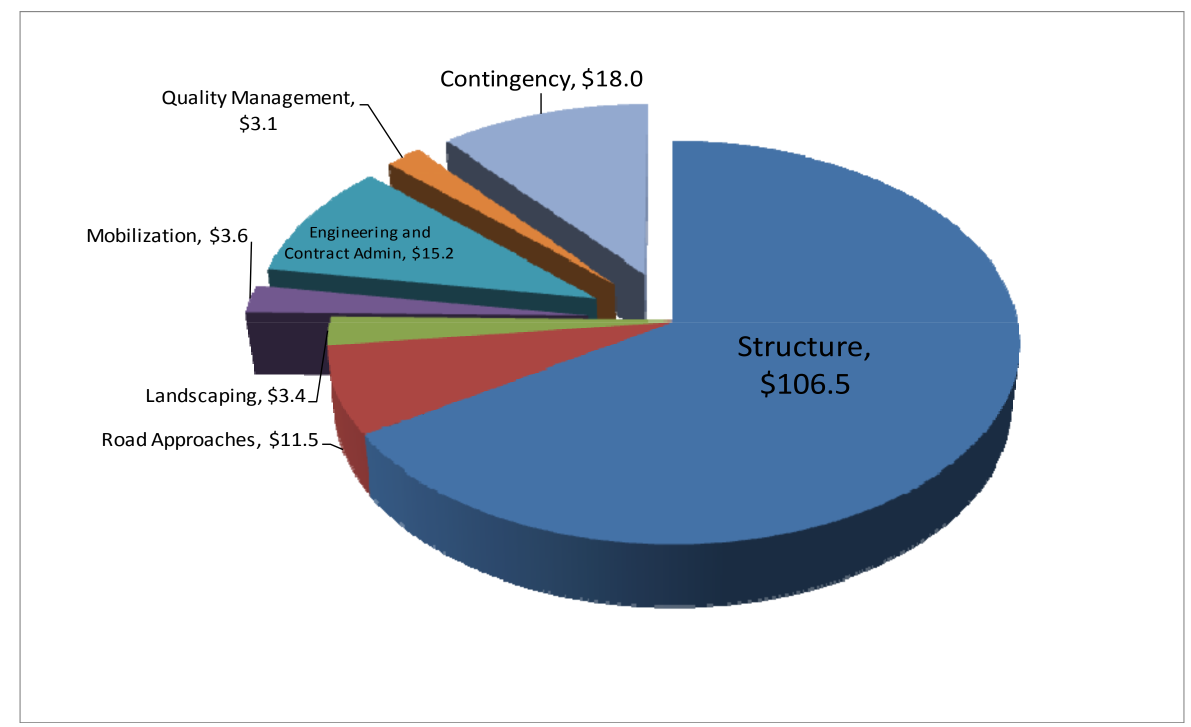


Figure 2 – Refined Bridge Design Capital Cost Breakdown

To put this refined Class 'B' cost estimate into further perspective, **Figure 3** shows the capital cost progression from the Arch With V-Piers design concept in the ESR to the current refined bridge design.

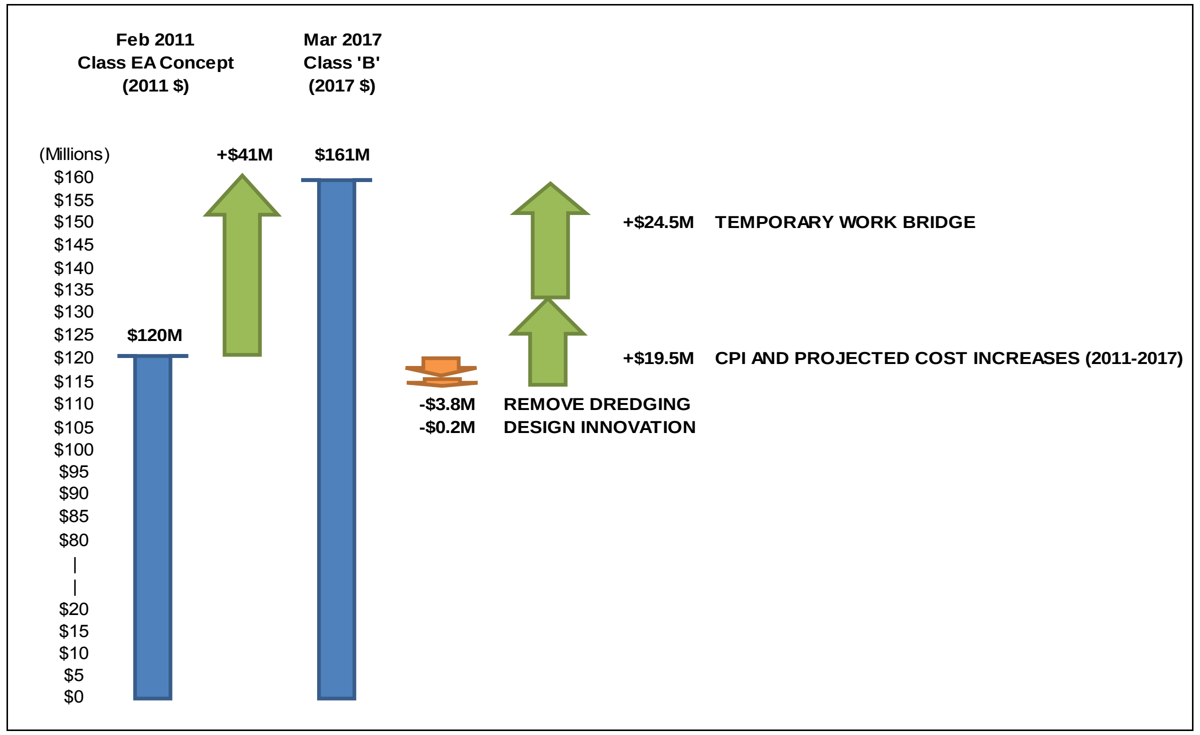


Figure 3 – Class EA Capital Cost Progression

Figure 3 shows that through design innovation, the cost to the project (from 2011), other than inflation and the preferred temporary work bridge construction option, is expected to remain the same.

8. Life Cycle Cost Considerations

A life cycle cost analysis was undertaken to determine the future capital and maintenance costs for the bridge through its service life of 100 years. With regular maintenance, it is expected that the design life of the bridge could extend well beyond 100 years.

The analysis includes costs associated with the repair and replacement of certain bridge elements to achieve the overall minimum 100 year design life. It focuses on minor rehabilitations every 15 years and major rehabilitations every 25 to 30 years. A summary of the analysis is provided in **Table 2** and **Table 3**. It shows the cost of all future capital and maintenance costs at present net value (in 2017 dollars) for the item using economic principles and a discount rate. The discount rate accounts for inflation and interest.

Table 2: Net Present Cost of Bridge Structure with Different Discount Rates

Discount Rate	Net Present Cost (2017)
3%	$156,500,000
5%	$137,900,000
7%	$126,500,000

Table 3: Net Present Cost of Road Approaches with Different Discount Rates

Discount Rate	Net Present Cost (2017)
3%	$20,300,000
5%	$16,300,000
7%	$14,300,000

9. Phase 4 Next Steps

The following activities will remain from the completion of the current project phase to the start of construction:

1. Continue stakeholder and First Nations consultations.
2. Finalize the Federal EIA with Parks Canada.
3. Confirm the need to prepare addenda to the ESR in light of current bridge design and constructability refinements.
4. Determine the preferred project delivery model.
5. Determine project financing.

6. Prepare final design drawings and specifications for construction.
7. Prepare detailed construction phasing, scheduling and cost estimates.
8. Obtain all permits and approvals required for construction.
9. Execute the land lease and construction agreement(s) with Parks Canada.
10. Obtain property easements and acquisitions for the project.
11. Procure the project (Pre-qualification, Proposal / Tendering, Agreements).

Additional studies that should be conducted during the detailed design stage include, but are not limited to, the following:

1. **Geotechnical Investigations:** The in-water test holes put down as part of the current project design phase were advanced at selected pier locations based on the previous 14-span V-pier arrangement. The refined bridge arrangement maintains the same abutment locations and overall bridge length, but now comprises 19 inverted U-frame piers. As such, most of the test holes are no longer within the footprint of the inverted U-frame pier locations. Though the relevance and applicability of the geotechnical assessments to the refined bridge arrangement is re-confirmed, additional field investigations should be carried out at the proposed U-frame pier locations during the detail design phase to confirm bedrock surface elevation and founding soil and bedrock conditions.
2. **Scour Study:** The effects of scour on bridge piers should be developed more fully during the detailed design process based on local bed conditions as well as refinements to the proposed pier design, pier construction and riverbed restoration techniques.
3. **Ice Study:** As part of the preliminary design, ice impact load was considered at two different locations, the high elevation of 74.9 m which corresponds to the maximum of the average water levels between the months of December to April; and the low elevation of 73.0 m which corresponds to the ice loading on the footing. Due to the adoption of the inverted U-shape pier for majority of the piers, it is anticipated that ice loading can be minimized. However, it is recommended that refined studies be carried out during detailed design to refine ice loading at the inverted U-shape and the V-piers that frame the arch. Consideration should be given to using pier nosing / ice breaker design and cut-water to minimize ice loading.
4. **Hydrology and Hydraulics Review:** The permanent bridge piers and associated rock scour protection that may be required will potentially amount to 3000-4000 m^2 of impacted floodplain area. On shore, within the current design, 1000-2000 m^2 of impacted floodplain is expected. With modifications to the design near the waterfront, it is possible that the total impact on east and west shorelines could be reduced to less than 1000 m^2. Therefore, in total, the impacted area is predicted to be less than 5000 m^2.

   The CRCA has recommended that a Hydrology and Hydraulics review be undertaken to demonstrate the potential effects (if any) of the 5000 m^2 impact area within the 1.5 million m^2 upstream area during a 1:100 year flood event. This work should be deferred to the detail design phase when the permanent bridge pier design and associated rock scour protection measures are further refined and confirmed.
5. **Archaeological Investigations:** The private lands on either side of John Counter Boulevard do not appear to have been extensively disturbed and may contain areas where archaeological potential still remains. Since archaeologists have no right of access to conduct archaeological testing on private lands, further assessment of the west side lands continues to be suspended, and should be resumed if the project proceeds to the detail design phase, and the affected private lands are acquired by the City.

   Regarding the east side lands, archeological site BbGc-127 and the identified survey marker should be further documented, and appropriate protocols put in place in advance of the project construction phase for:

   a) The removal through archaeological excavation of archeological site BbGc-127.
   b) The temporary removal of the identified survey marker for subsequent reinstatement in situ during the site restoration and rehabilitation sub-phase.
6. **Geo-Environmental Investigations:** Additional sampling and analyses of sediments both on-shore and in-water should be undertaken in order to further determine sediment contamination levels and ensure appropriate protocols are in place for both management and disposal measures in accordance with regulatory requirements during the site preparation and construction sub-phases.

7. **Natural Heritage Investigations:** Additional fieldwork of natural heritage resources (terrestrial and marine) should be undertaken to both further confirm the presence of sensitive natural heritage features and identify necessary design refinements to the C-NHPEP.

8. **Traffic Calming:** It is understood that vehicles moving eastbound along the bridge could turn southbound at Point St. Mark Drive and proceed through the Point St. Mark neighbourhood to avoid using the Highway 15-Gore Road intersection. Similarly, vehicles moving northbound on Highway 15 could turn west at Point St. Mark Drive to avoid using the Highway 15-Gore Road intersection. In response to this issue (referred to as traffic 'short-cutting'), there are five alternative traffic calming measures, listed below from 'least intrusive' (i.e. options 1 to 3) to 'most intrusive' (i.e. options 4 and 5):

   a) Turning restriction signs.

   b) Curb bump-outs within the Point St. Mark neighbourhood.

   c) Speed humps within the Point St. Mark neighbourhood.

   d) Directional closures at the Gore Road-Point St. Mark Drive entrance.

   e) Full closure at the Gore Road-Point St. Mark Drive entrance [with provisions for emergency vehicle and active transportation (e.g. cyclists, pedestrians) access].

   Typically, consideration would be given to implementing the above-noted traffic calming options in a progressive manner, as described above. However, the feedback received to date from Point St. Mark residents indicates concern that the least intrusive options would not solve the issue, whereas the most intrusive options would be too severe. As such, it is recommended that the City and Point St. Mark residents continue to advance collaborations on traffic calming options during the future detail design stage.

9. **Coordination with Highway 15 Upgrades:** Preliminary drawings have been developed for the three intersections within the project corridor, excluding the Gore Road-Highway 15 intersection, which is being determined under a separate Class EA study. As part of the Third Crossing Preliminary Design project, lane arrangements selected for the Gore Road-Highway 15 intersection have been co-ordinated with the Highway 15 Class EA work to ensure a cohesive design for this intersection. As such, it is recommended that collaborations continue to advance in this regard during the future detail design stage.

10. Other studies and investigations as deemed necessary by those authorities having jurisdiction.

1.0 INTRODUCTION

The City of Kingston (City) has retained a Project Team co-led by J.L. Richards & Associates Limited (JLR) and Parsons Inc. to undertake the enclosed Preliminary Design (pre-design) and Federal Environmental Impact Assessment (EIA) Report of the Third Crossing of the Cataraqui River (Report). The focus of the Report is a bridge over the Cataraqui River and associated shoreland works within the City that will link John Counter Boulevard on the west side and Gore Road on the east side (project). The Universal Transverse Mercator (UTM) coordinates, taken near the mid-point of the project corridor, is generally UTM 18T 382402 metres (m) East, 4901531 m North. At this location, the Cataraqui River forms part of the Rideau Canal (Canal), a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site (designated in 2007), National Historic Site (designated in 1925), Canadian Heritage River (designated in 2000) and Federally regulated navigable waterway.

The project is pursuant to an Ontario Municipal Class Environmental Assessment (Class EA), which was engaged in 2009 on behalf of the City by a team, also led by JLR. The Class EA was approved in 2013 by the Province of Ontario, signifying that the project could proceed to the implementation phase. As such, the enclosed Report represents the next phase in the City's Action Plan, which outlines the process needed to advance the project to 'shovel-ready' status.

As summarized in **Table 1.1**, the Project Team that prepared the enclosed Report consists of the following firms:

Table 1.1: Project Team

Team Partner	Team Role
J. L. Richards & Associates Limited	Project Management and Coordination, Transportation Planning and Engineering, Project Constructability Review and Cost Estimates, Permits and Approvals, Public and First Nations Consultation, Financial Plan Liaison
Parsons Inc. dtah	Bridge Design, Project Constructability Review and Cost Estimates
Golder Associates Ltd. JASCO Applied Sciences	Geotechnical Engineering, Hydrogeological and Geo-environmental Sciences, Natural Environment Sciences, Cultural and Heritage Sciences and Construction and Transportation Bio Acoustic and Transportation Human Noise assessments. The above disciplines provided input to the project design for these specific specialty areas in terms of project design, project construction cost estimates and Permits and Approvals.
CSW Landscape Architects Ltd.	Landscape Architecture
Leslie Higginson Surveying Ltd.	Legal and Topographic Survey

The enclosed Report outlines the following:

1. Refinements to the preferred bridge, roadway and landscape concept from the Class EA.
2. A review of potential environmental interactions and proposed measures to mitigate potential adverse environmental effects associated with the construction and operation phases of the refined concept.

1.1 Project Committees

As shown in **Table 1.1.1**, decision making and consultation activities during this current project phase have been facilitated by the following committees:

1. A Senior Management Committee to oversee the overall project direction.
2. A Technical Advisory Committee to provide technical guidance and act as a sounding board for technical decision making.
3. A First Nations Consultation Sub-Committee to facilitate consultations with First Nations communities having an interest in the project.
4. A Public Engagement Committee to provide guidance and input for public consultation activities.

1.2 Public Consultation

A comprehensive consultation plan has been implemented to facilitate meaningful input from the public and various agencies during this project phase. Public consultation has been facilitated through:

1. Maintaining an up-to-date project website at www.cityofkingston.ca/third-crossing.
2. Preparing regular project updates through various social media platforms.
3. Facilitating three Public Open Houses at the following key milestones:
    a) On September 29, 2016 at the LaSalle Secondary School which provided background information on the project and the progress of the pre-design work to date.
    b) On April 26, 2017 at the Loyalist College and Vocational Institute (LCVI), and on April 27, 2017 at the Ėcole Sir John A. Macdonald. These Public Open Houses presented the draft Report findings and recommendations.
4. Meeting with various staff with the City and other stakeholders on September 8, 2016 as part of a Sustainability Charrette on sustainability-specific design considerations for the project. The feedback report from the charrette is included in **Appendix A**.
5. Engaging in consultations on specific project issues with:
    a) Utilities Kingston (UK) staff on February 24, 2016 to discuss the status of the Kingston Water Master Plan Update, as it relates to potential water servicing accommodations within the project corridor.
    b) Kingston Hydro staff on February 26, 2016 and Hydro One Networks Inc. staff on March 29, 2016 regarding long-term strategic planning for the three Hydro One marine electrical cables [3-phase 44 kilovolt (kV) line] that currently cross the Cataraqui River in the project corridor area.
    c) UK staff on March 7, 2016 to discuss street, traffic and bridge lighting design issues and requirements.
    d) Kingston Transit staff on March 9, 2016 regarding current and long-term strategic planning for public transit within the project corridor.
    e) Senior staff with the City's Public Works Department on March 9, 2016 to discuss future bridge maintenance requirements.
    f) Cogeco Cable Canada Inc. staff on April 14, 2016 to discuss Cogeco's current and long-term utility distribution network planning within the project corridor.
    g) Parks Canada staff on April 15, 2016 regarding the pre-design work plan and activities undertaken to date.
    h) Infrastructure Ontario staff on June 9, 2016 to discuss the Business Plan.
    i) Senior staff with the City and Utilities Kingston on June 23, 2016 regarding the pre-design work plan and activities undertaken to date.
    j) Parks Canada staff on July 15 and 27, 2016 to discuss the Scoping Document in support of the Federal EIA.
    k) Senior staff with the City's Parks and Recreation Department on July 22, 2016 regarding current and long-term parks and recreation planning within the project corridor.

Table 1.1.1: Roles and Responsibilities of Project Committees

Committee	Structure	Roles and Responsibilities	Meetings To Date
Senior Management Committee	• senior City staff • senior Project Team members	• project oversight and administration • manage project budget and schedule • risk management and mitigation	• various meetings
Technical Advisory Committee	• various City Departments • senior Project Team members • Parks Canada • Fisheries & Oceans Canada (DFO) • Ontario Ministry of Natural Resources & Forestry • Ontario Ministry of Environment & Climate Change (MOECC) • Cataraqui Region Conservation Authority (CRCA)	• technical guidance on design refinements • vetting technical decision-making • identifying approval requirements	• March 11, 2016 • April 26, 2016 • June 1, 2016 • July 13, 2016 • August 17, 2016 • September 21, 2016 • November 16, 2016 • May 11, 2017
First Nations Consultations Sub-Committee	• senior City staff • senior Project Team members • special advisors	• led by the City • represents City and JLR Project Team • maintain a link with First Nations communities	• consultations undertaken through document sharing
Public Engagement Committee	• senior City staff • senior Project Team members	• Provide Input on Public Consultation Activities • Review Consultation Reports • Attend Public Open Houses	• various meetings

l) Infrastructure Ontario staff on August 25, 2016 as part of a Risk Workshop in support of the Business Plan.

m) A representative of the City's Municipal Accessibility Advisory Committee (MAAC) on September 19, 2016 to discuss accessibility and the City's Facility Accessibility Design Standards relating to the project.

n) The following stakeholders after the November 16, 2016 Technical Advisory Committee meeting on focused project issues:

   i. meetings with Parks Canada staff regarding bridge constructability, on-shore and in-water compensation related to bridge construction activities, and bridge design matters on November 29, 2016; February 2 and 16, 2017; and March 14 and 27, 2017;

   ii. a meeting with representatives of the Kingston Rowing Club on March 29, 2017 to discuss bridge design and constructability as well as rowing matters within the project corridor; and

   iii. meetings with a representative from the CRCA on March 21, 2017 and April 26, 2017 to discuss bridge design and constructability matters as well as proposed on-land and in-water protection, restoration and enhancement measures.

1.3 First Nations Consultation

The Crown, which is made up of the Federal and Provincial levels of government, has an obligation, based on its own inherent honour, to consult on matters affecting Aboriginal interests raised by First Nations. In 2010, the Supreme Court of Canada in the Rio Tinto ruling confirmed that the purpose of consultation with First Nations was not only based on the honour of the Crown but also, because of that honour, related to the onerous demands of the trial process. Accordingly, it has been established that consultations must be undertaken with the awareness not only of the constitutional fiduciary duty of the Crown to protect Aboriginal interests but also that the process stand as a surrogate for a full court process. As such, the 'Duty to Consult' is a means to ensure First Nations' interests and rights are identified and respected. It also helps the Crown to make better more durable decisions and strengthen its relationships with the First Nations of Canada.

Procedural aspects of First Nations consultation processes are often delegated to the project proponent. The project proponent is typically best-suited to speak to technical and environmental aspects of the project and where appropriate, is best-placed to address concerns raised by First Nations communities. As the proponent for this project, the City has been delegated the procedural aspects of First Nations consultation.

First Nations history in the region of Kingston is complex, in that the establishment of a European presence occurs far earlier here as compared to most other cities in Ontario. The City has sought to be recognized as a municipality which takes the Duty to Consult with First Nations communities as a serious obligation. This is due in no small part to the City's interest in understanding the rich and complex historic and continuing experience of First Nations as part of its overall cultural awareness. Consistent with this commitment, the City undertook consultations through document sharing with the following First Nations communities and associated government agencies as part of this current project phase:

1. Ardoch Algonquin First Nation.
2. Mississaugas of Alderville First Nation.
3. Mohawk Nation Council of Chiefs.
4. Mohawks of the Bay of Quinte.
5. Shabot Obaadjiwan First Nation.
6. Huron-Wendat Nation.
7. Algonquins of Ontario.
8. Algonquins of Pikwàkanagàn.
9. Mohawk Council of Akwesansne.
10. Metis Nation of Ontario.
11. Six Nations Grand River.
12. Department of Aboriginal Affairs & Northern Development.
13. Ontario Ministry of Aboriginal Affairs.

2.0 BACKGROUND INFORMATION

2.1 Municipal Class Environmental Assessment

The project is pursuant to a Class EA, which was engaged in 2009 on behalf of the City by a team led by JLR. Its purpose was to evaluate the need for and the feasibility of implementing additional transportation capacity across the Cataraqui River within the City. As shown on **Drawing 2.1.1**, the Class EA study area extended along the shoreline adjoining the Cataraqui River from the existing LaSalle Causeway-Highway 2 crossing in the City's downtown area in the south, to the existing Highway 401 crossing, 6 kilometres (km) to the north.

The Class EA proceeded as a Schedule 'C' Class EA as per the Ontario Municipal Class EA process. As the riverbed in the Class EA study area is owned by the Federal Government, the Class EA was also in process of addressing the Federal EA framework, until Federal changes to the Canadian Environmental Assessment Act (CEAA) in 2012 suspended this requirement.

The Class EA determined that the LaSalle Causeway was operating at capacity, and that travel volumes would continue to increase, based on urban growth and related travel volume demand forecasts done at the time. Thus, if left unaddressed, the increasing travel volumes would cause local traffic to divert north to use the Highway 401 crossing, thereby leading to further out-of-way travel, additional delays and potential local-regional traffic conflicts on Highway 401.

As per City requirements, the Class EA proceeded in two stages. Stage 1, which was completed in late May 2010, focused on Phases 1 and 2 of the Ontario Municipal Class EA framework, namely, the evaluation of the need for and the feasibility of implementing additional transportation capacity across the Cataraqui River (or 'Phase 1'), and the assessment of the following alternative solutions (or 'Phase 2'):

1. **Retain the status quo or do nothing:** This option was not a viable solution since:

   a) The LaSalle Causeway is operating at capacity and is expected to experience increased congestion during peak traffic periods as population and employment growth continues.

   b) It was also determined that focusing solely on active transportation (cycling and walking) and public transit, though laudable, would not be able to address the entire capacity on the LaSalle Causeway over the immediate-to-long-term.

2. **Increase the capacity of the LaSalle Causeway:** Though it was determined that widening the LaSalle Causeway-Highway 2 corridor was not a viable solution, traffic modelling done at the time confirmed that a series of Transportation Demand Management and Transportation Systems Management strategies could be a viable interim solution, subject to future monitoring of traffic conditions by the City.

3. **Increase the capacity of Highway 401 from Montreal Street to Highway 15:** Despite its capacity and expansion from four to six lanes, the Highway 401 crossing was not a viable solution, given its primary role as an inter-city freeway; the trip demand patterns of vehicles that favour crossing the Cataraqui River via the LaSalle Causeway to the south; and the related out-of-way travel and additional delays that would result from diverting local traffic 6 km north to use the Highway 401 crossing.

4. **Implement a new crossing at a location between the LaSalle Causeway and Highway 401 by either a tunnel or bridge:** As shown on **Drawing 2.1.2**, the Class EA study area was subdivided into six corridor areas with nine possible crossing alignment options based on potential connections to existing roads. The corridor areas were evaluated based on technical feasibility, transportation effectiveness and potential social, cultural, environmental and financial impacts. Area 2 and Area 4 were then short-listed for further assessment. Based on this exercise:

   a) A tunnel was not considered a viable alternative solution, given:

      i. vertical profile constraints, as the rock elevation is roughly 20 m to 40 m below the riverbed, and the acceptable geometric design criteria of a 6 percent (%) slope (or less) to match the existing elevation and intersections cannot be achieved;

      ii. substantial dredging of the riverbed and dewatering as well as excavations at both the west and east shores would be needed, resulting in severe environmental impacts;

      iii. capital costs would be prohibitive [in the range of $350 million (M) to $450M);

      iv. the transportation of dangerous goods may not be allowed through the tunnel for public safety reasons; and

Drawing 2.1.1: EA Study Area

Drawing 2.1.2: EA Corridor Areas

v. neither cyclists nor pedestrians would be allowed through the tunnel, also for public safety reasons.

b) The preferred solution, as shown on **Drawing 2.1.3**, was a bridge crossing at the John Counter Boulevard-Gore Road alignment, which:

i. by providing a mid-central arterial road corridor through the City, offers opportunities to improve urban transportation network connectivity in order to:

(a) relieve existing and future traffic congestion;

(b) enhance the delivery of municipal services such as public transit and utility infrastructure;

(c) promote walking and cycling as viable alternative modes of transportation; and

(d) accommodate planned future residential and employment growth on the east and west sides of the Cataraqui River; and

ii. by being both within the jurisdictional limits of the Canal and proximate to its southern boundary at Belle Island, offers opportunities to enhance the City's historic association with the Canal.

Stage 2 completed the Class EA by focusing on three bridge design concepts, shoreland road and landscape designs, mitigation measures, capital and maintenance costs and the Environmental Study Report (ESR). As shown on **Drawing 2.1.4**, the ESR recommended the Arch With V-Piers design concept, based on the following:

1. The double v-piers reduce in-water effects and their slender, open look minimizes visual impacts.

2. The 150 m pier-to-pier distance of the arch span provides unencumbered through-navigation for the Canal's navigable channel and adjacent rowing lanes.

3. The arch over the navigable channel and adjacent rowing lanes highlights the bridge as a 21^{st} Century gateway to-and-from the Canal and Inner Harbour to the south.

4. The bridge has an s-curve alignment which reduces noise and visual effects and provides a softer landscape for abutting residential lands on the east shore.

5. The bridge clearance above the water accommodates existing topographic conditions on both shorelines and exceeds the minimum 6.7 m vertical by 15 m horizontal Federally regulated navigable clearance requirement for the Canal.

As shown on **Drawing 2.1.5**, a 22.9 m wide bridge deck was recommended in the ESR, which comprises the following:

1. A 4-lane vehicular roadway (two 3.5 m wide lanes for westbound travel and two 3.5 m wide lanes for eastbound travel) with a 1.8 m wide median, the need for which was based on traffic demand forecasts and an assessment of various planned road network improvement scenarios in proximity to the project corridor.

2. A 3.6 m wide multi-use pathway on the south side of the bridge for active transportation.

3. A 1.5 m wide commuter cycling lane on the north side of the bridge for westbound travel, and a 1.5 m wide commuter cycling lane on the south side of the bridge for eastbound travel.

4. A 0.5 m wide area for a barrier separating the multi-use pathway and commuter cycling lane on the south side of the bridge.

5. A series of observation look-out/interpretive areas provided along the south side of the bridge to maximize opportunities for bridge users to both enjoy views of and learn about the Canal, Belle Island and the Greater Cataraqui Marsh.

As shown on **Drawing 2.1.5**, the ESR confirmed a staged approach could work (i.e. involving a 2-lane or 3-lane bridge for vehicular traffic) with a substructure that could accommodate widening the bridge deck to accommodate 4 lanes for vehicular traffic in the future. The viability of these options would be confirmed, subject to future monitoring of traffic conditions by the City.

Drawing 2.1.3: Project Site Location

Drawing 2.1.4: Arch with V-Piers Concept Plan View

Drawing 2.1.5: Bridge Alignment and Deck Configurations

As shown on **Drawing 2.1.6**, the ESR identified dredging a channel for construction barge access as the preferred solution to facilitate in-water bridge construction, based on the following:

1. The excavated channel could represent a mitigation measure in response to potential project effects, in that it would introduce a more pelagic habitat (particularly for larger species) to a marine environment that is currently dominated by Milfoil, a type of submerged vegetation.
2. Dredging would reduce capital costs in the range of 8% to 12% in comparison to the temporary work bridge option, which was also assessed as part of the Class EA.
3. Dredging could accommodate a potential east-west watermain within the excavated channel, which was being planned by UK at the time of the Class EA as part of the Master Plan for Water Supply for the City of Kingston Urban Area.
4. Dredging would require only one in-water disturbance and one related set of mitigation measures as part of its installation, since it was anticipated that the excavated channel would not be backfilled due to the installation of the east-west watermain.

As shown on **Drawing 2.1.7**, the ESR recommended the following roadway and landscape improvements for the west side lands:

1. For westbound travel:
   a) Two 3.5 m wide vehicular lanes on John Counter Boulevard along with a 3.25 m wide by 20 m long left-turn bay at the Village On The River apartment access on the south side of John Counter Boulevard; and shared through/right-turn access into the River Park subdivision on the north side of John Counter Boulevard (i.e. Ascot Lane).
   b) A 3.25 m wide by 60 m long left-turn bay and a right-turn bay at Montreal Street.
2. For eastbound travel, two 3.5 m wide vehicular lanes on John Counter Boulevard along with a 3.25 m wide by 20 m long left-turn bay at the River Park subdivision access; and shared through/right-turn access into the Village On The River apartments.
3. Provisions for a median barrier separating the westbound and eastbound vehicular lanes.
4. The John Counter Boulevard-Montreal Street intersection would be signalized, and the John Counter Boulevard-Ascot Lane intersection would be two-way stop sign controlled.
5. Two shoreland observation look-out/interpretive areas on the north and south sides of the bridge to maximize opportunities for those on-land to both enjoy views of and learn about the Canal, Belle Island and the Greater Cataraqui Marsh.
6. Both the 3.6 m wide multi-use pathway and 1.5 m wide commuter cycling lane on the south side of the bridge continue along the south side of John Counter Boulevard to Montreal Street and connect with the existing Elliott Avenue Parkette recreational trail on-land by a 3.6 m wide multi-use pathway.
7. The 1.5 m wide commuter cycling lane on the north side of the bridge continues along the north side of John Counter Boulevard to Montreal Street and also connects with the existing Elliott Avenue Parkette on-land by a 3.6 m wide multi-use pathway under the bridge.
8. A sidewalk on the north side of John Counter Boulevard, which extends from the multi-use pathway access to Montreal Street.

As shown on **Drawing 2.1.8**, the ESR recommended the following roadway and landscape improvements for the east side lands:

1. For westbound travel, two 3.5 m wide vehicular lanes on Gore Road along with a 3.25 m wide by 20 m long left-turn bay at Point St. Mark Drive and a right turn option at the Gore Road Library.
2. For eastbound travel, two 3.5 m wide vehicular lanes on Gore Road along with:
   a) A 3.25 m wide by 60 m long left-turn bay, through lane/left-turn lane and right-turn lane option east of Point St. Mark Drive at Highway 15.
   b) A 3.25 m wide by 20 m long left-turn bay at the Gore Road Library.
   c) A right-turn option at Point St. Mark Drive.

Drawing 2.1.6: In-Water Bridge Construction Option: Dredging

Drawing 2.1.7: Road and Landscape Concept: West Side

Drawing 2.1.8: Road and Landscape Concept: East Side

3. Provisions for a median barrier separating the westbound and eastbound vehicular lanes.

4. The signalization of the Gore Road-Point St. Mark Drive-Gore Road Library intersection and the Gore Road-Highway 15 intersection.

5. The 3.6 m wide multi-use pathway on the south side of the bridge is shown:

   a) Continuing along the south side of Gore Road west of Point St. Mark Drive and connecting to the existing trail into Point St. Mark.

   b) Extending under the bridge to connect with the trail network on the Gore Road Library property.

6. A 1.5 m commuter cycling lane is proposed on both sides of Gore Road.

7. The existing 1.5 m wide sidewalk would remain on the south side of Gore Road east of Point St. Mark Drive to Highway 15.

8. In regards to the Gore Road Library property:

   a) A proposed on-land observation look-out/interpretive area is shown to maximize opportunities for the public to both enjoy views of and learn about the Gore Road Library, Canal, Belle Island and the Greater Cataraqui Marsh.

   b) As the proposed roadway improvements would impact a portion of the traditional dry stone wall located on-site, it is recommended that the affected portion of this wall should be realigned (as shown conceptually on **Drawing 2.1.8**) and incorporated into the landscape improvements to mitigate associated cultural heritage impacts.

9. The incorporation of the two drainage routes that collect groundwater from the Point St. Mark residential neighbourhood and direct it to the Cataraqui River.

Stormwater collection and management would include on-shore treatment (for sediment removal) and release in accordance with regulatory requirements. Catchbasins along the curb lines would collect the stormwater which would then be piped to a stormwater management facility (either above grade or underground) on-land, where the release rate of the water would be limited to pre-development conditions.

As shown on **Drawing 2.1.9**, four sound attenuation barriers were recommended in the ESR at the following locations to reduce the predicted sound levels from the project at noise-sensitive areas:

1. Adjacent to the River Park subdivision along the north side of John Counter Boulevard:

   a) A 3 m high by 110 m long wall and/or berm extending west from the John Counter Boulevard-Ascot Lane intersection.

   b) A 3 m high by 96 m long wall and/or berm extending east from the John Counter Boulevard-Ascot Lane intersection.

2. Adjacent to the Point St. Mark subdivision along the south side of Gore Road:

   a) A 3 m high by 410 m long wall extending west from the Gore Road-Point St. Mark intersection onto the south side of the bridge deck and ending proximate to the Canal's navigable channel.

   b) A 2.4 m high by 96 m long wall extending east from the Gore Road-Point St. Mark intersection and ending proximate to the Gore Road-Highway 15 intersection.

The following are highlights from the ESR regarding how the bridge would get built over a three year timeframe:

1. The east and west side lands within the project corridor would undergo site preparation, and dredging of the riverbed east-to-west would commence in 150 m to 200 m segments. Given the limited vacant land on either shore, the Gore Road Library property on the east side, and lands adjacent to the John Counter Boulevard right-of-way on the west side would serve as the main sites for construction staging and lay-down areas as well as future stormwater management provisions.

2. The bridge substructure would then be constructed. Rock socketed piles would be driven into the bedrock. Once the silt and overburden was removed from inside the pile, the concrete would get delivered by barge or a line pump from shore.

Drawing 2.1.9: Location of Noise Barriers

3. In terms of the bridge superstructure, the steel girders pier-to-pier would then get installed along with the precast concrete bridge deck panels. Due to limited vacant land within the project corridor, a portion of the bridge components would most likely be fabricated off-site and delivered by barge or road.

In regards to the preliminary opinion of probable capital and maintenance costs for the various Arch With V-Piers conceptual bridge deck scenarios (in 2011 dollars and excluding applicable taxes), the ESR determined that:

1. The preliminary opinion of probable capital cost would be:
    a) $121M for the 2-lane bridge scenario.
    b) $179M for the 3-lane bridge (4-lane substructure) scenario.
    c) $196M for the 4-lane bridge scenario.
2. The preliminary opinion of probable maintenance cost was estimated to be up to $4,000 per lane km.

The ESR identified a series of potential environmental interactions associated with the 100-plus year design life cycle of the bridge, from construction through to operations and decommissioning. The following two tools were recommended in the ESR for the City to prepare and implement during future project phases to mitigate potential adverse environmental effects:

1. A Cultural-Natural Heritage Protection Plan (C-NHPP), which would include the extensive mitigation and enhancement measures recommended in the ESR.
2. A Community Action Plan (CAP) that would establish protocols for use by the City for notifying the general public of any service interruptions and addressing public issues arising from bridge construction activities as well as the subsequent use and maintenance of the bridge.

City Council approved the ESR in May 2012, following which, as part of the mandatory public and agency review period, four Part II Orders (commonly referred to as ‘bump-up requests’) were received by the MOECC. The MOECC reviewed the ESR and liaised with those who had filed the Part II Orders. In June 2013, the MOECC notified the City that the ESR had been officially accepted by the Province, and that the project could proceed to the implementation phase, subject to the following conditions prior to commencing construction:

1. That the City continue to liaise with the Mohawk Nation Council of Chiefs on bridge design issues.
2. That the City consult with the MOECC to confirm bridge construction protocols, mitigation measures as well as approval and permit requirements.

2.2 City of Kingston Action Plan

On February 19, 2013, City staff presented Council with an Action Plan (Report to Council No. 13-097) which was updated on September 19, 2015 (Report to Council No. 15-268). The Action Plan outlines the next steps needed to advance the project to ‘shovel-ready’ status, namely:

1. The recent completion of the Development Charges By-Law update and the 2015 Kingston Transportation Master Plan (KTMP), the latter of which confirmed that a 2-lane bridge and a 2-lane cross-section for the approach roadways are needed.
2. The undertaking of this current project design phase.
3. The preparation of a Business Plan which is focusing on cost-benefit and economic impact analyses of the project; project funding sources; and a preferred project delivery model. The Business Plan is being undertaken on parallel timelines with the undertaking of this current project design phase, but as a separate assignment.
4. The preparation of the final design for the project prior to construction.

2.3 Canadian Environmental Assessment Act (CEAA) Process

As noted earlier, the riverbed within and adjacent to the project corridor is owned by the Federal Government. As such, the Class EA was in process of addressing the Federal EA framework, until Federal changes to the CEAA in 2012 suspended this requirement.

Section 67 of the CEAA 2012 provides discretion regarding how to conduct an analysis to determine whether or not a project is likely to cause significant adverse environmental effects. Following the acceptance of the ESR by the Province in 2013, Parks Canada’s Directive on Impact Assessment was prepared in 2015. It outlines the legislative and policy requirements and accountabilities for the assessment of impacts of proposed projects within Parks Canada protected heritage places, which includes the Canal. In keeping with its mandated priorities, Parks Canada's EIA process examines how a project may lead to adverse effects on:

1. Natural resources, including Species at Risk, air, ground and surface water, soils, habitat features, as well as plants and animals found in the vicinity of a project or otherwise potentially affected by the project.
2. Cultural resources, including potential adverse effects to heritage value and character defining elements of known cultural resources, and risks to areas with high potential to contain cultural resources where no inventory has yet been completed.

In addition, the Parks Canada EIA process requires consideration of how the effects of a proposed project on natural resources may in turn cause:

1. Adverse effects to characteristics of the environment important to key visitor experience (how the project is anticipated to affect activities and/or visitors' enjoyment and connection to place, in relation to defined objectives for the protected heritage place).
2. Adverse effects to health and socio-economic conditions of First Nations and non-First Nations communities.
3. Adverse effects to First Nations communities' current use of lands and resources for traditional purposes

The Federal EIA process is part of the scope of this current project design phase, and shall continue into future project phases leading up to construction. Given the nature of the project and the sensitivity of the project area, Parks Canada's Director of Waterways has determined that the Detailed Impact Analysis (DIA) framework is to be used for the Federal EIA. The DIA is the most comprehensive level of assessment, intended for complex projects that require applied analysis of project interactions with valued components that may affect a particularly sensitive environmental setting or threaten one or more sensitive valued components.

Parks Canada, in consultation with the City and Project Team, prepared a Scoping Document for the DIA, which is included in **Appendix B**. The Scoping Document provides guidance on the following phases of the project that shall be addressed in the DIA:

1. Site preparation.
2. Construction.
3. Site restoration and rehabilitation.
4. Operation.

Decommissioning is not included as part of the scope of the DIA since it is anticipated that the bridge will have a life span of more than 100 years. As such, details regarding decommissioning works are not available at this time. If and when decommissioning is required, such works will be subject to impact assessment as per regulations current to that time.

The DIA shall describe and assess potential interactions (including timing, frequency, duration, residual effects, cumulative effects and mitigation) between the phases of the project noted above and various environmental components, focused within the project corridor. As outlined in **Table 2.3.1**, the environmental components are categorized as:

1. Valued Components, which represent the main focus of the DIA based on Parks Canada's mandate.
2. Secondary Components, which represent the secondary focus of the DIA, but are also reflective of Parks Canada's mandate.

Table 2.3.1: Valued and Secondary Components

Valued Components	Secondary Components
1. Greater Cataraqui Marsh Provincially Significant Wetland (PSW)	1. Groundwater quality and quantity
2. Fish and fish habitat	2. Terrain, geology and soils
3. Migratory birds and their habitat	3. Terrestrial wildlife
4. Species at Risk	4. Terrestrial vegetation
5. Surface water quality and quantity	5. Air quality and climate change
6. Hydrologic processes	
7. Aquatic habitat quality	
8. Aquatic wildlife and vegetation	
9. Surrounding cultural landscape	
10. Submerged cultural resources	
11. Rideau Canal's Commemorative Integrity	
12. Rideau Canal's Outstanding Universal Value	
13. Visitor experience and recreation	
14. Aesthetic values	
15. Navigation	

The nature and extent of consultations with First Nations communities (in accordance with the Duty to Consult protocol) and the general public shall also be documented as part of the DIA process.

Parks Canada has provided guidance to the City and Project Team during the DIA process. Parks Canada is also being assisted by the following Expert Federal Authorities:

1. Fisheries and Oceans Canada (DFO), pursuant to its role in administering the Fisheries Act.
2. Transport Canada (TC), in accordance with its role in administering the Navigation Protection Act.
3. Environment and Climate Change Canada (ECCC).

Finally, it should be noted that the ESR may be used if some or all of the DIA components are already provided in order to minimize duplication. As such, the evaluation, consultation and decision-making process for the DIA is being summarized through this Report. With this in mind, **Table 2.3.2** describes both the temporal and geographic scope for the DIA:

<table>
<tr><th colspan="5">Table 2.3.2: DIA Temporal and Geographic Scope</th></tr>
<tr><th rowspan="2"></th><th colspan="3">Temporal Scope</th><th rowspan="22">Geographic Scope</th></tr>
<tr><th>Preparation Phase</th><th>Construction Phase</th><th>Operation Phase</th></tr>
<tr><td>Valued Components:</td><td colspan="3" rowspan="11">1. Stage 1 / Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: see Figure 4.2 in Appendix B</td></tr>
<tr><td>Greater Cataraqui Marsh PSW</td></tr>
<tr><td>Fish and Fish Habitat</td></tr>
<tr><td>Migratory Birds and Habitat</td></tr>
<tr><td>Species at Risk</td></tr>
<tr><td>Surface Water Quality and Quantity</td></tr>
<tr><td>Aquatic Habitat Quality</td></tr>
<tr><td>Aquatic Wildlife and Vegetation</td></tr>
<tr><td>Cultural Landscape</td></tr>
<tr><td>Rideau Canal’s Commemorative Integrity</td></tr>
<tr><td>Rideau Canal’s Outstanding Universal Value</td></tr>
<tr><td>Visitor Experience and Recreational Opportunities</td><td colspan="3" rowspan="3">1. Stage 1 / Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: pre-design concept</td></tr>
<tr><td>Aesthetic Values</td></tr>
<tr><td>Navigation</td></tr>
<tr><td>Hydrologic Processes</td><td colspan="3" rowspan="2">1. Stage 1 / Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: see Figure 4.1 in Appendix B</td></tr>
<tr><td>Submerged Cultural Resources</td></tr>
<tr><td>Secondary Components:</td><td colspan="3" rowspan="3">1. Stage 1 / Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: see Figures 4.1 and 4.4 in Appendix B</td></tr>
<tr><td>Groundwater Quality and Quantity</td></tr>
<tr><td>Terrain, Geology, and Soils</td></tr>
<tr><td>Terrestrial Wildlife</td><td colspan="3" rowspan="2">1. Stage 1 / Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: see Figure 4.2 in Appendix B</td><td></td></tr>
<tr><td>Terrestrial Vegetation</td></tr>
<tr><td>Air Quality and Climate Change</td><td colspan="3">1. Stage 2 of the Class EA (see Figure 3 in Appendix B)
2. Pre-design scope: see Figure 4.3 in Appendix B</td><td></td></tr>
</table>

2.4 Mission Statement and Vision

The purpose of this current project design phase is to inform future project phases in accordance with the City's Action Plan. This also includes the continuation of the DIA process, pursuant to Section 67 of CEAA 2012. As such, the Project Team has prepared a Mission Statement, Vision and Values in **Table 2.4.1** to guide this multi-faceted process.

Table 2.4.1: Mission Statement, Vision and Values

A. Mission Statement	Continue to empower affected stakeholders in engaging in the pre-design of a new state-of-the art bridge which, by linking John Counter Boulevard and Gore Road over the Cataraqui River and the Canal, is functional and aesthetically appropriate within an established regulatory framework, and which advocates trust, and cultural, environmental, social and fiscal responsibility.
B. Vision	Through innovative planning, design, and consultation, the pre-design phase of the project will continue to reinforce the City's proud historic association with the Canal and its goal of becoming Canada's most sustainable City.
C. Values	
C.1 Cultural and Natural Heritage Integrity	1. Complement the heritage values of the Canal as a UNESCO World Heritage Site, National Historic Site of Canada and Canadian Heritage River. 2. Respect the customs and traditions integral to the distinctive cultures of First Nations communities. 3. Respect the history of engineering innovation with the Canal within a 21st Century design context. 4. Enhance the natural landscape of the corridor shore lands. 5. Ensure that impacts on Species at Risk are minimized and that there is no net loss of fish habitat and no net loss of wetland structure and function.
C.2 Healthy Community	1. Provide safe, cost-effective (in terms of capital, maintenance and lifecycle costs), convenient and accessible pedestrian, cycling, public transit and automotive circulation and connections. 2. Ensure through-navigation as a valued means by which to promote public understanding, appreciation and enjoyment of the Canal and the City's unique heritage and cultural character. 3. Achieve a design that is appropriate to and compatible with adjacent land uses, the immediate natural setting and the broader Belle Island and Canal contexts. 4. Provide functional and attractive lighting for motorists, public realms and bridge accentuation and which also mitigates light impacts on the natural environment. 5. Enhance day and night views towards the bridge by river users, non-motorists and motorists and maximize day and night viewing opportunities to the setting from the bridge for non-motorists and motorists.

Table 2.4.1: Mission Statement, Vision and Values	
C.2 Healthy Community	6. Maximize opportunities for the public to learn about the Canal, Belle Island and the Greater Cataraqui Marsh through such means as interpretive signage and public art.
C.3 Design Functionality and Integrity	1. Incorporate the constant gradual s-curve bridge alignment in order to reduce noise and visual impacts on Point St. Mark; provide softer landscaping options on the east shore; and reflect the 'urban-natural' transition point of the project corridor. 2. Incorporate the different elevations on both shores, while minimizing visual impacts. 3. Incorporate the arch over the navigable channel and adjacent rowing lanes to highlight the bridge as a 21^{st} Century 'gateway' to-and-from the Canal and Inner Harbour to the south. 4. Optimize the approach spans in order to minimize the related impacts to the natural environment. 5. Incorporate into the bridge deck and approach roadway design: a 2-lane cross-section for vehicular traffic; commuter cycling provisions on both sides of the vehicular cross-section; and a multi-use pathway network (on the south side of the bridge deck and on-land). 6. Confirm opportunities to incorporate utilities into the overall project design. 7. Incorporate safe and functional intersection designs at Montreal Street, Ascot Lane, Point St. Mark Drive and Highway 15.

Table 2.4.1: Mission Statement, Vision and Values

C.3 Design Functionality and Integrity	8. Incorporate observation look-out / interpretive nodes on the bridge deck and on-land to maximize opportunities for the public to learn about the Canal, Belle Island and the Greater Cataraqui Marsh. 9. Ensure the landscape improvements accentuate the public realm and provide a natural destination point. 10. Employ an integrated evaluation of net and cumulative environmental effects and prepare mitigation and enhancement design measures over the entire life cycle of the bridge. 11. Ensure the design integrates constructability and fabrication measures in order to reduce capital and future maintenance costs, environmental impacts as well as optimize the construction schedule. 12. Optimize the service life of the bridge by paying close attention to material quality and selection as well as life cycle costs in relation to identified capital and maintenance budget ratios.

3.0 BRIDGE AND APPROACH DESIGN CRITERIA

3.1 Parks Canada Bridge Design Guidelines

The Heritage Values and Guiding Principles for the Cataraqui River Sector of the Rideau Canal was prepared in 2010 in support of the Class EA process. It focuses the key heritage values of the lower Cataraqui section of the Canal on its historic, ecological and visual inter-relationships with the waterway and shorelands; the through-navigation of the Canal system itself; and its extensive wetlands and other natural heritage elements. These key heritage values are then reflected in the following strategic principles that serve to guide and inform the design of proposed development projects in the lower Cataraqui section of the Canal:

1. Recognize Parks Canada's jurisdiction of the Canal.
2. Protect natural and cultural heritage resources.
3. Maintain through-navigation of the Canal system.
4. Undertake First Nations consultations in accordance with the Federal Duty to Consult protocol.
5. Maintain view sheds and visual linkages.
6. Enhance public understanding and visitor experience of the Canal.

Parks Canada has also prepared bridge design guidelines that further articulate the strategic principles noted above for the lower Cataraqui section of the Canal. A draft of the design guidelines was originally prepared in 2010 by Parks Canada in support of the Class EA process. The draft guidelines were finalized on August 2, 2016 and incorporate the Heritage Values and Guiding Principles for the Cataraqui River Sector of the Rideau Canal noted above. Key highlights are summarized as follows:

1. The Canal warrants a world-class bridge design that:
   - a) Respects the natural and cultural heritage values of this part of the Canal as well as First Nations customs and traditions.
   - b) Is appropriate to and compatible with its natural setting to the north, the urbanized environment of the City to the south, east and west, and the Belle Island context, also to the south.
   - c) Responds to the Canal's history of engineering innovation and bridge design, but is an expression of its own time.
   - d) Supports a safe, enjoyable and memorable experience for bridge and Canal users.
2. Aesthetically, the bridge should respond to the significance of the Canal by achieving a landmark quality that is aesthetically pleasing. In more particular terms, it should:
   - a) Be an honest expression of its function.
   - b) Have a simple, economical form.
   - c) Be in scale with and compatible with its surroundings.
   - d) Minimize visual impact by maximizing transparency and lightness.
   - e) Use order, symmetry and rhythm to create harmony and visual balance.
   - f) Provide contrast and complexity through surface textures, colour and the play of light and shadow.
   - g) Use high-quality, durable and compatible materials.
   - h) Consider opportunities to introduce local stone and wood, particularly limestone.
   - i) Achieve timelessness through regular maintenance and by avoiding extremes of fashion or overt historicist references.
3. Key views should be taken into consideration, including:
   - a) Views to the bridge from the Canal's navigable channel and from the north and south.
   - b) Views to the Cataraqui Marsh and the slopes of the river valley from the Canal's navigable channel.

c) Views from the bridge to the Canal's navigable channel, the Cataraqui Marsh, the slopes of the river valley, Belle Island, the northern entrance to the Inner Harbour and the Kingston skyline.

4. The bridge design should take advantage of interpretive opportunities and views of the Cataraqui Marsh and the northerly portion of the Canal's navigable channel using signage, public art, viewing nodes and interpretive media along the bridge to educate and enhance the visitor experience.

5. The bridge design should maximize viewing opportunities from the bridge, including:

   a) Providing lookout vantage points or nodes along the bridge deck with seating, interpretive signage and public art.

   b) Providing minimum height barriers and open railings.

   c) Investigating the possibility of providing interpretation for boaters passing under the bridge.

6. The bridge design should enhance the pedestrian experience of the bridge by:

   a) Providing continuous open railings to optimize views.

   b) Using custom design to provide distinctive enhanced visual effects.

   c) Enhancing barrier-free design by providing lower inner barriers, custom-designed railings and innovative barrier wall terminations.

   d) Providing functional, high-quality and well-designed diffuse lighting that is simple and subtle.

   e) Ensuring that signage is well-integrated and planned with no overhead signs, both on the bridge and its approaches.

These guidelines will be used in support of the current project design phase and the continuation of the DIA into future project phases leading up to construction.

3.2 Design Codes

The design of the bridge will be undertaken in accordance with:

1. The Canadian Highway Bridge Design Code (CHBDC) CSA S6-14.
2. Ministry of Transportation Ontario (MTO) Structural Manual.
3. MTO's Geometric Design Standards for Ontario.
4. The Transportation Association of Canada (TAC) Geometric Design Guide for Canadian Roads.
5. The Post-Tensioning Institute (PTI): Recommendation for Stay Cable Design, Testing and Installation.
6. MTO Structural Manual.
7. Ontario Provincial Standards for Roads and Public Works.
8. Geometric Design Standards for Ontario (GDSOH).
9. FHWA, Wind Induced Vibration of Stay Cables, RDT 05-004.
10. Technical documents and/or memorandums issued by FHWA.

More specific bridge design requirements are as follows:

1. **Traffic Data:** The project corridor and adjoining roadways are classified as a future arterial road in the City's Official Plan. The annual average daily traffic (AADT) results in the roadway being a Highway Class A. The design speed of the roadway is 70 kilometres per hour (km/hr).

2. **Design Life:** The CHBDC requires a design life for new bridges of at least 75 years. The ESR stated that this bridge would have a design life exceeding 100 or even 120 years in terms of its structural elements and materials, intended function and maintenance requirements. As such, the bridge will be designed for a minimum 100-year design life. Structural components that cannot achieve a 100-year design life will be designed to be easily replaced. These components include: bearings, structural steel coating, asphalt and

waterproofing, electrical components, expansion joints, stay cables, etc. The replacement costs for these components have been included in the Life Cycle Cost Analysis in Section 8.19 of this Report.

3. **Loading:** The loading requirements for the bridge are as follows:

a) **Dead Loads:** The dead load of the bridge will include the weight of all components of the structure and appendages fixed to the structure. The material densities for common structural components are listed in **Table 3.2.1** and the superimposed dead loads are listed in **Table 3.2.2**.

Table 3.2.1: Unit Weights of Structural Components

Material	Unit Weight
Reinforced Concrete	24 kilonewton / cubic metre (kN/m^3)
Structural Steel	77 kN/m^3
Stay Cable Strand (Greased and Sheathed)	1.22 kilograms / metre (kg/m) (15.7mm dia. Seven-Wire Strand)

Table 3.2.2: Superimposed Dead Loads

Superimposed Dead Load	Unit Weight
Traffic Barrier – Median	5.5 kilonewton / metre (kN/m)
Traffic Barrier – Exterior	5.3 kN/m
Pedestrian Railing	1.4 kN/m
Drainage	2.6 kN/m
Paint	0.25 kN/m
Waterproofing and Asphalt	23.3 kN/m
Noise Barrier	1.4 kN/m

b) **Live Loads:** The bridge will be designed for the CL-625-ONT truck load and the CL-625-ONT lane load. The bridge will be designed to have two or three design lanes along the roadway whichever produces the governing loads. The multi-use pathway will be subjected to pedestrian loading of up to 4.0 kilopascals (kPa) and/or Maintenance Vehicle loading which has a gross loading of 80 kN.

c) **Seismic Loads:** The bridge has a classification of an irregular 'Major-Route Bridge' and a Site Class of D based on the site properties. Based on the fundamental period, the bridge is within Seismic Performance Category 2 and as such the seismic design will be based on the Performance Based Design method for the following performance levels:

i. 475 years event (10% probability in 50 years) – the service level is 'Immediate': "Bridge shall be fully serviceable for normal traffic and repair work does not cause any service disruption - and the damage level is 'Minimal'.";

ii. 975 years event (5% probability in 50 years) – the service level is 'Limited': "Bridge shall be usable for emergency traffic and be repairable without requiring bridge closure. At least 50% of the lanes, but not less than one lane shall remain operational. If damaged, normal service shall be restored within a month - and the damage level is 'Repairable'. Based on CSA S6-14, the design for this performance level is optional, unless required by the Owner or Regulatory Authority."; and

iii. 2475 years event (2% probability in 50 years) – the service level is 'Service Disruption': "The bridge shall be usable for restricted emergency traffic after inspection. The bridge shall be repairable. Repairs to restore the bridge to full service might require bridge closure - and the damage level is 'Extensive'."

The minimum analyses requirements for this bridge are Elastic Dynamic Analysis and Inelastic Static Push-Over Analysis.

4. **Wind Loads:** Based on the CHBDC, the bridge shall be designed based on the wind pressure associated with a return period of 50 years for which the hourly mean reference wind pressure, for a structure with a maximum span length less than 125 m, is 465 pascals (Pa) at this site. However, since the bridge is designed for a 100-year service life, it is prudent to design the bridge for a wind pressure of 520 Pa, based on a return period of 100 years.

5. **Ice Loads:** The effective crushing strength of ice is based on the principle that the ice breaks up and moves at melting temperature; is internally sound; and moves in large pieces. The 100 year ice thickness at the project corridor is estimated at 0.84 m. As such, the crushing strength of ice at the project corridor is estimated at 1100 kPa. The crushing strength will be used to calculate the dynamic ice force and the ice impact forces on the piers. A pressure of 5 kPa will be used for ice jams, as the clear opening between the piers is greater than 30 m.

   The ice impact load was considered at two different locations, the high elevation of 74.9 m which corresponds to the maximum of the average water levels between the months of December to April; and the low elevation of 73.0 m which corresponds to the ice loading on the footing. It is recommended that refined studies be carried out during detailed design to refine ice loading. Consideration should be given to using pier nosing and cut-water to minimize ice loading.

   The expected ice accretion thickness at this site as per the CHBDC is 31 millimetres (mm).

6. **Superimposed Deformations:** The bridge superstructure is classified as Type B: steel beams with concrete deck. For the City, the maximum mean daily temperature is 30° Celsius (C) and the minimum mean daily temperature is -30°C. An effective construction temperature of 10°C will be used for the design to balance the anticipated thermal movements of the structure.

7. **Vessel Collisions:** The bridge is classified as a Class 2 Bridge, signifying that the bridge has ‘regular importance’, and must remain open to emergency and security vehicles after a vessel collision. The design vessel for the calculation of the vehicle collision load is the Kawartha Voyageur which is 36 m long, 7 m wide and has 1.3 m draught. This is the largest vessel that regularly uses the Canal system. The total gross tonnage of the Kawartha Voyageur is 264 tonnes and it has a maximum speed of 7.6 knots (14.1 km/hr). The vessel collision load was applied to all piers.

8. **Barriers:** Based on the AADT, design speed, and geometry of the bridge, a TL-4 Performance Level traffic barrier is required. This will be required for the north barrier and the intermediate barrier. The south barrier will be subjected to pedestrian and cyclist loading as any maintenance vehicles will be travelling at slow speeds and, as such, will be designed to accommodate the CHBDC specified loading. The vehicular barrier on the north side will be extended to accommodate cyclists.

9. **Noise Walls:** All required noise walls will be designed in accordance with the CHBDC (as a light slender structure) and CAN/CSA-Z107.9, Standard for Certification of Noise Barriers.

10. **Scour:** The top of the riverbed is subject to scour and should be accounted for in the design. It is expected that scour protection will be required at the foundations.

11. **Cable Replacement/Loss:** As per the PTI, the structure will be designed to accommodate the replacement or loss of any cable.

12. **Highway and Municipal Roads:** Road design geometry in Ontario is based on MTO Geometric Design Standards for Ontario and the TAC Geometric Design Guide for Canadian Roads. Bridge geometry, as it pertains to the roadway elements, generally reference MTO standards. There are numerous geometric factors involved in highway design, including governing codes and standards, engineering design consensus and the impacts of such components as roadway/highway classifications, design speeds, traffic volume, curve radii and side clearances.

13. **Municipal Assets:** Examples of municipal assets that are to be designed in accordance with the City’s Technical Standards and Ontario’s Provincial Standards (where municipal standards are absent) include: road granular and asphalt pavement materials; buried infrastructure (pipes, manholes, catchbasins, services and other appurtenances); concrete curb, gutter and sidewalks; retaining walls; signage; and roadway painting and fencing.

The bridge will be designed to have redundancy with multiple load paths available. If it is not capable of providing multiple load paths, then internal redundancies will be detailed.

For this current project phase, the following material properties and strengths were used, as shown in **Table 3.2.3**.

Table 3.2.3 Material Properties for Third Crossing		
Material	**Location**	**Strength**
Concrete	Deck	30 MPa
	Piers/Abutments	30 MPa
	Caissons	30 MPa
Reinforcing	Carbon Steel	f_y = 400 MPa
	Stainless Steel	f_y = 420 MPa
Structural Steel	Approach Spans and Arches	f_y = 350 MPa (350 WT/350 AT)
Cables		f_{pu} = 1,860 MPa (15.7 mm dia. 7-wire strand – 140 mm^2 area)

3.3 Accessibility

In order to ensure that the project addresses both functional and accessible design elements, the Project Team met with a representative of the City's MAAC, and reviewed the current project design work through the lens of the City's Facility Accessibility Design Standards (FADS). As highlighted below, the FADS, which are currently under review by the City, apply mainly to accessible exterior circulation routes and associated elements for the project:

1. Accessible exterior circulation routes shall address the full range of individuals that may use them (e.g. wheelchairs, scooters, those pushing strollers, those travelling in pairs). As such:

   a) The City's existing minimum standard width of 1.5 m may be used.

   b) The running slope shall not be steeper than 1:25 (or 4%), unless accessible ramps are provided.

   c) Cane-detectable curbs at least 75 mm high shall be provided along the edges of planting beds and in areas where variations in grading are potentially hazardous.

   d) The cross slope shall not be steeper than 1:50 (or 2%).

   e) Exterior lighting shall be in compliance with Illuminating Engineering Society of North America (IESNA) Standards except in outdoor park settings, where routes are not normally illuminated, additional illumination is not required.

   f) Level rest areas shall be spaced no more than 30 m apart.

   g) Gratings and grills shall be located to one side.

Each of the components noted above include more specific design standards regarding such matters as the use of colour contrasting, directional signage, plantings (e.g. overhang), bench seating and street furniture design. Such standards, while of critical importance to the project, are beyond the scope of the current project design phase. It is recommended that the FADS continue to be reviewed and incorporated into the design work, should the project advance to the detail design phase.

3.4 Sustainable Design Strategies

The sustainable development of infrastructure is critical due to on-going concerns regarding its economic, environmental, and socio-cultural impacts on communities, and the need to provide holistic evaluations that guide the best investments of limited resources. The City and other major stakeholders have included sustainable development as major focal point for this project. As such, it is prudent to evaluate the overall life cycle of the bridge to ensure that the initial design optimizes performance and related costs (operations, maintenance and rehabilitation) in tandem.

1. Sustainable Development Charrette

A Sustainable Development Charrette was held on September 8, 2016 with representatives from the City, Project Team and other stakeholders. Its intent was to distill the overall sustainable development focus to specific goals, desired outcomes, and associated performance measures for the project. Each attendee was asked to consider design objectives from the perspectives of 'the City (Owner)', 'the community' and 'feasibility / local applicability' to decide which of the objectives should be viewed as having the highest priority. The design objectives and number of attendee responses (in parentheses) are shown in **Table 3.4.1.1**.

Table 3.4.1.1: Prioritized Sustainability Objectives from the Charrette

Owner Priorities	Community Priorities	Most Feasible/ Applicable
Safety (11)	Safety (13)	Improve Access and Mobility (12)
Improve Access and Mobility (10)	Engage Community Values and Sense of Place (13)	Safety (9)
Engage Community Values and Sense of Place (10)	Improve Access and Mobility (9)	Engage Community Values and Sense of Place (9)
Innovation (10)	Increase Lifecycle Efficiency (9)	Innovation (9)
Improve Local Economy (8)	Improve Local Economy (8)	Maintain Biodiversity (7)
Increase Lifecycle Efficiency (9)	Maintain Biodiversity (6)	Increase Lifecycle Efficiency (7)
Maintain Biodiversity (6)	Reduce Emissions to Air (5)	Optimize Waste Stream (4)
Optimize Waste Stream (2)	Innovation (5)	Improve Local Economy (4)
Reduce Energy Use (2)	Maintain or Improve Hydrological Regime Characteristics (1)	Reduce Virgin Material Use (2)
Maintain or Improve Hydrological Regime Characteristics (2)	Optimize Waste Stream (0)	Reduce Energy Use (2)
Reduce Emissions to Air (0)	Reduce Energy Use (0)	Maintain or Improve Hydrological Regime Characteristics (2)
Reduce Virgin Material Use (0)	Reduce Virgin Material Use (0)	Reduce Emissions to Air (1)

Table 3.4.1.1: Prioritized Sustainability Objectives from the Charrette

Numerous sustainability activities that are relevant to the project were also discussed at the charrette and possible key performance indicators for each activity were determined. Using these key performance indicators and supporting documentation, the potential scores in accordance with established sustainability design guidelines (e.g. TAC Sustainability Considerations for Bridges Guide; Institute for Sustainable Infrastructure: Envision) could be used to both calculate and monitor the extent to which sustainability for the project is being achieved. The feedback report from the charrette is included in **Appendix A.**

3.5 Specifications

The following major construction specifications and standards will govern the construction of the bridge:

1. Reinforcing Steel Institute of Canada, Reinforcing Steel Manual of Standard Practice (2004).
2. CSA, Concrete Materials and Methods of Concrete Construction / Test Methods and Standard Practices for Concrete (A23.1/A23.2).
3. CSA, Precast Concrete – Materials and Construction (A23.4).

4. CSA, Carbon-Steel Bars for Concrete Requirements (G30.18).
5. CSA, General Requirements for Rolled or Welded Structural Quality Steel/ Structural Quality Steel (G40.20/G40.21).
6. CSA, Design and Construction of Building Components with Fibre-Reinforced Polymers (S806).
7. Ontario Provincial Standards for Roads and Public Works.
8. MTO, Standard Special Provisions.
9. MTO, Non-Standard Special Provisions.
10. City of Kingston Standards and Specifications.
11. Standard details and specification from relevant utilities will be used, as required.
12. PTI, Recommendations for Stay Cable Design, Testing and Installation.
13. PTI, Specification for Grouting of Post-Tensioned Structures M55.1.
14. PTI/ASBI, Guide Specification for Grouted Post-Tensioning M50.3.
15. AASHTO / American Welding Society, D1.5 Bridge Welding Code.
16. ACI, Guide to Cold Weather Concreting (ACI 306R).
17. ACI, Guide to Curing Concrete (ACI 308R).
18. ACI, Guide to Hot Weather Concreting (ACI 305R).
19. ACI, Guide to Mass Concrete (ACI 207R).
20. ACI, Protection of Metals in Concrete Against Corrosion (ACI 222R).
21. Concrete Reinforcing Steel Institute, Specialty Steel Product Guide.
22. FHWA, Post-Tensioning Installation and Grouting Manual.
23. National Electrical Manufacturers Association Standards.

The schedule of items will be broken down in multiple sections. A preliminary item list of the sections for the bridge is as follows:

1. The General section, which will cover the general contract items such as traffic / pedestrian control plans, sediment and erosion control plan, field offices etc.
2. The Structural section, which will include all work associated with the bridge from the foundations, piers, abutments, structural steel girders, arch components, concrete bridge deck, barriers, joints, bearings, deck drains and pipes, etc.
3. The Roadway section, which will contain all items related to the approaches such as excavation, granular material, asphalt pavement, sidewalks and curbs, etc.
4. The Traffic section, which will include all work associated with the traffic handholes, concrete encased ducts, detector loops and traffic lights.
5. The Storm Sewers / Sanitary Sewers / Watermains section, which will contain all items related to the pipes, manholes, catchbasins, adjustments to existing manholes, etc.
6. The Electrical / Lighting section, which will include all the embedded work for the streetlighting, streetlights on the bridge and approaches including all posts and fixtures.
7. The Drainage section, which will contain all work associated with the stormwater management facility off of the bridge and drainage piping, catchbasins, etc. off the bridge.
8. The Landscaping section, which will include all items related to the vegetation, pathways, interpretive signs, etc.
9. The Utilities section, which will contain all utility requirements. It should be noted that specifications related to certain utility assets (e.g. electrical, telecommunications, etc.) may be subject to other specifications. In cases where either the design is not being completed by the utility provider or it abuts the utility itself, the provider must be consulted to confirm the specifications.

4.0 DIA AREA CONDITIONS

The Scoping Document prepared by Parks Canada (see **Appendix B**) provides guidance for the Federal DIA. It states that the DIA boundary shall be based on the Class EA study area, with a more focused assessment of the project corridor. This section of the Report discusses conditions within the DIA area.

4.1 Land Uses and Utilities

There are a wide range of environmental and land use features within the DIA area. These features, which are discussed throughout this Report, are highlighted below and are supplemented with **Drawing 4.1.1** to **Drawing 4.1.5**, which highlight the City's current Official Plan designations and overlay policies for the DIA area[1]:

1. The 'Central Business District' designation for the City's downtown core area, which serves to support and enhance the multi-faceted centre of the City and the surrounding region. It includes and accommodates the wide range of retail services, business offices, entertainment, cultural and recreational facilities, tourism and hospitality facilities, as well as institutional, open space and residential uses in the downtown core area.

2. The Cataraqui River, which has a water depth averaging 1.2 m except at the buoyed channel and the southern portion of the Inner Harbour. Watercraft navigation is an important feature of the DIA area, typified most directly by the Inner Harbour and Outer Harbour, the Her Majesty's Canadian Ship (HMCS) Cataraqui Facility immediately north of the LaSalle Causeway, the Kingston Marina (located in the Inner Harbour), Rideau Marina (located south of the Point St. Mark residential neighbourhood) and the Canal's navigable channel and the rowing lanes that run adjacent on either side of it. Most of these features are captured in the 'Harbour Area' designation, which also accommodates various water-related activities ranging from marine retail, mooring facilities, yacht clubs and rowing clubs (Kingston Rowing Club, Queen's University Rowing Club), to dry docks, marine salvage and repair services, tourism and hospitality uses.

3. The 'District Commercial' designation just south of Emma Martin Park and the Kingston Rowing Club on the west side of the Cataraqui River, which recognizes the character of the Woolen Mill as a designated cultural heritage property, its waterfront site and unique mix of land uses ranging from artisan workshops to businesses, professional offices and a restaurant.

4. Areas designated 'Residential' that pertain, in particular, to:

   a) The St. Lawrence Ward Heritage Area immediately adjacent to the downtown area to the north, which is one of the oldest areas of the City.

   b) The Barriefield Village Conservation District on the east side of the Cataraqui River, which contains historic residences, buildings, laneways and landscapes that reflect a 19th Century village setting.

   c) The Greenwood and Grenadier Village residential neighbourhoods, also located on the east side of the Cataraqui River.

   d) Within the project corridor specifically, the Village On The River apartments and the River Park subdivision along John Counter Boulevard (west side) and the Point St. Mark residential neighbourhood (east side).

5. The 'Environmental Protection Area' designation and associated natural heritage policy overlays, which includes:

   a) The Greater Cataraqui Marsh in recognition of its designation as a Provincially Significant Wetland and Provincially Significant Coastal Wetland.

   b) 'Riparian Habitat' areas extending from the confluence of the Cataraqui River and Lake Ontario up to and including the tributaries and channels within the Greater Cataraqui Marsh.

   c) The Provincially significant and contributory woodland areas along both sides of the Cataraqui River.

   d) An area extending 30 m from either shoreline of the Cataraqui River to encourage the protection of a 'ribbon of life' along the waterfront (note parks and pathways may be permitted in affected designated areas).

---

[1] As of the date of this Report, the City has recently passed By-law 2017-57, which is an Official Plan Amendment resulting from a statutory five-year review of the Plan. The Official Plan Amendment, which affects all lands within the City, has been submitted to the Ontario Ministry of Municipal Affairs and Housing, and will be in full force and effect after it has been reviewed and approved by same.

Drawing 4.1.1: City of Kingston Official Plan Schedule 3-A: Land Use

Drawing 4.1.2: City of Kingston Official Plan Schedule 7-A: Natural Heritage 'A'

Drawing 4.1.3: City of Kingston Official Plan Schedule 8-A: Natural Heritage 'B'

Drawing 4.1.4: City of Kingston Official Plan Schedule RC-1: Rideau Community

Drawing 4.1.5: City of Kingston Official Plan – Schedule 5 Pathways

6. The 'Open Space' designation, which includes park and open space areas as well as lands adjacent to the 'Environmental Protection Area' designation, such as Douglas Fluhrer Park, Emma Martin Park, Belle Park and Belle Island on the west side of the Cataraqui River.

7. A 'General Industrial' node south of the Canadian National Railway (CNR) line, east of Division Street and west of Montreal Street that contains older, heavy industrial uses.

8. The 'Business Park Industrial' designation for the St. Lawrence Business Park, which is also part of the Rideau Community Secondary Plan area and is located north of the Greenwood neighbourhood on the east side of the Cataraqui River. The St. Lawrence Business Park is intended to provide prominent locations for corporate administrative, research and development and related business industrial uses in a prestige, business park setting.

9. A 'Special Study Area' designation in the Rideau Community Secondary Plan area, which is subject to further planning and development analyses and includes:

   a) The Gore Road Library, which is located at the northwest corner of Gore Road and Highway 15 within the project corridor. The Gore Road Library is a designated cultural heritage property.

   b) The Pittsburgh quarry operation located north of the Gore Road Library.

10. The 'Institutional' designation, which serves to support and accommodate the City's major institutions, some of which are further designated as cultural heritage properties. Within the DIA area, the major institutions include:

   a) The Rideaucrest Home Long-Term Care Facility located on Rideau Street on the west side of the Cataraqui River.

   b) Fort Frontenac at the eastern end of Ontario Street adjacent the LaSalle Causeway which refers to both the archaeological remains of the 17^{th} century French fort (Fort Frontenac National Historic Site) and the present-day Department of National Defence barracks that occupy part of the same site.

   c) Canadian Forces Base (CFB) Kingston on the east side of the Cataraqui River which includes land and buildings for military purposes, armories, training facilities, administrative offices, residential accommodation, recreation facilities such as the Garrison Golf and Curling Club and complementary commercial support services.

   d) The Royal Military College (RMC), which is also part of the CFB Kingston land base and offers a wide variety of educational programs in Arts, Science, and Engineering at both the undergraduate and graduate levels.

   e) Fort Henry and the Kingston fortifications comprising Fort Frederick and the Murney, Shoal and Cathcart Martello Towers, which are part of the inscribed property of the UNESCO World Heritage Site for the Canal as well as National Historic Sites.

11. There are areas that either are or may be contaminated by a prior or current use, which are focused on the west side of the Cataraqui River at the former Davis Tannery site southwest of Belle Park and the Federal dredged sediment disposal site along the north shore of Belle Island.

12. The navigable channel within the Cataraqui River, which starts at the LaSalle Causeway and extends northwards as part of the Canal. Within the DIA area, the designated site of the Canal begins at Belle Island and follows the high-water marks on either shore, north to and beyond the limits of the DIA area.

13. There are a series of paths and trails for active transportation in various states of planned development. These include:

   a) A north-south route extending from the downtown-LaSalle Causeway along the west shoreline of the Cataraqui River and continuing northwest through City Centre Business Park and north of John Counter Boulevard and around Belle Park Fairways, ending north of John Counter Boulevard at Weller Avenue.

   b) A north-south route extending through the Point St. Mark residential neighbourhood and along the east shoreline of the Cataraqui River to and beyond Highway 401.

   c) Routes internal to Barriefield Village as well as the Grenadier Village and Greenwood Park subdivisions east of Highway 15.

   d) Though not shown on **Drawing 4.1.5**, the 2016 Waterfront Master Plan identifies the aforementioned recommended extensions to the pathway network within the project corridor from the Class EA, and links to those other areas noted above, particularly along the east and west shorelines of the Cataraqui River north and south of the project corridor.

There are also a series of commuter cycling lanes in various states of planned development. These include:

e) Routes along the main roads in the downtown area and extending north along Montreal Street up to and beyond Highway 401 with east-west routes connecting to Montreal Street at John Counter Boulevard and Benson Street-Dalton Avenue on the west side of the Cataraqui River.

f) Routes extending from the downtown, across the LaSalle Causeway and continuing along Highway 2 and Highway 15 on the east side of the Cataraqui River.

14. As shown on **Drawing 4.1.6** and **Drawing 4.1.7**, the major utilities highlighted below are present within the project corridor. This information was collected through specific consultations with utility providers:

a) **Hydro One:** Hydro One provides distribution voltage to parts of the City east of the Cataraqui River. From the Frontenac Transmission Station located on Division Street, 44 kV high voltage transmission lines carry power east towards the river. Within the project corridor along John Counter Boulevard from Montreal Street to the west shoreline, the high voltage transmission lines are located on overhead poles which are owned by Kingston Hydro. Two drop poles near the shoreline are connected to parallel transmission lines that extend underground to the west shoreline. These transmission lines connect to two pairs of submarine electrical cables (3-phase 44 kV line) which extend to the east shoreline, providing a major source of electrical service to the east end of the City. At the east shoreline, two sets of underground transmission lines follow the Gore Road corridor to Highway 15.

b) **Hydro One Lighting:** Hydro One owns and maintains overhead streetlighting east of the Cataraqui River.

c) **Kingston Hydro:** Kingston Hydro maintains distribution voltage and streetlighting on overhead poles along John Counter Boulevard, which provide electrical service to the River Park subdivision and other properties in the vicinity.

d) **UK (Lighting and Signalization):** UK maintains traffic signals at the John Counter Boulevard / Montreal Street intersection and the Gore Road / Highway 15 intersection as well as overhead streetlighting west of the Cataraqui River.

e) **UK (Sanitary):** The 900 mm Rideau Heights trunk sanitary main currently runs parallel to the west shoreline in close proximity to the proposed future west bridge abutment. In addition, a sanitary forcemain exists on the east shore within the Gore Road right-of-way.

f) **UK (Water):** Underground watermains are present within the John Counter Boulevard and Gore Road rights-of-way.

g) **Storm Sewers:** There is no piped storm system east of Montreal Street on the west approach. Storm sewers currently exist within the Gore Road right-of-way.

h) **Bell Canada:** Overhead and shallow buried services are located within the John Counter Boulevard and Gore Road rights-of-way.

i) **Cogeco Cable:** Overhead and shallow buried services are located within the John Counter Boulevard and Gore Road rights-of-way.

Gas infrastructure is not located within the project corridor.

Drawing 4.1.6: Existing Infrastructure: West

Drawing 4.1.7: Existing Infrastructure: East

4.2 Ecological Conditions

This section of the Report highlights ecological conditions within the DIA area. It is based on background information reviews, liaison with various regulatory bodies and fieldwork activities undertaken during the Class EA and current project design phase. The supporting report is found in **Appendix C**.

1. General

As shown on **Drawing 4.2.1**, within the DIA area, the following natural heritage features are identified:

1. The Greater Cataraqui Marsh is a PSW that extends from the Woolen Mill / Barriefield area in the southern portion of the DIA area to just north of Highway 401. It is also a Provincially Significant Coastal Wetland which means: its water levels are largely controlled by a Great Lake (Lake Ontario); it is a wetland that is within the floodplain of a Great Lake (Lake Ontario); and it is on a tributary to a Great Lake (Lake Ontario).

   The Greater Cataraqui Marsh PSW is internationally important as one of the most intact drowned-river mouth Great Lakes Coastal Wetlands in North America. The mean size for all 122 Great Lakes Coastal Wetlands in Lake Ontario and the St. Lawrence River is 150 hectares (ha), while the Greater Cataraqui Marsh PSW is 504 ha. The Canal's navigable channel is excluded from these designations.

2. Most of the identified Provincially significant and contributory woodlands in the DIA area are in narrow, fragmented strips, except for areas on the former Davis Tannery site, Belle Park Fairways, along the visible cattail portion of the Greater Cataraqui Marsh north of John Counter Boulevard and Belle Island whereon its old oak grove is well-documented for its ecological significance.

3. Areas of Natural and Scientific Interest (ANSI), which are areas having identified life science or earth science values, are focused on the visible cattail portion of the Greater Cataraqui Marsh and the buffering woodlands on both sides of the Cataraqui River more than 120 m north of the project corridor.

4. The Cataraqui River, its seven tributaries, and the Greater Cataraqui Marsh PSW (including its visible cattail portion north of John Counter Boulevard) provide significant habitat for a wide range of terrestrial and aquatic wildlife species, including feeding areas for migratory waterfowl, over 200 bird species (at least 21 of which are dependent on the marsh for nesting habitat), at least 26 sport and forage fish species that use the river system for spawning, nursing and rearing, and 16 amphibian and reptile species.

5. Available data on mammal populations is more limited, but at least 25 species have been observed or reported.

6. Further to the above, the Cataraqui River and its shoreline are considered animal movement corridors. The river provides a linkage for fish species moving from Lake Ontario and the St. Lawrence River to upstream areas. The 30 m riparian area along the river, referred to earlier as a 'ribbon of life' in the City's Official Plan, also enables wildlife to move along the shorelines between habitats.

2. Project Corridor

The more detailed accounting of ecological conditions within the project corridor is divided into the following four sub-sections:

1. Ecological Land Classifications.
2. Faunal Species Inventory Findings.
3. Greater Cataraqui Marsh Wetland vegetation.
4. Marine ecology.

(A) Ecological Land Classifications

Ecological Land Classification (ELC) is an integrated approach to surveying and classifying land and resources. Its goal is to reduce complex natural variation to a reasonable number of meaningful ecosystem units. Development of the ELC mapping during the Class EA involved background information reviews, liaison with various regulatory bodies, a number of site visits (June 14, 2008; May 26 and June 11, 2009; and July 25, July 28, August 27 and September 3, 2010), and aerial reconnaissance. This assessment was then supplemented during the current project design phase by additional background information reviews and fieldwork, the latter of which occurred on June 13 and July 2, 2016.

Drawing 4.2.1: Ecological Conditions

As shown on **Drawing 4.2.2**, there are no ELC community types on the west side lands. This has remained unchanged since the Class EA. The land is dominated by cultural influences, including John Counter Boulevard, which slopes down to the Cataraqui River shoreline and is used as a boat launch; single dwellings; light industries; the River Park subdivision; and the Village On The River apartments. Manitoba Maple is the main tree species present, growing along the road rights-of-way and on the residential properties. Ornamental garden plants are also present on some of the residential lots. European Buckthorn is the main shrub in the area. The bulk of the ground cover plants are weedy species typically found along road edges, such as Ragweed, Burdock, Sow Thistle and Mullein. No trees that are listed in either the Provincial Endangered Species Act (ESA) or the Federal Species at Risk Act (SARA) are present.

As also highlighted on **Drawing 4.2.2**, there are four ELC community types found on the east side lands, which have remained unchanged since the Class EA:

1. A 'Cultural Thicket' (CUT) community type is found within the Gore Road right-of-way. It is characterized as having a shrub cover greater than 25% and a tree cover of less than 25%.

   There are a few large diameter Sugar Maple, Red Oak, White Oak and Bur Oak trees that are likely over 100 years old, and a number of shrub-sized White Ash and Manitoba Maple, but the overall dominant species that characterizes this area is European Buckthorn. Other shrub species include Tartarian Honeysuckle, Staghorn Sumac, and Riverbank Grape. The ground cover is mostly weedy non-native species such as Knapweed, Burdock, Trefoil, Fragrant Bedstraw (native), Thistles, Dames Rocket, Crown Vetch, and Garlic Mustard.

   Many of the dominant plant species present are considered Category I invasive species[2].

   Site disturbances include an underlay of large rock fill, making much of the Gore Road right-of-way roughly 6 m to 8 m higher in elevation than the woodlot to the north.

   The shoreline component (about the first 20 m) of the Gore Road right-of-way is dominated by tree cover, but this area is too small to be considered a separate ELC community. The main tree species along the shoreline is Crack Willow, but Manitoba Maple and European Buckthorn are also noted down to the shoreline. Off-shore, there is little wetland vegetation, possibly due to the deposited rock fill and the existing limestone pavement. A fringe of Narrow-leaved Cattails extends to the north and south.

   A second CUT patch is located west of the Gore Road Library, and extends into the off-leash dog park. Weedy species are common. Riverbank Grape is abundant along with Buckthorn and Staghorn Sumac, though there is no clear dominant species. Manitoba Maple is the most common tree.

2. 'Dry-Fresh Sugar Maple – White Ash Deciduous Forest' (FOD5-8) is found north of the Gore Road right-of-way and extends northward in fragmented segments to the Pittsburgh quarry operation. This forest type is typical of lands that have a history of disturbance.

   The dominant canopy tree species is Sugar Maple, with lesser amounts of White Ash. Manitoba Maple, Ironwood, Black Cherry, Shagbark Hickory, Basswood, Red Oak and White Oak are also present. It appears, based on historic photographs from 1945, 1953, 1962 and 1978, that much of the FOD5-8 forest area was used for agricultural purposes. This would coincide with the mostly young age of the woodlot, with many of the trees in the 30-year range. There are a few older trees in the 80-100 year range that, in the historic aerial photographs, are isolated within the agricultural areas.

   This woodlot has a high degree of edge due to its uneven shape, and has high fragmentation due to the numerous trails within it. Common trees in the edge include Manitoba Maple and White Ash, but European Buckthorn dominates, with Garlic Mustard as a common understory plant. Overall, the Buckthorn-dominated edge areas are almost greater in size than the area dominated by Sugar Maple.

   The woodlot also contains two drainage routes (shown as circles on **Drawing 4.2.2**). The drainage routes collect groundwater from the Point St. Mark residential neighbourhood and direct it to the Cataraqui River. The more easterly drainage route discharges at the base of the rock fill, near the current Gore Road-Point St. Mark Drive intersection. The other drainage route discharges within the FOD5-8 area, roughly 50 m west and 20 m north of the first discharge point at the base of the rock fill. During the site visits as part of the Class EA, the drainage routes were seen to be dry only once. During the site visits in support of the current project design phase, more than one seep was observed. As such, this area qualifies as significant wildlife habitat, including the forest ecosite that contains them.

---

[2] Category I species are those species that can dominate a site to the exclusion of all other species and remain on-site indefinitely.

Drawing 4.2.2: Ecological Land Classifications Community Types

The shoreline component of the FOD5-8 area has an approximate 15 m wide verge of wetland vegetation that is too small to be considered a separate ELC community type.

3. A 'Cultural Woodland' (CUW) area is found in the southwest quadrant of the Gore Road-Point St. Mark Drive intersection. This area is also too small (less than 0.5 ha) to be considered a separate ELC type, but it is noted here. Like the nearby FOD5-8 woodland, Sugar Maple and White Ash are common, but numerous other tree species are also present, many of which were likely planted. The ground cover and shrub layers are mostly weedy non-native species.

4. The two 'Cultural Meadow' (CUM) patches, like most cultural meadows within urban settings, are dominated by weedy species and both have a history of disturbance. The more easterly CUM area adjacent to Highway 15 is part of the off-leash dog park.

Combined, the ELC communities on the east side lands are small (less than 40 ha). However, they are within 30 m of the Cataraqui River which is a waterbody, and associated with significant natural and cultural heritage features. As such, these woodlands are identified as Provincially significant and contributory in the current Official Plan.

(B) Faunal Species Inventory Findings

Information on endangered or threatened species was gathered concurrent with the ELC fieldwork during both the Class EA and the current project design phase. Highlights are as follows:

1. A total of 73 bird and waterfowl species have been identified, of which there are currently four at risk bird species having a moderate-to-high probability of occurring within the project corridor:

   a) The Barn Swallow, which is listed as 'threatened' under the Provincial ESA, with no status under the Federal SARA. This species was observed foraging within the project corridor. Potentially suitable nesting habitats in privately owned buildings and the rock cut along the CNR line (west side) were also noted.

   b) The Chimney Swift, which is listed as 'threatened' under the Provincial ESA (species and habitat protection) and Federal SARA (species protection). Although this species was not observed during the fieldwork, it is known to occur within the project corridor. Potentially suitable nesting habitats in privately owned buildings (abandoned chimneys) and large cavity trees were also noted.

   c) The Common Nighthawk, which is listed as 'special concern' under the Provincial ESA and 'threatened' under the Federal SARA. Although this species was not observed during the fieldwork, it is known to forage over open habitat areas within the project corridor.

2. Although very few turtles were observed during the fieldwork, it is recognized that the project corridor supports turtles, most notably:

   a) The Blanding's Turtle, which is listed as 'threatened' under the Provincial ESA (species and habitat protection) and Federal SARA (species protection). Although this species was not observed, it is known to occur within the project corridor. Potentially suitable nesting habitats along and close to the Cataraqui River shoreline (in open areas, gravel shoulders, parking lots and residential lawns) were also noted.

   b) The Northern Map Turtle, which is listed as 'special concern' under the Provincial ESA and Federal SARA. This species was observed within the project corridor. Potentially suitable nesting habitats close to the Cataraqui River shoreline (in open areas, gravel shoulders, parking lots and residential lawns) were also noted.

   c) The Snapping Turtle, which is also listed as 'special concern' under the Provincial ESA and Federal SARA. Predated nests and eggs were observed within the project corridor.

3. The project corridor was assessed during the current project design phase for its potential to support bat maternity roosts. Potentially suitable habitat is present for:

   a) The Small-footed Bat, in the rock faces and talus along the CNR line (west side). This species is listed as 'endangered' under the Provincial ESA (species and habitat protection), with no status under the Federal SARA.

   b) The Little Brown Bat and the Northern Bat, in the large cavity trees on the Gore Road Library property (east side) as well as the large cavity trees near-shore and in privately owned buildings (west side). Both species are listed as 'endangered' under the Provincial ESA (species and habitat protection) and Federal SARA (species protection).

c) The Tri-coloured Bat, in the foliage and leaf clumps in all treed areas within the project corridor. This species is listed as 'endangered' under the Provincial ESA (species and habitat protection) and Federal SARA (species protection).

4. The Butternut Tree is listed as 'endangered' under the Provincial ESA (species and habitat protection) and Federal SARA (critical habitat has yet to be established). This species is often found in hedgerows, along stream banks, on wooded valley slopes and in deciduous and mixed forests. Although Butternut Trees were not observed in publicly accessible areas within the project corridor during the fieldwork, they may be present on privately owned lands.

5. 12 taxa of butterflies and dragonflies were identified during the fieldwork as part of the current project design phase. Of these species, the Monarch Butterfly is listed as 'special concern' under the Provincial ESA and Federal SARA. Although this species was not observed, butterflies generally may use virtually any of the areas within the project corridor as migratory stopover habitat, particularly the east side lands where there is a mixture of forest and open areas.

6. Other fauna species present are those normally found in a near urban site and are mostly considered habitat generalists (e.g. Beaver, Eastern Chipmunk, Red Squirrel, White-tailed Deer, Eastern Gartersnake, American Toad, etc.). There is some species movement, including Red Fox that may hunt in the area as well.

(C) Greater Cataraqui Marsh Wetland Vegetation

Drawing 4.2.3 illustrates four vegetation communities within the project corridor, which were documented during the Class EA in a manner generally consistent with both wetland evaluation protocols and the Ontario Wetland Evaluation System (OWES):

1. The majority of the project corridor passes over only one vegetation type (suW1) and the balance over open water areas (OW). The suW1 community is a vegetation community with only one vegetation form (submerged vegetation), dominated by Milfoil. The OW areas are non-vegetated areas, which in this area is due to the maintenance of dredged channels for watercraft. As noted above, these areas are not part of the Greater Cataraqui Marsh PSW.

2. The suW2 community is found along the west shoreline. It consists of two vegetation forms (submerged vegetation and floating-leaved plants), dominated by Milfoil and Waterlilies.

3. The reM3 community is made up of two vegetation forms (robust emergents and narrow-leaved emergents), dominated by Cattails and Grasses.

4. The reM6 community consists of two vegetation forms (robust emergents and ground cover), dominated by Cattails and Purple Loosestrife. It is proximate to Belle Island.

The Class EA concluded that these vegetation communities had changed very little over the past 20 years. This assessment has been reviewed during the current project design phase and its relevance to date is re-confirmed.

(D) Marine Ecology

The Cataraqui River is roughly 1,150 m wide at the project corridor and has water depths ranging from about 1.2 m over the majority of the section to approximately 4.5 m at the navigable channel. Water flow speed is estimated to be 0.4 metres / second (m/s). The riverbed substrate consists of soft, unconsolidated muck. The shoreline substrate includes bedrock, boulders, cobbles, gravels and fines. Some areas are hardened with large boulders and/or rip rap. The shorelines also have a variety of riparian vegetation types such as wetland, forested areas that are limited mainly to the east shoreline, manicured parkland with scattered trees and manicured grass to the water's edge. The shorelines are exposed to wave action from boats passing through the navigable channel.

The Cataraqui River, as part of the Greater Cataraqui Marsh PSW, is listed as having a regional significance in terms of fish spawning and rearing potential. Fish habitat is considered to be warm-water, though salmonids are known to migrate north towards Kingston Mills.

Drawing 4.2.3: Greater Cataraqui Marsh Vegetation Communities

As shown on **Drawing 4.2.4**, in order to assess the potential impacts from a bridge on aquatic habitat, the project corridor was divided into west side, mid channel and east side zones during the Class EA. Information on fish and fish habitat was collected by:

1. 5 shoreline and 12 offshore transects to confirm substrate, riparian and aquatic vegetation and available cover conditions.

2. Fish community sampling using a boat electroshocker and bag seine net. The boat sampling was done during the night on April 12, July 19 and October 17, 2010. The seine netting was completed during the day at four sites on July 20 and October 18, 2010. All fish were identified, measured [fork length (FL) or total length (TL) depending on the species] and released unharmed prior to continuing to the next site.

The fieldwork results from the Class EA were reviewed during the current project design phase and their relevance to date is re-confirmed. These results are summarized in **Table 4.2.1**, and the profiles of the shoreline habitat are shown on **Drawing 4.2.4**. The habitat within the project corridor is fairly homogenous, consisting of a slow moving glide with fine sediments and dense submergent vegetation. The aquatic vegetation along the shoreline within the bay created by Belle Island consists mainly of extremely dense floating and submergents with a thin band of emergent cattails. Offshore, but still within the bay at the mid channel sites, the vegetation is chocked with dense submergent vegetation. The navigable channel contains the deepest habitat, but lacks aquatic vegetation. The presence and role of the Canal's channel helps to reduce the density of aquatic vegetation within the channel and along the east side of the Cataraqui River.

The only spawning activity observed during the field sampling consisted of Yellow Perch which were found spawning throughout the mid channel sites during the spring visit. However, the presence of young-of-the-year (YOY) Pumpkinseed, Bluegill, Largemouth Bass and the occasional Rock Bass and Brown Bullhead suggests that these species are also spawning within the project corridor.

Overall, the fish species found during the Class EA fieldwork were mainly common warm to cool water sport and forage fish that prefer slow moving water bodies and spawn within aquatic vegetation or algae. The sportfish captured were Northern Pike, White Sucker, Yellow Bullhead, Brown Bullhead, Rock Bass, Pumpkinseed, Bluegill, Largemouth Bass, Black Crappie and Yellow Perch.

In addition, based on records reviewed during the current project design phase, the Cataraqui River is known to provide habitat for the American Eel as it migrates to spawning areas. This species is listed as 'endangered' under the Provincial ESA, with no status under the Federal SARA.

4.3 Cultural Heritage Conditions

This section of the Report highlights cultural heritage conditions within the DIA area. It is based on background information reviews, liaison with various regulatory bodies and fieldwork activities (on June 14 and 23, 2011) undertaken during the Class EA. This assessment has been reviewed during the current project design phase and its relevance to date is re-confirmed. The supporting reports are included in **Appendix D**.

1. General

As shown on **Drawing 4.3.1**, there are 72 identified cultural heritage sites within the DIA area, highlights of which are as follows:

1. The LaSalle Causeway, which is a municipally listed property and its Bridge Office and Shop portion is also a Federal heritage building.

2. The Canal, which is a 202 km long waterway, built by the Royal Engineers between 1826 and 1832 to provide a secure alternate supply route in the event of a military blockade by the Americans. The Canal is a UNESCO World Heritage Site (designated in 2007), National Historic Site (designated in 1925), Canadian Heritage River (designated in 2000) and Federally regulated navigable waterway (which is officially closed to watercraft from Thanksgiving to Victoria Day). Within the DIA area, the designated site of the Canal (for all three designations) begins at Belle Island and follows the high-water marks on either shore, north to and beyond the limits of the DIA area. The inscribed property of the UNESCO World Heritage Site includes the Canal National Historic Site as well as the Fort Henry and Kingston fortifications (Fort Frederick and the Murney, Shoal and Cathcart Martello Towers) National Historic Sites in the southern portion of the DIA area.

Drawing 4.2.4: Aquatic Vegetation and Fish Sampling Sites

Table 4.2.1: Summary of Shoreline Habitat Profiles and Fish Sampling Results

	West Side Zone						Mid Channel Zone				East Side Zone						
	Shoreline Transect		Offshore Transect				Offshore Transect				Shoreline Transect			Offshore Transect			
	A	B	1	2	3	4	5	6	7	8	C	D	E	9	10	11	12
Shoreline Habitat Profile	White water-lily and stonewort at shoreline. 100% in-stream cover. Substrate was soft / mucky.	Reed canary grass, cattails, flowering rush buckthorn, nannyberry, staghorn sumac at shoreline. 20% in-stream cover near-shore, up to 60% offshore. Substrate was firm.									Reed canary grass and broad-leaved cattail at shoreline. 30% in-stream cover near-shore, up to 70% offshore. Substrate was firm with a mix of boulders / fines.	Reed canary grass, hog-peanut, black medick, common buckthorn, dogwood, red oak, crack willow and white ash at shoreline. 20% in-stream cover near-shore, increasing to 50% offshore. Substrate was firm with a mix of boulders / fines.	Reed canary grass, cattails, fern, nannyberry, white ash, field bindweed, meadowsweet at shoreline. Sparse in-stream cover observed in Fall only. Substrate was firm.				
Spring Fish Sampling:																	
No. of Fish			174	163	155	107	173	179	198	95	N/A	N/A	N/A	165	106	72	85
Summer Fish Sampling:																	
No. of Fish			59	81	125	106	81	108	68	90	102	99	242	54	26	29	20
Fall Fish Sampling:																	
No. of Fish			97	69	194	55	147	183	26	61	155	232	160	167	161	436	299

Note:

1. The percentage of sportfish captured with the boat electrofisher and seine net were 83% and 86%, respectively.
2. The boat electrofishing catch across all the offshore transects was represented mainly by Yellow Perch (35%), Pumpkinseed (34%), Brook Silversides (10%) and Bluegill (8%).
3. The seine net catch at the shoreline transects was represented mainly by Yellow Perch (67%), Round Goby (9%), Pumpkinseed (7%) and Largemouth Bass (6%).

Drawing 4.3.1: Cultural Heritage Resources

3. On the east side of the Cataraqui River:

   a) The Barriefield Village Conservation District which encompasses the entire village, including its buildings, landscape features, topography, and archaeological sites and resources. Buildings are not individually designated, but are protected as elements of the district. Management of the district is governed by a Conservation Plan, which strives to: maintain the low density residential profile of the Village; avoid destruction of its built and landscape fabric; maintain the visibility of St. Mark's Church; and preserve its viewscapes from the Village towards the Cataraqui River and St. Lawrence River, Fort Henry and downtown Kingston.

   b) As noted above, the Fort Henry site and RMC site comprise many overlapping designations, including a portion of the Canal's UNESCO World Heritage Site designation at Fort Henry, four National Historic Sites (Fort Henry, Point Frederick Buildings, Navy Bay and Kingston Fortifications), 35 Federal heritage buildings and numerous plaques erected by Federal, Provincial, municipal and private authorities. The heritage value of these sites includes important viewscapes, both between the various sites and to-and-from other significant landmarks, such as Kingston Harbour, City Hall and the Barriefield Village Conservation District.

   c) There are three Federal heritage buildings at CFB Kingston on the east side of Highway 15 and two other farmhouse properties that are municipally designated on both sides of Highway 15, north of Gore Road.

4. On the west side of the Cataraqui River:

   a) Fort Frontenac which refers to both the archaeological remains of the 17th century French fort (Fort Frontenac National Historic Site), and the present-day Department of National Defence barracks (formerly Tête du Pont Barracks) that occupy part of the same site, at the eastern end of Ontario Street.

   b) Within the area bound by Ontario Street, Queen Street, Montreal Street, and North Street there are 45 identified cultural heritage properties, including municipal listings and designations, plaques erected by various government authorities and private organizations, and a Federal heritage building. Well-known heritage properties include the Kingston Armouries, Wellington Terrace, St. Paul's Anglican Church and burial ground, Cataraqui School, and the Wellington Street Brewery.

   c) The area north of North Street has comparatively few identified heritage properties. The City has designated five properties (including the old stone Imperial Oil building, the Woolen Mill, the stone Depot School, the Grand Trunk Railway Station property and the stone Grand Trunk Railway Terrace) and listed six properties.

2. Project Corridor

The more detailed accounting of cultural heritage conditions within the project corridor is divided into the following three sub-sections:

1. The Rideau Canal.
2. The Gore Road Library.
3. The west side lands.

(A) The Rideau Canal

UNESCO World Heritage Site designations are based on 10 criteria. The Canal's designation in 2007 was based on two of these criteria[3], namely:

1. That it remains the best preserved example of a slackwater Canal in North America demonstrating the use of European slackwater technology in North America on a large scale. It is the only Canal dating from the great North American Canal-building era of the early 19th century that remains operational along its original line with most of its original structures intact.

2. That it is an extensive, well preserved and significant example of a Canal which was used for a military purpose linked to a significant stage in human history, that of the fight to control the north of the American continent.

---

[3] There are eight other UNESCO World Heritage Site designation criteria that do not apply to the Canal. These criteria relate to the interchange of human values within cultural areas, traditional human settlements, living traditions having outstanding universal significance, or areas representing natural, ecological, or biological phenomena.

The Statement of Outstanding Universal Value for the Rideau Canal UNESCO World Heritage Site further reflects these two criteria, wherein it states that:

> "The Rideau Canal is a large strategic Canal constructed for military purposes which played a crucial contributory role in allowing British forces to defend the colony of Canada against the United States of America, leading to the development of two distinct political and cultural entities in the north of the American continent, which can be seen as a significant stage in human history."

Parks Canada is responsible on behalf of the Federal government for managing and protecting the Canal as a National Historic Site and Canadian Heritage River. Parks Canada is also responsible on behalf of the UNESCO World Heritage Committee for ensuring that the Outstanding Universal Value is maintained and enhanced, and that the integrity (wholeness and intactness) and authenticity (expression of value through attributes such as use, function, location and setting) of the Canal is protected and preserved.

Parks Canada's mandate regarding the Canal is further reflected in its Commemorative Integrity Statement (CIS), which was approved in 2000 in support of the Canal's designation as a National Historic Site. The CIS reflects the Canal's unique historic and natural environment, including its rich and varied landscapes. It identifies the following three strategies to ensure the protection and enhancement of this section of the Canal:

1. Maintaining through-navigation of the Canal system to help assure the preservation of the Canal's unique historic environment and cultural resources.

2. Safeguarding the heritage character of corridor shore-lands from inappropriate development or uses.

3. Safeguarding the landmarks, viewscapes and natural ecosystem features of the Canal's islands, shore-lands and wetlands that are related to the construction of the Canal and which are part of the Canal's unique historical environment.

In the spirit of both guiding the bridge design process and confirming its own role as an approval authority, the bridge design guidelines highlighted in Section 3 of this Report articulate the heritage values and strategic principles of the section of the Canal within which the project corridor is located.

(B) The Gore Road Library

The Gore Road Library is located at the northwest corner of Gore Road and Highway 15. It was acquired by the City in 1997, and designated as a cultural heritage property in 2007 under By-Law No. 2007-166. The cultural heritage value of the property lies in its physical and design values:

1. The physical / design value of the property resides in the 19th century stone house as a finely crafted example of the vernacular Classical Revival style; in the dry stone wall, which is one of only a few surviving examples of 19th Century dry stone walls in the area; the remains of the formal gardens around the house; and in the remnants of farming activities, including barns, barn foundations and orchards.

2. The historical / associative value of the property lies in its historic associations with the Ruttan and the Hay families.

3. The contextual value of the property pertains to its landmark status along Highway 15 as a Library, park, off-leash dog park, and its views of the Canal.

By-Law No. 2007-166 lists heritage attributes of the property which must be conserved in order to retain its heritage value. These include: i) the interior and exterior of the stone house; ii) the dry stone wall; iii) the evidence of historic garden and farming activities; iv) the intangible associations with the Ruttan and the Hay families; v) the pathways and views of the Canal; vi) the role of the property as a Library and centre for community activities; and vii) its status as a landmark along Highway 15.

(C) The West Side Lands

There are neither cultural heritage properties on the City's heritage list, nor any properties with potential cultural heritage value on the west side lands from John Counter Boulevard west up to Montreal Street.

4.4 Landscape and Viewscape Conditions

This section of the Report highlights landscape and viewscape conditions within the DIA area. It is based on background information reviews and site visits undertaken during the Class EA. This assessment has been reviewed during the current project design phase and its relevance to date is re-confirmed. The supporting reports are included in **Appendix D**.

There are two landscape character types within the DIA area. The lower Cataraqui section of the Rideau Canal south from Highway 401 to the northern entrance of Kingston's Inner Harbour near Belle Island is a rare example of the waterway where the natural environment was not altered during Canal construction. Over the intervening 178 years, the extensive wetlands of the Great Cataraqui Marsh, as well as the river valley's sloped physiography and forested landscapes adjacent to the Canal's navigable channel have remained largely intact. This natural setting has contributed to the unique historical, ecological and visual environment of this section of the waterway, which is further reinforced in Parks Canada's 'Rideau Corridor Strategy Landscape Character Assessment & Planning and Management Recommendations of the Rideau Corridor'.

As shown on **Figure 4.4.1** to **Figure 4.4.3**, as boaters proceed from the Highway 401 crossing southward (roughly 4 km north of the Inner Harbour entrance), the visible cattail portion of the Greater Cataraqui Marsh dominates the landscape at first, with its shallow water and emergent aquatic plants, near continuous overhanging tree canopy and shrub understory. The City's urban landscape then becomes increasingly more visible in the background as boaters pass through the visible cattails. At roughly 1 km north of the Inner Harbour entrance near Belle Island, the project corridor emerges, where the natural landscape evolves into an increasingly urban, more manicured landscape against the backdrop of Belle Island immediately to the south.

Figure 4.4.1: On Water View Looking South (at Buoy S65)

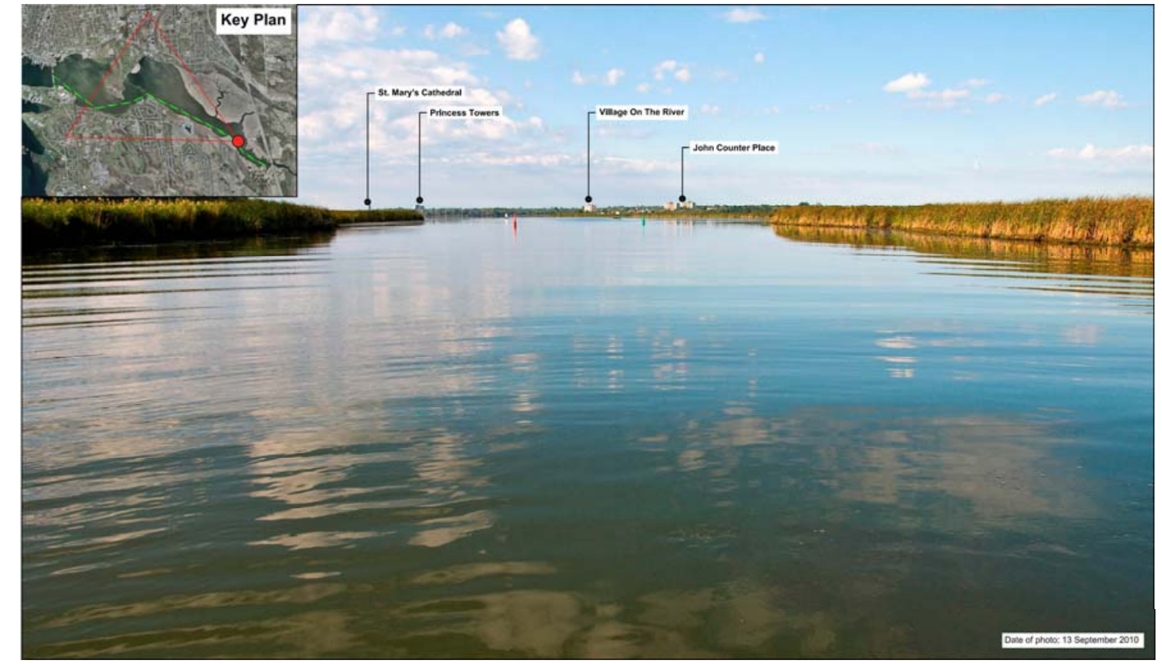


Figure 4.4.2: On Water View Looking South (at Buoy S47)

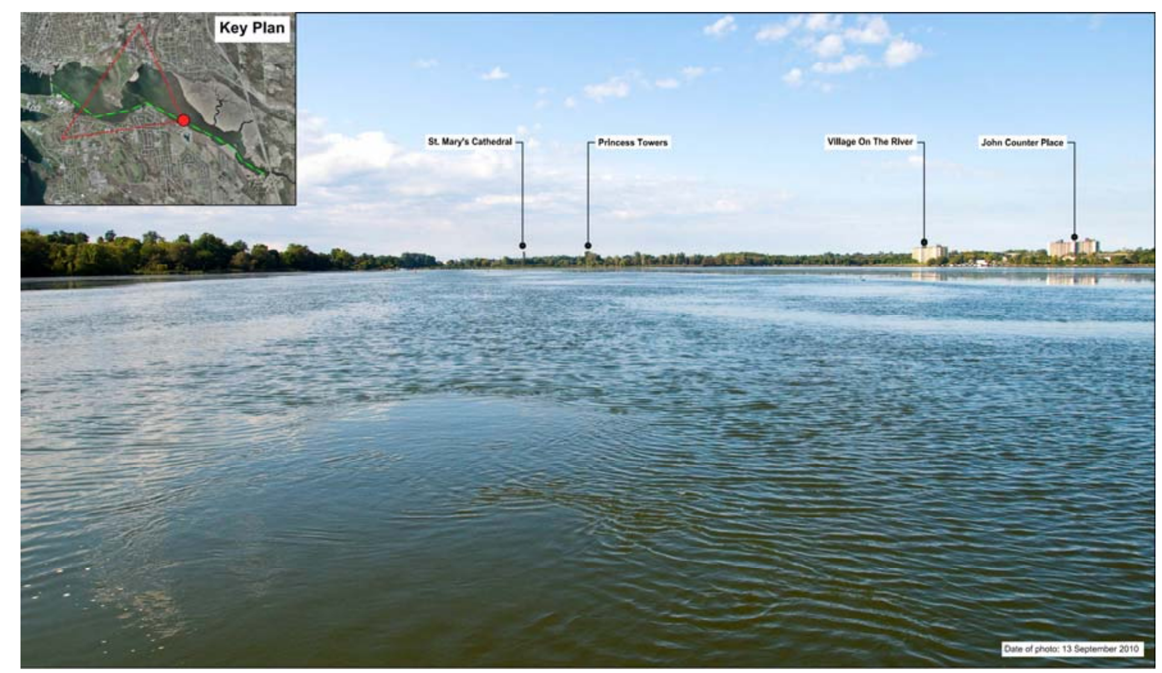


Figure 4.4.3: On Water View Looking South (at Buoy S33)

Views further south of Belle Island are blocked by the tree line along the northern portion of Belle Park and Belle Island as well as by the extension of the eastern shoreline whereon the Gore Road

Library, Point St. Mark residential neighbourhood and Rideau Marina are located. As shown on **Figure 4.4.4,** views of the project corridor are similarly blocked by these features for boaters proceeding from the LaSalle Causeway northward.

Figure 4.4.4: On Water View Looking North (at Buoy S15)

This includes the protected views related to Fort Henry and Kingston fortifications in the southern portion of the DIA area. As shown on **Figure 4.4.5**, views of the Inner Harbour are obscured in the background at Fort Henry, not only by distance but also by the CFB Kingston and RMC facilities in the foreground. Furthermore, the tree line along the southern portion of Belle Park and Belle Island, in conjunction with the proximate extension of the eastern shoreline, blocks views to the project corridor, and the remaining DIA area further north to Highway 401. This context establishes a more limited impacted viewshed as a project design consideration.

Figure 4.4.5: Fort Henry View Looking North

4.5 Archaeological Conditions

This section of the Report highlights archaeological conditions within the DIA area. It is based on background information reviews, liaison with various regulatory bodies and fieldwork activities undertaken during the Class EA. More specific site reconnaissance within the project corridor included:

1. Stage 2 archaeological testing, including focused Stage 3 testing, of the east side lands.
2. A sonar survey of the riverbed to both locate buried objects and prepare a riverbed profile.
3. Extracting riverbed sediment cores at 10 locations by Vibrocoring to determine the potential for marine archaeological resources.
4. Test pitting along both the east and west shorelines.

This assessment has been reviewed during the current project design phase and its relevance to date is re-confirmed.

1. General

Table 4.5.1 highlights the cultural history of the Kingston area.

Table 4.5.1: Cultural Chronology of the Kingston Area

Period	Timeframe	Description
Paleo	Circa 12000-10000 Before Present (BP)	The first inhabitants of Ontario lived in small family-based groups, depending on plants and large game animals (moose, deer, caribou, elk) for their food. These nomadic peoples used stone, skin, antler bone, wood, and plant fibres to produce the tools and goods necessary for their survival. A survey of Allen Point along the Rideau Canal system north of Kingston Mills resulted in the identification of a late Paleo point, the first recorded find from this period in Kingston.
Early Archaic	Circa 5000 Before Christ (BC)	Early Archaic peoples produced a greater variety of items than their predecessors. Of particular importance were the dugout canoes and stone tools made by grinding rather than by flaking. The water craft allowed the Early Archaic peoples to travel greater distances, facilitating the exchange of new ideas and goods.
Middle Archaic	Circa 3000 BC	The early people who inhabited Eastern Ontario during the Middle Archaic Period participated in a trade network that spanned the Great Lakes region. For example, copper obtained from the shores of Lake Superior was traded in Eastern Ontario, where it was made into awls, needles, knives, fish hooks, spear points, and bracelets. The earliest recorded human burials in Eastern Ontario date to the Middle Archaic Period.
Late Archaic	Circa 700 BC	Changes that characterized the Late Archaic Period include increased population size, distinction in social status, and new hunting techniques. Evidence of these changes is the inclusion of trade goods in the burial of selected individuals and tool kits consisting of a variety of projectile point types.
Early Woodland	Circa 300 BC	Peoples living in Eastern Ontario began to use pottery during the Early Woodland Period. Early pots were crudely made, with thick walls and a distinct cord-marked exterior surface. The practice of including grave goods with burials continued, influenced by the Adena Culture, centred in the Ohio River Valley, and the Middlesex tradition, which was focused in New York State.
Middle Woodland	Circa 900 Anno Domini (AD)	During the Middle Woodland Period regionally distinct pottery styles developed, and trade networks began to disintegrate. Ceramic vessels were of a higher quality than previously, and appeared in a greater range of shapes and with a greater variety of decorations. The disintegration of trade networks toward the end of this period coincided with the decline of major cultural influences centred in Ohio and Illinois. Agriculture was introduced to Eastern Ontario towards the end of the Middle Woodland Period. Middle Woodland sites are located throughout the region including the 1000 Islands, the Cataraqui River (Belle Island), the Gananoque River System and along the Napanee River system. Middle Woodland ceramics were recovered in

Table 4.5.1: Cultural Chronology of the Kingston Area

Period	Timeframe	Description
		the excavation of Fort Frontenac suggesting that this was once the location of settlement prior to the arrival of the Europeans.
Late Woodland	Circa 1600 AD	Domesticated plants (corn, beans, and squash) increased in significance as supplements to the more traditional foods such as deer, fish, and wild plants during the Late Woodland Period. Agriculture allowed the Late Woodland Peoples to live in permanent villages. Increasing conflict between groups resulted in the construction of palisades around some of these villages. There is only one identified permanent settlement that can be attributed to this period in the region and it is located in the Cataraqui Creek area. This is a proto Huron or Middleport site. The Kingston Outer Station was a fishing camp utilized throughout the Late Woodland period.
Proto-Historic	Circa 500 to 350 BP	Distinguished by the introduction of European influences prior to the actual settlement of the region. This was a turbulent period for Aboriginal populations in the area. The St. Lawrence Iroquois located just east of the region had been absorbed into other Iroquoian peoples, including the Mohawk, Onondaga and Wendat-Huron, by the time of Champlain's arrival in the area in 1612. The Huron, initially located along the north shore of Lake Ontario, moved to the Lake Simcoe-Georgian Bay area where they too were eventually dispersed in 1649. Fort Frontenac, established in 1673, was the first permanent European settlement in the region. Also established were a series of mission sites along the north shore of Lake Ontario including one in the Napanee area and La Presentation near the present day site of Ogdensberg New York. By the early 18th century, the Iroquois had been driven from the north shore of Lake Ontario by the Mississauga.
Historic	15th Century to Today	Kingston benefited considerably by the presence of the military and developed fairly quickly through the early-to-mid-19th century. The War of 1812 increased activity and development of military property in the region. The potential for shipwrecks and associated marine structures in the area is high.

Given the rich ecological resources of the Cataraqui River and the archaeological evidence found in nearby areas, the DIA area in all likelihood would have been used and periodically inhabited by peoples for the last 10000 years or more. Archaeological evidence of this has yet to be verified and archaeological potential in some areas may have already been removed due to subsequent urban development. Still, since a large percentage of the DIA area remains essentially unaltered, indicators point to virtually the whole DIA area exhibiting high archaeological potential, except for:

1. The land-based features of Belle Park Fairways, the Pittsburgh quarry operation as well as the Rivers Edge and Point St. Mark residential neighbourhoods.

2. The marine-based features associated with the in-water development of the LaSalle Causeway, the HMCS Cataraqui Facility, the Rideau Marina, the Federal dredged sediment disposal site along the north shore of Belle Island, the Canal's navigable channel as well as the existing marine utilities associated with the River Street Pumping Station and Hydro One marine electrical cables within the project corridor.

Areas within the DIA area containing known or potential archaeological resources include the following:

1. Significant archaeological resources are present on both sides of the LaSalle Causeway. Despite the extent of modern developments in that area, intact archaeological remains representing Pre-Contact First Nations, French and British Military Periods (especially at Fort Frontenac, RMC and Fort Henry), and remains relating to subsequent urban development are present.

2. The area between the LaSalle Causeway and Belle Island contains 14 registered Euro-Canadian shipwrecks in its southern portion and intact Euro-Canadian archaeological remains relating to subsequent urban development.

3. Belle Island contains an extensive Middle Woodland Period archaeological settlement site and cemetery. Only two small portions of the island have been archaeologically tested and the archaeological potential of the untested areas is very high. Despite recent developments, portions of the shoreline opposite Belle Island also have a high archaeological potential for Pre-Contact First Nations, Historic First Nations, and Historic Euro-Canadian archaeological sites. The archaeological significance of Belle Island is further reinforced by the 2001 City Council resolution acknowledging Belle Island as a site of significant Aboriginal cultural heritage. This resolution engaged a strategy that was subsequently formalized through negotiation between the City and representatives of local First Nations communities and is embodied in an agreement that was endorsed by City Council in 2006. The framework of the agreement includes a process that would set Belle Island physically apart from the mainland and place Belle Island under the joint ownership of the City and the Mohawk Nation Council of Chiefs.

4. The Kingston Outer Station site north of Belle Island and John Counter Boulevard on the west side of the Cataraqui River contains intact archaeological remains of a Pre-Contact First Nations and Historic First Nations hunting and fishing camp.

5. While other areas north of Belle Island have had minimal development disturbance to date, there is high potential for Pre-Contact and Historic First Nations archaeological remains in this portion of the DIA area.

2. Project Corridor

The more detailed accounting of archaeological conditions within the project corridor is divided into the following three sub-sections:

1. The east side lands.

2. The west side lands.

3. Marine environment.

(A) The East Side Lands

The east side lands, based on the Stage 2 archaeological testing during the Class EA, are typical of what much of the lower Cataraqui River valley must have looked like before modern development. As shown on **Drawing 4.5.1**, from the Cataraqui River shoreline, the land rises in a series of steps, controlled by the horizontally bedded limestone bedrock which underlies the area. Exposed limestone bedrock is present at the shoreline. Proceeding easterly, a foreshore backs on to a steep, 2 m high forested bank. The land to the rear of the bank is generally level. The southern half is heavily forested and the northern half consists of open meadow. The eastern margin of these areas is defined by an abrupt rise in elevation, consisting of a bedrock and talus scarp face. Above the scarp, the terrain is essentially level limestone plain. The Gore Road Library lies on the level plain, between the scarp edge and Highway 15.

As also shown on **Drawing 4.5.1**, there were two areas from which cultural materials were recovered during the Stage 2 archaeological testing:

1. Archaeological Site BbGc-127 which, based on subsequent Stage 3 investigations, identified a small dwelling area or camp, dating to the last decades of the 18th century.

2. A stone survey marker on the south boundary of the Gore Road Library (Lot 10 in the Concession East of the Great Cataraqui River).

(B) The West Side Lands

Visual examination of the west side lands suggests that virtually all lands within the existing road rights-of-way have been disturbed to the extent that any archaeological testing in those areas is almost certain to be futile. On the other hand, the private lands on either side of John Counter

Boulevard do not appear to have been extensively disturbed and may contain areas where archaeological potential still remains. However, since archaeologists have no right of access to conduct archaeological testing on private lands, further assessment of the west side lands continues to be suspended, and will be resumed if the project proceeds to the detail design phase.

(C) Marine Environment

The findings from the marine archaeological fieldwork were as follows:

1. The riverbed is relatively featureless aside from the scour lines caused by boat traffic, which are present near the west shore and at the centre of the river. Mounds were also identified near the navigable channel, which were verified as spoil from previous dredging activities of the channel.

2. The paleo-environment suggests a marsh environment, similar to the existing marsh to the north, wherein small, isolated areas of raised elevations are evident as opposed to a discrete, submerged paleo-shoreline.

3. There was neither evidence of, nor potential for, marine archaeological resources.

4.6 Geo-Environmental Conditions

This section of the Report highlights geo-environmental conditions within the DIA area. It is based on background information reviews, liaison with various regulatory bodies and fieldwork activities undertaken during the Class EA and current project design phase. The supporting reports are included in **Appendix E** and **Appendix F**.

1. General

Within the DIA area, there are approximately 750 +/- sites where on-site operations have had spills reported to have either ‘high’ or confirmed environmental impacts (285 +/- sites), ‘medium’ or possible environmental impacts (270 +/- sites), or ‘low’ or no anticipated environmental impacts (200 +/- sites).

Historically, the lands on the west side of the Cataraqui River from the LaSalle Causeway to just north of John Counter Boulevard were more heavily industrialized than in other portions of the DIA area. **Drawing 4.6.1** highlights areas having the highest densities of potential environmental impact. These include:

1. The Downtown area bounded by Brock Street, Barrie Street, North Street and Ontario Street.

2. The Cataraqui Street / Orchard Street / River Street area.

3. Joseph Street between Montreal Street and Patrick Street.

4. Segments of Montreal Street in the downtown area and between Raglan Road and James Street, Stephen Street and Railway Street, John Counter Boulevard and Drennan Street as well as Weller Avenue and Sutherland Drive.

5. Belle Park and its vicinity.

6. Areas bounded by Hickson Avenue, Harvey Street, John Counter Boulevard and Montreal Street.

7. The southwestern portion of the Inner Harbour, where sediment contamination has been found to exceed Provincial and Federal guidelines.

Drawing 4.5.1: East Side Terrestrial Archaeological Fieldwork Area

Drawing 4.6.1: Highest Densities for Potential Environmental Impact

2. Project Corridor

Drawing 4.6.2 and **Drawing 4.6.3** highlight geo-environment findings from a field survey undertaken on June 8, 2016 during the current project design phase:

1. 919 Montreal Street is currently occupied by an automobile collision centre. An above ground storage tank (AST) was formerly present at the collision centre (no longer present based on a visual assessment of the exterior of the building). Due to historical presence of the AST, combined with the on-site land use, this location is considered a Potential Contaminating Activity (PCA). Given the nature of the operation, this PCA is considered to have resulted in an Area of Potential Environmental Concern (APEC).

2. 931 Montreal Street is the former location of B & S Transmission Service. It is possible that this former land use was located on the northeast corner of Montreal Street and John Counter Boulevard. The presence of a former transmission service garage is considered a PCA. Previous information also identifies this property was contaminated by metals and petroleum hydrocarbons but was subsequently remediated and redeveloped. However, impacts may have subsequently migrated on-site (with no remediation), and is therefore considered a potential APEC.

3. A fenced yard was observed at the east end of John Counter Boulevard where it meets the Cataraqui River. The yard contained several drums, an abandoned recreational vehicle, a shipping container and several piles covered with tarps. Drum and vehicle storage is considered a PCA. Since this site is within the proposed laydown area on the west shore, this PCA is considered an APEC.

4. Fill and vent pipes were observed at 630 and 612 John Counter Boulevard indicating the presence (or former presence) of a heating oil storage tank at the residences. The operation of fuel oil storage tanks is considered a PCA, however, it is likely that these storage tanks are ASTs which are more common in residential homes. If the latter applies, this would lower the degree to which the PCA may have resulted in an APEC. But regardless, both PCAs are still considered APECs, since both sites are within the proposed laydown area on the west shore.

5. 603 John Counter Boulevard was previously occupied by a marina. Marinas typically offer fueling services for boats which is considered a PCA. In addition, boat building and repairs at the marina also occurred, which is a PCA. These PCAs are considered an APEC, since the site is within the proposed laydown area on the west shore.

6. Fill of unknown origin may be present under the roadways and is considered a PCA and an APEC. In addition, fill was reportedly placed along the west shoreline and likely associated with the former railway alignment between John Counter Boulevard and the Cataraqui River.

7. Past use of de-icing agents (road salt) along the roadways should be considered a PCA in the context of off-site soil management. However, this is not considered an APEC in terms of in-situ condition.

Geo-environmental sampling was also undertaken in conjunction with the geotechnical investigations highlighted in Section 4.7 of this Report. The sampling was done to confirm potential areas for subsurface impacts that might affect materials management. Soil samples were recovered using split spoon sampling equipment from 12 of the 15 boreholes (BH) that were advanced within the project corridor (BH16-205, BH16-206 and BH16-209 did not recover enough material for analysis)[4]. The results are as follows:

1. Regarding soil samples collected in boreholes from the west abutment area:

    a) All the soil samples exceed 2011 MOECC Table 1 [Full Depth Background Site Condition Standards – Residential / Parkland / Institutional / Industrial / Commercial / Community (R/P/I/I/C/C) Property Use] standards for soil.

    b) Despite the above, select chemical parameters from BH16-203 and BH16-204 meet:

        i. 2011 MOECC Table 3 [Full Depth Generic Site Condition Standards in a Non-potable Groundwater Condition – Residential / Parkland / Institutional (R/P/I) Property Use] standards for soil; and

[4] The management of excavated soil and fill in Ontario is regulated under the Environmental Protection Act, which is managed and enforced by the MOECC. The management of excavated sediments in the Cataraqui River is regulated under the Canadian Environmental Quality Guidelines (CEQGs), which is managed by the Canadian Council of Ministers of the Environment (CCME) and enforced by Parks Canada.

Drawing 4.6.2: Geo-environmental Findings – Field Survey East Shore

Drawing 4.6.3: Geo-environmental Findings – Field Survey West Shore

ii. 2011 MOECC Table 7 [Generic Site Condition Standards for Shallow Soils in a Non-Potable Ground Water Condition – Industrial / Commercial / Community (I/C/C) Property Use] standards for soil.

Material excavated at these locations during construction could be re-used on-land at the project corridor or within the City's right-of-way network.

c) Select chemical parameters from BH16-202 and BH16-201 exceed MOECC Table 17 and Table 3 (R/P/I) standards but meet MOECC Table 3 (I/C/C) standards. An exception was that MOECC Table 3 (I/C/C) is exceeded for sodium absorption ratio from a depth of 2.29 m to 2.9 m below ground surface (bgs) in BH16-201. Material excavated from this depth at this location during construction would need to be analyzed further (for sodium absorption ratio) for soil management purposes to determine if the exceedance is persistent.

2. Soil samples collected in boreholes from the east abutment area meet 2011 MOECC Table 1 standards for soil. Material excavated at these locations during construction would be considered 'inert fill'.

3. In-river sediment samples were collected from depths of 1.3 m to 2.8 m below the mudline. All sediment samples meet the Canadian Council of Ministers of the Environment (CCME) sediment quality guidelines for probable effects level.

   Should in-river material be brought to land during construction, it would then be considered soil and evaluated under MOECC soil standards. Once on-land, the material would have to be dewatered using such accepted methodologies as settlement ponds, geotubes or filter presses.

   A comparison to the MOECC soil standards demonstrates that the sediment material at depths greater than 1.3 m below the top of the sediment:

   a) Does not meet MOECC Table 1 (R/P/I/I/C/C) standards for metals. Therefore, restrictions would be placed on where disposal could occur.

   b) Meets MOECC Table 3 (I/C/C) standards, and therefore could be used on a Table 3 site elsewhere in the City or re-used on-site following a risk management assessment.

4.7 Geotechnical Conditions

This section of the Report highlights geotechnical conditions within the DIA area. It is based on background information reviews, liaison with various regulatory bodies and fieldwork activities undertaken during the Class EA and current project design phase. The supporting reports are included in **Appendix G**, **Appendix H** and **Appendix I**.

1. General

The DIA area is located in the physiographic region of Southern Ontario known as the Napanee Plain. The Napanee Plain is flat to undulating, and is characterized by relatively shallow soil deposits overlying bedrock. Geologic mapping indicates that the bedrock within the Napanee Plain consists of grey limestone/dolostone of the Gull River Formation, which contains some shale partings and seams.

The overburden soils within the Napanee Plain generally consist of glacial till, although alluvium is present in river and stream valleys. In the southern portion of the Plain, low-lying areas are typically covered with deposits of stratified clay. Water well records indicate that the average depth to bedrock within the Napanee Plain is approximately 2 m. However, in many areas, bedrock outcrops are observed at ground surface, while deeper soil deposits (in the order of 10 m) are present in the northern portion of the Plain and within and adjacent to river valleys throughout the Plain.

As shown on **Drawing 4.7.1**, the DIA area is generally characterized by shallow limestone bedrock. Where overburden is present, it consists mostly of post-glacial silts and clays. Much of the Cataraqui River bank south of Highway 401 and north of Weller Avenue as well as Belle Park (excluding the Federal dredged sediment disposal site along the north shore) are lined with organic deposits. The elevation of the Cataraqui River is at roughly 74.5 m (+/-). The bedrock at either shoreline is at elevation 73 m (+/-) which dips to elevations that vary from 36 m to 55 m (+/-) within the Cataraqui River. This 'bedrock valley' is made up of clay soils and organic deposits.

Drawing 4.7.1: Geotechnical Conditions

2. Project Corridor

The geotechnical fieldwork undertaken in the project corridor during the Class EA included a geotechnical subsurface investigation and an electrical resistivity imaging (ERI) survey. As shown on **Drawing 4.7.2**, the bedrock surface appears to be variable across the corridor. The bedrock is exposed or near surface on both sides of the Cataraqui River (at an elevation of 73 m at the east bank and 76 m at the west bank) and then dips to elevations ranging from elevation 30 m to elevation 55 m within the river. Limestone, present on the banks of the river, is underlain by a 3 m to 5 m layer of Shadow Lake shale. The ERI profile indicates that Precambrian rock is likely present beneath the shale across the whole corridor. There are two zones where low resistivity is observed within the bedrock beneath the river, centered at distances of 320 m and 970 m along the survey line. These areas are most likely associated with the Frontenac Axis.

As also shown on **Drawing 4.7.2**, the subsurface conditions of the project corridor consist of overburden soils that vary from limited thickness (2 m to 3 m) at the river banks to about 40 m within the river. Along the banks, the overburden consists of fill over peat over silty clay or glacial till. Within the river, the overburden consists of peat over silty clay.

The geotechnical fieldwork during the Class EA was supplemented by additional fieldwork during the current project design phase. It was carried out from September to October 2016 and included boreholes and Seismic Cone Penetration Tests (SCPTs) that were put down at 15 locations within the river channel and on-land along the east and west approaches. As shown on **Drawing 4.7.3**, the boreholes were advanced at 7 proposed V-pier locations; 1 at each of the 2 proposed abutment locations; and 6 along the approach. SCPTs were put down adjacent to three of the in-water boreholes.

The 2016 fieldwork was carried out in two phases. The first phase included advancement of the in-water boreholes and SCPTs from a barge-mounted drill rig within the river channel. Archaeological monitoring of the in-water boreholes was also carried out with representatives of the Huron Wendat First Nation. The second phase included advancement of the on-land boreholes at the proposed approaches and abutments, as well as geophysical testing consisting of down-hole Vertical Seismic Profiling (VSP) or Multi-Spectral Analysis of Surface Waves (MASW) surveying at the proposed abutment locations.

As also shown on **Drawing 4.7.3**, the bedrock is exposed or near surface on both sides of the Cataraqui River and then dips within the river to elevations ranging from elevation 29 m (encountered at a borehole put down within the western portion of the river channel) to elevation 54 m (encountered at a borehole put down within the eastern portion of the river channel). Sedimentary bedrock is present on-land and consists of dolostone at the west abutment, and limestone at the east abutment. The overburden in the river channel is underlain by metamorphic gneissic bedrock.

Along the banks, the overburden typically consists of fill overlying peat and silty clay to depths of up to about 4.5 m, but typically less than 2 m. Within the river channel, the overburden is up to 46 m deep and consists of several metres of organic river bottom deposits overlying an extensive deposit of silty clay to clay. Glacial till or granular deposits were encountered directly above the underlying bedrock in three of the six in-water boreholes.

In general, the proposed bridge piers will be located within the river channel where the overburden is deep (between 20 and 46 m below the river surface) with the exception of the easternmost pier, where the bedrock is within 1 metre of the existing ground surface. The bridge abutments will be located on-land where the bedrock is within 4.5 m of the existing ground surface.

Drawing 4.7.2: Electrical Resistivity Imaging Survey Results

Drawing 4.7.3: Geotechnical Survey – Borehole Stratigraphy

4.8 River Hydrology and Hydraulics

This section of the Report highlights river hydrology and hydraulic conditions within the DIA area. It is based on background information reviews and liaison with various regulatory bodies undertaken during the Class EA. This assessment has been reviewed during the current project design phase and its relevance to date is re-confirmed.

1. Water Conditions

As noted earlier, the Cataraqui River has a water depth averaging 1.2 m except at the buoyed channel and the southern portion of the Inner Harbour. Water levels are primarily defined by the water levels in Lake Ontario. The Cataraqui River is a slow moving waterbody with flow velocities ranging from negligible to 0.4 m/s.

The historic water levels for Kingston depending on the months of the year are shown in **Figure 4.8.1**. Basic water levels at the site are summarized in **Table 4.8.1**.

The ESR has taken into account variable water levels on Lake Ontario, Cataraqui River discharges, and waves and surges associated with wind setup on the Cataraqui River from both winds from the north and the south. Water levels were also analyzed for both ice and ice free periods. The ESR indicates that:

> "The water level at the proposed crossing is largely a function of the water level in Lake Ontario, and under most typical conditions on the watercourse, can be assumed to be equal to Lake Ontario levels. Under conditions of significant wind or seiches in the Lake however, the water level at the site may be slightly higher or lower than lake levels."

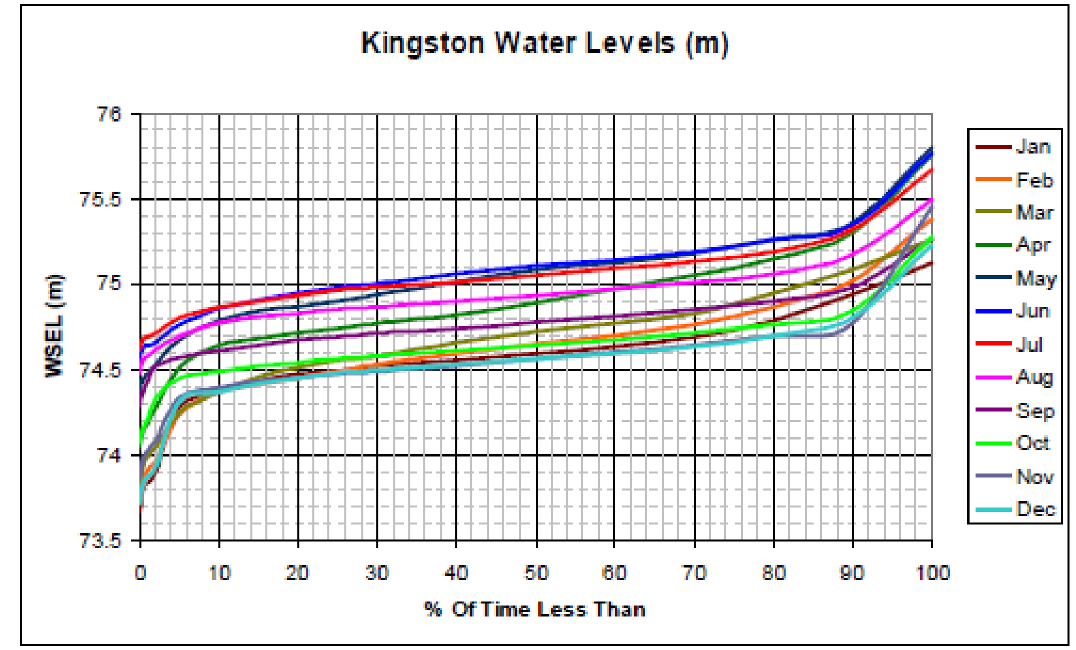


Figure 4.8.1: Historic Water Levels at Kingston

Table 4.8.1: Relevant Site Water Levels		
Condition	**Water Surface Elevation (WSEL)**	**Reference**
Low Water Datum (LWD)	74.16 m	Canadian Hydrographic Service (Lake Ontario)
Average High Water (AHW)	75.26 m	Ministry of Natural Resources (Lake Ontario)
Regulatory Floodplain	76.3 m	CRCA

2. Ice

Winter ice cover is variable from year to year. It is not typically established until mid-to-late December, and can last up to late April. This indicates that thick lake ice does not develop until early February. An analysis of annual measured extremes would suggest that the ice can get as thick as 0.84 m and would have a strength of 1100 kPa under dynamic (100 year) ice conditions. Due to low flow velocity of the river at the project corridor, the ice tends to melt in place. Current speeds of approximately 0.4 m/s should be assumed for dynamic ice loading conditions.

Recommended ranges of water levels for ice conditions at the project corridor are shown in **Table 4.8.2**.

Table 4.8.2: Ice Cover Water Levels (December through April)

Condition	WSEL
Long Term Average (Static Ice)	74.49 m to 74.84 m
Historic Extremes (Static Ice)	73.70 m to 75.61 m
100 Year Extreme (Dynamic Ice)	73.65 m to 75.86 m
Winter Surge Conditions	-0.25 m to +0.47 m

3. Scour

As part of the Class EA, general and local scour estimates were prepared based on the hydraulic modelling and as per CHBDC requirements. Given the width of the watercourse and limited flow-generated velocities at the project corridor, the general scour estimates are in the order of 2 newton / square metre (N/m^2). For local scour, the preliminary estimate during the Class EA suggested a local scour depth allowance of 7.5 m. The ESR notes that this value "… is a preliminary estimate, and should be developed more fully during the detailed design process based on local bed conditions and proposed pier construction and riverbed restoration techniques. The proposed pile-supported piers to bedrock would prevent undermining of the pier footings, but exposure of any significant length of the piles should be accounted for in the structural design considerations, or appropriate scour protection should be provided as required to accommodate structural capacities."

4.9 Traffic

As noted earlier, the ESR recommended a 4-lane bridge would ultimately be required, subject to future monitoring of traffic conditions by the City. The ESR also recommended that all intersections along the east and west approaches should be signalized, with the exception of the John Counter Boulevard-Ascot Lane intersection, which should be two-way stop controlled.

Since the completion of the ESR, the recommended bridge cross-section has been reduced to two vehicle lanes as per the 2015 KTMP and subsequent direction by City Council (Report No. 15-268). The City has also recently updated their Travel Demand Model for the Third Crossing to account for new mode share targets that were established since the completion of the 2015 KTMP.

4.10 Marine Navigation

Marine navigation remains an important feature of the DIA area. As shown earlier on **Drawing 2.1.1**, a navigable channel extends northward from the LaSalle Causeway and into the regulatory limits of the Canal. There is a 6.7 m vertical by 15 m horizontal Federally regulated navigable clearance requirement for the Canal. Direction from Parks Canada states that the vertical clearance of 6.7 m shall be measured above the upper controlled water elevation limit. Given the potential influence of Lake Ontario on the high water elevation in this part of the Cataraqui River, the 6.7 m vertical clearance was measured from the CRCA Regulatory Floodplain elevation of 76.3 m. The navigable channel is officially closed to watercraft from Thanksgiving to Victoria Day.

As shown on **Drawing 4.10.1**, the project corridor also transects an active 7-lane rowing course, which is maintained by the Kingston Rowing Club. Rowing lanes are divided with three northbound lanes on the east side of the navigable channel that are typically used for warm up and four southbound lanes on the west side of the navigable channel which are used for timing and race preparation. The course is 2 km long and rowers require the full length of the course and additional room at either end for deceleration and turning.

Drawing 4.10.1: Rowing Course

5.0 CONCEPT OPTION DEVELOPMENT AND ANALYSIS

5.1 Alignment and Profile

The Class EA envisioned horizontal curvature in the bridge in order to enhance user experience, provide architectural enrichment, mitigate impacts on adjacent land uses, and meet geometric and existing terrain constraints.

The conceptual horizontal alignment of the bridge as part of the current project phase has been modified slightly from the ESR to include two relatively large 2200 m radii horizontal curves. This has achieved a normal crown on the bridge deck, and avoided the need for superelevation on the entire structure, based on a roadway design speed of 70 km/hr, and a posted speed of 60 km/hr. A normal crown will also simplify the construction of the deck, as it will remain constant along the entire length of the bridge, and will result in a more efficient superstructure.

Drawing 5.1.1 shows the difference between the recommended horizontal alignment in the ESR (in black) and the conceptual horizontal alignment as part of the current project phase (in red). The east approach is on a 500 m radius horizontal curve which begins immediately east of the bridge abutment and would require up to a 4% superelevation to accommodate the design speed. The west approach does not contain appreciable horizontal curves.

The recommended vertical profile in the ESR rises gently from west-to-east with a high point over the navigable channel. It then drops in elevation before rising on-shore towards Highway 15. There are three vertical curves: one crest near the arch above the navigational channel and one sag curve near each shoreline.

Several options were considered for the vertical profile of the bridge during the current project phase, which are shown on **Drawing 5.1.2**. These options included a constant sloping bridge that rises from west-to-east (similar to the ESR); and a profile that shows a horizontal bridge which then rises up the east riverbank at a constant slope. Upon review of this latter option, there were challenges meeting necessary bridge drainage requirements. As such, a vertical profile based on the recommended vertical profile in the ESR was acknowledged as preferred and its geometry was then further refined.

Vertical profiles that included 1.25% longitudinal slopes and varying lengths of vertical curves were evaluated. Important considerations were ensuring that vertical curve length, deck drainage criteria, vertical clearance and sight lines would meet Provincial design guidelines. Opportunities to reduce the overall bridge height were then investigated, since reducing bridge height would present an opportunity to reduce capital costs (by reducing material costs and construction effort).

Drawing 5.1.3 shows the preferred conceptual vertical profile of the bridge. The low points are designed to be off the bridge to facilitate stormwater management (i.e. collect stormwater on-shore and prevent it from flowing onto the bridge) and to optimize the number of deck drains required on the bridge.

The vertical profile was also governed by the requirements for the navigable channel and rowing lanes as well as the CHBDC which requires that the bridge soffit have a minimum 1 m vertical clearance above the normal water level. The vertical alignment in the ESR had a high point elevation of approximately 92.5 m which occurred on the east side of the arch. As part of the current pre-design work, the vertical profile was refined such that the crest was centered on the arch span. It is considered important to center the vertical curve on the arch span to facilitate design and construction of the arch and to make the arch the focal point of the bridge.

The length of the crest vertical curve is also a key factor in the design as any 'flat' areas of the bridge need to be minimized as much as possible to ensure proper stormwater management and drainage. On this basis, a vertical curve of 80 m in length with a 1% road grade from the arch span to the approaches was subsequently carried forward, as shown in **Drawing 5.1.4**.

Upon further design development and constructability review, it was determined that substantial efficiencies can be achieved from lowering the profile and adjusting the grade to 0.75%. These efficiencies could be found primarily by decreasing the height of the v-piers – thereby facilitating their construction – and reduced the approach embankments. One drawback, however, was reducing the leg-length of the v-piers would result in the need for an additional pier in order to maintain girder-span efficiencies. This lower bridge profile included 0.75% grades from the arch span to the approaches and a high point bridge deck elevation of 88.35m (2.8 m lower at the arch-crest). This profile is shown in **Drawing 5.1.5**.

Drawing 5.1.6 compares the 1% longitudinal grade profile to the 0.75% profile. In addition, a comparison matrix was developed between the higher and lower profiles, as shown in **Table 5.1.1** below. The matrix takes into account span arrangement, profile, vertical clearance, differences in cost and constructability of structural steel and v-piers, aesthetics, deck drainage, operation, future maintenance and environmental considerations. The 0.75% profile was carried forward.

Drawing 5.1.1: Adopted Horizontal Alignment

Drawing 5.1.2: Vertical Profile Alternatives

Drawing 5.1.3: Vertical Alignment Elements

Drawing 5.1.4: Preliminary General Arrangement (High Profile)

Drawing 5.1.5: Preliminary General Arrangement (Low Profile)

Drawing 5.1.6: Comparison of Profile Alternatives

Table 5.1.1: Comparison Matrix between Lower and Higher Profiles

Criteria	Sub-Criteria	Higher Profile	Lower Profile
Span Arrangement		10 spans on west side, arch span, 2 spans on east side for a total of 13 spans and 12 v-piers	11 spans on west side, arch span, 2 spans on east side for a total of 14 spans and 13 v-piers
Profile		High Point of 91.15 m at center of arch with 1% grade to abutments	High Point of 88.35 m at center of arch with 0.75% grade to abutments
Navigation Clearance	Minimum 6.7 m above Average High Water (AHW)	When compared to lower profile ~3 m additional clearance for temporary works during construction	-
Structural Steel	Max Span Length	101 m	92.5 m
	Girder Sizes	-	Decreased flange sizes/ shorter webs due to decrease in span lengths
	Cost*	$2.8 Million more	-
V-Piers	Max Height	~12.5 m high	~9.8 m high
	Volume of Concrete – including caissons	~18,250 m^3	~17,650 m^3
	Cost*	Negligible Cost Difference	Negligible Cost Difference
Arch Span		Arch span has a clear span of 119 m	Arch span decreased to 117 m clear span to maintain arch geometry
West Abutment Pathway		3.8 m vertical clearance between the proposed bridge soffit and pathway finished grade at 76.5 m elevation, ~1.2 m above AHW	2.65 m vertical clearance between the proposed bridge soffit and pathway finished grade at 76.1 m elevation, ~0.8 m above AHW
Construction	Mobilization	12 mobilizations for v-pier construction and 13 mobilizations for crane	13 mobilizations for v-pier construction and 14 mobilizations for crane; Smaller crane can be used due to size and weight of girders
	Duration	Increase in construction duration to construct the taller v-piers	Increase in construction duration due to additional mobilization
Aesthetics		Taller v-piers	Shorter v-piers; Both options provide openness under the structure
Deck Drainage	Limiting the spread to the shoulder width only 2 m	Depending on the drain type the number of deck drains required are either: (26 Standard MTO deck drains or 18 Neenah Scuppers) (Longitudinal grade exceeds the minimum CHBDC required grade of 0.5% for deck drainage)	Minimal increase in the number of deck drains (30 Standard MTO deck drains or 18 Neenah Scuppers) (Longitudinal grade exceeds the minimum CHBDC required grade of 0.5% for deck drainage)
Operation and Future Maintenance		Less bearings to maintain but larger jacks will be required to replace the bearings in future; Less but longer and higher piers to maintain	More bearings to maintain One more pier to maintain
Environmental		Smaller river foot print at ~1500 m^2	Larger river foot print at ~1615 m^2 (~8% larger)

* Note: Cost is the difference between the two profile options and not the absolute cost of the elements.

5.2 Cross Section

Defining the overall bridge cross-section width early in the pre-design process was important as it affects the total weight of the structure, the number of traffic lanes on the bridge as well as the superstructure (arch and approach spans) and substructure design and configuration.

The ESR was used as the baseline for comparison of various cross-section width options. A basic cross-section that merges the ESR and the KTMP update recommendations is shown at the top of **Drawing 5.2.1**. It has a total overall outside width of 16.05 m with paved shoulders adjacent to the vehicular traffic lanes.

Based on the current design speed and future posted speed for the bridge, the MTO Geometric Design Standards for Ontario Highways was referenced for requirements on vehicular lane widths and side clearance zones (adjacent to the barriers). Assuming these speeds, the lane width is required to be 3.5 m (minimum) to 3.75 m (desirable); and the side clearance (shoulder) is required to be 2 m (where no sidewalk is present). Discussions with City staff indicated a preference for the wider 3.75 m lane width to assist with snow clearing and other maintenance activities. However, the ample 2 m side clearance, combined with encouraging cyclists to use the multi-use path, allows for consideration of a 3.5 m vehicular lane width. This would not compromise the experience or safety of the vehicles since this width also provides additional buffer should there be a vehicle break-down or maintenance vehicle stopped on the bridge. This layout is shown in the center of **Drawing 5.2.1** with a total width of 17.95 m.

Upon review, a 2.5 m to 3 m multi-use path (commonly accepted minimum width exclusive of cycling lanes) in addition to 1.5 m cycling lanes appeared incongruent with the projected use of the project corridor. Providing a combined cycle and multi-use width of 4 m of shareable space would meet accessibility standards and provide for sufficient active transportation space. It also exceeds multi-use path standards of 3 m, which is common in the City. Some additional merits of separating vehicles from cyclists/multi-use path include: segregation of uses (vehicle and non-vehicle); ease of cyclists passing other cyclists on the bridge; ability of cyclists or path users to slow down or pull over and rest on the bridge; and elevated safety and anticipated lower risks of vehicle/bicycle conflicts. An operational consideration is the need to move the cyclist traffic back to their directional side of travel along the road rights-of-way at either end of the bridge. However, this could be managed safely through traffic management provisions at the signalized intersections. As such, the proposed cross section is shown at the bottom of **Drawing 5.2.1**, with a total width of 16.5 m. Additional information on the proposed cross section is discussed in Section 8.2 of this Report.

The decision to design the bridge as a two lane structure with the current configuration of v-piers and an arch would make it cost-prohibitive to widen the structure to a four lane bridge in the future. However, it is possible to provide one additional lane in the future if the interior barrier and multi-use pathway were removed. It is noted that there are minimal options to allow the bridge to expand to a three lane structure. The current configuration that permits a segregated multi-use path area could not be accommodated. A narrow sidewalk and shoulders that could also be used as bicycle lanes would be possible; however, the cross section geometry would not be ideal. Finally, any future widening to accommodate two additional lanes would require a separate structure adjacent to the bridge.

One other consideration for the cross-section of the bridge dealt with roadway cross-fall. As discussed in Section 5.1 of this Report, a consistent cross-fall for the length of the bridge that avoids superelevation was an important factor for construction efficiency. In addition, ensuring that stormwater was captured on the bridge (i.e. did not outlet directly to the watercourse without treatment) was also a factor. Since the bridge was now physically divided, stormwater runoff could be captured at the barriers adjacent to the shoulders on the north and south side of the vehicle lanes. Therefore, the bridge cross section will include a crown on the vehicular portion of the bridge with a 2% cross-fall in either direction towards drains located adjacent to outer concrete barriers.

For the multi-use path, a 2% cross-fall towards the inner barrier was selected. This will allow the stormwater runoff to be collected using drains adjacent to the barrier and will eliminate the need for an additional stormwater pipe running along the multi-use path fascia.

Drawing 5.2.1: Functional Cross Section

The approaches of the bridge will include standard urban cross-sections with concrete curb and gutter and formalized stormwater management. Painted hatch/gore markings and/or a raised concrete median will generally separate eastbound and westbound traffic and, where required by traffic demands, the road cross section is wider within the approaches where turning and merging lanes are necessary. Paved shoulders that continue from adjacent roadways and enter the corridor will continue with a minimum width of 1.5 m. Transitioning active transportation users from either side of the road to promote use of the multi-use path on the south side of the bridge is expected at the intersections on both bridge approaches. Multi-use path connections from the bridge to adjacent pathway networks on Highway 15 on the east approach and John Counter Boulevard on the west approach will be accommodated within the project corridor.

5.3 Structural Options

Based on the ESR, a bridge supported on v-piers with an arch span over the navigable channel and adjacent rowing lanes is the preferred option.

5.3.1 Approach Spans

Several options were considered for the superstructure of the approach spans, including: concrete precast girders, concrete post-tensioned segmental boxes, steel plate girders, and trapezoidal box girders.

The use of concrete girders / boxes for the superstructure was eliminated as an option for the following reasons:

1. It has a higher weight-to-strength ratio than steel girders, which would increase the dead load and effectively result in larger foundations, and also introduce larger seismic loading in the case of a seismic event.

2. Concrete girders would require larger cranes to erect the girders.

3. Cold weather would affect any segmental construction that requires cast-in-place concrete to join pre-cast segments.

The use of steel girders for the superstructure is the preferred option for the following reasons:

1. It significantly reduces the weight of the structure, which is advantageous when considering seismic forces.

2. Steel girders provide a high degree of redundancy between spans.

3. Steel girders reduce construction time due to Contractor familiarity, especially in comparison to segmental post-tensioned concrete box construction and hence, effect potential cost savings.

Two different steel girder cross-sections were considered for the structure: three box girders (see **Figure 5.3.1**); and four plate girders (see **Figure 5.3.2**). **Table 5.3.1.1** compares the box girder and the plate girder options. The use of plate girders is the preferred option due to: the lower weight of steel required; the minimal interference with drainage pipes; the placement of the v-pier ties; the ease of fabrication and erection; and associated economic efficiencies.

Table 5.3.1.1: Comparison between Box Girders and Plate Girders

Criteria	Box Girders	Plate Girders
Weight of Steel	~5000 tonnes	~4700 tonnes
Girder Depth	2.6 m	3 m
Girder Width	Varies from 2.8 m to 4.8 m	0.7 m to 0.8 m
Number of Bearings	2 or 4 per pier	4 per pier
Erection	Box Girders are more stable during erection	Plate Girders have to be erected in pairs and should be braced during erection
Transportation	Non-Routine Oversize / Overweight Loads	Routine Oversize / Overweight Loads
Drainage	Deck Drains will be located within box girders and/or drainage pipes will have to pass through box girder, which is not allowed by the CHBDC without approval. Potential issues if pipe freezes and bursts. Durability issue having pipe inside box girder.	Minimal interference with drainage pipes
Coating Area	Only exterior surface would require a 3-coat system	Larger surface area for coating

Table 5.3.1.1: Comparison between Box Girders and Plate Girders		
V-Pier Configuration	Large wall type v-pier	Two separate v-piers
Cost	More expensive due to the additional weight of steel required and fabrication complexity	Less expensive

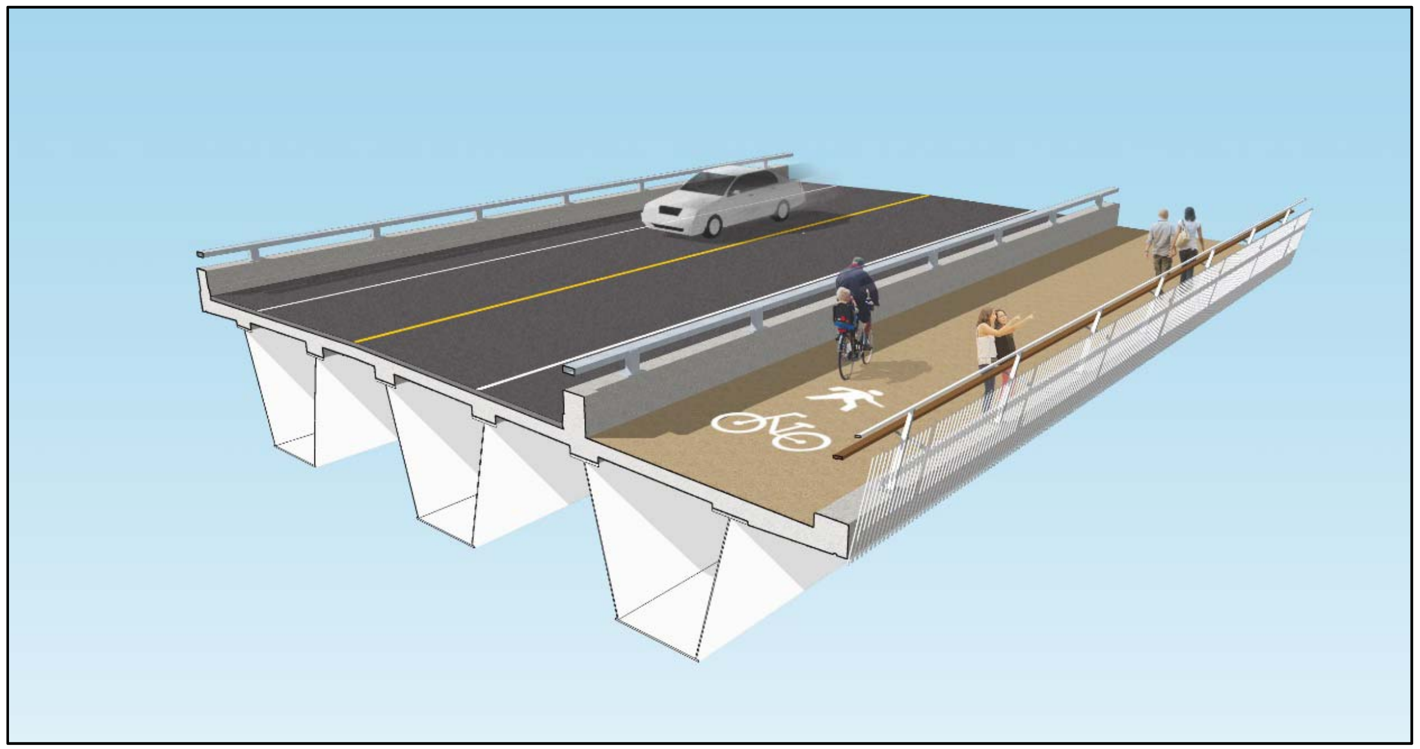


Figure 5.3.1: Three Box Girder Option

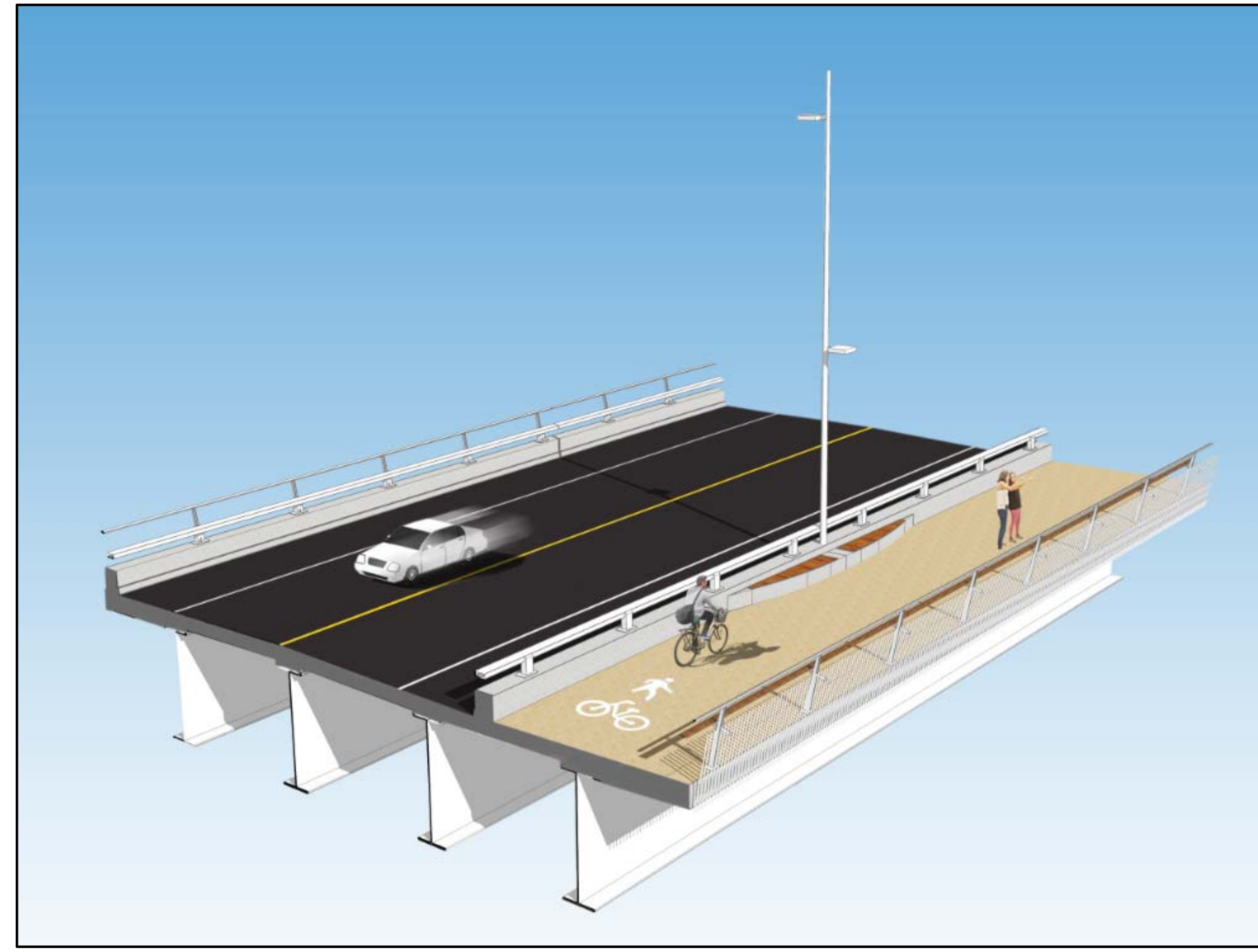


Figure 5.3.2: Four Plate Girder Option

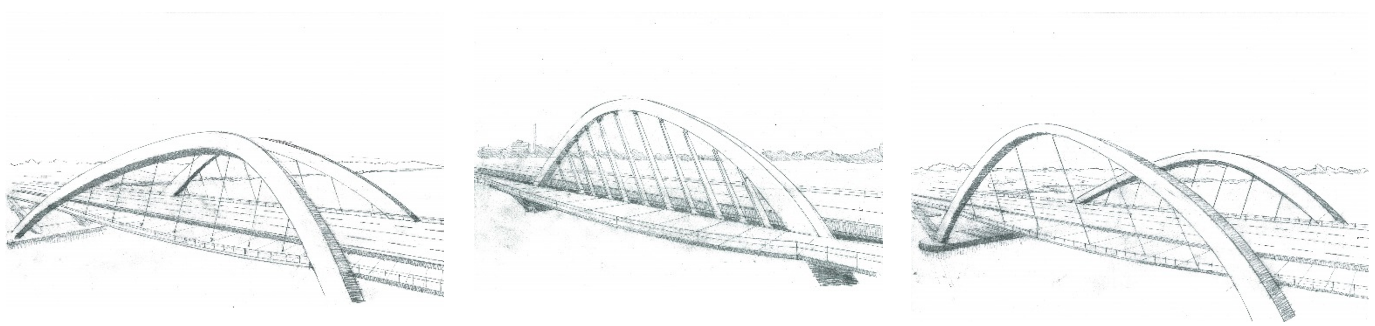
5.3.2 Arch Span

The minimum clear span between the piers for the arch is dictated by the envelope for the navigable channel and adjacent rowing lanes, which is approximately 137 m due to the 28° skew of the channel to the arch span as shown in **Drawing 5.3.2.1**. The span to height ratio of the arch was dictated by structural efficiencies and aesthetics.

The arch has to be tall enough to be the focal point of the bridge, but not so tall as to negatively impact views of the Cataraqui River. A span-to-height ratio of 6:1 was used with a rise of ~20 m and a span length of ~117 m.

Drawing 5.3.2.1: Arrangement of Arch Span over Navigation Channel

There are multiple different types of arches that can be considered for the bridge (see **Figure 5.3.3**). However, based on the perched nature of the arch-support, the lateral thrust from the arch needs to be minimized such that large lateral forces are not transferred to the substructure. Accordingly, an in-plane longitudinal tie will be utilized to accommodate the thrust. Tied arches and network tied arches were both investigated as viable arch options for the bridge.



Inclined Inwards Arch Chords	*Single Chord Arch*	*Inclined Outwards Arch Chords*

Figure 5.3.3: Arch Concept Sketches

It is worth noting that the main difference with a network arch from a conventional one is the hangers for a network arch are inclined and intersect each other, as shown in **Figure 5.3.4**. A tied arch is the preferred option, as the cost savings associated with the reduction of the arch members is not significant enough to justify the additional cables required for the network tied arch.

Figure 5.3.4: Network Tied Arch (Hastings Bridge)

Figure 5.3.5 shows the main components of the arch. The arch ribs support the deck grillage by hangers, and are tied together from one end to the other using a tie. The deck grillage is comprised of transverse floorbeams at the hanger locations, and longitudinal stringers in between. The concrete deck will be supported on the grillage.

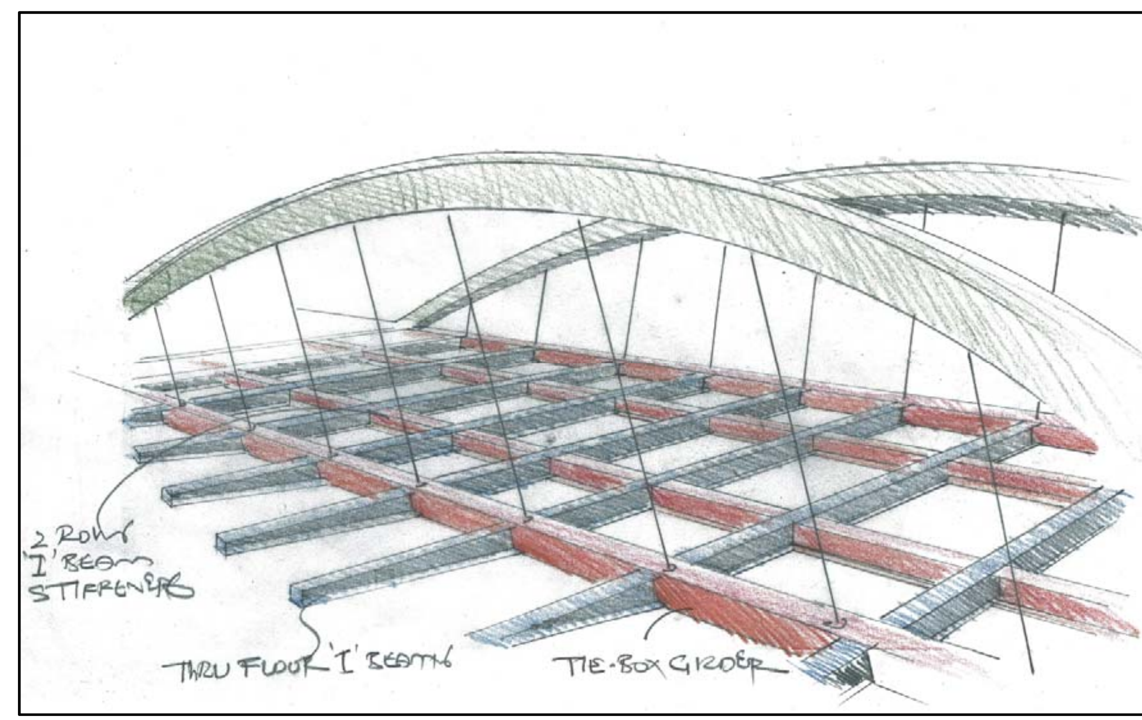


Figure 5.3.5: Artist Rendering of Tied Arch Main Components

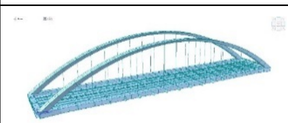
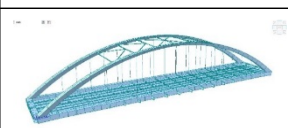
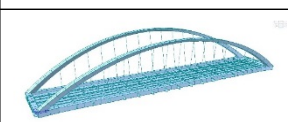
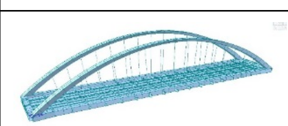
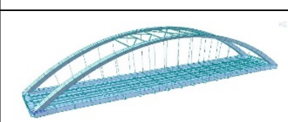
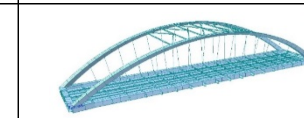
5.3.3 Arch Geometry

The following structural aspects were considered for the arch geometry:

1. Inclination of arch chords: inclined 10° outwards, vertical, and inclined 10° inwards.
2. Bracing system: braced arches or free standing.
3. Orientation of cables: vertical or flared.
4. Span-to-height ratio: optimized at a ratio of 6:1.

Multiple parametric models were created using these structural aspects to determine their effect on the structural behaviour and design of the arch. The steel weights of the various options were compared, as shown in **Table 5.3.3.1**.

Table 5.3.3.1: Comparison of Arch Geometry Concepts

Option	Description	Isometric View	Total Mass (Tonnes)	% of Total Mass Compared to Option 1
1	Vertical Arches with Vertical Cables		1673	100%
2	Braced Vertical Arches with Vertical Cables		1234	74%
3	Inclined Outward Arches with Vertical Cables		1673	100%
4	Vertical Arches with Flared Cables		1673	100%
5	Braced Vertical Arches with Flared Cables		1234	74%
6	Inclined Outward Arches with Flared Cables		1673	100%
7	Inclined Inward Arches with Flared Cables		1180	71%
8	Braced Inclined Outward Arches with Vertical Cables		1392	83%

Highlights of this evaluation are as follows:

1. The use of bracing significantly reduces the weight of steel in the arches (up to 25%), as it reduces the lateral deflection of the arches.
2. The use of either vertical or flared cables has no significant difference on the structural behaviour of the arches.
3. The inclination of up to 10° outwards of the arch ribs has little effect on the overall weight of the arch, as compared to the vertical arch ribs.
4. The inclined inward arches would have to be set further away from the roadway to ensure they would not impact the vehicular envelope required for the traffic lanes, which would increase the width of the piers and the size of the v-piers.
5. There structural differences between the vertical and 10° inclined outwards arches are negligible.
6. There was consensus, based on internal City-Project Team and TAC discussions, that the inclined outward arches are more aesthetically pleasing. As such, Option 8 – the braced, inclined outward arches with vertical cables – is the preferred option.

Two arch rib configurations are currently being considered:

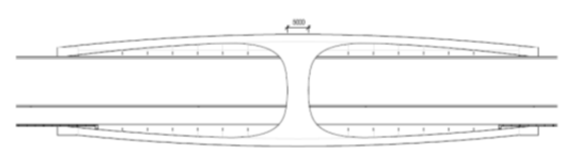
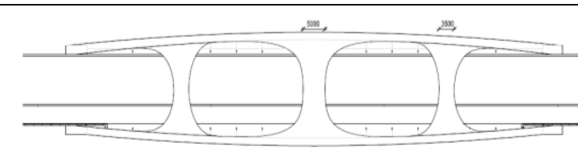
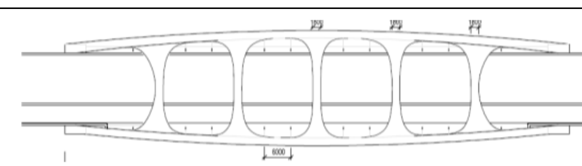
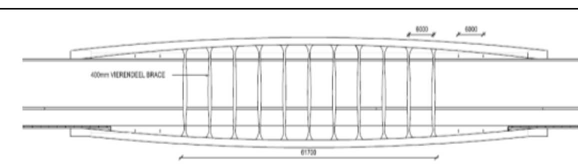
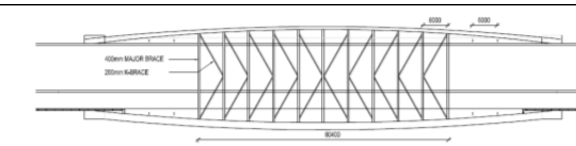
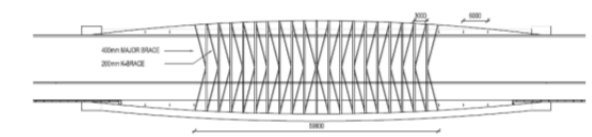
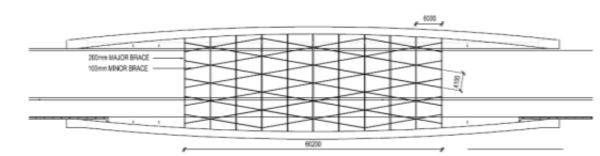
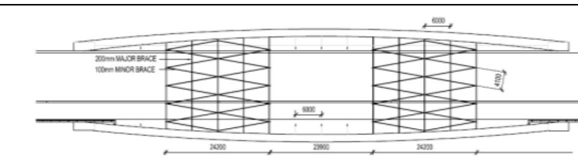
1. The first option is for the rib to be a constant width of 2000 mm and varying depth, as shown in **Drawing 5.3.3.1**. Keeping a constant width would allow for the flanges to remain square which simplifies fabrication.

2. The second option is for the rib to vary in width from 2000 mm at the knuckle to 1200 mm at the crown of the arch and varying depth, as shown in **Drawing 5.3.3.2**. Having the rib tapered in both directions decreases the weight of steel required, but increases the complexity of fabrication.

5.3.4 Arch Bracing

The bracing of the arches reduces the lateral deflection of the arches which in turn decreases the size of the arch ribs. Multiple bracing options were evaluated, as shown in **Table 5.3.4.1**.

Table 5.3.4.1: Arch Bracing Options

Option	Description	Isometric View
1	Single Shell	
2	Triple Shell	
3	Quintuple Shell	
4	Vierendeel Truss	
5	K-Brace	
6	K-Brace	
7	Solid Weave	
8	Dual Weave	

Drawing 5.3.3.1: Preliminary Arch Layout – Ribs Tapered Vertically

Drawing 5.3.3.2: Preliminary Arch Layout – Ribs Tapered Both Ways

Highlights of this evaluation are as follows:

1. The single shell and triple shell options were eliminated as they do not provide efficient arch designs.

2. The K-Brace and the Weave options were eliminated due to the number of connections that would be required. In addition, due to the arch geometry, each brace would be different and would add complexity to the fabrication.

3. There was consensus, based on internal City-Project Team and TAC discussions, that a combination of the Quintuple Shell and the Vierendeel Truss is the preferred option. Having five lateral braces connecting the arch ribs provides the optimal structural support without having excessive amount of bracing.

   The braces will be shaped similar to the Vierendeel Truss but will have less straight portions and more flare at the connection to the arch rib, as shown in **Figure 5.3.6**.

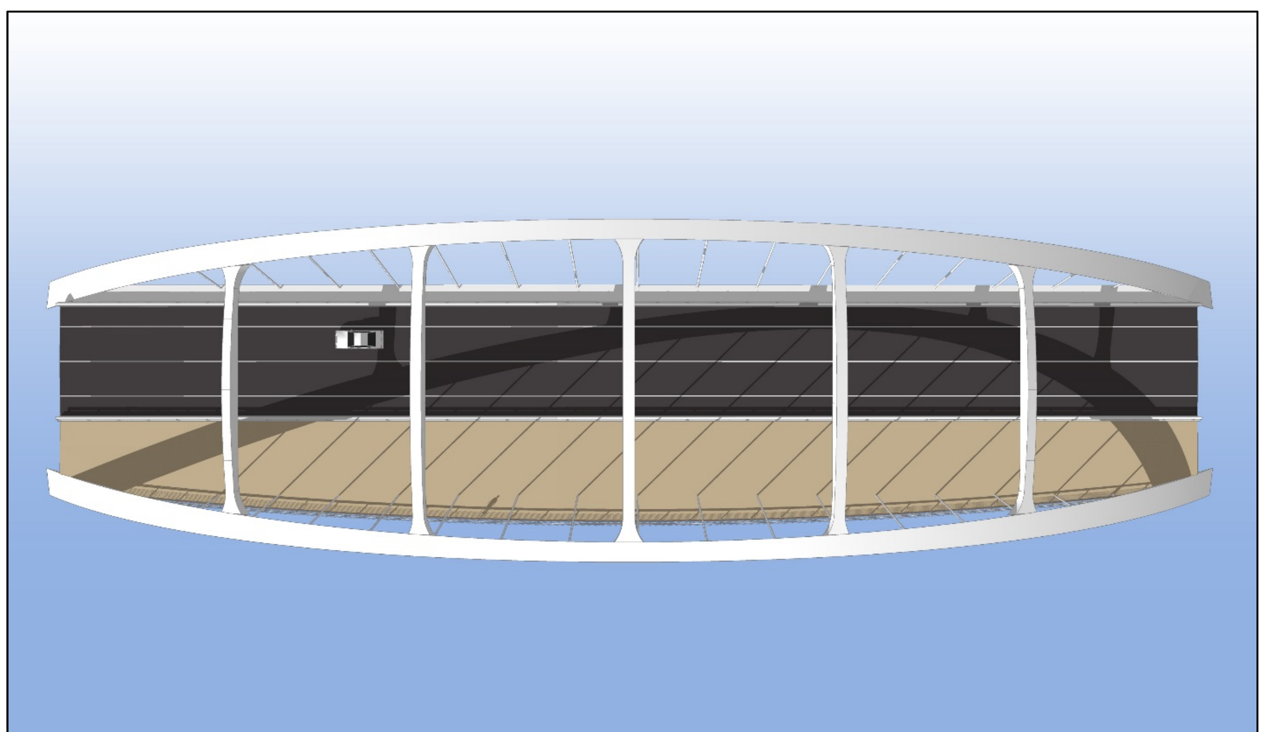


Figure 5.3.6: Preferred Bracing Option

5.3.5 Arch Hangars

Two different hanger options were considered: wire ropes; and multi-strand hangers. The use of multi-strand hangers is the preferred option, as they are more durable, and have triple corrosion protection (whereas wire ropes are only galvanized).

The anchorages for the hangers will be designed to allow for ease of cable/hanger replacement as well as hanger force adjustment, if required.

5.3.6 Structural Steel Coating

There are multiple coating options available to preserve the structural steel. Three options considered for the bridge were:

1. A three-coat system consisting of a zinc primer, an epoxy mid-coat and a urethane top coat over all the structural steel.

2. Metallization of the structural steel.

3. Use of Atmospheric Corrosion Resistant steel.

A coating system would be applied in the shop and then touched-up after erection and at the field splices. The benefits of using a coating system are that the colour of the structural steel can be changed to appease the architectural look of the bridge; and a three-coat coating system has an average service life of 25 to 30 years. At that time, an access platform will be constructed with an environmental protection enclosure in order to sand blast the existing coating off of the structural steel down to base metal and apply a new three-coat system.

Metallizing consists of coating the structural steel in a thin layer of zinc or aluminum to act as a sacrificial layer to protect the underlying structural steel. Metallizing can occur in a shop or in the field as it is spray-applied. Metallizing has a higher initial cost than a three-coat system but it has a lower life cycle cost, since it is more durable. Using metallization over a three-coat system adds an additional 5 years to its average service life. It is standard practice to apply a layer of coating on top of the metallization to provide further protection and change the colour.

Atmospheric Corrosion Resistant (ACR) Steel, often known as weathering steel, is approximately four times more resistant to corrosion than plain carbon steels. ACR steel forms a rust patina which inhibits further corrosion of the structural steel. ACR steel will have a rust colour and is generally uncoated, except for the girder ends in the vicinity of the expansion joints.

A combination of these methods could be used to provide additional protection in corrosion prone areas such as the exterior girders and the ends of the girders at the expansion joints. Four different options were considered for the bridge approach span structural steel:

1. Three-coat system.
2. Metallization and one coat system.
3. ACR steel.
4. ACR steel and one coat system on exterior girders.

An evaluation matrix was prepared to compare the different alternatives as shown in **Table 5.3.6.1**.

Table 5.3.6.1: Evaluation Matrix for Structural Steel Coating Option*

Criteria		**Three-Coat System**	**Metallization and One Coat System**	**ACR Steel**	**ACR Steel with one coat system on exterior girders**
Initial Cost	Structural Steel	$12.9M	$12.9M	$13.8M	$13.8M
	Coating	$3.8M	$5.3M + $1.5M = $6.8M	N/A	$0.3M
	Total	$16.7M	$19.7M	$13.8M	$14.1M
Estimate Service Life		25-30 years	30-35 years	100 years	1. 100 years for steel 2. 25 to 30 years for coating
Aesthetics		1. Can paint it a specific colour	1. Can paint it a specific colour	1. Structural Steel will be a rust colour due to patina	1. Exterior girders will be painted a specific colour 2. Interior girders will be a rust colour due to the patina
Maintenance		1. Localized coating repairs 2. Full coating removal and replacement at end of service life.	1. Localized coating repairs 2. Full coating removal and replacement at end of service life.	1. No maintenance	1. Localized coating repairs on exterior girders 2. No maintenance on interior girders 3. Overcoat on exterior girders at end of service life

* Only evaluates the approach span structural steel.

5.3.7 V-Piers

The ESR recommended v-piers as they would reduce the number of footings by half; and with two legs, they would reduce the superstructure spans and would also result in a shallower superstructure. As such, both concrete and steel v-piers were considered during the current project phase.

Steel v-piers are rigid steel structures that are integral with the superstructure. Steel v-piers require a tall concrete pedestal in marine environments to prevent contact between the water and the structural steel. If the steel v-piers are integral with the steel superstructure, the bearings would be located at the base of the v-pier on the concrete pedestal.

Steel v-piers are more complex to design and fabricate, as each pier would be different. In addition, steel v-piers still require a concrete pedestal to be built in order to support them. However, steel v-piers are lighter than concrete v-piers, which decreases the dead load on the foundations. Integral steel v-piers were used for Champlain Bridge, as shown in **Figure 5.3.7**.

Figure 5.3.7: Steel V-Piers (Champlain Bridge)

Concrete v-piers can either be cast-in-place or made of precast sections. Concrete v-piers may utilize a tie to balance the inclined loading in the v-pier legs. The ties can be either a steel section or post-tensioned concrete beam that is anchored into the v-pier legs. The bearings for concrete v-piers may be located at the top of the v-pier legs, since the pier is not integral with the superstructure.

Concrete v-piers are considerably heavier than steel v-piers, but the use of hollow precast concrete sections can significantly reduce their weight. This approach was used on the Woodrow Wilson Bridge, as shown in **Figure 5.3.8**.

Figure 5.3.8: Concrete V-Piers (Woodrow Wilson Bridge)

The use of concrete v-piers is the preferred option due to the fact that the steel v-piers have bearings at the base which could be a durability issue with the varying water levels. As noted above, a tall concrete pedestal would still be required at each pier location for the steel v-piers; therefore, there is limited savings in the schedule by having the steel v-piers fabricated off-site. In addition, the steel v-piers would require larger bearings which are more difficult to maintain and replace in the future.

Four different v-pier options were considered, as shown on **Drawing 5.3.6.1**. A comparison of these options is provided in **Table 5.3.6.1**.

Table 5.3.6.1: Comparison of V-Pier Options

Criteria	Option 1	Option 2	Option 3	Option 4
Description	2 separate v-piers with 2 tie-beams	2 v-piers connected with a header beam and 1 tie-beam	2 v-piers connected with a header beam and 2 tie-beams	Wall type v-pier with 2 tie beams
Advantages	1. Simplest to construct 2. Open and transparent pier design	1. Open and transparent pier design	1. Open and transparent pier design	1. Easy to construct 2. Aesthetically pleasing in elevation
Disadvantages		1. Header beam increases complexity of construction and overall weight of pier 2. Forces in single tie-beam would be large and create difficulties with header beam design	1. Header beam increases complexity of construction and overall weight of pier	1. Substantially more concrete than other options. 2. Increased load on footing 3. Single v-pier will look bulky from the view along the bridge.
Comparative Cost	$	$$$	$$	$$

Option 1 is the preferred option, as it is simpler to construct, more economical and structurally viable, and provides a more open and transparent pier design.

Based on the geotechnical investigation, four different foundation options were investigated to determine the most practical and cost effective method of supporting the structure. A comparison of these options is provided in **Table 5.3.6.2**. The footing layout for each different caisson and pile option is provided in **Drawing 5.3.6.2**.

Table 5.3.6.2: Comparison of Foundation Options*

Option	Description	Details	Estimated Total Comparative Cost for All Piers
1	2100 mm dia. Caissons	4 caissons per pier. Steel liner seated 4.2 m into bedrock, reinforcing cage and cast-in-place concrete full length of caisson	~$15.4M
2	914 mm dia. Pipe Piles	16 to 24 pipe piles per pier. Pile seated into bedrock, reinforcing cage and cast-in-place concrete in top section of the pile to create fixity with foundation	~$11.1M
3	1067 mm dia. Pipe Piles	12 to 18 pipe piles per pier. Pile seated into bedrock, reinforcing cage and cast-in-place concrete in top section of the pile to create fixity with foundation	~$13.8M
4	3000 mm dia. Caissons	2 caissons per pier. Steel liner seated 6 m into bedrock, reinforcing cage and cast-in-place concrete full length of caisson	~$15.5M

* Notes:

1. The estimated comparative cost is based on Ice Loading at Low Water elevation of 73.0 m.
2. The use of steel H-Piles was also considered, but it was not carried forward as each pier would require a significant amount of battered piles to resist the lateral forces adding constructability complexities that would compound risk, given the driving conditions, depth to competent bedrock and poor overburden soil conditions.

Drawing 5.3.6.1: Concrete V-Pier Options

Drawing 5.3.6.2: Foundation Options and Layout

The lateral design of the deep foundation is governed by the ice loading. Two different ice loads at two different elevations are being considered, based on the effective ice strength as described earlier in this Report. The effects on the foundation design, based on the different ice loading for the caisson options, are provided in **Table 5.3.6.3.** The foundation design is currently based on an ice crushing strength of 1100 kPa at the low water elevation of 73.0 m.

Table 5.3.6.3: Effects of Ice Level on Large Diameter Caissons

Ice Level (Top of Ice Elevation)	Option 1		Option 4	
	1100 kPa	700 kPa	1100 kPa	700 kPa
High (74.9 m)	6 - 2100 mm ϕ Caissons	4 - 1800 mm ϕ Caissons	2 - 3800 mm ϕ Caissons	2 - 3000 mm ϕ Caissons
Low (73.0 m)	4 - 2100 mm ϕ Caissons	4 - 1800 mm ϕ Caissons	2 - 3000 mm ϕ Caissons	2 - 3000 mm ϕ Caissons

The preferred foundation option will be dependent on: the above parametric analysis; the results of the geotechnical investigation; the construction duration of each of the above options; the availability of pile driving equipment locally; and the scour mitigation measures required. At present, both the pipe piles and caissons options will be carried forward for further design refinement.

5.4 Deck Drainage

The vertical profile of the bridge allows the stormwater to actively drain from the middle of the arch to the approaches. Drains along the curb lines will collect the stormwater which will be piped to a stormwater management facility on-land.

An option of treating the stormwater on the bridge so that it can be directly discharged into the river was investigated. But it was determined that there is not a viable solution that could treat the stormwater for all the constituents within the confines of the bridge that can be easily maintained.

Rainfall data obtained from ECCC was used to calculate the rainfall intensity for the City. The MTO Highway Drainage Design Standards was used to specify the design criteria for the flow spread which stated that the design storm with a minimum return period of ten years shall be used to calculate the flow spread and that the maximum lateral spread distance shall be such that a minimum of 2.5 m of the lane adjacent to the median barrier or curb remains clear of any flooding.

It was determined, in addition to the MTO Standards, that a flow spread that is restricted to only the shoulders of the bridge (meaning a flow spread of 2 m for a design storm with a minimum return period of 10 years) and a bicycle friendly option (which would allow for 0.5 m width free of stormwater on the shoulder for a design storm with a minimum return period of 2 years and 5 years) should be analyzed as well.

Two different deck drains were used in the flow spread analysis:

1. Ontario Provincial Standard Drawing (OPSD) 3340.150 Deck Drain: 1 m by 0.23 m grate with the long side of the drain located adjacent to the barrier and parallel to the flow.

2. Neenah Enterprise Incorporated (Neenah) R-4014-B1 Series Scupper Drain: 1.1 m by 0.4 m grate with the short side of the drain adjacent to the barrier and the long side perpendicular to the flow.

Based on the design criteria, the spread flow analysis was run for a longitudinal grade of 1% and 0.75% for the two deck drain options, and which are further based on the two vertical profile options. This analysis is summarized in **Table 5.4.1**.

Table 5.4.1: Comparison of Deck Drain Types

	1% Longitudinal Grade				0.75% Longitudinal Grade			
Deck Drain Types	**OPSD 3340.150**		**R-4014-B1**		**OPSD 3340.150**		**R-4014-B1**	
	West	East	West	East	West	East	West	East
MTO – 3.5 m flow spread, 10 years	5	0	3	0				
2 m flow spread, 10 years	12	1	8	1	13	2	8	1
Bike Friendly – 1.5 m flow spread, 2 years	11	2	8	1	11	2	8	2
Bike Friendly – 1.5 m flow spread, 5 years	15	3	11	2	15	3	11	2

For the multi-use pathway, two options were considered: the first, having a minimum of 1.5 m clear of flooding; and the second, having a minimum of 2.5 m clear of flooding. The number of deck drains required for a 1% longitudinal grade for the multi-use path is summarized in **Table 5.4.2**.

Table 5.4.2: Comparison of Deck Drain Types for the Multi-Use Path

	1% Longitudinal Grade			
Deck Drain Types	**OPSD 3340.150**		**R-4014-B1**	
	West	East	West	East
Minimum 1.5 m clear of flooding	5	0	3	0
Minimum 2.5 m clear of flooding	13	2	10	2

Based on the current cross-section configuration:

1. For both the 1% longitudinal grade and the 0.75% longitudinal grade, two drainage pipes are required: one on the north side of the road collecting the stormwater from the north side of the roadway; and one on the south side that collects the stormwater from the south side of the road and the multi-use pathway.

2. For the 1% longitudinal grade, a 375 mm pipe is required on the north side of the bridge and a 450 mm pipe on the south side.

3. For the 0.75% longitudinal grade, the pipe on the south side has to be upgraded to a 525 mm diameter pipe and the pipe on the north side can remain as 375 mm diameter.

4. Arch drainage can either be intercepted via deck drains ahead of the expansion joints and piped through the joint, or intercepted using a trough system at the joint. The former option of intercepting the flow ahead of the joint is recommended.

There was consensus, based on internal City-Project Team and TAC discussions, that the key criteria for the deck drainage is the 2 m flow spread based on the 10 year design for the traffic lanes, a 1.5 m allowable flow spread based on a five year storm event for the bike friendly traffic lanes and 1.5 m flow spread for a 10 year design storm for the multi-use pathway.

5.5 Arrangement of Approaches

The 2-lane bridge will be integrated into the existing road network on-shore: John Counter Boulevard on the west; and Gore Road on the east. Affected intersections will also require reconfiguration to accommodate related turning movements and queued vehicles.

At the west approach, two intersections along John Counter Boulevard are within the project corridor: Montreal Street and Ascot Lane. Montreal Street is considered a major intersection, in that it has existing signalization and will require modification. Ascot Lane is considered a minor intersection and is currently un-signalized.

The west approach arrangement is shown in **Drawing 5.5.1**. There is opportunity to reconfigure Ascot Lane as a perpendicular intersection to John Counter Boulevard. There may also be merit to upgrade this intersection in the future to include signalization in order to allow both cyclists and pedestrians to cross at the intersection on the west side of the bridge as well as to service turning traffic into and out of the reconfigured intersection as shown in **Drawing 5.5.2**.

Drawing 5.5.1: West Approach Arrangement

Drawing 5.5.2: Integration of Cycling and MUP Infrastructure (West)

At the east approach, two intersections along Gore Road are within the project corridor: Highway 15 and Point St. Mark Drive. Highway 15 is considered a major intersection, in that it has existing signalization. The Highway 15 corridor from Highway 2 (south) to Highway 401 (north) is currently part of a Class EA and Preliminary Design Study which, when implemented, will see the corridor (or portions thereof) expanded to four vehicular lanes plus cycling, pedestrian and multi-use path infrastructure. Point St. Mark Drive is considered a minor intersection and is currently un-signalized. As per the ESR, the existing entrance to the Gore Road Library will be reconfigured to align with Point St. Mark Drive at a new signalized intersection. The east approach is shown on **Drawing 5.5.3**.

Kingston Transit was consulted to discuss future transit service within the project corridor. It was noted that the 2017-2021 Kingston Transit Business Plan (KTBP) was being prepared, but it was not expected to indicate any service for the project corridor, since the bridge would not be built within the planning horizon of the KTBP. Kingston Transit recognizes the opportunity for east-west routes that will be incorporated along the project corridor in the future. As such, Kingston Transit has made the following suggestions to accommodate future transit planning considerations along and adjacent to the project corridor:

1. Mid-block stops are not ideal for transit riders unless there is a specific mid-block destination being served. Transit stops are generally placed on the far side of an intersection and proximate to the intersection. This allows riders to use cross-walks.
2. Bus bays or ‘laybys’ are not generally used along a bus route unless the bus stop is at a location where the bus is expected to idle for several minutes. In certain circumstances, dedicated discharge lanes for transit are used to provide priority to transit vehicles at intersections.
3. Intersection improvements at Montreal Street and John Counter Boulevard are welcome, since the current layout is not ideal for pedestrian circulation. A future eastbound transit stop location is currently shown near the Montreal Street intersection, as shown on **Drawing 5.5.1**. Other potential transit stop locations near the Montreal Street and Highway 15 intersections are shown conceptually on **Drawing 5.5.1 and Drawing 5.5.3** and will be confirmed at a later date.

5.6 Innovation Considerations

Key innovative features which are being evaluated during the current project phase include:

1. Flexibility in the design of the superstructure to allow different erection methods for the arch and the approach spans, depending on the means and methods of the Contractor.
2. Designing the arch components from completely sealed components to enhance the long term life and durability of the structure.
3. Bridge Service Life considerations, which will evaluate the overall life cycle of the asset so that the initial design ensures optimized performance and related operations / maintenance / rehabilitation costs in tandem.
4. Structural health monitoring systems (SHMS) or ‘smart bridge’ technologies, which are increasingly being discussed in bridge design, particularly for long-span arch structures. While the ability to assess a bridge more frequently and (potentially) more proactively offers promise, the perceived benefits must be weighed against: the City’s larger ITS infrastructure and capacity to process and evaluate generated data; and the actionable nature of the data generated and the durability of monitoring system themselves versus an ‘early-age’ performance / condition assessment.
5. A hanger system comprised of multi-strand cables and anchorages with adjustment nuts, which would enable quick and easy adjustment (and replacement) of the cable forces throughout the life of the bridge.
6. The use for stainless steel / galvanized and GFRP reinforcing steel rather than non-coated carbon steel in areas prone to high corrosion.
7. Consideration for a coating system that extends the coating life including a four coat system and the potential metalizing of the arch components.
8. Providing adequate concrete cover, the use of stainless steel, and/or galvanized reinforcing steel in the deck to extend its life and enhance durability.
9. The use of LED light fixtures, which would significantly reduce energy consumption, and last longer than any other known lighting system.
10. Paying close attention to aesthetics both globally and in detail to create a structurally sound engineered and aesthetically pleasing bridge, with the optimum in sustainable features.
11. Consideration for de-icing and anti-icing systems.
12. Consideration for Renewable Energy Generation in the form of solar electricity.

Drawing 5.5.3: East Approach Arrangement

6.0 CONSTRUCTABILITY

6.1 Options and Analysis

Three different constructions options were considered along the bridge route: dredging, a temporary work bridge, and a temporary earth berm. The Class EA recommended dredging a channel as it would only involve one in-water disturbance and one related set of mitigation measures; would be more economical than the temporary work bridge and earth berm / causeway; and the channel could accommodate the east-west watermain that was being planned by UK at that time. During the current project phase, each option was further evaluated.

6.2 Dredging

As shown in **Figure 6.2.1**, dredging would consist of dredging approximately 1.5 m below the mudline which is mostly peat and vegetation. Oversized barges would be used to transport equipment and personnel to each pier location. After construction, the dredged channel would either be back-filled or left in place. During construction, multiple barges would be required. Dredging could be conducted via mechanical or hydraulic methods.

The bottom width of the dredged channel would be 20 m with 3:1 to 6:1 side slopes to accommodate the oversized barges required for the cranes. The overall in-water footprint of the dredged channel would be approximately 36,500 m^2.

Figure 6.2.1: Dredging

6.3 Temporary Earth Berm

The temporary earth berm would consist of infilling an access road with rock fill to provide a temporary east / west access road extending from the shore to the navigational channel on both sides as shown in **Figure 6.3.1**. A boat would be used to transport material, equipment and personnel from one side of the navigation channel to the other. The rock fill would be placed on removable fabric / geotextile such that after construction, the earth berm could be removed without significantly affecting the riverbed.

The causeway would be 10 m to 12 m wide to accommodate vehicle movement and the depth of fill would range from 2 m to 2.5 m. The in-water footprint of the causeway would be approximately 17,000 m^2 which is less than half of the dredged channel footprint.

It would take approximately one to two months to construct the causeway, which could be completed in conjunction with the substructure construction. After construction, it is estimated that it would take one to two months to remove the causeway.

Figure 6.3.1: Temporary Earth Berm

6.4 Temporary Work Bridge

The temporary work bridge would consist of either end bearing or friction piles driven into the riverbed every 10 m to 12 m supporting a cap beam and track beams with a timber crane mat. At the pier locations, there would be extensions of the work bridge to allow for additional material and equipment for the construction of the piers. The temporary work bridge would extend from the shore to the navigation channel on both sides of the river. A boat would be used to transport material, equipment and personnel from one side of the navigation channel to the other. The work bridge could be approximately 11 m wide to accommodate the large cranes and equipment required to construct the piers and lift the girders into place as shown in **Figure 6.4.1**. The total estimated work bridge area is 10,000 m^2.

Figure 6.4.1: Temporary Work Bridge

It would take approximately three to four months to construct the work bridge. The construction of the work bridge would likely not occur continuously but would rather be advanced in conjunction with other construction activities, i.e. pier construction.

6.5 Comparison of Alternatives

An evaluation matrix was created for the comparison between the three construction options as shown in **Table 6.6.1**. The evaluation matrix compares the alternatives based on associated costs, Parks Canada's priorities, project risks, uncertainties, implications and additional assessments that need to be completed in addition to those undertaken during the current project phase.

6.6 Environmental Impact / Footprint

Through further consultation with Parks Canada, it was determined that Parks Canada's main goal is to minimize the effects to the rare wetland; and that dredging a channel and the temporary causeway was not an option as it would have the greatest impact. Parks Canada preferred the temporary work bridge option, as it has the least impact on the wetland and there are no long-term effects expected on the vegetation, habitat and water quality of the Cataraqui River. The impacted area is minimal and can be mitigated.

6.7 Preferred Method – Temporary Work Bridge

The preferred method for the construction of the bridge is the use of a temporary work bridge. The temporary work bridge has the smallest impact on the wetland with no anticipated long term effects. The work bridge will consist of pipe piles driven into the riverbed which support an access platform as shown in . Localized excavation of the riverbed is limited to the v-pier footings, which would have had to be completed for all three construction options. The temporary work bridge also provides the greatest access for the construction as there will be continuous and uninterrupted access to all pier locations.

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
Description of Project			
Overview	Infilling an access road with rock fill to provide a temporary east / west access road extending from the shore to the navigational channel on both sides. Use of a boat to transport equipment and personnel from one side of the channel to the other. The rock fill would be placed on removal fabric/geotextile and removed after construction.	Dredge approximately 1.5m below the mudline which consists of mostly peat and vegetation. Barges will be used to transport equipment and personnel to each pier location. Dredged channel will either be back-filled or left in place. This operation will require multiple barges including crane barges, material barges, tug boats and service boats. Could be conducted via mechanical (e.g., clamshell) or hydraulic (e.g., cutter suction dredge) methods.	Construction of a temporary work bridge from the shore to the navigation channel on both sides. Temporary work bridge supported on piles which would be removed or cut-off below top of riverbed after construction. Barges would be used to transport equipment and personnel from one side of the channel to the other. The work bridge would be designed to support cranes as well as construction material
Conceptual Access Schedule	1 to 2 months to construct 1 to 2 months to remove This work can be completed in conjunction with other construction operations.	2 months to dredge channel.	3 to 4 months to construct work bridge. This work will not be completed continuously. It will be built in sections in conjunction with other construction activities.
Conceptual Construction Schedule		Slowest in comparison to causeway and work bridge as a barge will be required to access shore.	
Constructability	Simple to construct. Material and equipment readily available.	Requires dredging equipment and over-sized barges to accommodate large cranes for construction.	Requires multiple pieces of equipment to construct including Engineering and Barges.
Safety/Winter work	Safest option for labour and equipment. Can be used all year.	Working from a barge would require extra safety precautions. Limitations during winter freezing conditions	Safe. Can be used year round
Access to Site	Would allow continuous access to each pier location during construction	Access between each pier location and shore will be governed by barge movement.	Would allow continuous access to each pier location
Size	Berm would be at between 10 m to 12 m wide (adjusted to accommodate vehicle movement). Depth of fill would range of 2.0 to 2.5m. Berm would be removed after construction.	The barge required would be ~18.3 m wide, ~45.7 m long with a draft of ~1.8 to 2.4 m to support the crane. Bottom width of dredged channel would be 20 m with 3:1 side slopes (total channel affected width of 29m). Boats required to move the barge would require a draft of about 2.4 m. The channel will be dredged by about 1.5 to 2.0 m	Work bridge would be up to 10 m wide (30'). (At the locations of the piers and crane pick-up locations the bridge will be expanded to allow vehicles to pass the crane). Total work bridge area is estimated at 10,000 m^2
In-water footprint	~17,000 m^2	~36,500 m^2	~3000 m^2
Costs			
Construction (excluding sediment management and dredging)(from Parsons Comparisons Matrix October 20, 2016)	~$2.35 to 2.9 M (~$65 to 80 /m^3)	~$3.0 to 4.0M (~$65 to 80 /m^3)	~$16M - $19 M (|$1,600 to 1,900 /m^2)
Environmental controls/ mitigation (e.g., silt curtain)	$100,000	$100,000	$100,000
Construction environmental monitoring	$100,000 to 200,000	$100,000 to 200,000	$100,000 to 200,000
Dredged material management (dewatering, water treatment, staging area, disposal)	$3 to 4.5 M ($85 to 125/m^3)	$4 to 5 M ($85 to 125/m^3)	Only cost for a 3000 m^2 maximum footprint for the actual bridge piers – at 2 m average depth
Reinstatement of river bed	$2.0 to 2.4 M	$3.0 to 4.0 M	N/A
Re-establish Wetland with security and contingency	$200,000	$200,000	N/A
Supporting Studies/Plans	$300,000 to 600,000	$300,000 to 600,000	$300,000 to 600,000

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
Parks Canada Considerations			
• Area of wetland affected	63,000 m^2 “One of the largest impacts on any wetland within the jurisdiction of Parks Canada”	43,000 m^2 “One of the largest impacts on any wetland within the jurisdiction of Parks Canada”	600 m^2 (at work bridge pile support locations).
• Changes to substrate	• Construction of a berm will cause compaction of substrate	• Removal of riverbed may result in change in substrate that subsequently changes species composition.	• Effects to several smaller areas; long-term effects not expected.
• Re-vegetation	• Re-establishment of aquatic vegetation expected to be slow (greater than 1 to 2 years) • Change in bathymetry of riverbed expected to reduce potential for natural re-propagation of vegetation.	• Re-establishment of aquatic vegetation expected to be slow (greater than 1 to 2 years)	• Effects to several smaller areas; long-term effects not expected.
• Habitat	• Berm will cause loss of access while the berm is in place as well as fragmentation of habitat. • Hard substrates used in construction may attract turtles and put them at greater risk of mortality or non-viable nests.	• No physical barrier to mobility of aquatic animals. • Value of “different habitat type” after dredging considered to be low.	• Effects to several smaller areas, as a result post-disturbance rehabilitation expected to be faster and therefore long-term effects not expected.
• Water quantity	• Berm may affect water flow and result in flooding.	• Potential for change in water flows due to change in riverbed elevation along dredged channel.	• Small footprints, no effects expected.
• Water quality	• Potential for creation of stagnant zones with reduced water quality. • Potential for re-suspension of sediment and dispersion of associated contaminants	• Re-suspension of sediment and dispersion of associated contaminants during dredging • Potential change in sediment dynamics and subsequent elevation in ambient turbidity following dredging	• Localized potential for sediment re-suspension. • No expected long term change to sediment dynamics and ambient turbidity.
Project Risks, Uncertainties, and Implications			
Geotechnical			
• Slumping (inward)	• Not expected	• Due to soft nature of substrates, there is potential for slumping of side walls during dredging.	• Not expected.
• Displacement (outward)	• Potential for displacement (i.e., forcing of soft substrates laterally) of soft substrates during placement of material to construct berm.	• Not expected. Displacement inward may occur due to unstable material, resulting in larger volumes of dredged material than calculated.	• Not expected.
• Compaction	• Placement of material may cause compaction of underlying substrates. • Settlement of the placed Berm/Causeway may impair project (needs analysis) • Behaviour of placed material with loads from construction material needs geotechnical assessment.	• Not expected.	• Not expected except in localized area of pile supports.
Risks and Uncertainties	• Larger footprint disturbed, potentially exceeding area stipulated in the EA approval for the project. Regulatory implications of exceeding permitting spatial area of impact need to be considered. Potentially could result in a regulatory or injunctive termination of the project. • Compaction of substrate a concern of Parks Canada – may influence ability to receive permission for project.	• Larger footprint disturbed, potentially exceeding area stipulated in the EA approval for the project. Regulatory implications of exceeding permitting spatial area of impact need to be considered. Potentially could result in a regulatory or injunctive termination of the project. • Depth of dredged channel may require maintenance dredging (going back to dredge and material management costs currently not accounted for).	• Risk of exceeding approved project footprint area low because of large approved area of work.
River Hydraulics			
• Flooding	• Berm may temporarily alter flows and result in flooding (Parks Canada) • Note: Berm is part way across, water expected to flow around the Berm but Parks Canada may require a river hydraulics/flooding assessment.	• Not expected	• Not expected

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
• Flows and sediment dynamics	• Berm will temporarily constrict river during construction and thus may change flows and sediment dynamics • Note: assessment may be required by Parks Canada for possible effects of scour as water is confined through a smaller cross-section.	• Dredging will result in a near-term permanent lowering of the riverbed, which may change flows and sediment dynamics such as deposition and scour of habitats in the area. • Alternatives by using a cross braced sheet pile channel could be available at increased cost and would require similar hydraulic assessments as a berm. • Note: this presumes that replacement of dredged material will not be allowed. Some room for regulatory discussions may exist but this will add to project cost/complexity/uncertainty	• Minor localized temporary potential change in flows
Risks and Uncertainties	• Future liability for damages if such damages are caused. • Downstream water quality effects, particularly as a result of scour or turbidity from placement/removal of the material. • Change in sediment deposition which may affect existing habitats. The change need not be particularly negative in terms of functional ecology but objectives in Parks are oriented around environmental preservation (no change) vs conservation (change with compensatory habitat).	• Potential future downstream water quality effects if sediment transport and turbidity dynamics change. • Future change in sediment deposition which may affect existing habitats. • Parks Canada has, at present stipulated that dredged material may not be returned. This will change currently estimated costs for dredged material management. • Further regulatory negotiation may be needed to obtain permission to replace dredged material. Material will be poorly consolidated compared with existing.	• Localized temporary changes not expected to have substantial cumulative effect beyond new bridge supports where compaction will occur and some potential for scour along the sides of the supports could occur.
Disposal of Sediment			
• Water management and turbidity control	• Berm will need to removed. Disposal location will be needed. If material testing for Berm construction is not sufficient for land-based disposal, it may need to be tested to obtain regulatory approval for land disposal use. • Disposal location needed. • Cost of excavation/handling will need to be considered if not already included	• Project approval not likely (per communications from Parks Canada) to be received for returning dredged material to riverbed or for use in habitat offsetting therefore offsite disposal is likely. • Prior to transport for disposal, sediments will likely need to be dewatered to “spadeable” condition, which may need to be facilitated with the use of thickeners/flocculants or other methods.	• NA - disposal of sediment not anticipated. Potentially disposal of sediment for piers of final bridge
• Suitable disposal location	• Unless it can be returned to its source, a disposal location for the berm construction material will be needed.	• Location relative to site to be confirmed.	• NA - disposal of sediment not anticipated.
Risks and Uncertainties	• Regulatory standards to be applied will be based on disposal location • Disposal location is needed • Testing may be needed. • Methods of excavation?	• Project approval from Parks Canada for returning dredged sediment to riverbed not likely based on their letter; therefore, offsite disposal would likely be required – this has implications for cost and schedule. • Need to confirm that an off-site disposal location is available with sufficient volume, including slumping into the dredge cut. • Dewatering of sediment needs to be factored into overall schedule and costs if going offsite. • Additional equipment (water treatment) and suitable staging area would be needed.	• NA - disposal of sediment not anticipated.
Aquatic Habitat			
• Fish	• Relatively large aquatic footprint. • During construction, berm may be a barrier to fish migration	• Relatively large aquatic footprint. • Has potential to affect fish migration and spawning	• Potential to affect fish via underwater noise. Method dependent – could result in mortality • May require bubble curtain or other mitigation
• Turtles	• Berm may overlap habitat for hibernation • Hard substrates of berm may attract turtles for nesting and basking (Parks Canada)	• Dredging could result in mortality to hibernating turtles or incubating eggs. • Depending on the species’ conservation status, dredging could potentially be seasonally halted if turtles are buried in mud near the dredging area (e.g., Burnaby Lake dredging and painted turtles)	• May need to schedule pile driving around sensitive time period. • May need to halt work or conduct seismic surveys in pile locations if turtles are buried in mud at locations of driven piles. • Depending on method, underwater noise/”percussion” of diesel hammer (if used) may have negative effects on turtles. Unknown if mortality could/would be caused.

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
• Offsetting/ rehabilitation costs	• Potentially substantial costs associated with restoring footprint and functions due to importance of wetland	• Potentially substantial costs associated with restoring footprint and functions due to importance of wetland.	• Lowest area affected and therefore lowest costs expected. Parks Canada suggests relatively fast recovery due to overall small area associated with multiple small footprints.
Risks and Uncertainties	• Project approval from Parks Canada may not be issued due to concern with loss of habitat. • Rehabilitation or mitigation costs could be substantial. • Schedule may be affected by need to stage work around regulatory exclusions and sensitive life stages (e.g., spawning, spawning migration, hibernation).Future liability - proponent will be responsible for ongoing restoration or mitigation alternatives if planned work is not successful.	• Project approval from Parks Canada may not be issued due to concern with loss of habitat. • Amount of habitat disturbed is likely to be considerably higher than the dredge prism designed. For quantitative purposes, assume that the slope will “unravel” to a 5:1 (H:V) beyond the dredge prism for calculation purposes. • Re-dredging may be needed and may be constrained by seasonal effects. • Rehabilitation or mitigation costs could be substantial – these costs are currently unknown as the offsetting associated with this option has not been designed nor is there indication from Parks Canada that it would necessarily accept habitat offsets, what the offset ratios might be etc. • Schedule may be affected by need to stage work around sensitive life stages (e.g., spawning, spawning migration, hibernation). • Future liability - proponent may be responsible for ongoing restoration or mitigation alternatives if planned work is not successful.	• Relatively low rehabilitation costs expected. • Schedule may be affected by potential need to stage work around sensitive life stages. • Unknown effect of percussive blast wave propagation through mud on turtles. • May need to mitigate pile driving effects (underwater noise)
Terrestrial Habitat			
• Riparian Vegetation	• Access may require removal of vegetation if present in staging area.	• Access may require removal of vegetation	• Access may require removal of vegetation
• Birds	• Removal of trees may affect nesting birds (possible seasonal limitation)	• Removal of trees may affect nesting birds	• Removal of trees may affect nesting birds
• Wildlife	• Wildlife access and dens/burrows may be affected	• Wildlife access and dens/burrows may be affected	• Wildlife access and dens/burrows may be affected
• Offsetting/ rehabilitation costs	• Shoreline may need to be restored and vegetation replaced.	• Shoreline may need to be restored and vegetation replaced.	• Shoreline may need to be restored and vegetation replaced.
Risks and Uncertainties	• May need to be scheduled around sensitive life stages. • Permitting process associated with disturbing birds or wildlife. • Proponent will be responsible for ongoing restoration or mitigation alternatives if planned work is not successful	• May need to be scheduled around sensitive life stages. • Permitting process associated with disturbing birds or wildlife. • Proponent will be responsible for ongoing restoration or mitigation alternatives if planned work is not successful.	• Permitting process associated with disturbing birds or wildlife. • Proponent will be responsible for ongoing restoration or mitigation alternatives if planned work is not successful.
Water Quality			
• Induced turbidity	• Placement of material may be reasonably expected to mobilize riverbed sediments and cause elevated turbidity • Narrowing of river cross-section may result in higher velocity in constricted parts of the river and scour in those locations	• Dredging of sediment will mobilize sediments and cause elevated turbidity • Hydraulic dredging generates approximately 10:1 water to sediment ratio – water needs to be managed which may require treatment to reduce suspended solids. May require use of flocculants, thickeners, geotubes etc.	• Temporary, localized effects to water quality. • Temporary effects again during pile removal especially if pulled vs cut piles are used.
• Contaminant dispersion	• Sediments not contaminated – no effect expected	• Sediments not contaminated – no effect expected.	• Sediments not contaminated – no effect expected.
Risks and Uncertainties	• Project approval from Parks Canada may not be issued due to concern with water quality effects. • Schedule delays where construction slowed or stopped to meet performance objectives. • Can be managed with additional cost for environmental controls such as a silt curtain or other barrier	• Project approval from Parks Canada may not be issued due to concern with water quality effects. • Can be managed with additional costs associated with controls such as a silt curtain or other barrier. • Schedule delays where dredging slowed or stopped to meet performance objectives. • Use of flocculants increases potential risk of water quality concerns where the effluent discharge is to the river.	• Can be managed without substantial additional cost for specialized environmental controls. • To Consider: Parks Canada may require piling removal. This may or may not be feasible without a large disturbance. If Turtles like the hard substrate consider cutting to mudline and finishing off with a rock mound over the pile as a series of small habitat reefs

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
Navigation/Recreation			
• Boat passage	• Likely outside boundaries specified in Navigation Protection Act so no formal notification/permitting expected. • Navigation channel will be substantially reduced in width during period of construction	• Likely outside boundaries specified in Navigation Protection Act so no formal notification/permitting expected. • Safety perimeter around dredging equipment will be needed but relatively smaller width of channel expected to be affected.	• Likely outside boundaries specified in Navigation Protection Act so no formal notification/permitting expected. • Temporary bridge may be a hazard to navigation (vertical clearance) and design will need to consider vessel passage provisions through a section
Risks and Uncertainties	• Relatively higher impact on vessel access restriction which may affect recreational users of the waterway. • Communications plan, navigation markers/lights may be needed	• Relatively lower likelihood that boating access will need to be restricted. • Communications plan, navigation markers/lights may be needed for certain parts of the project.	• Relatively higher likelihood that boating access will need to be restricted. • Communications plan, navigation markers/lights may be needed for the temporary structure
Archaeology			
Loss/ disturbance of artefacts	• Placement of construction materials may bury artefacts.	• Dredging may remove artefacts.	• Installation of piles may bury/damage artefacts, but in a relatively small area.
Risks and Uncertainties	• Can be managed with archaeological monitoring and appropriate chance find management. • Project shut-down if human remains found.	• Can be managed with archaeological monitoring and appropriate chance find management. • Project shut-down if human remains found.	• Can be managed with archaeological monitoring and appropriate chance find management. • Project shut-down if human remains found. • Overall footprint of disturbed materials is smaller and therefore risks of intersecting cultural materials is considered to be lower than for other options.
Noise and Air Quality / Nuisance			
Construction noise	• Some noise generated through placement of material (e.g., motors, metal upon metal, metal upon rock).	• Some noise generated through dredging (e.g., motors, metal upon metal).	• Depending on the method used, pile driving can be relatively noisy and result in nuisance complaints.
Air quality	• Typical emissions from construction equipment. • Truck traffic involved in two way material movement	• Typical emissions from construction equipment. • Dredged and dewatered sediment will need to be managed to minimize dust.	• Typical emissions from construction equipment.
Risks and Uncertainties	• Municipal bylaws may restrict when construction work can happen to minimize nuisance noise in residential areas, which may have an influence on the overall schedule.	• Municipal bylaws may restrict when construction work can happen to minimize nuisance noise in residential areas, which may have an influence on the overall schedule. • Additional controls may be needed for dust management.	• Municipal bylaws may restrict when construction work can happen to minimize nuisance noise in residential areas, which may have an influence on the overall schedule. • Communications plan to address complaints.
Traffic			
Import of material	• Additional traffic through adjacent communities if construction materials brought in by truck.	• Not expected.	• Additional traffic through adjacent communities if construction materials brought in by truck
Export of dredged material	• Not expected.	• Additional traffic through adjacent communities if dredged sediment transported to a landfill by truck.	• Not expected.
Risks and Uncertainties	• Intermediate number of truck trips for this option. • Municipal bylaws may restrict truck routes and schedules, which may have an influence on the overall schedule.	• Greatest number of truck trips for this option. • Municipal bylaws may restrict truck routes and schedules, which may have an influence on the overall schedule.	• Least number of truck trips for this option. • Municipal bylaws may restrict truck routes and schedules, which may have an influence on the overall schedule.
Studies/Plans Needed in Addition to Preliminary Design			
Geotechnical	• Plan for placement and recovery of material • Berm side-slope and confirmation of spatial impact zone • Deformation of existing sediment surface adjacent to the berm • Stability of work surface and settlement of material	• Assessment of potential for slumping of side walls of dredge channel	• Assessment of seating depth for temporary pilings. • Methodology of piling driving and development of mitigation plans (e.g., bubble curtain). • Type of piling and need for preservatives (e.g., creosote) if not steel pile

Table 6.6.1: Evaluation Matrix for Construction Options

Variable	Temporary Earthen Berm / Causeway	Dredging	Temporary Work Bridge
River Hydrology	• Potential for flooding • Change in water flows and natural hydrologic and sediment transport processes • Ice scour • Bathymetry • Geophysical (sediment thickness)	• Change in water flows and natural hydrologic and sediment transport processes. • Ice scour • Bathymetry • Geophysical (sediment thickness)	• Hydraulic design of pier • Scour analysis
Sediment and erosion control	• Silt curtain configuration • SECP	• Silt curtain configuration • SECP	Silt curtain configuration
Sediment dewatering	• Methods for effective dewatering of dredged sediments • If flocculants are proposed, bench-scale testing and toxicity testing may be needed. • Water quality monitoring plan • Staging area	• Methods for effective dewatering of dredged sediments • If flocculants are proposed, bench-scale testing and toxicity testing may be needed. • Water quality monitoring plan. • Staging area	• Water quality monitoring plan
Water treatment	• Water treatment may be needed for the subaqueous portions of the berm material when it is removed.	• Methods for effective treatment of water generated during hydraulic dredging. • If flocculants are proposed, bench-scale testing and toxicity testing may be needed.	N/A
Sediment disposal	• Location of disposal of the Berm material (and over-excavated sediment) • Sampling and analysis of Berm material to support material management at the disposal location • Locations that can accept sediment of this type, cost analysis of transportation and tipping fees.	• Locations that can accept sediment of this type, cost analysis of transportation and tipping fees.	• Possibly required for permanent bridge piers. Volumes will be small. Can be managed with geotubes and local disposal or landfill disposal.
Noise/air	• Dust management plan • Odor Controls	• Dust management plan • Odor Controls	• Assessment of noise associated with installation of temporary pilings for work bridge • Noise monitoring plan • Communications plan for addressing complaints.
Archaeology	Management Plan	Management Plan	Management Plan
Restoration	• Restoration planning, including long-term monitoring	• Restoration planning, including long-term monitoring	• Method of pile removal and options for different methods (e.g., cut and cover, remove entire pile) • Environmental management planning

Drawing 6.7.1: Temporary Work Bridge

7.0 DESIGN CONCEPT REFINEMENT

The City and Project Team collaborated extensively with Parks Canada to determine how the environmental and economic aspects associated with building the bridge could be balanced. The solution was to refine the v-pier design for the approach spans and convert them into conventional piers with pier caps supporting the superstructure. These conventional piers were shaped to form a cohesive part of the architectural design.

7.1 Conventional Piers versus V-Piers

7.1.1 Alternative Pier Design

The use of v-piers for all the pier locations would have an impact to the sensitive wetlands as each foundation would require excavation of the riverbed and create a permanent footprint in the river. Alternative pier options were investigated to minimize the impacts to the riverbed as well as reduce the overall cost of the substructure. The piers which support the arch span would remain unchanged for aesthetics reasons.

The first option that was considered was conventional piers which consist of circular piers on top of the caissons with a pier cap as shown in **Figure 7.1.1.1**. With the use of conventional piers instead of v-piers, the foundation requirements are reduced significantly. As there is less ice loading on the piers due to their circular shape and no footing at the river level, the foundation requirements can be reduced from five 2400 mm diameter caissons to two 1800 mm diameter caissons, using an ice loading of 1100 kPa at an elevation of 75.9 m, which is the high ice loading. The circular caissons would extend above the high-water level and be protected by a steel casing to add protection to the concrete from ice and abrasion.

7.1.2 Span Arrangement

Five additional piers will be required with the conventional pier option (four to the west of the arch and one to the east of the arch) as the elimination of the v-piers would have increased the span lengths (had a similar pier spacing been used for the conventional one). The span lengths to the west of the arch will be consistent at 59.2 m except for the first span which will be 47.2 m and the span adjacent to the v-pier which will be 58.9 m for geometric reasons. To the east of the arch, there will be two spans at 49.0 m and one span at 38.1 m. shows the difference in the span arrangements from the v-pier option to the conventional pier option. Having consistent span lengths will create efficiencies during construction. As the span lengths are shorter overall than the span lengths with the v-piers, there is a reduction in both the structural steel weight of approximately 450 tonnes and associated costs.

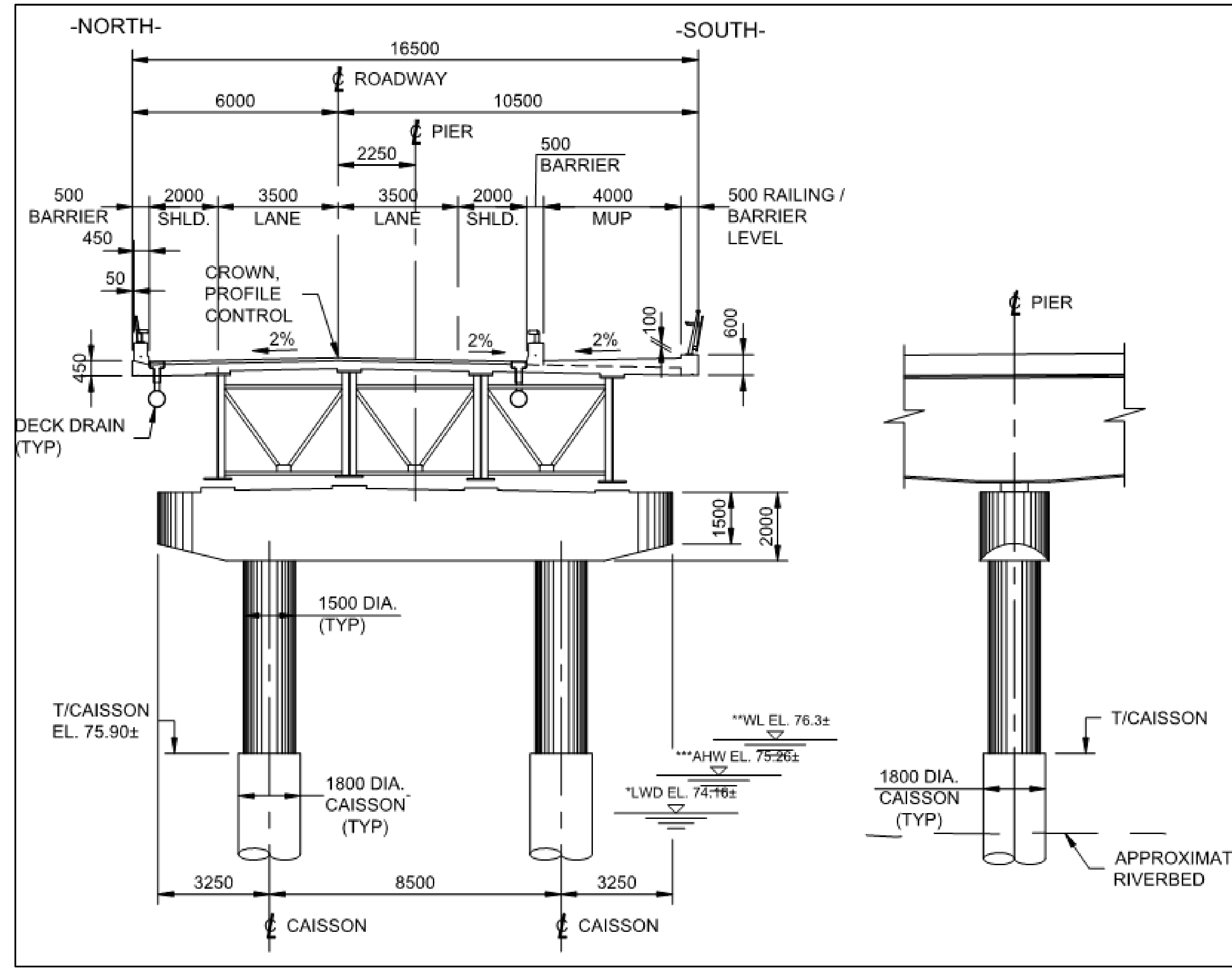


Figure 7.1.1.1: Conventional Circular Piers with Hammerhead Pier Cap

Drawing 7.1.2.1: Span Arrangement Comparison

7.1.3 Comparison with V-Piers

An evaluation matrix was created as shown in **Table 7.1.3.1** to compare the advantages and disadvantages of v-piers and conventional piers.

Table 7.1.3.1: Evaluation matrix for Different Pier Options.

Criteria	Sub-Criteria	V-Piers	Conventional Piers
Description		This option would consist of three wall-type flared piers at the west side with ten v-piers. The v-piers will be supported on five 2400 mm diameter caissons with a pile cap. Each v-pier will require post-tensioned ties. The arch span will be supported by two v-piers on eight 2100 mm diameter caissons.	This option would consist of 16 simple piers that will comprise of two 1800 mm caissons with two 1500 mm circular piers and a pier cap. There will be 4 additional piers west of the arch and 1 additional pier east of the arch. The arch span will be supported by two v-piers on eight 2100 mm diameter caissons.
Permanent Foundation In-Water Footprint / Wetland Impacts (excluding scour protection)		~ 2400 m^2	~ 1100 m^2
Cost	Piers Only	~$53.8M	~$24.4M
	Superstructure	No change.	-$2.2M
	Total	~$53.8M	~$22.2M
Ease of Construction	Caissons	Would require larger equipment to install the larger diameter caissons.	Equipment for caisson installation would be more readily available.
	Formwork / Falsework	V-piers would require specialty formwork / falsework or be made of precast box sections or varying geometry. Temporary supports would be required for some of the v-pier legs during construction.	The piers would require simple standard formwork.
	Reinforcement	Reinforcing will be more complex to match the geometry of the v-piers. Post-tensioning will be required in the ties.	Reinforcing could be tied off-site for the piers and lifted into place.
Construction Duration Per Pier[1]	Considerations	Five caissons required. The piers will take longer to form as each one is geometrically different. V-piers require post-tensioning in the ties and potentially in the v-pier legs. Five different pours – caissons, pile cap, base of v-pier, v-pier legs, and tie.	Two caissons required. The piers will be simple to form using standard formwork. Three different pours – caissons, circular piers and pier caps.
	Estimated Total Duration	~15 weeks per pier.	~7 weeks per pier.
Aesthetics	Substructure	More aesthetically pleasing v-piers.	V-Piers only at the arch, conventional piers elsewhere.
	Superstructure	Similar.	Similar.
	Arch	Similar.	Similar.
User Experience	On the Bridge	Similar.	Similar.
	On Boat	Similar.	Similar within navigation channel
Maintenance and Operation Costs	Bearings	More bearings to maintain - 96 bearings.	Less bearings to maintain – 92 bearings.
	Concrete	Greater surface area of exposed concrete.	Lower portion of caissons will be jacketed with steel liner to provide extra protection. Smaller exposed concrete surface area.
Maximum Spacing Between Piers[2] (excluding arch span)		~90 m	~58m
Design	Advantages	N/A	Less area exposed to ice loads. Conventional pier design. Less demand on the substructure components.
	Disadvantages	Piers will require special treatment to break the ice.	N/A

1. This evaluation matrix does not account for the arch v-piers as they are the same for both options.
2. V-piers have two legs and two lines of supports, this criterion measures the spacing between the centerline of the v-piers.

Based on the matrix, the conventional pier option is preferred, as it is the least expensive; has less impact to the wetland; is easier to build; and is easier to subsequently maintain and repair.

7.1.4 Class 'C' Cost Estimate

A Class 'C' comparative cost estimate was conducted to determine the cost difference between the two pier options as shown in **Table 7.1.4.1**. The use of conventional piers decreases the number and size of caissons required, even with the additional piers. This is because the ice loading is considerably less on the conventional piers due to their circular shape and smaller surface area. The cost savings from the use of conventional piers in caissons alone is approximately $13.8M. The conventional piers have less concrete than the v-piers, are less expensive to form and do not require a post-tensioned tie. The overall cost savings based on the Class 'C' Cost Estimate is $29.4M for the piers alone, which does not include the additional $2.2M in savings from the reduction in structural steel in the approach spans.

Table 7.1.4.1: Class 'C' Cost Comparison between V-Piers and Conventional Piers

Piers	Three Wall Type Piers, Remaining Piers are V-Piers	Sixteen Conventional Piers and Two Arch V-Piers	Difference
Item Description	**Total Cost**	**Total Cost**	
Dewatering Structure Excavations	$375,000	$375,000	
Supply Equipment for Installing Caisson Piles	$1,890,000	$1,890,000	
Caisson Piles	$11,600,000	$6,246,000	$5,174,000
Excavate Rock Sockets	$3,000,000	$2,100,000	$900,000
Tremie Concrete - Caissons	$8,376,000	$2,976,000	$5,400,000
Reinforcing Steel – Black – Caissons	$3,840,000	$1,504,000	$2,336,000
Concrete in Pile Cap	$2,980,000	$1,010,000	$1,970,000
Reinforcing Steel – Black – Pile Cap	$1,056,000	$384,000	$672,000
Concrete in Pier – Wall Type	$480,000	$290,000	$190,000
Concrete in V-Piers	$12,636,000	$4,716,000	$7,920,000
Reinforcing Steel – Galvanized – V-Piers	$5,070,000	$1,950,000	$3,120,000
Concrete in V-Pier Ties / Pier Caps	$1,056,000	$456,000	$600,000
Reinforcing Steel – Galvanized – V-Pier Ties / Pier Caps	$351,000	$195,000	$156,000
Pier – Stressing System	$1,075,000	$107,500	$967,500
Total for Piers Section	**$53,785,000**	**$53,785,000**	**$29,405,500**

7.2 Refinement of Conventional Pier Design

The City and Project Team continued to collaborate with Parks Canada in refining the conventional pier design to better match the aesthetics of the v-piers at the arch and the arch geometry. The use of inclined rectangular piers instead of circular piers provides a cohesive look along the bridge as the incline of the pier legs matches the inclination of the v-piers and the tilted arch. A standard transition from a circular caisson to a rectangular pier leg would be used to convert the circular form into the rectangular pier leg over a height of 1.5 m. The use of a custom steel form could be used to form the transition which could be re-used multiple times. Keeping the inclination of the pier legs consistent at 10˚ and the pier cap width at 13.5 m, the caisson spacing would have to vary to maintain the same geometry. As the piers get taller, the caissons get closer together. The inside face of the pier legs would also be inclined at 10˚ to match the shape of the v-piers as shown in **Figure 7.2.1**. The refinement of the conventional piers to inverted u-frame piers is shown in **Drawing 7.2.1**.

The total additional costs for the inverted u-frame piers option over the circular piers with pier cap option is approximately $268,000 for all the piers. There is less concrete and reinforcement in the pier cap for the inverted u-frame option than the circular pier option. However, there is more concrete in the pier legs and it is slightly more expensive to form the inverted u-frame pier legs than the circular piers, which is why there is an increase in cost as shown in **Table 7.2.1**.

Table 7.2.1: Cost Comparison between Circular Pier Option and Inverted U-Frame Pier Option

		Circular Piers with Pier Cap			Inverted U-Frame Piers			Difference
Item Description	**Unit**	**Estimated Quantity**	**Unit Price**	**Total Cost**	**Estimated Quantity**	**Unit Price**	**Total Cost**	**Total Cost**
Piers								
Caisson Piles – 1800 mm Dia.	m	1150	$ 4,200	$4,830,000	1150	$4,200	$4,830,000	$-
Caisson Piles – 2100 mm Dia.	m	350	$5,000	$1,750,000	350	$5,000	$1,750,000	$-
Tremie Concrete - Caissons	m3	4130	$800	$ 3,304,000	4130	$800	$3,304,000	$
Excavate Rock Sockets	m	190	$10,000	$1,900,000	190	$ 10,000	$1,900,000	$
Reinforcing Steel - Black - Caissons	t	990	$3,200	$3,168,000	990	$3,200	$3,168,000	$

Table 7.2.1: Cost Comparison between Circular Pier Option and Inverted U-Frame Pier Option

		Circular Piers with Pier Cap			Inverted U-Frame Piers			Difference
Item Description	Unit	Estimated Quantity	Unit Price	Total Cost	Estimated Quantity	Unit Price	Total Cost	Total Cost
Concrete in Pile Cap	m3	1010	$ 1,000	$1,010,000	1010	$1,000	$1,010,000	$-
Reinforcing Steel - Black - Pile Cap	t	120	$3,200	$384,000	120	$3,200	$384,000	$ -
Concrete in Pier	m3	180	$ 1,000	$180,000	420	$1,200	$504,000	$(324,000)
Concrete in Piers - V-Piers	m3	2620	$ 1,800	$4,716,000	2620	$1,800	$4,716,000	$ -
Reinforcing Steel - Galvanized - Piers	t	490	$3,900	$1,911,000	500	$3,900	$1,950,000	$(39,000)
Concrete in Pier Caps	m3	870	$1,200	$1,044,000	760	$1,300	$988,000	$56,000
Reinforcing Steel - Galvanized - Pier Caps	t	90	$ 3,900	$351,000	80	$3,900	$312,000	$39,000
Concrete in V-Pier Ties	m3	230	$1,200	$276,000	230	$ 1,200	$276,000	$ -
Reinforcing Steel - Galvanized - V-Pier Ties	t	30	$3,900	$117,000	30	$3,900	$117,000	$ -
Pier - Stressing System	t	1	$215,000	$107,500	1	$215,000	$107,500	$-
Total				**$25,048,500**			**$25,316,500**	**$(268,000)**

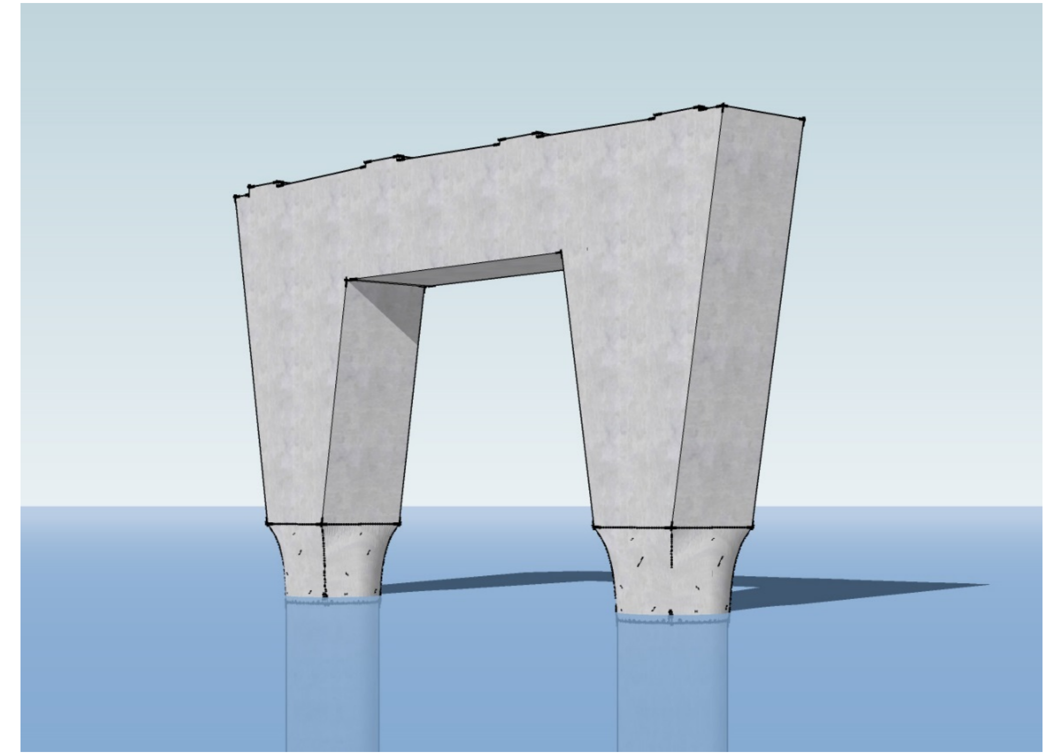


Figure 7.2.1: Rendering of Inverted U-Frame Pier

7.3 Benefits of Alternative Design

There are numerous benefits to the use of inverted u-frame piers over v-piers:

1. The reduction of the impact to the wetland.
2. Substantial cost savings with the v-pier option by over $30M.
3. The use of consistent spans which will simplify construction of the structural steel.
4. A simpler design which will simplify construction.
5. It will take substantially less time to construct as they are much simpler to form and do not require any complex formwork or post-tensioning.
6. Dewatering activities will not be required as the caisson liners extend above the water level.
7. The design adheres to the aesthetic guidelines as the consistent outside face angle of the piers match the tilted angle of the arches to provide a cohesive overall rhythm that gradually increases in height towards the arch.

Drawing 7.2.1: Pier Refinement

8.0 PROJECT DESCRIPTION

8.1 Overall

The Third Crossing is a 21-span, 1.2 km long bridge on an s-curve which will cross the Cataraqui River and connect Gore Road on the east shore to John Counter Boulevard on the west shore. The bridge will have a vertical curve centered on the main span which will consist of an inclined outward tied arch over the navigational channel. The arch will have five transverse braces and a total of 32 multi-strand cables which will support the floorbeams to suspend the concrete deck from the arch. The arch will be supported on concrete v-piers on both sides and the remaining 16 piers will be inverted u-frame piers with flared pier legs to match the inclination of the arch which support the approach spans. The approach spans consist of four structural steel plate girders that are haunched at the piers.

The bridge will have an overall width of 16.5 m which consists of two 3.5 m wide vehicular lanes with a 2 m wide asphalt shoulder on each side, and a 4 m wide multi-use pathway on the south side. The bridge will have a 225 mm thick reinforced concrete deck with 90 mm of asphalt and waterproofing at the roadway and two storm sewer pipes that run underneath the bridge to collect the stormwater. A preliminary general arrangement is shown in **Drawing 8.1.1**. Renderings of the preferred option can are shown in **Figure 8.1.1** to **Figure 8.1.6**.

The preliminary drawing package (provided under separate cover) includes drawings associated with the approach roadways, bridge structure and electrical and signal layout as well as landscape restoration and enhancement. Approach roadway drawings include lane arrangement, grading, stormwater management, underground infrastructure, and conceptual construction staging and laydown drawings. Bridge structure drawings include general arrangement, caisson and footing layout, abutment details, inverted u-frame pier details, v-pier details, bearing and girder layout, arch details, and temporary work bridge and riverbed impact details.

Drawing 8.1.1: Preliminary General Arrangement

Figure 8.1.1: Bridge Rendering from the Elliott Avenue Parkette

Figure 8.1.2: On-Water Bridge Rendering Looking South (Close to Buoy S33)

Figure 8.1.3: On-Water Bridge Rendering Looking South at Night (Close to Buoy S33)

Figure 8.1.4: Bridge Rendering Looking from Point St. Mark During Winter

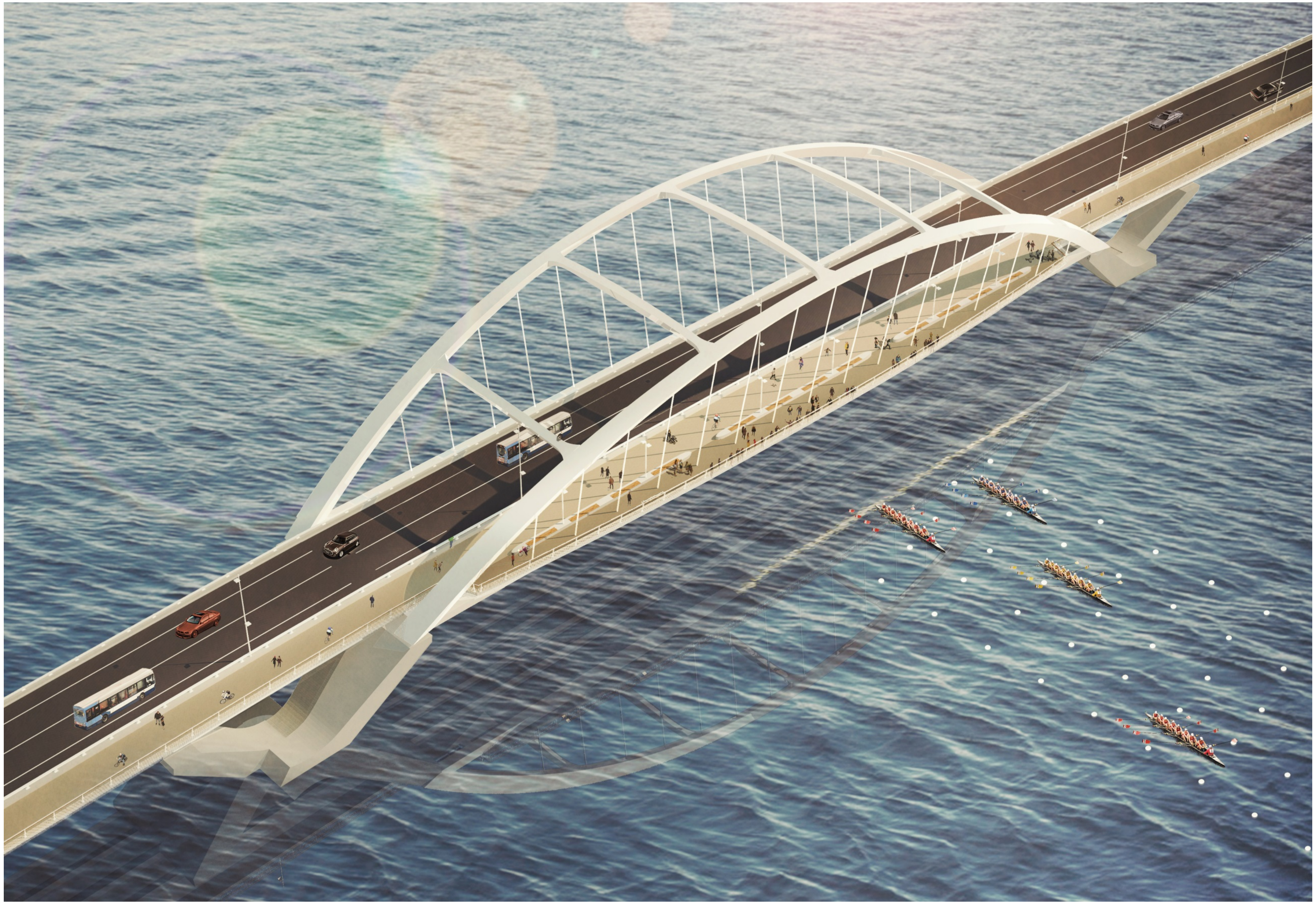


Figure 8.1.5: Bridge Rendering of Birdseye View of Arch

Figure 8.1.6: On-Water Bridge Rendering Looking North (Close to Buoy S15)

8.2 Bridge Cross Section

The vehicular bridge cross-section is uniform throughout, except at the arch where the multi-use pathway curves outward to provide a wider lookout area, with a varying width of up to 9.5 m over the navigable channel, and the rowing lanes. This is shown on **Drawing 8.2.1**.

More specific bridge cross-section components are as follows:

1. Where benches are integrated into the center barrier, the multi-use pathway width is narrower than 4 m. However, it is still wider than the standard 3 m wide multi-use pathways adopted by the City, and is in keeping with the two-way shared pedestrian lane width of 3 m to 4 m, as recommended by the TAC. This is shown in **Figure 8.2.1.1**.

2. At the lookout there will be benches that line the exterior of the multi-use path to provide a continuous multi-use pathway through the lookout area and separate the pathway from the lookout area. On the benches, there will be additional light standards to light up the lookout area as shown in **Figure 8.2.1.2**. The hangers will be protected from maintenance vehicles by curbs.

3. Cyclists will be encouraged to utilize the separated multi-use pathway. Provisions are included in the design to direct cyclists on the north side of the road (westbound direction) to cross to the separated multi-use pathway on the south side of the bridge, and then return to the north side of the approach roadway.

4. The paved shoulders provide for temporary snow storage, drainage, cyclist travel (should cyclists choose to use the shoulder instead of the multi-use pathway), and for passing, should there be a vehicle break-down or maintenance vehicle stopped on the bridge.

5. A normal crown on the vehicular portion of the bridge is provided with a 2% cross-fall in either direction towards drains located adjacent to the vehicular barriers. On the south side of the bridge, the multi-use pathway will incorporate a 2% cross-fall inwards from the south edge of the bridge deck to the concrete barrier separating the vehicular lanes and multi-use pathway. This is to facilitate drainage and snow removal activities. In the case of heavy snowfall or built up windrows, snow plowing within the multi-use pathway area will push snow to the center barrier. The windrows could then be blown over the barrier and into trucks for transport off the bridge.

Figure 8.2.1.1: Multi-Use Pathway West of Arch

Figure 8.2.1.2: Multi-Use Pathway with Lookout Area

Drawing 8.2.1: Preliminary Cross-Sections

8.3 Approach Roadway Cross Section

The approach roadway lane widths are also 3.5 m, but the shoulders are 1.5 m wide, as per current City standards for cycling infrastructure. The bridge approaches also include a normal center roadway crown with 2% cross-fall in either direction, except for the superelevation near the east approach, where a cross-fall of up to 4% northwards is provided.

8.4 Horizontal Alignment

As shown earlier on **Drawing 5.1.1**, the horizontal alignment of the bridge includes two 2200 m radii horizontal curves. This achieves a normal crown on the bridge deck and avoids the need for superelevation on the structure, based on the design speed and posted speed criteria.

8.5 Vertical Profile

The 0.75% vertical profile option as described earlier in this Report is recommended. More specific components are as follows:

1. The vertical crest is centered on the arch span to facilitate design and construction.
2. The grade on both sides of the crest is the same to allow for repeatability in the arch piers.
3. Sags on the approaches to bridge are incorporated to allow for bridge deck drainage.
4. The bridge clearance above the water accommodates existing topographic conditions on both shorelines and exceeds the Rideau Canal's minimum 6.7 m Federally regulated navigable requirement.
5. Adequate vertical clearance of the pathway is also provided at the west abutment.

8.6 Span Arrangement

The 1.2 km bridge is separated into 21 spans with a main span of 117 m supported on v-piers which have a jump span of 26.4 m. The distance pier-to-pier at the arch span provides unencumbered through-navigation for the Canal's navigable channel and adjacent rowing lanes. There are 14 inverted u-frame piers to the west of the arch and 2 inverted u-frame piers to the east. The span lengths on east side are consistent at 59.2 m except at Span 1, which is from the west abutment to Pier 1, and has a span length of 47.2 m. The span lengths to the east are consistent at 49 m except Span 21 (from Pier 18 to east abutment) is 38.1 m. The arch v-piers are similarly configured to facilitate construction.

8.7 Superstructure

8.7.1 Structural Steel - Approaches

The selected superstructure for the approach spans consists of four plate girders supporting a reinforced concrete deck. The framing system for the girders consists of a combination of diaphragms and cross-frames as required for lateral stability during construction and for live load sharing. The structural steel girders will have variable depths from 2 m at mid-span to 3 m at the pier locations to maximize the efficiency of the steel superstructure. This efficiency can be achieved if girders are erected from the work bridge.

Consideration should be given to having a constant depth girder if launching the girders from the approaches is selected as the construction means. In plan, the girders can either be curved to match the horizontal alignment or kinked to simplify fabrication. The girders would be kinked at the field splice locations which are located approximately 20% of the span length away from supports. Given the large horizontal radii of the roadway alignment, kinked girders would have a minimal effect on the deck overhang as shown in **Drawing 8.7.1.1**.

The approach span girders have typical K-frame or X-frame cross bracing comprised of angles spaced at a maximum spacing of 8 m. Additional cross bracing would be required on either side of a kink location should this option be selected. The lateral bracing will be located in one exterior bay only, and will likely be comprised of WT sections at half the spacing of the cross bracing. **Figure 8.7.1.1** shows the approach span superstructure. A catwalk could be installed between the middle girders if required, allowing for partial inspection of the soffit and access to the south side sewer pipe.

Drawing 8.7.1.1: Kinked vs Curved Plate Girders

Figure 8.7.1.1: Rendering of Approach Span Superstructure

Consideration should be given to a five-plate girder option as opposed to a four-plate girder option during detailed design as shown in **Figure 8.7.1.2**. Having five girders can reduce the width of the concrete cantilever to 1.65 m instead of 2.5 m. Cast-in-place concrete overhangs are costly to form as they require extensive temporary brackets to support the wet concrete and the exterior girders will have to be modified to account for the loading during concrete placement depending on the spacing and detailing of the overhang brackets. With the five-plate girder option, the girders would be shallower and the additional steel fabrication and erection cost would be offset by the reduction in the number of overhang supports required and the labour associated with their installation.

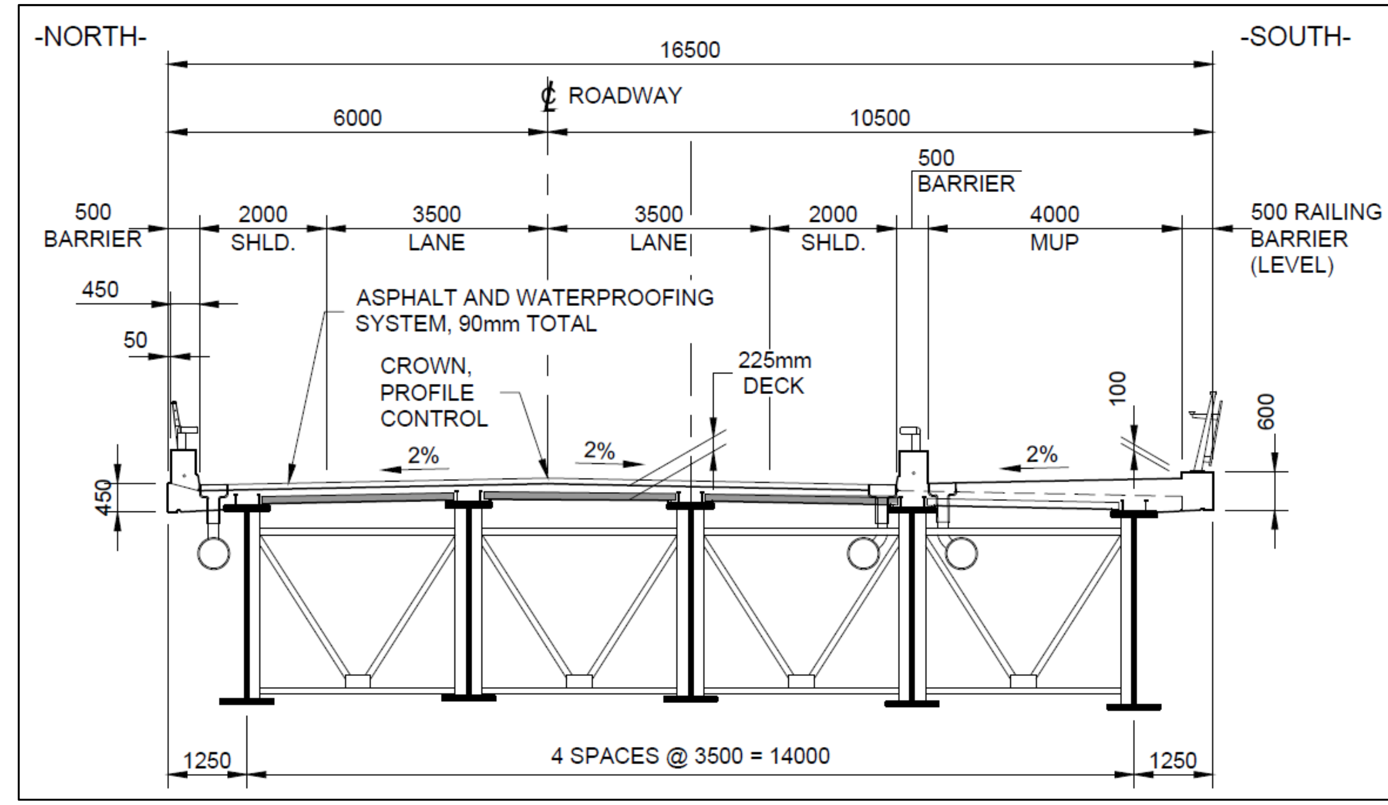


Figure 8.7.1.2: Cross-Section with Five Plate Girders

8.7.2 Arch

The arch is a tied arch, with 10° inclined outwards arch ribs, vertical cables, and five braces as shown in **Figure 8.7.2**. Although the arch is on a curved horizontal alignment, the arch is designed so that the arch ties are parallel and wide enough apart to support the widened deck due to the mild alignment curvature. The tied arch is supported on the v-piers.

As the bottom chord of the arch is in tension, the structural steel ties will be fracture critical members and will require some form of redundancy. This can be achieved either: using built-up members for the tie, thereby creating an internal redundancy or by internal post-tensioning to ensure that the tie is consistently in compression even under service loads.

Each arch will have 32 hangers that are connected to the transverse floorbeams, which will be built-up steel sections supporting the bridge deck. The multi-strand cables will be comprised of 7 to 14 seven wire strands with a diameter of 15.7 mm. Consideration should be given for additional strands for corrosion and service life monitoring in some of the hangers. The hanger system will be designed to withstand the loss of one stay cable without any effect on the overall structural integrity. The cables can be replaced by reducing the live load in the area that is supported by the cable. The anchorages of the cables will consist of an upper pin connection at the arch rib and a lower fixed connection at the floor beams. The tension in the cables will be able to be adjusted using anchorages with an adjustment nut at the floorbeams.

The transverse floorbeams will extend past the south side tie to support the cantilevered lookout zone. Five stringers will run perpendicular to and frame into the floorbeams to make the grillage system, which will support the concrete deck. A major diaphragm will be located at each end to stabilize the arch transversely. The arch bracing will be a built-up box section which flares at the connections to the arch.

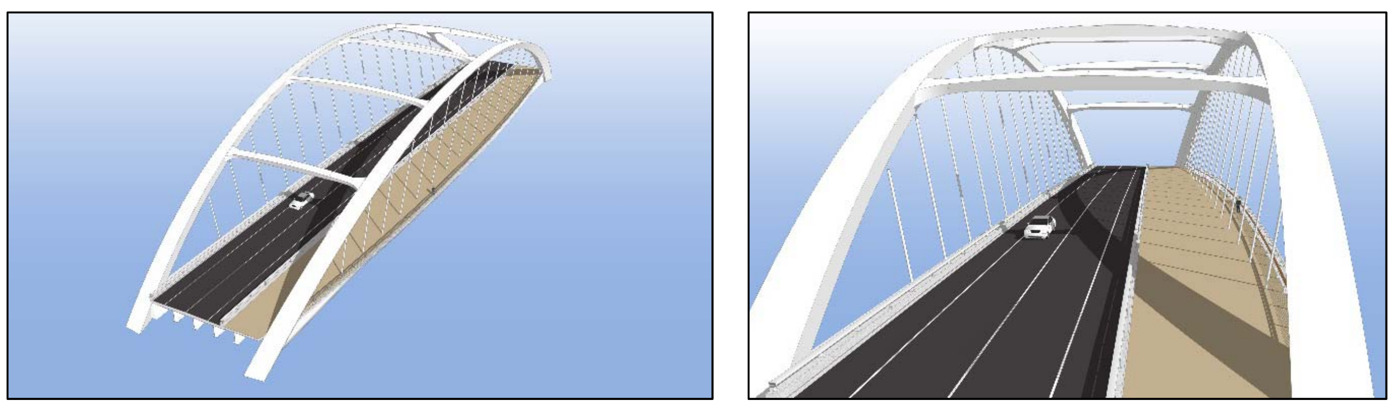


Figure 8.7.2: Design Concept for Arch

The overall height of the arch will be approximately 20 m higher than the bridge deck at its highest point. Since the arch will be centered at the high point of the bridge deck (as described in Section 5.1), the top of the arch will be the highest point on the bridge.

8.7.3 Joints and Bearings

Expansion joints are required at four different locations on the bridge: at both abutments and at the ends of the arch span. Due to the length of the west approach spans, modular joints will be required at the west abutment and the west end of the arch. At the arch east support and at the east abutment, strip seal expansion joints will be used.

The joints will be designed such that they can be easily inspected and replaced without permanent modifications to any load carrying component other than the concrete deck. The expansion joints at the arches shall include a secondary seal, gutter and/or trough to prevent any water infiltration, leading to deterioration over the v-piers which are not easily accessible for rehabilitation. The expansion joints shall be designed to be safe for both cyclists and pedestrians on the multi-use pathway and on the roadway as well as be designed to withstand snow plow wear.

The bearings will be designed to account for large movements due to the continuous arrangement of the west approach while supporting large vertical loads due to the length of the spans. Guided pot bearings will be considered for the approach spans and the arch. A bearing will be required at each girder for each pier and one bearing at the end of the rib / tie connection on the arch span. Different pot bearings are expected for the multi-directional bearings; uni-directional guided bearings; fixed bearings; and the bearings supporting the short jump span directly adjacent to the arch would require uplift restraints.

Uni-directional transversely fixed bearings will be used under one girder at all support locations, except for Pier 8 and Pier 17 to fix the bridge in the transverse direction. Pier 8 and Pier 17 will have a fixed bearing for one girder and uni-directional longitudinally fixed bearings for the remaining girders as that bearing location is at approximately the mid-point of the west side and east side, respectively. Multi-directional bearings will be used for the remaining approach span support locations. A fixed bearing will be used at west end of the arch span (Pier 15), along with a longitudinally fixed uni-directional bearing at the same end. The opposite end will have a transversely fixed uni-directional bearing and a multi-directional bearing.

The piers and bearings will be designed such that the bearings can be easily accessed for inspection and replacement without modifications to the pier cap and steel girders. The piers will be designed with the provision for future jacking for the replacement of the bearings without need for temporary falsework. The bearing pads will be designed to provide active drainage such that water does not pond against the bearings.

8.7.4 Barriers

A low wall concrete barrier with steel railing (Minnesota Combination Barrier) is recommended for the roadway section of the bridge so that it can provide unimpeded views for drivers. A similar barrier system was used for the Vimy Memorial Bridge in Ottawa over the Rideau Canal and is shown below in **Figure 8.7.4.1**.

Figure 8.7.4.1: Low Wall Concrete Barrier with Steel Railing (Vimy Memorial Bridge)

The barriers and railings on the bridge will be designed in accordance with CHBDC for a posted speed of 60 km/hr. It was determined that a TL-4 barrier would be required for the roadway based on the roadway being a Highway Class A with a design speed of 70 km/hr. All barriers except for the center barrier will have a minimum overall height of 1.37 m to accommodate a cyclist railing. The center barrier between the roadway and the multi-use path will not have any cyclist specific railings on top to ensure that cyclists have free movement over the barrier during a collision in accordance with the TAC Guide to Bridge Traffic and Combination Barriers, except at locations where there are benches or light standards on the multi-use path.

For the barrier on the south side for the multi-use pathway, open railings will be used to maximize the viewing opportunities from the bridge. A small concrete curb will be at the base of the south barrier to allow snow plows to ride against it without damaging the railing system as well as prevent salt-laden water from flowing down the fascia. Utility ducts for streetlighting and telecommunications will be located within the barrier between the roadway and the multi-use pathway to allow for maintenance. Spare ducts can be provided in the north barrier.

As discussed later in this Report, a noise barrier is required on the south side of the bridge which will extend 117 m west from the east abutment. The noise barrier on the bridge is required to be 1.5 m tall as measured from the asphalt surface and will be placed on the south side of the center barrier. As the noise barrier will be placed adjacent to traffic, a crash tested noise barrier system is recommended. Consideration will be given to noise barrier systems that do not hinder views and are bird friendly. It is optimal to have the noise barrier closer to the roadway to further diminish the noise as shown in **Figure 8.7.4.2**.

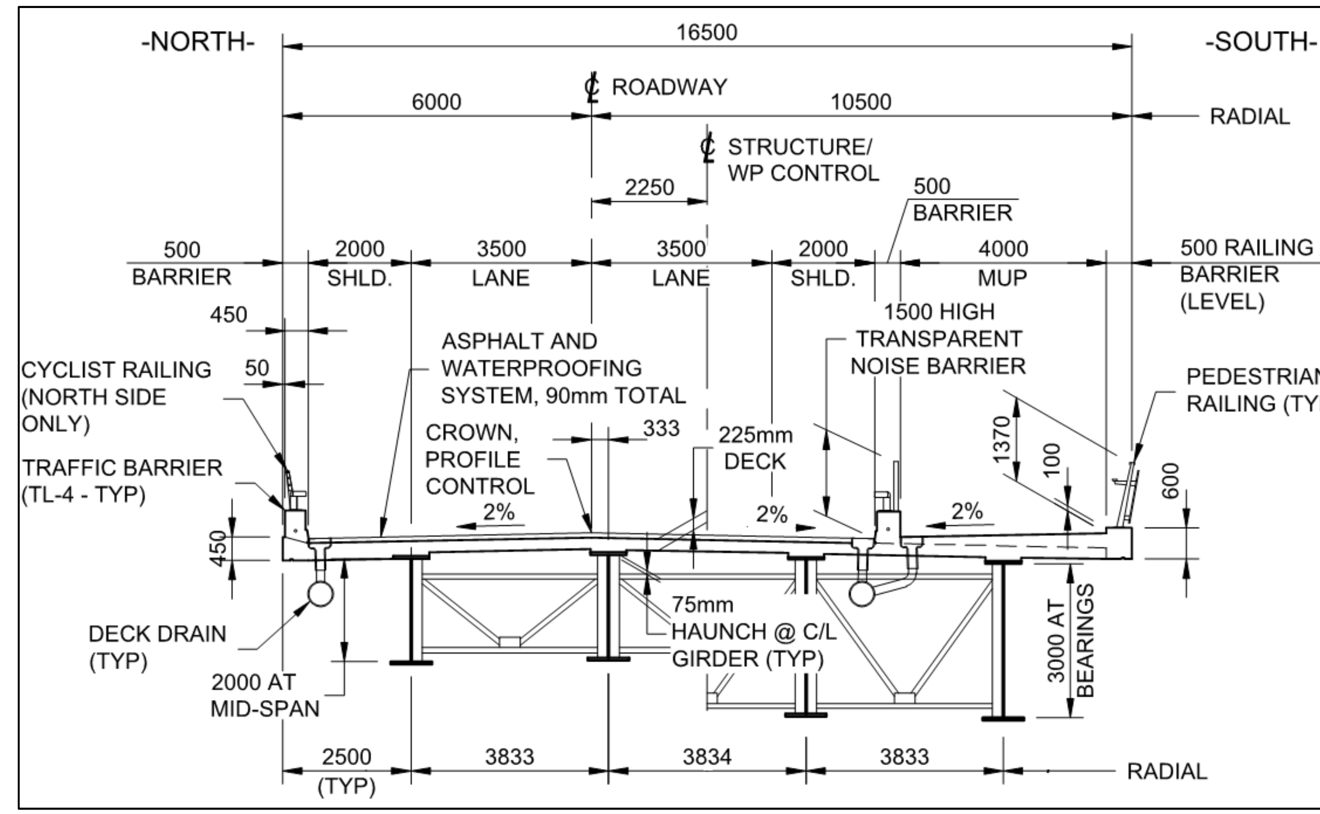


Figure 8.7.4.2: Cross-Section of Bridge East of the Arch with Noise Barrier

8.7.5 Deck

A conventional 225 mm concrete deck will be required for both the approach spans and the arch span. The concrete will be protected using a hot-applied asphalt waterproofing system and protection boards and two layers of asphalt for a total thickness of 90 mm. Galvanized/ GFRP and/or stainless steel rebar will be used in corrosion prone areas. No utilities will be located within the concrete deck to enhance the deck's durability and to prevent concrete deck damage. The wearing surface for the multi-use path portion of the deck will be a concrete surface protected by a sealant coating.

The concrete deck can either be cast-in-place or precast or a combination of both. The precast panels can either be partial depth as shown in **Figure 8.7.5.1** with a cast-in-place concrete overlay or they can be full depth with closure pieces in between.

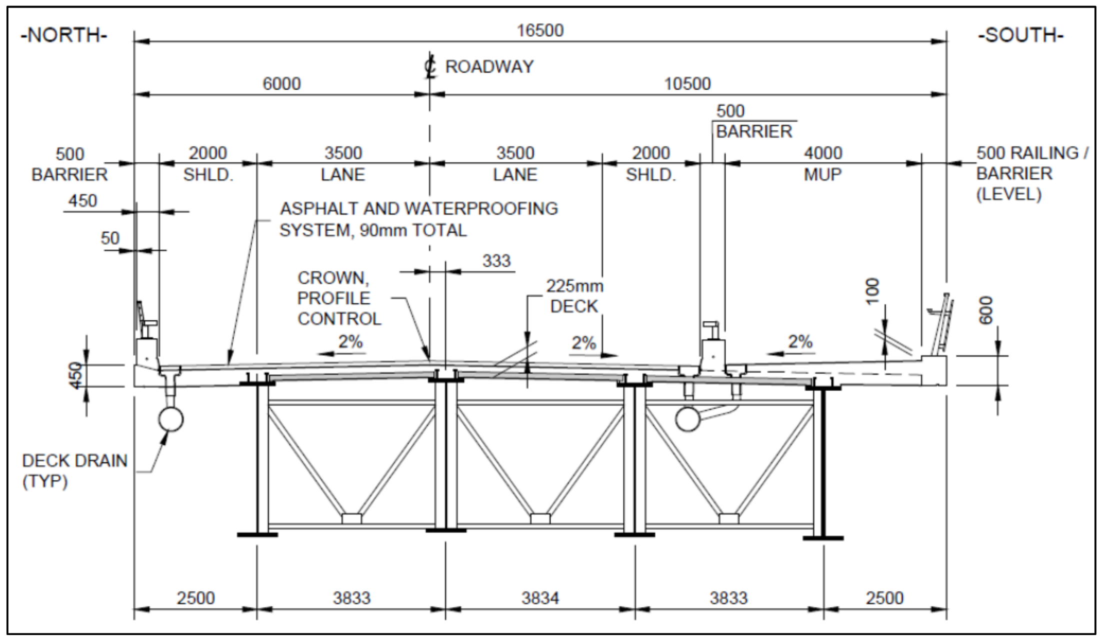


Figure 8.7.5.1: Cross-Section with Partial Precast Panels

8.7.6 Future Conversion into Additional Vehicle Lane

The bridge was analyzed to see the effects of converting the multi-use pathway into an additional traffic lane by removing the center barrier. It was determined that the substructure and approach span structural steel would not require any major modifications to account for the additional loads as the weight of the barrier and the additional concrete on the sidewalk that would be removed offsets the live loading from the additional lane. The cost of the arch span would increase by approximately 10% as it would require larger hangers and tie-beams.

8.8 Substructure

8.8.1 V-Piers at Arch

The piers at the arches will be concrete v-piers with a 26 m long jump span. The v-piers will be situated on eight-2100 mm diameter caissons rock socketed in the bedrock. The caissons will support a 2.5 m deep footing which supports the v-pier legs. The top of footing will be at an elevation of 74.0 m which is lower than the low water datum, therefore the footing will always be beneath the water. A portion of the riverbed will be excavated to construct the footing. This will either be done by using cofferdams or placement of a precast concrete shell.

The v-piers will be inclined at an angle of 43˚ from the horizon to match the shape of the arch. The interior radius of the v-pier is situated at approximately an elevation of 77.1 m which is 0.8 m above the regulatory water level so that the v-piers will always have a distinguishable V-shape. The v-piers will have different geometry on the arch and on the approach side to properly support the arch and the plate girders as shown in **Figure 8.8.1.1**. The approach side legs will have two separate legs with a 10˚ inclination on both sides to match the approach span piers and the inclination of the arch. Each pier leg will support two lines of girders based on the four-plate girder option. The arch side will consist of two wider legs in order to support the arch bearings that will be connected by a header beam at the top of the pier. There will be six bearings on the arch side leg, four for the plate girders and two for the arch. The arch pier legs and the approach pier legs are required to be tied together for stability. The ties are envisaged as post-tensioned precast concrete elements. For aesthetic reasons, the tie-beam would be hidden between the plate girders so that they are not visible in elevation. A portion of the arch legs will be formed to have a recessed texture appearance to match the geometry of the approach side pier legs. On the arch legs, there will be a ledge on the interior face where the approach span girders can be jacked to facilitate bearing replacement in the future. The use of post-tensioning strands within the v-pier legs would help to minimize the tensile stresses in the pier legs and prevent cracks.

The arch pier footing will be fitted with a pier nosing composed of either granite or steel which will act as an ice breaker to minimize the ice loading placed on the pier. The pier nosing will be inclined so that as the ice moves, it will be lifted and break apart. A further study will be required to refine the forces that will be developed by the ice movement.

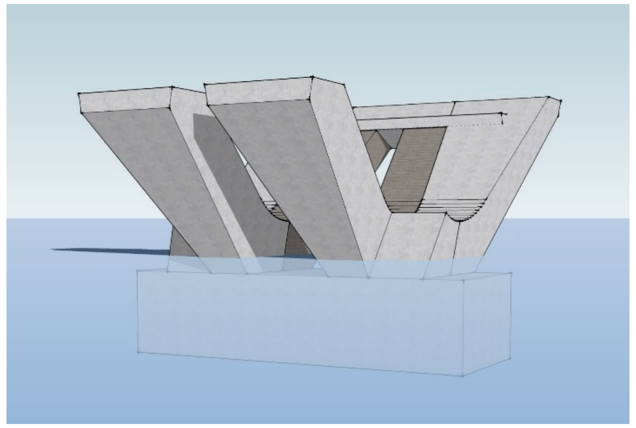


Figure 8.8.1.1: Rendering of V-Piers at Arch

8.8.2 Inverted U-Frame Piers

The bridge will have 16 inverted u-frame piers: 14 piers to the west of the arch and 2 piers to the east of the arch. The inverted u-frame piers will support the four plate girders for the approach spans. The piers will be founded on two-1800 mm diameter caissons which will be rock-socketed into the bedrock. The caissons will have a steel casing which will have a coating system applied to the top portion and for a length that will accommodate the varying water level to further protect the caissons. On top of the caissons, the pier will transition from a circular caisson to a square pier leg over a height of 1500 mm. The pier legs will be inclined outwards 10˚ to match the inclination of the v-piers and the arch. The pier legs can be cast separately from the pier cap to simplify the concrete placement. The pier caps will have a uniform shape and size for all piers, 13.5 m wide, 1.8 m long and 2 m deep to facilitate construction. The pier cap will be designed to provide jacking points on either side of the bearings to allow for jacking of the girders directly to replace the bearings. Pier leg heights will vary from 0 m tall to 4.2 m tall and the spacing of the caissons will range from 7.7 m to 11 m as shown in **Drawing 8.8.2** to maintain the constant pier cap dimensions.

8.8.3 Abutments

The abutments will be reinforced concrete founded on fourteen-600 mm diameter caissons rock socketed into bedrock. The west abutment will require minimal excavation for the construction of the abutment and the east abutment will be in a fill condition, requiring the construction of the approach embankments to achieve finished grade levels. Both abutments will have conventional concrete wingwalls. Rock protection will be used on the front and side slopes of the embankments to prevent any erosion and loss of embankment material.

8.9 Deck Drainage

As noted earlier, the key criteria for the deck drainage is the 2 m flow spread based on: the 10 year design for the traffic lanes; a 1.5 m allowable flow spread based on a five year storm event for the bike friendly traffic lanes; and 1.5 m flow spread for a 10 year design storm for the multi-use pathway. For the 0.75% longitudinal grade associated with the lower profile, the design would require 15 deck drains (OPSD 3340.150) west of the arch and 3 deck drains east of the arch. For the multi-use path, the key criterion for the drainage is that a minimum of 2.5 m remains clear of flooding during a 10-year design storm. This results in 13 deck drains to the west of the arch and 3 deck drains to the east. The deck drains will be required along the inside face of the north barrier and both sides of the south intermediate barrier. A 525 mm diameter storm sewer pipe will be required on the south side of the bridge and a 375 mm diameter sewer pipe will be required on the north side. There will be a sleeve through the abutment walls to allow the sewer pipes to go through and connect to the storm system on the approaches.

The current design for roadway drainage can accommodate more than the 10 year storm event which exceeds current best practices. Cyclists that are on the bridge during rainfall events which exceed the 10 year storm event would be able to use an area clear of flooding within the traffic lane or the multi-use pathway.

8.10 Approach Roadway Layout

The conceptual west approach arrangement was shown earlier on **Drawing 5.5.1** and includes two intersections with associated turning lanes in each direction. Vehicular lanes are 3.5 m in width and a cycling lane is provided near each curb with a 1.5 m width. The Montreal Street intersection will require an upgraded lane arrangement in all directions as part of a reconfiguration that accommodates the lanes approaching the bridge.

The conceptual east approach arrangement was shown on **Drawing 5.5.3** and also includes two intersections with associated turning lanes in each direction. Vehicular lanes are 3.5 m in width and a cycling lane is provided near each curb with a 1.5 m width, similar to the west approach. A key modification to the east approach involves the re-alignment of the Gore Road Library entrance with Point St. Mark Drive, and the signalization of this intersection.

Drawing 8.8.2: Pier Arrangement

This will enable pedestrians to cross Gore Road safely. Since the Library entrance will be located further west, the longer laneway will also provide additional queuing length at the intersection and layby parking along the sides.

Both east and west approach roadways will adopt a conventional road cross section with raised curb and gutter along the edge of pavement. Catchbasins required for stormwater management will include cycle friendly grating or side-inlets. Sidewalks and multi-use pathways are located adjacent to, or offset from, the roadway.

Integration of cycling infrastructure, pedestrian and multi-use path into the arrangement of the approach corridors is an important consideration. Over the bridge, cyclists will be encouraged to use the multi-use pathway. In order to manage the transition from roadside cycling lanes to the multi-use pathway, enhanced crossing movements may be integrated near intersections such as at Montreal Street and the reconfigured Gore Road Library-Point St. Mark Drive Entrance. As discussed earlier, at Ascot Lane, there is soft merit for including signalization at this intersection where cyclists, pedestrians and multi-use pathway users can safely cross John Counter Boulevard. The intersection has been laid out to accept signalization at a future date.

8.11 Traffic Management

A transportation assessment has been completed to confirm the turning lane requirements at three intersections along the east and west approaches to the bridge:

1. John Counter Boulevard-Montreal Street.
2. John Counter Boulevard-Ascot Lane.
3. Gore Road-Point St. Mark Drive.
4. Gore Road-Highway 15 (confirmed by others as part of the Highway 15 Class EA).

As noted earlier, the ESR presented projected volumes for a 4-lane crossing. Since the completion of the ESR, the recommended bridge cross-section has been reduced to two vehicle lanes as per the 2015 KTMP and subsequent direction by City Council (Report No. 15-268). The City has also recently updated their Travel Demand Model for the Third Crossing to account for new mode share targets that were established since the completion of the 2015 KTMP.

The performance of the three intersections within the approach areas was analyzed under the projected 2034 volumes, including the assumption that other conditions such as the widening of Highway 15 to four lanes between Gore Road and Highway 2 and a list of Development Charge Projects planned for implementation by 2019 are in place. For the purposes of this analysis and consistent with the ESR, it has been assumed that all intersections would be signalized, with the exception of the John Counter Boulevard-Ascot Lane (which would be two-way stop controlled).

The analysis was completed using the software package Synchro 8, based on the Level of Service (LOS) criteria established by the Highway Capacity Manual for signalized and un-signalized intersections. The intersection lane arrangement, signal control type, signal timing, and cycle length were optimized for each intersection in order to achieve an acceptable LOS for all approaches where possible.

Turn lane requirements were identified for each intersection based on the 2034 PM peak hour volumes. A signal warrant analysis was also completed for the following two minor intersections:

1. John Counter Boulevard-Ascot Lane.
2. Gore Road-Point St. Mark Drive.

The warrant analysis was completed using Book 12 of the Ontario Traffic Manual (OTM). Justification 7 was evaluated using the projected 2034 PM peak hour volumes. Based on these volumes, the warrants for the installation of new traffic signals were not met. Although the installation of traffic signals was deemed not to be warranted based on the OTM analysis, other factors should be considered such as the need for a protected crossing for pedestrian and cyclists at these locations.

A Class EA is currently underway for the widening of Highway 15. As part of the Third Crossing Preliminary Design project, lane arrangements selected for the Gore Road-Highway 15 intersection have been co-ordinated with the Highway 15 Class EA work to ensure a cohesive design for this intersection.

Preliminary PHM-125 drawings (which are used to plan signalized intersection layouts) have been developed for the three intersections within the project corridor (excluding the Gore Road-Highway 15 intersection, which is being determined under the separate Class EA study), as shown in **Drawing 8.11.1** to **Drawing 8.11.3**. This includes the John Counter Boulevard-Ascot Lane intersection for consideration of signalization at a future date.

Drawing 8.11.1: Preliminary PHM-125 Drawing – Montreal Street

Drawing 8.11.2: Preliminary PHM-125 Drawing – Ascot Lane

Drawing 8.11.3: Preliminary PHM-125 Drawing – Point St. Mark Drive

The issue of traffic 'short-cutting' following the construction of the bridge has also been revisited. Short-cutting is the use of local or collector streets through a residential area by roadway users to avoid perceived congestion and/or delays on the regularly travelled arterial roadway system. In this instance, it is understood that vehicles moving eastbound along the bridge could turn southbound at Point St. Mark Drive and proceed through the Point St. Mark neighbourhood to avoid using the Highway 15-Gore Road intersection. Similarly, vehicles moving northbound on Highway 15 could turn west at Point St. Mark Drive to avoid using the Highway 15-Gore Road intersection. In response to this issue, the following five alternative traffic calming measures, listed from 'least intrusive' (i.e. options 1 to 3) to 'most intrusive' (i.e. options 4 and 5), should be explored:

1. Turning restriction signs.
2. Curb bump-outs within the Point St. Mark neighbourhood.
3. Speed humps within the Point St. Mark neighbourhood.
4. Directional closures at the Gore Road-Point St. Mark Drive entrance.
5. Full closure at the Gore Road-Point St. Mark Drive entrance [with provisions for emergency vehicle and active transportation (e.g. cyclists, pedestrians) access].

Figure 8.11.1 conceptually shows how options 1 to 3 could be implemented.

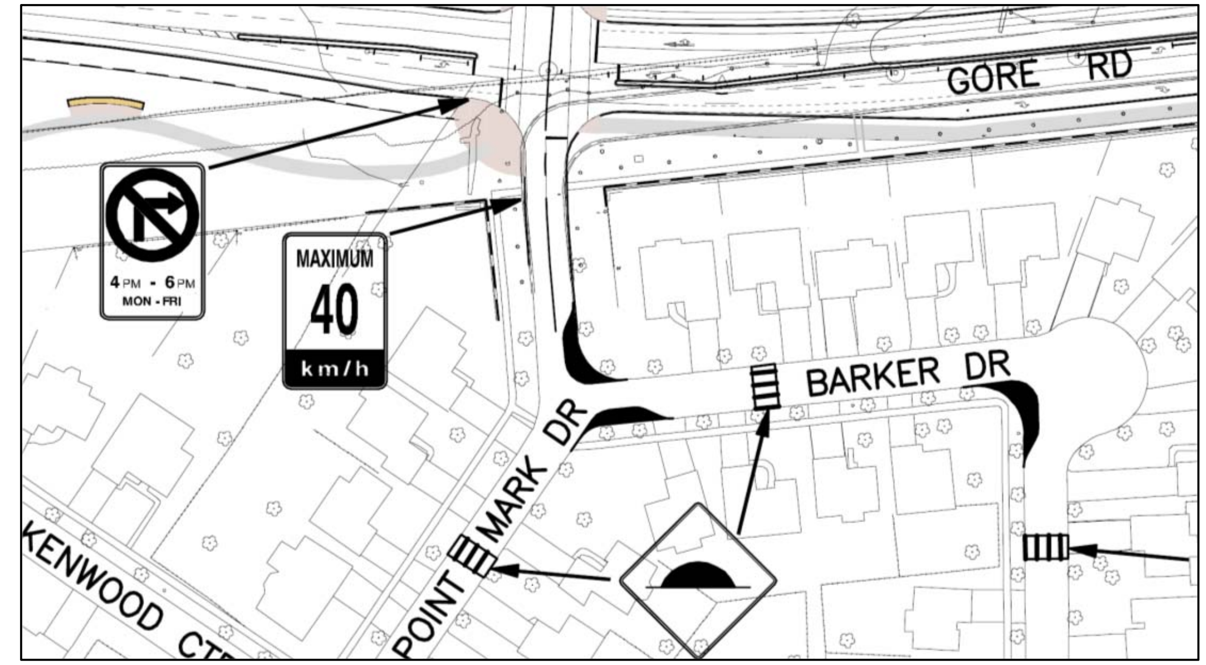


Figure 8.11.1: Traffic Calming Options 1 to 3

Directional closure and full entrance closure through options 4 and 5 respectively could also be implemented at the intersection of Point St. Mark Drive and Gore Road in order to fully eliminate the possibility of short-cutting, as shown conceptually in **Figure 8.11.2** and **Figure 8.11.3**. It should be noted that, regarding option 5 (**Figure 8.11.3**) in particular: emergency vehicle access would still need be accommodated; and the traffic signals at this intersection would also have to be reviewed to reflect the full entrance closure, yet still accommodate active transportation access (i.e. through such means as a pedestrian / cycling crossing signal).

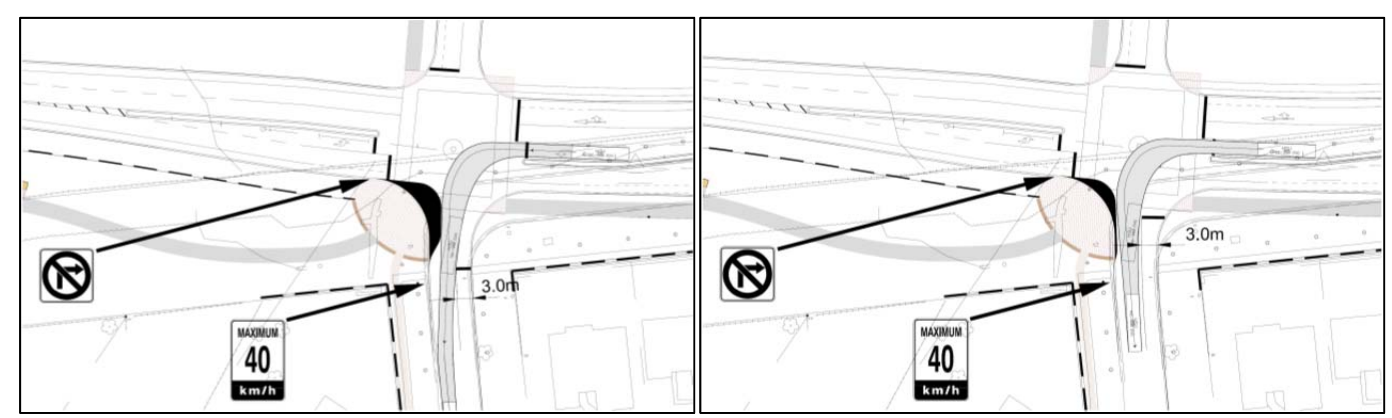


Figure 8.11.2: Traffic Calming Option 4

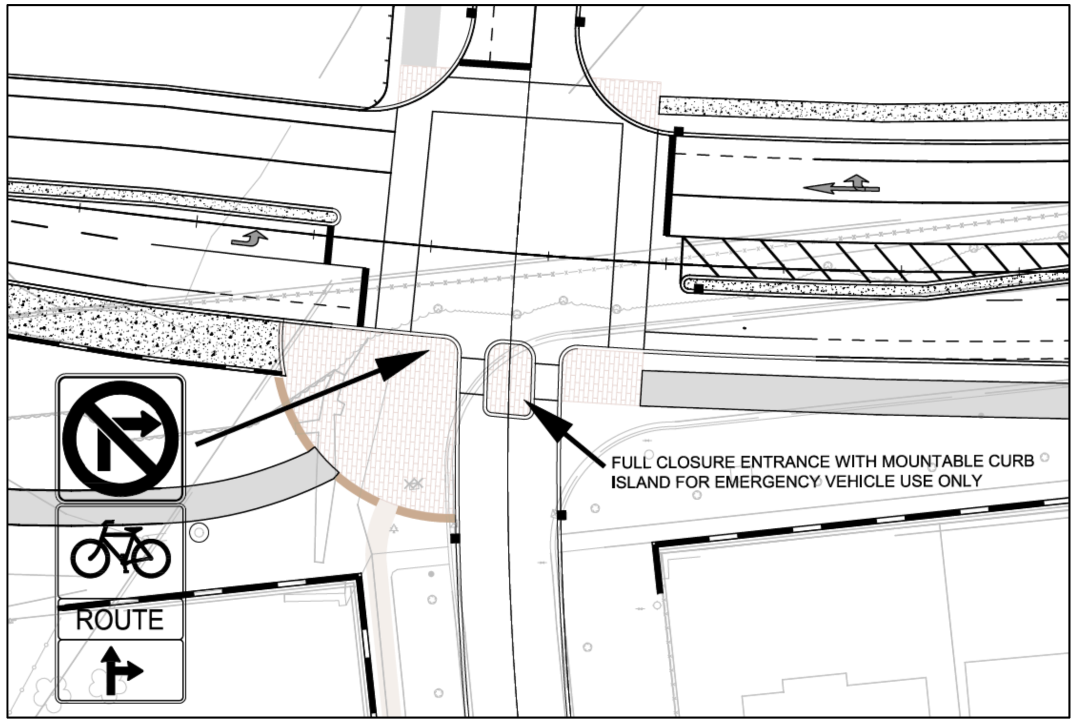


Figure 8.11.3: Traffic Calming Option 5

Typically, consideration would be given to implementing the above-noted traffic calming options for the Point St. Mark Drive-Gore Road intersection in a progressive manner, as described above in the list of alternatives. However, the feedback received to date from Point St. Mark residents indicates concern that the least intrusive options would not solve the issue, whereas the most intrusive options would be too severe. As such, it is recommended that the City and Point St. Mark residents continue to advance collaborations on traffic calming options during the future detail design stage.

8.12 Lighting, Electrical and Communications

8.12.1 Lighting

Illumination of the bridge can be provided for a number of elements, resulting from a need to meet certain legal or municipal obligations, a desire to highlight certain aspects of the bridge from an aesthetic perspective and/or an overall desire to provide reasonable but not overly dramatic illumination of the spaces. There are, in essence, five elements of the bridge and its approaches that need to be considered.

1. **Roadway Illumination:** The City has developed Roadway Illumination guidelines (Technical Standards and Specifications, City of Kingston, Technical Schedule 2, Appendix 2F: Design Standards – Streetlighting Guidelines) that ensures safe, effective illumination for all its roadways. As an Undivided Urban Arterial, the recommended illumination design levels along the project corridor should have an average, maintained, horizontal illuminance level of 17 lux with an average to minimum ratio of 3:1. These levels can be achieved with 13 m poles mounted 40 m apart in the median throughout the length of the bridge and its approaches from both Highway 15 along Gore Road on the east side to Montreal Street along John Counter Boulevard on the west side.

2. **Multi-Use Pathway Illumination (on the bridge):** The City's Pathways Study (2003) as well as the IESNA guidelines have been referenced for guidance on pathway illumination. Recommended illumination design levels for walkways distant from roadways (or independent of roadways) should have an average, maintained, horizontal illuminance level of 5 lux. These levels can be achieved with a smaller wattage luminaire on the same 13 m pole mounted 40 m apart throughout the length of the project corridor as noted above.

3. **Bridge Structure Illumination:** Independent of the roadway and walkway illumination requirements, the bridge illumination is strictly an aesthetic consideration, and is currently being considered. The conceptual basis for aesthetic illumination of the bridge will be to provide illumination of the arch span, including the arch v-piers.

4. **Intersection Illumination:** The intersection of illuminated roadways, whether signalized or not, require additional illumination levels. It is proposed that all intersections related to the bridge and its intersections with other roadways will be provided with 50% more illumination. These intersections will include Highway 15 and the Point St. Mark Drive-Library access on the east side, and Ascot Lane and Montreal Street on the west side.

5. **Park Illumination:** Park areas are planned for both the east and west sides of the bridge with the intention of connecting the pathways and walkways of these areas with the multi-use pathway on the bridge. It is intended that these park and pathway areas will be fitted with decorative luminaires located at strategic points to blend in with the surrounding landscape. Illumination may not be required on pathways that are not adjacent or immediately offset from the roadway [as per the City Pathways Study (2003)]. However, illumination on pathways near the bridge and under the bridge near abutments will be required.

Consideration of light fixtures that prevent light pollution both to the sky and over the side of the bridge to the river must be considered. Lighting must be focused on the roadways and multi-use pathways.

Bridge navigational safety lighting is also anticipated. The base of the arch v-piers will require navigational lighting and/or warning lights near the surface of the water. Preliminary lighting arrangement and power supply is shown in **Drawing 8.12.2.1**.

8.12.2 Electrical and Communications

The illumination of the areas noted previously requires service points to deliver electrical power. Furthermore, there is the potential for future requests for electrical power and/or security elements to the areas. Due to the length of the roadway and bridge structure, it is intended to provide three separate supply points located at strategic points along the bridge. The catwalk proposed for the bridge will provide the ideal location and conduit pathways for both power and any communications requirements design. It is anticipated that three supply points [Supply Control Cabinets (SCCs)] will provide satisfactory coverage of the electrical requirements. Electrical supply for the bridge is anticipated to be from Kingston Hydro sources on the west side of the bridge.

The furthest SCC will be located near the west side of the arch, approximately 300 m from the east abutment, and will supply electricity to the arch and locations on the bridge east of the arch. The remaining two SCCs (one located equidistant from the west abutment and the second located near the mid-point of the bridge), will service the west side of the bridge. These three SCCs will provide all the lighting and electrical requirements for the bridge structure, including the roadways, the multi-use pathway, bridge illumination and navigation safety lighting as well as auxiliary power receptacles. The remaining intersection and park illumination requirements will be serviced by local SCCs with power available from sources on either approach.

Penetrations through the bridge deck at any location are to be minimized. It is therefore intended that branch circuit wiring between luminaires will be restricted to the concrete barrier separating the roadway from the multi-use pathway. This will ensure that the deck penetrations for the roadway and multi-use illumination occur where the service point feeds the first luminaire in a string of ten luminaires.

In addition to electrical services, communications services on the bridge will be installed via a communications raceway system located under the bridge with access on the proposed catwalk. Communications services will provide the option of providing emergency call button, closed circuit video monitoring, weather monitoring, bridge health monitoring or other real-time system.

8.13 Utility Accommodations

As discussed below, certain utility relocations will be required due to widened road approaches leading up to the bridge on both east and west shores; bridge abutments; stormwater management facilities; and other related infrastructure. In addition, the ESR presented a landscape concept of the project corridor that was free of overhead utilities on the west approach (similar to existing conditions on the east approach):

1. **Hydro One:** Relocation of the existing Hydro One owned 44kV lines located on poles on John Counter Boulevard west of the Cataraqui River will be required. Overhead lines will be relocated to two sets of 44kV underground duct banks from west of Montreal Street to the submarine cables. Underground services may be located under the 3 m wide pathway on the north side of John Counter Boulevard between the bridge and Montreal Street. A duct containing six conduits (3H:2V) will accommodate the power cabling.

   Relocation of underground transmission lines on Gore Road near Highway 15 (due to road widening as well as area of bridge approach fill) may also be required in addition to relocation of poles near the Highway 15 intersection. Relocation (raising) of overhead utilities on poles alongside Highway 15 near the existing dog park is similarly expected to accommodate a future bridge construction access road at this location. Temporary power lines to future bridge construction staging areas on the east shore can be also anticipated.

2. **Kingston Hydro:** Relocation of Kingston Hydro's distribution voltage currently located overhead on John Counter Boulevard to underground from west of Montreal Street to the bridge abutment (to service future bridge electrical requirements) will be required. Underground services have been requested by Kingston Hydro, separated from the Hydro One services within their own three conduit duct bank. A pad mount transformer located adjacent to the west bridge abutment will be necessary to service the power requirements of the bridge.

Drawing 8.12.2.1: Electrical and Communications Single Line Diagram

3. **Utilities Kingston Sanitary:** Relocation of the Rideau Heights trunk sanitary main along the west shoreline will be required to permit additional room for staging and laydown during construction as well as stormwater management facility(s). Given its age, the sanitary trunk sewer must also be moved away from the west bridge abutment and renewed in order to ensure vital infrastructure does not underlay new infrastructure.

8.14 Approach Drainage and Stormwater Management

Stormwater management provisions are required for lands modified as part of the bridge. In particular, the approach roadways (where low permeability / higher runoff volumes are expected) generally require formalized stormwater management where stormwater quantity and quality is sufficiently managed. Bridge runoff will be directed to shore as well. Where both flows converge, techniques for quantity and quality control are also required. The supporting report is included in **Appendix J.**

The accepted practice for stormwater management involves a comparison of pre-development to post-development flows to demonstrate that flows are adequately managed. Factors to be considered include identification of major (overland) and minor (underground) drainage pathways, sizing and type of treatment facilities, and discharge method at both shorelines. **Drawing 8.14.1** shows a comparison of stormwater catchment areas within the project corridor (pre-development and post-development conditions):

1. On the west approach:

    a) The Pre-Development condition has no piped storm system east of Montreal Street. There is an informal ditch system along north side of John Counter Boulevard, no formal drainage along south side of John Counter Boulevard (overland flow is east towards Cataraqui River) and no current formal outlet on the west bank (runoff enters the river as sheet flow).

    b) The Post-Development condition, as shown on **Drawing 8.14.2**, includes:

        i. the upgraded and widened Montreal Street intersection, which is disconnected from Montreal Street (south) and diverted to John Counter Boulevard (east), where stormwater is diverted from the additional lanes at this location;

        ii. a dry pond facility on the west bank for quantity control and stormwater treatment unit for quality control;

        iii. a new minor system of stormwater piping (1:10 year event via to low point on the approach road) using a 450 mm diameter pipe;

        iv. from the low point, the minor system is piped to the dry pond facility whereas major event flows will flow overland to the dry pond facility; and

        v. bridge drainage joins the approach drainage also at the low point.

2. On the east approach:

    a) The Pre-Development condition includes an existing 600 mm diameter sewer on Gore Road which captures an area east of Highway 15 and the existing catchbasins on Gore Road. Flows are discharged into natural springs which then transitions to small creek flow discharge into the Cataraqui River. Overland flow that is not captured by the creek flow enters the river as overland sheet flow.

    b) The Post-Development condition, as shown on **Drawing 8.14.3**, includes:

        i. continued maintenance of the existing minor system that drains directly to the river;

        ii. a dry pond facility on the east bank for quantity control and stormwater treatment unit for quality control;

        iii. a new minor system of stormwater piping (1:10 year event via to low point on the approach road) using a 375 mm diameter pipe into the dry pond facility;

        iv. accommodation of bridge drainage and overland flows from major events into the dry pond facility; and

        v. a new minor system on the north side of Gore Road to capture the road widenings, including west of Point St. Mark Drive.

Drawing 8.14.1: Stormwater Catchment Areas

Drawing 8.14.2: Post Development West Catchment Area

Drawing 8.14.3: Post Development East Catchment Area

Stormwater Treatment Units for quality control (Oil-grit separator units such as 'Stormceptors') will be used ahead of the dry pond facilities. Dry ponds on both shores are anticipated to include a 4:1 length to width ratio, with an active storage depth of less than 1 m and side slopes of 4:1. Ponds are self-draining and conceptual water quality release rates and pond sizing (area and volume) are shown in **Table 8.14.1** through **Table 8.14.3**.

Table 8.14.1: Water Quantity Release Rates

	West Pond (m^3/s)	East Pond (m^3/s)
Pre-development maximum flow to river	0.43	1.29
Maximum runoff from bridge surface	0.25	0.05
Target flow: pre-development plus bridge runoff	0.68	1.33
Post-development: maximum flow to river	0.60	1.32

Table 8.14.2: West Pond Stage Storage Relationship

West Pond	Elevation (m)	Area (m x m)	Volume (m^3/s)
Base of Pond	76.3	102	0
Maximum Water Level	77.3	344	218
Top of Pond	77.6	439	331

Table 8.14.3: East Pond Stage Storage Relationship

West Pond	Elevation (m)	Area (m x m)	Volume (m^3/s)
Base of Pond	76.3	181	0
Maximum Water Level	77.2	456	285
Top of Pond	77.6	560	458

Pond outlets will include orifice and spillways to manage outlet flow. Orifices will be connected to 450 mm pipes. A level spreader that is approximately 50 m long will reduce discharge velocities to less than 0.9 m/s along the west shoreline.

8.15 Project Corridor Restoration and Enhancement

The Natural Heritage Protection and Enhancement Plan (NHPEP) provided in **Appendix K** includes best management practices and design measures to both protect and enhance the cultural and natural heritage landscape within the project corridor. The recommended best management practices to protect the landscape during the construction and operation phases of the project are discussed later in this Report. This section of the Report focuses on design measures which will restore and enhance the landscape as part of and following the construction phase.

Firstly, the intent of the preferred bridge concept is to provide a world-class signature design that is appropriate to its context, and is balanced with structural feasibility, constructability, and cost-effectiveness. This is achieved through the following aesthetic expression:

1. A 1.2 km bridge configured in a subtle s-curve that provides:
   a) An elegant overall visual effect.
   b) An organic reflection of the bridge within the context of its 'transitional' location between the natural character of the waterway to the north and the more urbanized environment of the City to the south, east and west.
   c) An expanded viewscape experience for bridge users, in that open views would be provided of the natural character of the waterway to the north and the more urbanized environment of the City to the south, east and west.
2. A feature tilted arch span over the navigable channel and adjacent rowing lanes using v-piers that acts as a focal and destination point of the whole composition.
3. A series of inverted U-frame piers having an outside face angle that both matches and gradually increases in height toward the tilted arch span, and which provides a cohesive overall rhythm towards the arch span as the focal point of the bridge.

4. The bridge clearance above the water, which accommodates existing topographic conditions on both shorelines, exceeds the Rideau Canal's Federally regulated navigable requirement, and mitigates visual impacts, in that its silhouette would be below the tree line when viewed from on-water and on-land.

5. Girders placed at a maximum setback from the edge of the bridge deck and at a minimum depth to emphasize visual lightness.

6. The design of noise attenuation barriers which mitigate noise impacts from the bridge on nearby sensitive receptors and also maintain lightness and transparency along the affected portion of the bridge.

7. The design of barriers and railings to maximize public safety as well as visual lightness, transparency and views to the river setting.

8. Enhanced pedestrian experiences crossing the bridge through such means as:

    a) Universally accessible provisions, including:

        i. the 4 m wide multi-use pathway, which increases to 9.5 m under the arch span to provide a look-out over the navigation channel and adjacent rowing lanes;

        ii. rest areas incorporated into the south side of the barrier separating the roadway and multi-use pathway;

        iii. a pedestrian railing along the south side of the bridge deck;

        iv. contemporary lighting of the multi-use pathway that provides safe access as well as comfortable and evenly distributed light in accordance with IESNA Standards; and

        v. deck drains that are not located within the multi-use pathway, but rather along the north side of the barrier separating the roadway and the multi-use pathway.

    b) Interpretive panels along the south side of the bridge deck that respond to special aspects of the area context, such as the Canal, Belle Island, and the Greater Cataraqui Marsh.

9. Materials and finishes that are durable, high quality, and aesthetically pleasing, especially when experienced up close.

10. Roadway lighting that is functional, low maintenance, and contemporary in appearance.

11. Accent lighting that highlights the feature arch span and V-piers in a subtle manner that provides a pleasing aesthetic effect by night.

Secondly, the landscape concept developed for the east and west side lands, as shown on **Drawing 8.15.1** and **Drawing 8.15.2**, respectively, further informs the opportunities to restore and enhance the natural and cultural heritage values of the project corridor. Cross-section and elevation schematic plans taken at certain reference points on the landscape concepts are shown on **Drawing 8.15.3**.

The main components of the landscape concepts are as follows:

1. The constant gradual s-curve of the bridge, which lands north of the Point St. Mark residential neighbourhood, and offers opportunities for:

    a) Reduced potential noise and visual impacts on Point St. Mark.

    b) 'Softer landscaping' along the Gore Road right-of-way.

2. Grounding the bridge structure dramatically and distinctively at each abutment using materials and proportions that reference and enhance the cultural landscape without overt imitation of heritage architecture.

3. The use of native plant materials to provide landscape variety and hardiness.

4. The incorporation of observation look-out / interpretive areas in order to:

    a) Bring attention to the waterfront trail system at an appropriate scale with the bridge and gateway elements.

    b) Provide a natural destination point, resting place or rendezvous.

    c) Accentuate the public realm by accommodating interpretive panels about the Canal, Belle Island and the Greater Cataraqui Marsh, public art installations and site furniture.

Drawing 8.15.1: Restorative Landscape Design East Approach

Drawing 8.15.2: Restorative Landscape Design West Approach

Drawing 8.15.3: Landscape Cross-Section and Elevations

5. The incorporation of active travel and commuter cycling provisions to connect with existing non-automotive networks on both sides of the Cataraqui River.

6. Accessible multi-use pathways in terms of: width (i.e. 3 m); running slope (i.e. 4% or less); cross slope (i.e. 2% or less); and lighting (i.e. contemporary, comfortable and evenly distributed, and compliant with IESNA Standards). Note that the accessible route to the east waterfront area will be from the pathway on Kenwoods Circle, as shown in **Drawing 8.15.1**.

7. Restoration of the natural shorelines and forest and the installation of natural vegetation buffers around the bridge approaches following construction.

More specific design provisions on the east side lands include:

1. An urban landscape theme with avenue tree plantings to serve as a buffer from the Gore Road / Highway 15 intersection area to a plaza space at the Gore Road / Point St. Mark Drive / Gore Road Library intersection where a more natural landscape theme then takes over closer to the bridge and shoreline. This includes meandering rock walls in order to:

   a) Break up the grade change and thereby provide a more natural approach.

   b) Maximize the usable 'meadow' space for future park development.

2. Selected plant materials are based on the list of vascular plants observed on the east side lands as well as native and non-invasive plant species suitable to the area, and which are resilient to environmental stresses. More specifically:

   a) Reforestation planting will include predominantly mixed deciduous trees and shrub species.

   b) Shrub planting will include a mix of deciduous and coniferous shrubs as well as a large variety of fruiting species to provide a food source for wildlife.

   c) The meadow area will be re-established using existing topsoil (stockpiled during construction) with seed sources from the existing seed bank as well as a seed mix of native grasses and perennials.

   d) The river's edge will be restored using hydric soils (stockpiled during construction) containing local seed and root stock as well as riparian shrub planting.

3. In regards to multi-use pathway provisions:

   a) A circular 3 m wide multi-use pathway (asphalt) from the Gore Road Library parking lot to the shoreline and observation look-out / interpretive area (complete with two pedestrian bridges over the existing watercourses and a secondary stone dust path connection). The network of pathways follow existing established trails as well as the same route through the woodlot as the proposed future construction access road (discussed later in this Report).

   b) A 3 m wide multi-use pathway and 1.5 m wide sidewalk arrangement with the sidewalk only on the north side of Gore Road and the multi-use pathway link along the south side of Gore Road with a proposed crosswalk / cross-ride at the Gore Road-Point St. Mark Drive-Gore Road Library intersection.

4. A realigned portion of the dry stone wall and reinstated dog park on the Gore Road Library property.

5. A dry stormwater pond, also on the Gore Road Library property.

6. The provision of wildlife micro-habitat such as bat boxes, areas suitable for turtle nesting, duck boxes and snake hibernacula. The use of limestone block walls, which will minimize the extent of grading needed for the bridge and associated infrastructure, will also provide habitat for certain species of bats, snakes and insects. Log piles will also be retained to provide cover for wildlife.

More specific design provisions on the west side lands include:

1. The removal of existing metal piling and the reinstatement of a more natural shore line with hydric soils (stockpiled during construction), riparian shrub planting, native grasses and forbs that further integrate the proposed stormwater outlet.

2. Avenue street tree planting with native, drought tolerant species as well as clusters of specimen tree planting, including both deciduous and coniferous species, to provide screening to adjacent properties.

3. An area of reforestation planting to the north of the bridge to extend the existing corridor of woodland vegetation along the western shore of the river.

4. A 3 m wide multi-use pathway on the north side of John Counter Boulevard, to the west of Ascot Lane, in order to allow:

   a) A potential future connection to the multi-use pathway route north of John Counter Boulevard.

   b) a connection with the existing Elliott Avenue Parkette to the south by a multi-use pathway under the bridge at elevation 75.78 m (note that though the flood plain elevation is at 76.3 m, based on consultation with the CRCA, the multi-use path can be located within 0.8 m below the flood plain elevation).

5. The extension of the multi-use pathway to the east of Ascot Lane on the south side of John Counter Boulevard, which:

   a) Connects with the existing Elliott Avenue Parkette and proposed observation look-out / interpretive area.

   b) Provides an alternate route for pedestrians and cyclists, in addition to the multi-use pathway under the bridge.

6. A buried utility corridor along the north side of John Counter Boulevard.

7. A dry stormwater pond and outlets, also on the north side of John Counter Boulevard, near the west shoreline.

8. A parking area for ten vehicles on the southeast corner of the John Counter Boulevard / Ascot Lane intersection.

9. The use of noise attenuation which would include landscape elements such as climbers to soften their appearance.

10. Though not shown on **Drawing 8.15.1**, should access to the project corridor via water be preferred by the Contractor during the construction phase, the associated water dockage provisions could be transformed post-construction into a permanent boat launch facility, subject to further review and consideration by those authorities having jurisdiction.

Thirdly, as discussed later in this Report, in-water construction of the bridge will be facilitated by a temporary work bridge. The temporary work bridge will be approximately 11 m wide, and supported on piles every 10 to 12 m. It will be advanced incrementally in conjunction with the construction of the permanent bridge from shore to the navigable channel on both sides. It would take up to three months to remove the temporary work bridge following construction of the permanent bridge. The temporary piles could either be removed completely or cut below the top of the riverbed and left in place.

Discussions with Parks Canada have confirmed that restoration of the Greater Cataraqui Marsh PSW areas disturbed by the temporary work bridge piles would not be required, due to their small footprint and anticipated ability to rebound faster post-disturbance. However, compensation for PSW areas permanently lost due to the footprint of the permanent bridge, estimated to be up to 5000 m^2, should be implemented.

As shown in **Figure 8.15.1**, the goal of the proposed in-water works is to apply a 1:1 compensation ratio to restoring the wetland structure and function of an area near-shore on the west side of the project corridor following the project construction phase. This area has sustained various impacts related to the former marina operation, and includes three wetland plant communities that were documented during the Class EA, namely:

1. Submerged Vegetation (SuW1).

2. Submerged Vegetation: Floating-leaved Plants (SuW2).

3. Robust Emergents: Narrow-leaved Emergents (reM3).

Restoration activities will include the following:

1. Sedimentation and soil erosion control measures installed during the construction phase will be maintained, and removed only after the restoration work is complete and the exposed substrates are stabilized by vegetation.

2. The bottom substrate could be contoured to desired elevations (optional).

3. Wildlife habitat enhancement structures, such as reptile basking structures as well as submerged and emergent stumps or logs will be installed in areas that complement other desired recreational access and usage of the Cataraqui River.

4. Re-vegetation of the area using dominant wetland species in each of the three affected wetland plant communities will be accomplished by seeding (i.e. broadcasting above the water level or seed mixed with clay pellets below the water level), plugs or live shoots / stakes, depending on water depth, turbidity and anticipated wave energy.

5. The restored area will be periodically reviewed by a qualified wetland scientist.

Preventative actions that could be implemented to avoid disturbance to the restored area include:

1. Confirming during the future detail design stage that the more specific location of the restoration works is at a suitable distance away from the proposed stormwater outlet.

2. Signs or buoys to discourage vessel traffic in the area.

3. Vessel speed / wake restrictions.

4. Public awareness initiatives to educate the general public and stakeholders on the restoration works and associated behaviours to facilitate success of the program.

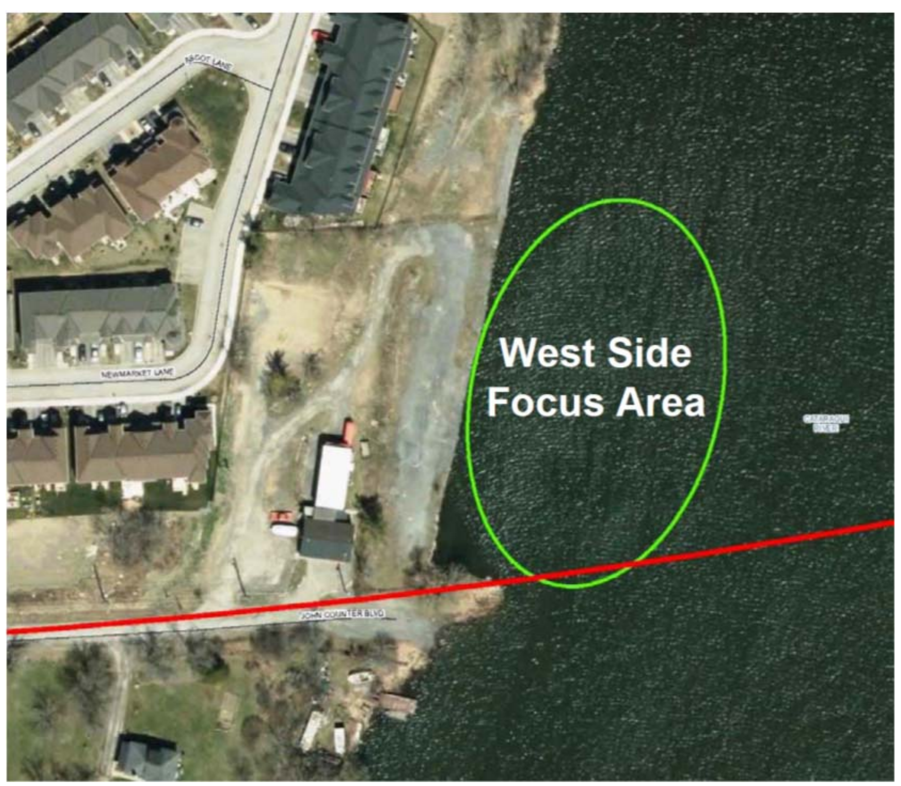


Figure 8.15.1: In-Water Compensation

8.16 Construction Strategies

8.16.1 Site Access and Staging

Staging for bridge and road construction may be undertaken in different forms depending on Contractor preferences and equipment availability. Generally, the bridge could be constructed from a combination of work bridge, barges (where allowed/applicable), the immediate west shore at the current limit of John Counter Boulevard and the immediate east shore at the end of the road allowance of Gore Road. Availability of other remote locations in Kingston is limited. Access routes to the project corridor are shown in **Figure 8.16.1.**

Due to its location, construction of the bridge must mitigate impacts to the navigable channel and adjacent rowing lanes. Boat traffic along the Rideau Canal occurs from mid-May through mid-October. Active rowing begins soon after the ice melts in the spring and extends through the Fall.

Access to the project corridor via water could be accommodated from Lake Ontario or the St. Lawrence River through the LaSalle Causeway. The width and height of the bascule lift bridge will need to be considered by the Contractor, should marine equipment be brought by water to the project corridor. The bridge has limited operating hours during the open season and is generally closed in the winter. The Bridge Master on-site should be contacted to confirm capacity and timing of bridge operations, as well as confirming other special accommodations that the Contractor may require. In between the LaSalle Causeway and the project corridor, the navigable channel also has a finite width that may limit certain vessel sizes. In addition, the draft of the navigable channel is limited in most locations and, without dredging, access may be difficult.

As discussed earlier, construction of a temporary work-bridge is the preferred method of construction based on on-going discussions with Parks Canada in order to minimize potential impacts and required mitigation measures.

On the west shore, approaching from the intersection of Montreal Street and John Counter Boulevard, construction access will be available to the Contractor in order to launch materials and equipment onto the bridge. There is limited area in this location to manoeuver materials due to the narrow access; however, launching of longitudinal pieces (such as girders) may be possible. Water access on the west shore is limited. Access on the west approach is shown in **Figure 8.16.2** which also highlights property acquisition and/or easement requirements to facilitate construction access along the west shore and south of the John Counter Boulevard right-of-way.

Figure 8.16.1: Construction Access Locations

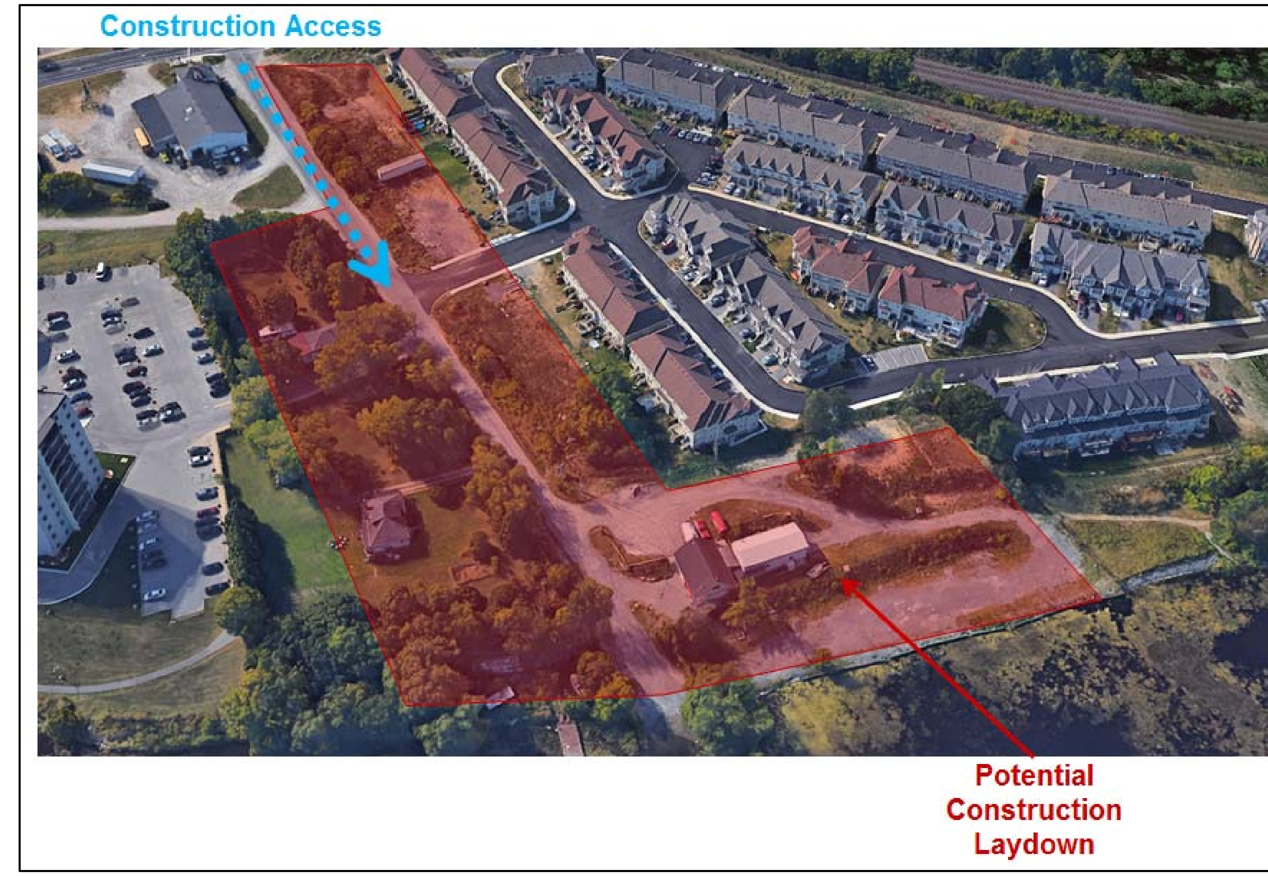


Figure 8.16.2: Construction Access (West)

On the east shore, site access is from Highway 15. City owned lands include the area surrounding the Gore Road Library from the dog park located at the north end of the property, to the east bank of the Cataraqui River, south to the extension of Gore Road in the road allowance. Access to this property is from Highway 15 near the dog park and along Gore Road. A looped access road is envisioned which will assist with traffic management of trucks that are required to transport fill to create the bridge approach embankments. Using a circular movement, trucks will be able to arrive from the north on Highway 15, turn into the site, loop down through a meadow near the water and return to Gore Road to exit the site. This movement is shown conceptually in **Figure 8.16.3**.

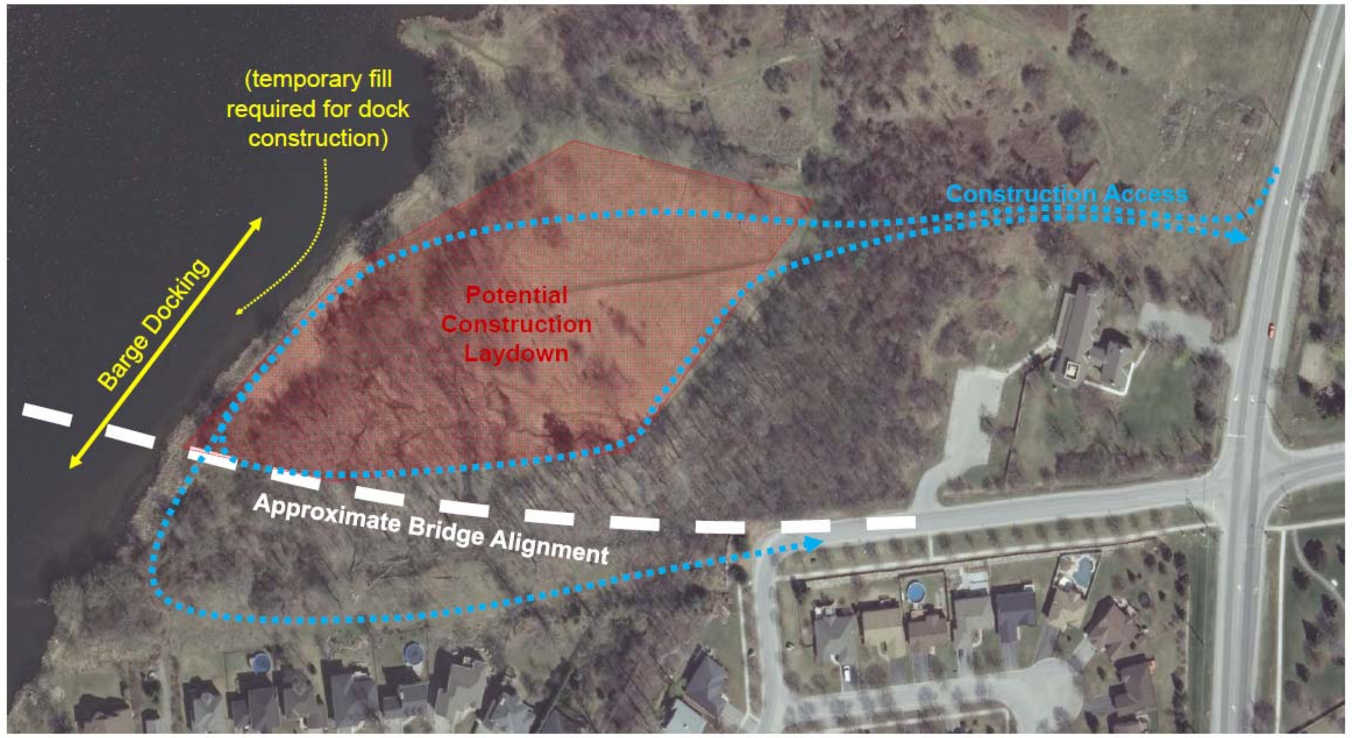


Figure 8.16.3: Construction Access (East)

Examples of construction staging techniques that can be utilized include:

1. Clearing lands on both shores, and providing sufficient water dockage, should access to the project corridor via water be preferred by the Contractor.
2. Installing temporary construction roads through the laydown locations.
3. Constructing the bridge components in laydown areas on-shore and subsequent transfer into position.
4. Installing the substructure components (this is typically advanced from the foundations, through to the piers and into the above water substructures).
5. Installing the superstructure and deck components (these may be either lifted into place or moved laterally into place from shore, depending on the Contractor's means and methods).
6. Constructing the arch component, which can be constructed in a separate location, brought into position and raised to bridge deck height depending on the Contractor's means and methods. Bridges in other locations that utilize arches have successfully used this technique for erection.

Ensuring sufficient flexibility in staging and laydown accommodation to the Contractor promotes creative, innovative, and cost effective bridge and road construction methods. Providing as much land area and waterfront access in close proximity to the construction site will be a priority. Nevertheless, for environmental considerations, incentive should be provided to the Contractor to minimize impact to vegetated staging areas. Since construction of the bridge and approach roadways is expected to take up to three years, various staging configurations within the available lands is possible.

8.16.2 Temporary Facilities

Clearing of lands within laydown area lands on both shores, and providing sufficient access to the bridge alignment and at pier locations for via the temporary work bridge will be the first activities on site. In addition, construction roads and temporary electrical and communications service to the site will be required.

Temporary construction roads are anticipated within the Gore Road Library property on the east shore and are envisioned to enter the site near the existing dog park and loop south of the bridge abutment and exiting on Gore Road near Point St. Mark Drive. Relocation (raising) of overhead utilities will be required near the existing dog park where a construction entrance is envisioned. Temporary relocation of the dog park to an off-site location during construction will be required.

Since construction access roads will be required in an existing park-like area, existing open cut pathways should be used to minimize tree removal that would otherwise be required. There is opportunity to re-use the construction roads and modify them into formalized multi-use pathways post-construction.

Electrical and communication services to site trailers as well as on-shore work areas may be anticipated for the duration of the project. Temporary overhead servicing via temporary utility poles may be required.

At the conclusion of the project, site restoration activities will include removing excess fill that was placed for construction roads and temporary utility services.

8.16.3 Laydown Areas

The land adjacent to the future bridge approaches was identified as the most accessible and appropriate. In particular, the City-owned Gore Road Library property on the east shore was viewed as valuable for construction laydown activities. Sufficient land exists at this location for several uses including storage of materials, equipment, site trailers and off-site assembly of bridge components. Three laydown areas have been identified that include: (1) the meadow, (2) dog park, and (3) Library entrance. Each of these areas is shown in **Drawing 8.16.1**.

Due to the proximity of the Point St. Mark neighbourhood on the south side of Gore Road, erection of sound barrier walls prior to construction is anticipated. Relocation (raising) of overhead utilities will be required near the existing dog park where a construction entrance is envisioned. Temporary relocation of the dog park to an off-site location during construction will also be required. Significant vegetation/tree clearing along the bridge and approach alignment is anticipated, as well as along the shore on the north and south sides of the alignment. Additional vegetation/tree clearing will be required on the north side of the bridge alignment to facilitate water access for transfer of materials.

On the west shore, land on the north side of John Counter Boulevard as well as waterfrontage near the former Music Marina is available for construction staging and material laydown. Certain lands on the south side of John Counter Boulevard are expected to become available with future City acquisition of these properties.

Due to the proximity of the Ascot Lane Townhouse complex on the north side of John Counter Boulevard, erection of sound barrier walls prior to construction is anticipated. Contractors will need to review the stability of existing sheet-piling near the former Music Marina should significant staging and laydown occur close to shore. Each of these areas is shown in **Drawing 8.16.2**.

8.16.4 Property Impacts

Property considerations are necessary in three locations with respect to the bridge and approach roadways: the east approach (on land); the bridge span (over water); and the west approach (on land).

The east side of the bridge corridor utilizes an unopened road allowance at the west end of Gore Road (north of the Point St. Mark neighbourhood) and the City-owned Gore Road Library property at the northwest corner of Highway 15 and Gore Road. All east side lands required for the construction and operation of the approach roadway, active transportation provisions and landscape works, embankment leading to the bridge abutment, bridge footprint and stormwater management areas will be contained within City-owned property.

The Cataraqui River bed is owned by the Federal government and managed by Parks Canada. As such, it will be necessary to recognize the footprint of the bridge both within and over the river as well as the construction and operation of the bridge through a future land lease and construction agreement(s) with Parks Canada.

The west side of the bridge corridor predominantly uses an existing unopened road allowance at the west end of John Counter Boulevard. The City has already purchased the former Music Marina property on the north side of the road allowance near-shore, up to the River Park Subdivision. This property will partially accommodate construction staging and laydown area requirements as well as future stormwater management provisions. Additional lands will also be required:

1. On the south side of the road allowance to accommodate construction staging and laydown areas, the re-located John Counter-Boulevard-Ascot Lane intersection as well as active transportation and landscape works.
2. At the John Counter Boulevard-Montreal Street intersection for widening John Counter Boulevard to accommodate eastbound turning and through lanes.

Construction activities (which include site preparation, construction, and site restoration and rehabilitation) on the affected properties within the staging and laydown areas will include the following tasks (and potentially others depending on Contractor means and methods):

1. Contractor mobilization to site (equipment, site trailers and materials begin to arrive at site).
2. Installation and monitoring of environmental controls (e.g. erosion and sedimentation control measures, perimeter silt fences), with modifications/enhancements thereto, as required.
3. Construction of noise attenuation barriers.
4. Designation of low, medium, high impact areas (i.e. parking, offices, material storage, active material assembly / construction).

Drawing 8.16.1: East Shore Laydown Area

Drawing 8.16.2: West Shore Laydown Area

5. Relocation of the dog park on the Gore Road Library property to a temporary off-site facility.
6. Site vegetation and earth stripping as well as rough grading.
7. Relocation of utilities (above ground and below ground) and the installation of temporary utilities for construction uses.
8. Installation of temporary traffic controls and signalization (where necessary).
9. Construction of stormwater management facilities.
10. Construction of temporary access and egress haul roads for bringing earthen fill and bridge materials to site as well as temporary truck turning areas.
11. Construction of the temporary work bridge along with related on-shore access provisions.
12. Placement of the approach road embankments.
13. Bridge material staging and assembly (assembly of long girders).
14. Staging for construction of the bridge components in-place.
15. Road building, landscaping, pathway installation and site restoration (including shoreline enhancements).
16. Demobilization activities (e.g. site cleanup, trailer and material removals, temporary utility / facility removals).
17. Removal of temporary erosion and sediment control measures after the terrestrial vegetation is re-established as part of the landscape improvement works.

It should also be noted that the assembly and staging of materials for bridge construction will require space on-land that is not available on the temporary work bridge. For example, the assembly of the bridge structures (e.g. girder pairs, formwork, reinforcement steel cages) would likely take place on-land within the staging and laydown areas, and then transported via the temporary work bridge and subsequently placed into position. This could be the case for the long approach spans as well as the arch. In particular, assembly of the arch (which would likely take place on the east shore) will require significant on-land space. Given the limited available lands both on the east and west shores, it is anticipated that the Contractor will make use of all available lands within the staging and laydown areas, subject to the best management practices and mitigation measures that will be in place to either reduce or eliminate the potential negative effects of specific construction activities.

8.16.5 Substructure

Foundations can be constructed from the temporary work bridge and will require driving the caisson liners through the overburden and seating them firmly into bedrock using a crane situated on the work bridge. For caissons, this will be followed by excavating the native material from within the casing then drilling rock sockets into competent bedrock. A reinforcing steel cage will be lowered using cranes into the caissons and tremie concrete will be poured into the caisson from a concrete pump on the work bridge. Minimal dewatering is anticipated for this operation if the caisson liner is extended above the high-water level.

For the inverted u-frame piers, following the installation of the caissons, a custom transition form will be placed on top of the caisson to convert the circular caisson into a rectangular shape over a height of 1500 mm. Standard steel/ timber formwork can be used to form the rest of the pier legs. The piers will consist of two separate concrete pours: one for the pier legs (above the caissons) and another for the pier caps.

For the arch v-piers, a concrete footing will be supported on the caissons and will require localized excavations of the river bed. The excavated material will be shipped off-site for proper disposal. Cofferdams will be required for the construction of the footings and may include a concrete shell that will be lowered over the caissons and form part of the permanent footing or sheet piles driven into the riverbed. Once the v-pier footing has been poured, the v-pier legs will be formed and temporary supports will be used to support the legs. The temporary supports can either be off of the temporary work bridge or be separate piles driven into the riverbed. The v-piers legs should be poured simultaneously to balance the load. Temporary ties will be required between both legs to provide stability. Once the legs are constructed they will be post-tensioned. The use of precast box sections for the v-pier legs is a viable option which can be explored by the Contractor. The tie can be formed off the pier legs and poured in place or can be precast and post-tensioned. Once the tie has been placed the tie will be post-tensioned prior to the removal of the temporary supports.

The bracing and diaphragm of the girders in the vicinity of the v-piers will be designed to avoid conflict at the tie location. The use of cross-frames and/or wide flanged deep beams should be considered at the tie-beam locations.

The abutments will be founded 14 – 600 mm caissons founded on bedrock. Earth excavation will be required at the west abutment for the perched abutment; and at the east abutment, the embankment will be backfilled with engineered fill to the base of the abutment.

8.16.6 Superstructure

The steel plate girders for the approach spans can be assembled on the approaches and can either be lifted into place by means of cranes from the temporary work bridge or can be launched from the approaches. The use of inverted u-frame piers instead of v-piers throughout facilitates launching the plate girders from the approaches, as there will be no interference between the girder bracing and the v-pier ties. The plate girders can either be kinked or curved in plan to facilitate Contractor means and methods. With the curved plated girders, the concrete overhangs will be constant but the girders will be more difficult to fabricate and transport. For the kinked plate girders, the concrete overhangs will vary but the girders will be easier to fabricate and transport.

If the approach span girders are lifted into place from the temporary work bridge, the following construction sequence would likely occur, as shown in **Drawing 8.16.6.1** to **Drawing 8.16.6.4**:

1. Assemble the girders into pairs by connecting cross-bracing.
2. Transport the girder pairs onto the work bridge.
3. Lift, install, and stabilize the girder pair segments over the pier **(Drawing 8.16.6.2)**.
4. Lift, install, and stabilize the girder pair segments over the adjacent pier **(Drawing 8.16.6.2)**.
5. Lift the girder pair segments over the drop-in spans (in between piers) and field splice to the erected girder segments (over piers) **(Drawing 8.16.6.3)**.
6. Complete the installation of cross bracing and lateral bracing.
7. Repeat the above steps for the next span(s).

Drawing 8.16.6.1: Approach Span Construction Sequence 1

Drawing 8.16.6.2: Approach Span Construction Sequence 2

Drawing 8.16.6.3: Approach Span Construction Sequence 3

Drawing 8.16.6.4: Approach Span Construction Sequence 4

The erection of the plate girders between the v-pier legs will be more complex than the other spans due to the presence of the v-pier ties. The v-pier tie will be erected prior to the erection of the structural steel. The girder sections will have to be erected singularly instead of in pairs as the cross-bracing will be designed to go around the v-pier ties and will not be erected until after the v-pier is in place. Alternatively, the interior pair of girders can be erected together followed by the exterior girders.

The arch can be assembled on the approach and launched into position from the east shore; the arch can be assembled on the work bridge and lifted into position; or the arch can be erected in place while accommodating the navigation channel and rowing requirements and constraints. The arch construction will follow the following sequence, as shown in **Drawing 8.16.6.5** to **Drawing 8.16.6.20**:

1. Install the temporary supports, install the ends of the bottom chord to beyond the first transverse brace and install the structural steel grillage system between the bottom chords **(Drawing 8.16.6.5).**

2. Build up the second temporary support to support the arch rib and install the temporary compressive struts and the first sets of hangers **(Drawing 8.16.6.6).**

3. Install the temporary supports for the next segment of bottom chord and grillage system to beyond the second transverse brace **(Drawing 8.16.6.7)**.

4. Install the second portion of the arch rib, the second temporary compressive strut and the second set of hangers **(Drawing 8.16.6.8)**.

5. Complete the installation of the bottom chord and deck grillage system **(Drawing 8.16.6.9)**.

6. Complete the installation of the arch rib and installation of the hangers **(Drawing 8.16.6.10)**.

7. Transfer the arch from the temporary supports to a movable platform with jacking towers **(Drawing 8.16.6.16)**.

8. Slide the arch into position along the south side of the bridge via a temporary trestle **(Drawing 8.16.6.17)**.

9. Remove the temporary compressive struts and lift the bridge to its proper elevation **(Drawing 8.16.6.18)**.

10. Slide the bridge onto the v-piers and complete the arch erection **(Drawing 8.16.6.19)**.

The arch can either be moved using Self-Propelled Modular Transporters (SPMT) as shown in **Figure 8.16.6.1**, strand jacks or Hilman style rollers. SPMT's are generally the most expensive option but provide the greatest maneuverability and are the faster option. The Hillman style roller is the most economical, but has limitations to the flexibility of movements during transport.

Figure 8.16.6.1: Erection of Hastings Bridge Using SPMT

The approach span and arch structural steel will require a special oversize/overweight hauling permit to be transported by highway carrier on Provincial highways and municipal roads. Any prefabricated component that exceeds any of the following limitations (including the transportation vehicle) will require a permit:

1. Length = 19 m.

2. Width = 3.5 m.

3. Height = 2.6 m.

4. Weight = 30,000 kg.

Drawing 8.16.6.5: Arch Construction Sequence 1

Drawing 8.16.6.6: Arch Construction Sequence 2

Drawing 8.16.6.7: Arch Construction Sequence 3

Drawing 8.16.6.8: Arch Construction Sequence 4

Drawing 8.16.6.9: Arch Construction Sequence 5

Drawing 8.16.6.10: Arch Construction Sequence 6

Drawing 8.16.6.11: Arch Construction Sequence 7

Drawing 8.16.6.12: Arch Construction Sequence 8

Drawing 8.16.6.13: Arch Construction Sequence 9

Drawing 8.16.6.14: Arch Construction Sequence 10

Drawing 8.16.6.15: Arch Movement Sequence 1

Drawing 8.16.6.16: Arch Movement Sequence 2

Drawing 8.16.6.17: Arch Movement Sequence 3

Drawing 8.16.6.18: Arch Movement Sequence 4

Drawing 8.16.6.19: Arch Movement Sequence 5

Drawing 8.16.6.20: Arch Movement Sequence 6

There are two categories for oversize/overweight loads: Category A: Routine Oversize / Overweight Loads and Category B: Non-Routine Oversize / Overweight Loads. The approach span structural steel would require a Category A permit as the maximum depth of the girders is approximately 3 m, which if laid on its side, is less than the 4.3 m requirement for a Category B permit. The girders will have to be properly supported in order to not place excessive stress on the webs of the girders during construction. The transportation of the arch may require a Category A or B permit, depending on the locations of the splices which will be determined by the Contractor's construction engineer.

The deck can be either cast-in-place or precast depending on the design requirements. A precast deck would involve either: full depth precast in which precast panels will be supported on the girders with cast-in-place concrete poured at the joints or partial depth precast panels with a cast-in-place concrete overlay on top. Precast decks panels can be erected from shore or from the work bridge whereas a cast-in-place deck/overlay would require a concrete conveyance system from both shores. It is anticipated that the deck will be poured in segments as the steel superstructure erection advances. This will provide access so that the sidewalk, barrier, railings and remaining deck related work can be completed.

The v-pier leg formwork will be tied together and will have to be poured simultaneously to balance the load. For the v-piers, temporary supports will be required to support the formwork for the legs. The use of precast box sections will be investigated for the use for the v-pier legs. The tie can be formed off of the pier legs and poured in place or can be precast and post-tensioned. The use of post-tensioning strands can be used to accommodate the tensile stresses that will be placed on the concrete v-pier legs once the braced formwork is removed. Furthermore, post-tensioning of the v-pier legs is anticipated to minimize the tensile stresses in the pier legs and the associated cracks.

The bracing and diaphragm of the girders in the vicinity of the piers will be designed to avoid conflict at the tie location. The use of cross-frames and/or wide flanged deep beams will be investigated at the tie-beam locations.

8.16.7 Approaches and Utilities

Construction activities within the bridge approach areas will first require consideration of construction staging and laydown requirements as well as utility relocations. This can then be followed by rough grading and finished road construction near the end of the project construction period.

As discussed earlier, key utilities will require relocation, particularly on the west shore where high voltage power lines owned by Hydro One and located on Kingston Hydro Poles are required to be moved underground. These lines will also require positioning around the west bridge abutment. In addition to the high voltage lines, distribution voltage owned by Kingston Hydro, as well as other utilities such as Bell and Cogeco cable will require relocation.

On the west shore, the trunk sanitary sewer main is also recognized as significant existing buried infrastructure that requires relocation prior to bridge construction activities. The west bridge abutment and future stormwater management facility will require that this infrastructure be moved. This also provides opportunity for renewal of the sewer pipe since it is significantly aged and ensures the new bridge approaches are not constructed on top of deteriorated piping that may require renewal itself within the lifespan of the bridge.

In the later stages of construction activities when staging areas for bridge materials are no longer required, rough grading of the abutment fill areas can be finalized (ensuring consolidation of materials) and fine grading, placement of curbs and paving can be completed.

Temporary utilities required for construction laydown as well as relocations to facilitate construction road access (e.g. construction road from Highway 15 near the dog park) will be required.

8.16.8 Permits and Approvals

As noted earlier, Parks Canada is responsible on behalf of the Federal government for managing and protecting the Canal as a National Historic Site and Canadian Heritage River. Parks Canada is also responsible on behalf of the UNESCO World Heritage Committee for protecting the Canal as a UNESCO World Heritage Site. The City and Project Team are currently working with Parks Canada on achieving an agreement-in-principle regarding the DIA as part of this current project phase.

Following the formal approval of the DIA during the future final design phase, the City will be required to enter into an agreement with the Government of Canada (represented by Parks Canada) to ultimately proceed to construct and subsequently operate the bridge for the duration of its life cycle, pursuant to the Federal Real Property and Federal Immovables Act. Approvals from the CRCA would also be required for the construction work, pursuant to its role in administering Ontario Regulation 148/06: Development, Interference with Wetlands and Alterations to Shorelines and Watercourses.

In addition, there are also a number of permits and approvals that will be required from various regulatory authorities in support of the design work as it proceeds from the pre-design stage to the final design stage. Such approvals are related to various non-passive fieldwork activities in support of the design work (e.g. from MNRF, DFO, MOECC, CRCA), which could also include authorizations pursuant to:

1. The Endangered Species Act.
2. The Permit To Take Water requirements under the Ontario Water Resources Act.
3. Ontario Regulation 148/06.

8.16.9 Community Action Plan

As stated earlier, the purpose of the CAP is to establish protocols for use by the City for notifying the general public of any service interruptions and addressing public issues both prior to and during bridge construction activities as well as during the subsequent use and maintenance of the bridge. Recommended CAP provisions for the City are outlined below:

1. During the construction phase:
    a) Provide information on construction activities and advance notices on upcoming service interruptions (including their anticipated duration) through such means as a project website, various social media platforms and on-site signage.
    b) Ensure the Contractor has a Construction Liaison Officer whose specific role would be to liaise with – and address issues from – the general public and other stakeholders.
2. During the operations phase:
    a) Provide information (and advance notices) on upcoming service interruptions related to maintenance and public events (including their anticipated duration) through such means as a project website, various social media platforms and on-site signage.
    b) Retain a Bridge Liaison Officer whose specific role would be to:
        i. educate the general public and other stakeholders regarding restoration and enhancement works within the project corridor as well as associated preventative actions and appropriate behaviours to facilitate success of these works; and
        ii. liaise with – and address issues from – the general public and other stakeholders.
        iii. Prior to, and during construction, maintain intimate dialogue with the Kingston Rowing Club in order to maintain access to their facilities and provide safe passage to rowers.

8.16.10 Pre-Construction Scheduling

Following completion of the current project phase, there are a number of tasks that will ultimately lead up to construction of the bridge, as shown on **Table 8.16.10.1**.

Table 8.16.10.1: Pre-Construction Tasks

Tasks	Timeline (not sequential)
Obtain Permits and Approvals (Parks Canada)	6 - 24 months
Obtain Permits and Approvals (Other Regulators)	6 - 24 months
Finalize Project Delivery Method	0 - 12 months
Secure Project Funding	Unknown
Finalize Property Acquisition	6 - 24 months
Complete Detail Design (dependent on project delivery model)	12 months
Contractor Prequalification and Tendering (dependent on project delivery model)	3 months
Complete Pre-Construction Tasks	12 - 24 months

8.16.11 Construction Scheduling

Preliminary scheduling of the project has included a review of the order of construction operations for both on-land and on-water activities (and acknowledging that the Contractor may approach construction scheduling differently). It is understood that a number of activities will take place concurrently both on-land, on-water and off-site and, as such, these activities can be scheduled simultaneously. A draft schedule is included in **Figure 8.16.11.1 and Figure 8.16.11.2** which show an approximate three year construction period. The schedule is a function of the Contractor operations including access means and methods and the availability of equipment and crews.

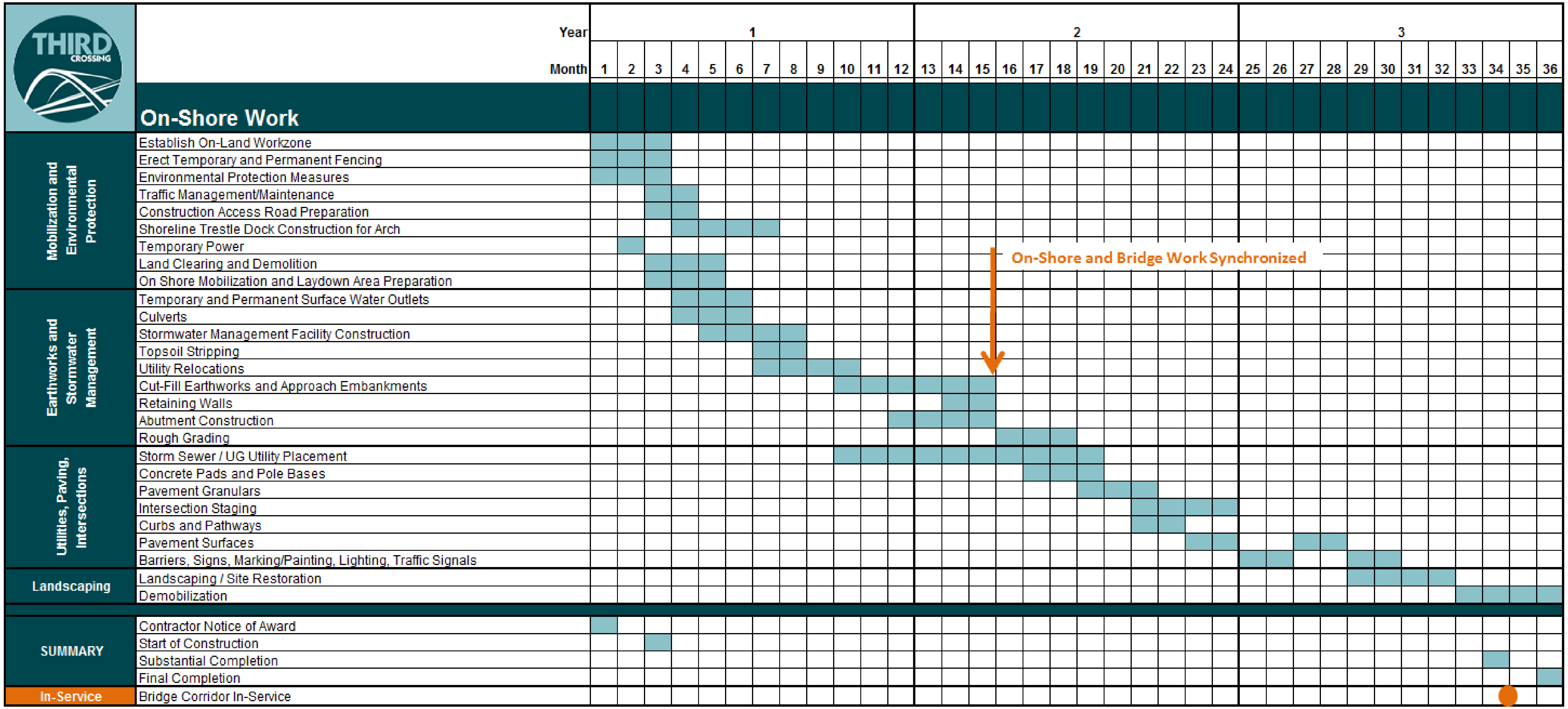


Figure 8.16.11.1: Conceptual Construction Schedule (On-Shore Work)

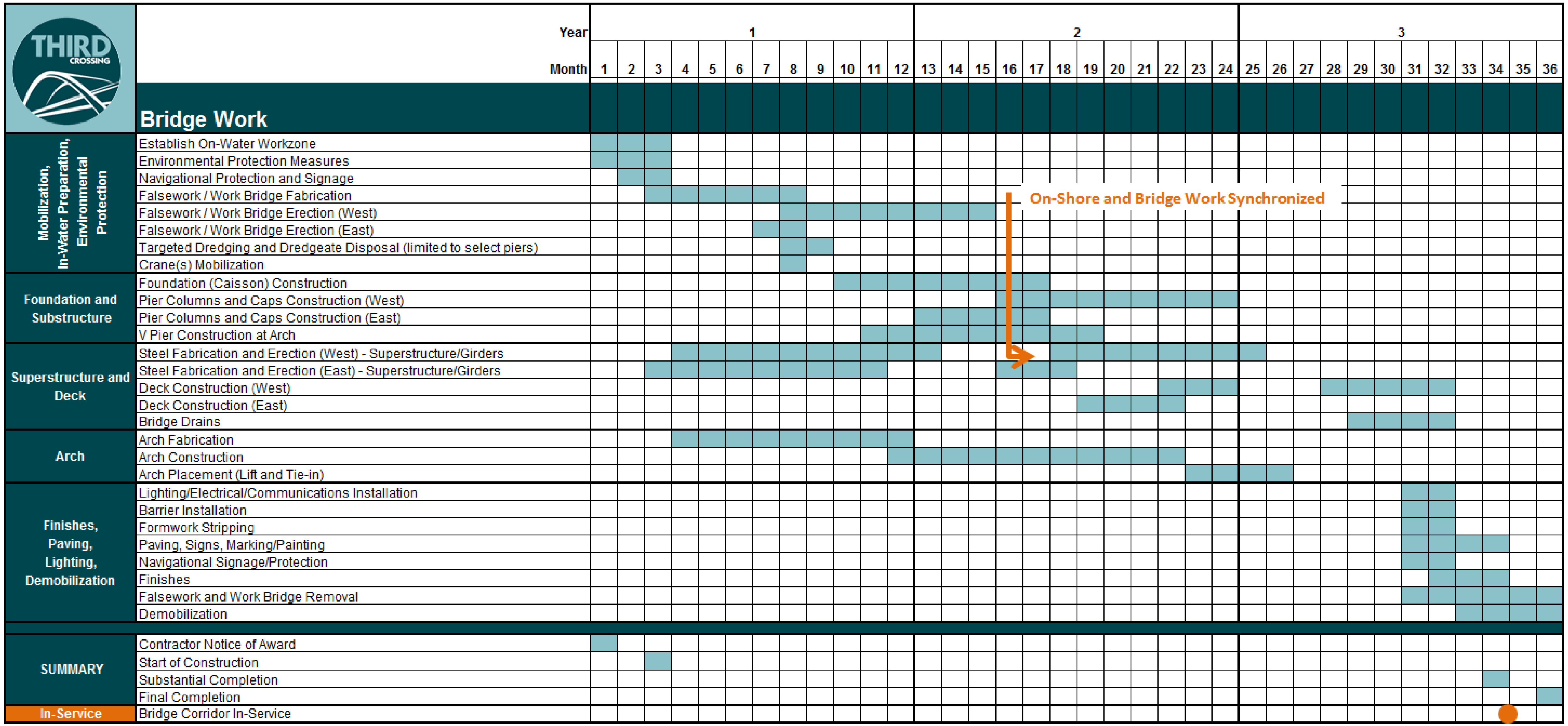


Figure 8.16.11.2: Conceptual Construction Schedule (Bridge Work)

On-shore work will generally follow an order of operations that includes:

1. Mobilization and C-NHPEP (protection) / CAP implementation.
2. Earthworks and stormwater management.
3. Utilities, paving and intersections.
4. C-NHPEP (enhancement) implementation.

Bridge construction work will generally follow an order of operations that includes:

1. Mobilization, C-NHPEP (protection) / CAP implementation.
2. Steel superstructure (Girders and arch) Fabrication.
3. In-water preparation.
4. Foundation and substructure.
5. Steel superstructure (Girders and arch) Erection.
6. Concrete Deck.
7. Utilities, paving and lighting.
8. C-NHPEP (restoration / enhancement) implementation.
9. Demobilization.

Based on feedback received from the Kingston Rowing Club, construction activities should be planned so that are at least three southbound rowing lanes and one northbound rowing lane are available at all times during the training season (ice thaw to ice formation). All construction equipment in the vicinity to the rowing lanes must have lights as well as all obstructions and permanent elements.

Consideration should be given to installing the arch outside of the navigation season so that the channel can be used to erect the arch and to eliminate any potential disruptions of the navigation channel.

8.16.12 Decommissioning

The demolition of the bridge will follow the reverse sequencing of the construction. First, all of the additional dead loads will be removed from the bridge (e.g. barriers, railings, lighting, benches, asphalt, etc.). Then the concrete deck will be sawcut into small segments so that it can be easily lifted and removed. The girders will be lifted off of the piers and removed. The piers will be demolished and the caissons will be cut below the riverbed and will remain.

If the approach span structural steel was launched, it can be jacked and placed on rollers to be removed similar to how it was launched. The use of temporary towers and cables can be used to support the spans as they become unsupported by the piers.

The arch will be lifted off of the bearing and lowered in one piece like it was erected. Once it is lowered it will be moved to the approaches to be dismantled.

8.17 Operational Maintenance Considerations

To ensure the long term safety and viability of the new structure, operational maintenance will be taken into consideration during the pre-design. The following items were taken into consideration during the design concept phase:

1. **Winter Provisions:** Snow removal is key aspect to prolong the life of a structure as salt-laden snow will cause deterioration to the concrete if it is left in place for too long. In order to ensure that all snow will be removed from the bridge deck efficiently, there will be no obstructions on the roadway or multi-use pathway that will collect snow which cannot be removed by a snow plow vehicle. The lighting for the bridge will be on the roadway parapet wall and the lighting for the multi-use pathway will have benches around them which will taper back into the barrier wall to provide a smooth line. The multi-use pathway will be sloped towards the roadway such that the water from the snow will flow towards the deck drains.

   In some instances, heated bridge deck are proactive/preventative snow and ice removal alternatives that can be used on their own, or in addition to, traditional plowing and sanding operations (which are viewed as reactive snow and ice removal measures) or other anti-icing applications. These technologies are often seen as advantageous on bridges where icing conditions can be accelerated compared to surrounding roads, where traditional chloride-based road salts can have a detrimental effect on the environment, where salts cause corrosion issues with the bridge structure itself, and finally where sand and grit can clog bridge drains and stormwater management devices. Types of heated bridge deck options include hydronic piping and electrical resistant technologies. Many jurisdictions have invested in heated bridge deck technologies or pilot projects; however, due primarily to construction, operation and maintenance costs they have largely not been adopted as mainstream winter strategies. Introducing mechanical systems into a bridge does increase initial capital cost and ongoing maintenance costs. The Third Crossing will be a long and narrow bridge. This type of geometry does not lend well to integrated pavement systems due to the resources required to either maintain heated fluid or adequate power for a significant distance. To overcome these challenges, significant cost and the potential expense of architectural bridge elements would be a direct result. In-deck piping running in the plane of the deck or electrical heating systems embedded in the cementitious wearing surface were not recommended due to excessive durability risk for the bridge deck. Therefore, it was found that the bridge is not a good candidate for heated pavements.

Anti-icing is a pro-active approach to winter road maintenance, which involves the application of freezing-point depressants to prevent ice and snow from bonding to the roadway surface rather than applying chemicals to melt ice and snow after they have already formed. As opposed to being a replacement for snow removal operations, in particular in heavier snowfall conditions, anti-icing is a preventive measure that is often used in concert with other snow and ice control techniques. Various Fixed Anti-Icing System Technology (FAST) systems were reviewed and compared. FAST systems are custom designed depending on the specific bridge configuration. They can also differ in complexity and operations resulting in varying capital and operations costs. If a FAST system is implemented, it is recommended that the system requirements be structured such that: any embedded element shall have the same service life as the element into which they are embedded, replaceable elements have a minimum 20 year useful life and that any pressurized piping shall be located outside of box-girder sections and shall employ double-containment provisions.

2. **Expansion Joints:** Cleaning joints and replacing expansion joint seals is an ongoing maintenance and cost issue on all bridges. Minimizing the number of joints is important to reduce the amount of maintenance and operational cost in the future.

3. **Drainage System:** The inspection of the drainage system is important as leaks can cause corrosion of the structural steel if left unnoticed and unrepaired.

4. **Cables:** The replacement of arch cables can be a costly and complex procedure. The arch cables will be designed such that there is redundancy in the system so one cable can be replaced at a time without the need to provide any additional support to the arch.

5. **Structural Steel Coating:** The durability of the structural steel is of the upmost importance for the long-term service life of the bridge. A coating system that is suitable for the environment over the Cataraqui River will be chosen to ensure the durability of the structure. Alternatively, Atmospheric Corrosion Resistant (ACR) steel will be considered for the approach spans and this will minimize the long term coating maintenance cost.

6. **Bearings:** Although current bearing technology ensures maintenance free units for many decades, they have in the past been susceptible to seizing and general wear-and-tear due to their continual movement. Hence, regular inspection is required to ensure that unwanted forces are not imposed on the bridge due to malfunctioning bearings.

7. **Inspections:** Regular inspections is the best way to reduce rehabilitation costs in the future as ongoing maintenance can eliminate major repairs in the future. A catwalk will be placed under the bridge to facilitate the inspection of the structural steel, drainage systems, soffit, etc.

8. **Emergency Provisions:** In case of an emergency on the bridge, there is sufficient space to allow for both lanes of traffic to continue to flow if all vehicles are pulled over onto the shoulder of the bridge.

   In case of a full road closure on the bridge:

   a) There is ample room for non-emergency passenger vehicles to turn around. The vehicles would then be detoured to either the Highway 401 crossing to the north or the LaSalle Causeway crossing to the south.

      There are no bridge design codes requiring that emergency vehicles be able to turn around on a bridge. As such, emergency vehicles would have to maneuver, based on the actual road closure conditions and traffic control provisions that are in place during the emergency event.

b) The multi-use pathway will be subjected to pedestrian loading of up to 4.0 kPa; and/or Maintenance Vehicle gross loading of 80 kN, which at this time can accommodate an ambulance. A fire truck is much heavier, but can be added as a load case during the future detail design stage. Based on such provisions, it should then also be noted that removable bollards should be considered at both approaches to prevent non-emergency vehicle access onto the multi-use pathway.

9. **Other Provisions:** The Project Team understands that the weight of a typical army tank is in the range of 70 tonnes. This is comparable to the 63.7 tonne CL-625-ONT truck load used to design the bridge. If required, army tanks can be added as a load case during the future detail design stage. Nevertheless, it should be noted that the use of track-mounted army tanks directly on the bridge deck would damage the wearing surface. Army tanks are usually transported on trucks, which distribute the load on multiple axles.

8.18 Class 'B' Cost Estimate

As noted earlier, a preliminary opinion of probable capital cost was developed during the Class EA for the Arch With V-Piers bridge deck conceptual design scenarios (in 2011 dollars and excluding applicable taxes). The preliminary opinion of probable cost of a 2- lane bridge (in 2011 dollars and excluding applicable taxes) was $121M. As part of the pre-design work, an updated Class 'C' estimate was developed for the original v-pier design concept, based on its current status in February 2017 that included the preferred temporary work bridge construction option. The result was a significant capital cost escalation, in the range of $200M (2017 dollars).

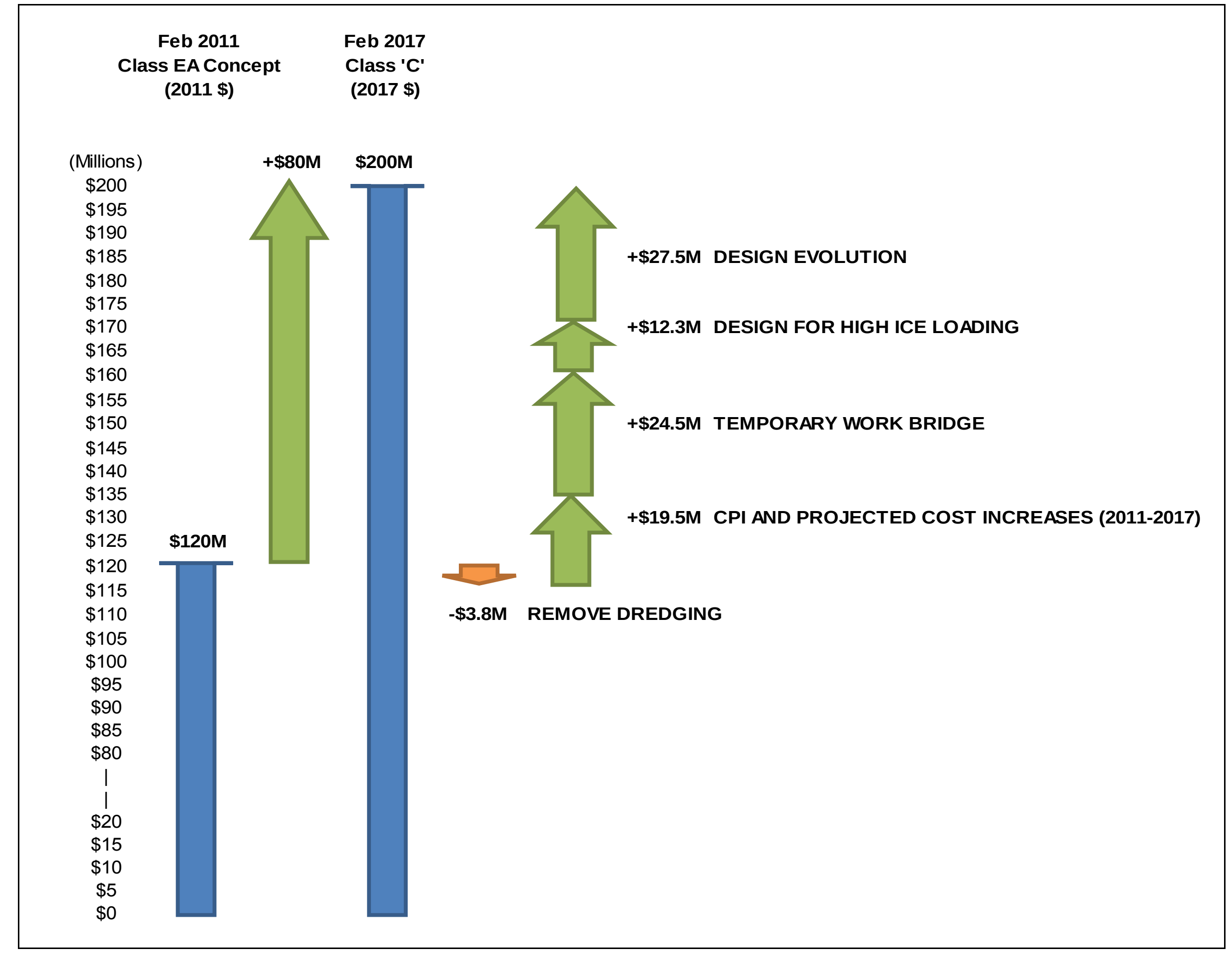


Figure 8.18.1: Capital Cost Escalation Considerations

As referenced earlier, the refined pier design offered an opportunity to reduce costs along with environmental impacts and retaining aesthetic design and user experiences. The design innovation associated with the inverted U-shape pier design allowed for considerable offsets to the increased costs associated with the temporary work bridge.

An updated Class 'B' estimate was prepared for the final preliminary design using HiCo, MTO's infrastructure costing system and knowledge of local construction pricing. The capital project cost including the refined pier design and temporary work bridge option amounted to $161M, a $40M decrease compared to the initial design. A summary is provided in **Table 8.18.1**.

Table 8.18.1: Class 'B' Cost Estimate	
Sub-Total for Structure Construction	$106,500,000
Sub-Total for Construction of Bridge Approaches	$11,500,000
Sub-Total for Landscaping	$3,400,000
Sub-Total for Construction Costs	**$121,400,000**
Mobilization (3%)	$3,600,000
Engineering and Contract Administration (12.5%)	$15,200,000
Quality Management (3.0%, 2.5% Structural)	$3,100,000
Contingency (15%, 10% Landscape)	$18,000,000
Total Estimated Construction Cost	**$161,300,000**

Proportionate costs relative to construction costs (75%) and indirect costs (25%) are shown in **Figure 8.18.2**.

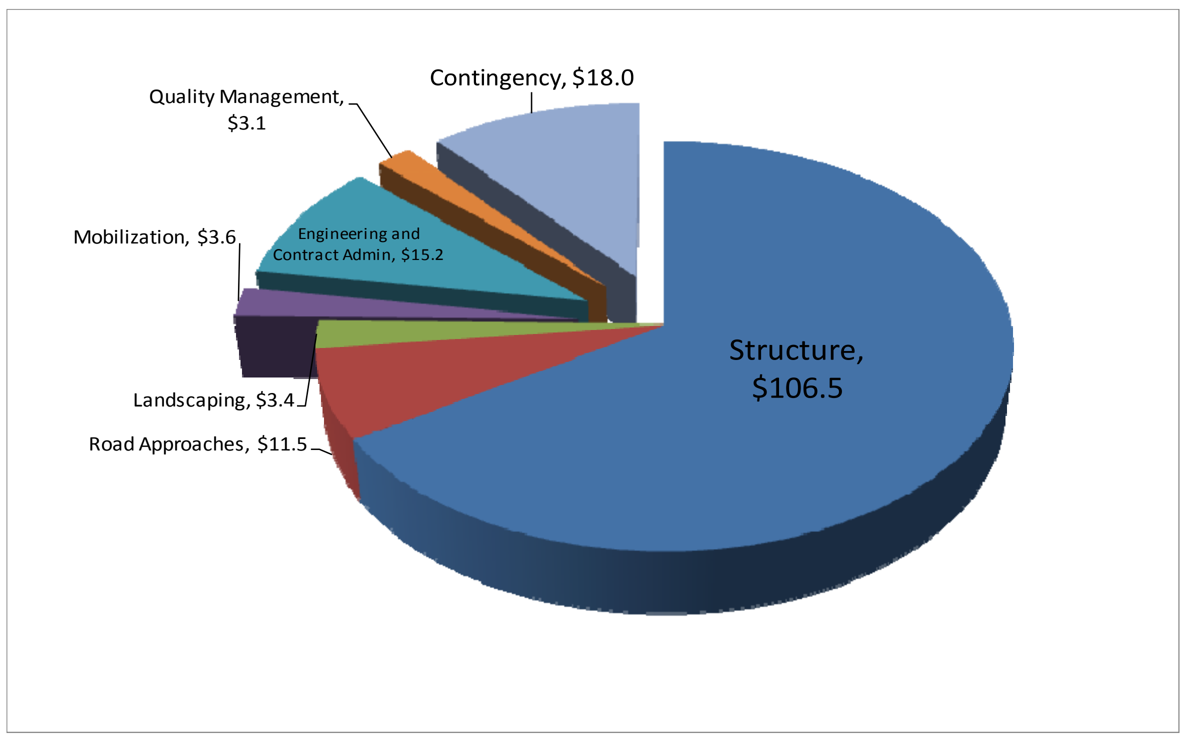


Figure 8.18.2: Proportionate Construction and Indirect Costs

Further perspective on the capital cost progression from the Arch with V-Piers design concept in the ESR to the current refined bridge design is shown in **Figure 8.18.3**.

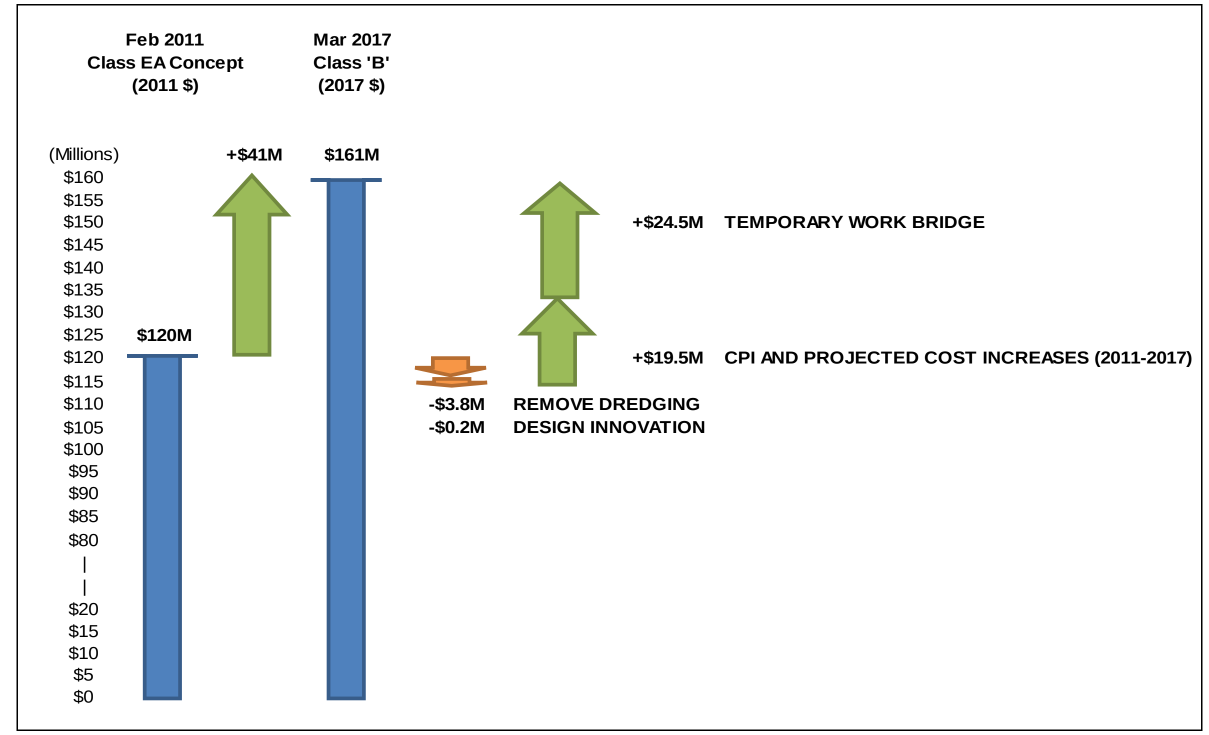


Figure 8.18.3: Class EA Capital Cost Progression

Through design innovation, the cost of the project (from 2011), other than inflation and the preferred temporary work bridge construction option, is expected to remain the same.

8.19 Life Cycle Cost Analysis

A life cycle cost analysis was undertaken for the bridge in accordance with the current MTO Financial Analysis Manual, to determine the future capital and maintenance costs for the bridge through its service life of 100 years. With regular maintenance, it is expected that the bridge can last more than 100 years. The life cycle cost includes the costs associated with bridge elements that have a design life less than the overall design life of the bridge which will be replaced and bridge elements which will require repairs to achieve the overall design life of the bridge. **Table 8.19.1** shows the service life of the different bridge elements and whether they will require replacement over the course of the bridge's service life.

The concrete deck is anticipated to have a 100-year design life with continuous maintenance of the waterproofing system as the deck will be reinforced with galvanized/GFRP and/or stainless steel reinforcement and have additional cover over traditional concrete decks. The life cycle cost analysis considers the annual maintenance and operation costs as well as inspections costs. Visual inspections will occur every two years and a comprehensive detailed and underwater inspection will occur every two years or so prior to a major rehabilitation to determine the scope of the rehabilitation work. The life cycle cost analysis does not account for any reconfiguration of the bridge in the future.

It is anticipated that a minor rehabilitation would be required every 15 years which would consist of: mill and paving of the asphalt deck surface, and replacement of the expansion joint seals.

A major rehabilitation would occur every 25 to 30 years, depending on the existing condition of the element, and would consist of: replacement of the waterproofing membrane and asphalt, replacement of the bearings, replacement of the modular and strip seal joints, replacement of the noise barriers, localized concrete repairs and re-coating of structural steel.

At 60 years, a major rehabilitation will occur which will include the items of the previous major rehabilitation and in addition will include: replacement of the drainage system and replacement of the traffic railings.

The future rehabilitation costs are presented in constant 2017 dollars and are separated into individual cost estimates for each element. Each rehabilitation option includes a mobilization and demobilization fee of approximately 2%. The costs are based on the assumption that each rehabilitation is completed separately and there may be cost savings with completing multiple rehabilitations simultaneously with regards to traffic control and access costs. The rehabilitation options have a 20% contingency and a 15% allowance for engineering services. The annual maintenance and operation cost has a 20% contingency. The inspection costs have a 5% contingency. These contingencies, as described earlier, account for variability of market forces in the future.

Table 8.19.1: Service Life of Bridge Components

Bridge Element	Service Life (Years)
Permanent Elements:	
Foundations, including caissons/ footings	100
Piers	100
Abutments	100
Concrete Deck	100
Steel Superstructure and Arch	100
Arch Cables	100
Replaceable Elements:	
Bridge Bearings	30
Strip Seal Expansion Joint -- Neoprene Seals	15
Strip Seal Expansion Joints – Assemblies	30
Modular Expansion Joints – Assemblies	30
Deck Wearing Surface – Asphalt Top Lift	15
Deck Wearing Surface – Complete System	30
Deck Waterproofing	30
Traffic Railing	60
Coating System for Structural Steel	30
Noise Barriers	30
Drainage System	60
LED Luminaires	20
Light Standards and Brackets	50

For the concrete repairs task, it is estimated that there will be:

1. 100 m^2 of concrete repairs on the vertical piers and pier caps.
2. 50 m^2 on the two arch v-piers which is approximately 3% of the surface area.
3. 100 m^2 on the soffit which is approximately 0.5% of the surface area.
4. 50 m^2 on the barriers which is approximately 1% of the surface area.
5. 5 m^2 on the abutments and wingwalls which is approximately 5% of the surface area.

The life cycle cost analysis presents the cost of all future capital and maintenance costs as present net value (in 2017 dollars) for the item using economic principles and a discount rate. The effective discount rate used for the financial analysis was 3% with a sensitivity analysis of life cycle cost using discount rates of 5% and 7%. A summary of the life cycle cost analysis are shown in **Table 8.19.2**.

Table 8.19.2: Net Present Cost of Bridge Structure with Different Discount Rates

Discount Rate	Net Present Cost (2017)
3%	$156,500,000
5%	$137,900,000
7%	$126,500,000

In general, much of the road approach components will require repairs over the design life of the bridge as well. **Table 8.19.3** shows the service life of the different road approach elements and an estimated replacement schedule over the course of the bridge's service life.

Renewal of asphalt components as well as landscaping, stormwater facility maintenance, traffic light and overhead lighting is expected as with any road in the city. Underground utilities will require replacement/rehabilitation during the life of the adjacent bridge as well. The life cycle costing has considered the annual maintenance and operation costs of the road approaches, including an allowance for winter maintenance.

Similar to the bridge structure, future rehabilitation costs are presented in constant 2017 dollars and are separated into individual cost estimates for each element. Each rehabilitation option includes a mobilization and demobilization fee, traffic control (where applicable) and contingency and engineering services allowances.

Table 8.19.3: Service Life of Road Approaches

Road Approach Element	Service Life (Years)
Surface Course Asphalt (1 lift)	15
Surface and Minor Base Asphalt (2 lifts)	30
Major Road Rehabilitation/Reconstruction incl. Storm Sewers and Structures, Granulars, Asphalt, Guide Rail, Storm Treatment Devices, Concrete Sidewalks	60
Granular Pathway Maintenance (Rehab)	15
Landscaping Renewal	25
Stormwater Management Pond Maintenance	25
Traffic Lights and Controllers	20
Noise Barriers / Fencing	30
LED Luminaires	15
Light Standards and Brackets	50

Table 8.19.2: Net Present Cost of Road Approaches with Different Discount Rates

Discount Rate	Net Present Cost (2017)
3%	$20,300,000
5%	$16,300,000
7%	$14,300,000

9.0 POTENTIAL PROJECT EFFECTS

As noted earlier, the intent of this Report is twofold, namely:

1. Refine the preferred bridge, roadway and landscape concept from the Class EA.
2. Review potential environmental interactions and proposed measures to mitigate potential adverse environmental effects associated with the construction and operation phases of the refined concept.

The proposed refinements to the preferred bridge, roadway and landscape concept further reinforce the potential of the project to provide an overall community benefit to the City:

1. The identified roadway improvement works should maintain the flow of traffic along this critical mid east-west arterial corridor at an acceptable LOS over the long-term. This analysis has also demonstrated that short-cutting of traffic through the Village On The River Apartments on the west side is not anticipated. Furthermore, additional traffic calming alternatives have been proposed at the reconfigured Point St. Mark Drive-Gore Road Intersection, which should prevent short-cutting of traffic through the Point St. Mark residential neighbourhood on the east side.
2. The purpose of the active transportation provisions on the bridge and on-land is to connect with, and thereby enhance, existing non-automotive networks on both sides of the Cataraqui River.
3. The intent of the preferred bridge concept, in conjunction with on-land design provisions in the C-NHPEP, is to enhance the cultural and natural heritage landscape within the project corridor and as part of the broader Canal context.

It is equally acknowledged however, that the C-NHPEP will be a critical piece of the broader package of mitigation measures required during the project construction and operation phases to either reduce or eliminate potential negative project impacts on the surrounding cultural and natural heritage landscape. These potential project effects are outlined below. In certain cases, specific DIA area conditions or project design mitigation considerations are discussed for ease of reference.

9.1 The West and East Side On-Land Effects

1. Potential Natural Heritage and Cultural Heritage Effects

The potential effects of the project on the on-land natural and cultural heritage features of the project corridor include:

1. Exhaust emissions and airborne dust from equipment traffic during construction and from the subsequent use and maintenance of the bridge could impact air quality (particulate matter).
2. Though the alignment would avoid Archaeological Site BbGc-127 and the stone survey marker on the south boundary of the Gore Road Library, both sites would still be affected by bridge construction activities.
3. As shown earlier on **Drawing 8.16.2**, it is anticipated that, due to a lack of available vacant land on the west side, certain privately owned properties (either in whole or in part) would be required for the road, stormwater management and C-NHPEP works, and as a bridge construction lay-down and staging area. Moreover, though visual examination of the west side lands suggests that virtually all lands within the existing road rights-of-way have been disturbed to the extent that any archaeological testing in those areas is almost certain to be futile, the private lands on either side of John Counter Boulevard do not appear to have been extensively disturbed and may contain areas where archaeological potential still remains.
4. As noted earlier, the bridge, by landing north of the Point St. Mark community, would impact the woodland, former fields, and recreational pathways on the lower plateau portion of the Gore Road Library. As shown earlier on **Drawing 8.16.1**, it is also anticipated that, due to a lack of available vacant land on the east side, a portion of the lower plateau would be required for stormwater management provisions and as a bridge construction lay-down and staging area.

   In addition, the widening of Gore Road would also require the removal of the formal gardens that extend along the southerly portion of the Gore Road Library property as well as the relocation of a 12 m portion of the dry stone wall that extends perpendicular from the Library into the Gore Road right-of-way on the upper plateau. These features are significant attributes of the Gore Road Library property that contribute to its heritage value and landmark status along Highway 15.

5. All peat, silty clay and clayey silt within the footprint on the west embankment (i.e. about 2.1 m) and east embankment (i.e. about 0.6 m) would need to be stripped, since these soils are compressible, and would be expected to settle under increased loads. As discussed earlier in this Report, there are a number of APECs on the west side lands. Site preparation and bridge construction activities could disturb potentially contaminated soils in these areas. Furthermore, the existing ground surface is within 1 m of the existing river level at the west embankment as well. If the west abutment is to be supported on spread footings bearing on the dolostone bedrock, the excavation work could be carried out in conjunction with the abutment footing construction. Otherwise, the excavation work would require some water-tight shoring to enable work below the river level.

6. As it is understood that the bridge approaches would match existing grades:

   a) Up to 4 m of fill would be required from the existing grade of John Counter Boulevard to the proposed west abutment.

   b) Up to 9 m of fill would be required from the existing grade of Gore Road to the proposed east abutment.

   The preferred use of suitable fill such as Select Subgrade Material or rock will need to confirmed during the detail design phase, including the need for appropriate erosion mitigation works of the embankment side slopes due to surface water runoff.

7. The bridge would impact existing faunal wildlife habitats and species on both sides of the Cataraqui River. As noted earlier, certain faunal species are also at some level of risk under the Provincial ESA and Federal SARA. Lands would be required for road, stormwater management and C-NHPEP works, and as a bridge construction lay-down and staging area. Such activities would involve:

   a) Riparian vegetation removal.
   b) Stripping and stockpiling of topsoil.
   c) Shoreland excavation works.
   d) Heavy equipment use and maintenance.
   e) Heavy material use and storage.
   f) Sanitary and construction waste management.
   g) Accidents and malfunctions.

   Without mitigation measures in place, these activities would lead to increased levels of sensory disturbance, loss of habitat, species mortalities, restricted species movement, shoreline erosion, sediment deposition and a subsequent decrease in surface water quality.

8. The bedrock on-shore could potentially be frost susceptible, as it is at relatively shallow depths of about 1.7 m and 3.1 m at the east and west banks, respectively.

It is equally important however, to reiterate the role of the C-NHPEP in restoring and enhancing the cultural and natural heritage landscape within the project corridor, relative to the fieldwork that was done during the Class EA and current project design phase:

1. There have neither been deer yards identified in the project corridor nor is there any identified moose late winter habitat.

2. There are no banks, rocky islands or peninsulas suitable for colonial bird nesting habitat.

3. Though the Cataraqui River and Greater Cataraqui Marsh PSW are known to provide support to waterfowl during migration times, no terrestrial stopover or staging habitat were observed.

4. The project corridor does not have areas of suitable shorebird foraging habitat. In addition, no concentrations of shorebirds or presence of the listed species were identified.

5. Given the relatively small size of terrestrial natural features within the project corridor and the urban context to the south, east and west, the project corridor is unlikely to provide suitable land-bird stopover areas.

6. Ideal raptor winter roosting areas are generally located in mature mixed or coniferous woodlands that abut windswept fields that do not get covered by deep snow. The project corridor does not provide such suitable areas.

7. Suitable habitat for wild turkey includes a mix of forest and open land such as natural grassland or agriculture. For wintering, wild turkeys tend to prefer large dense coniferous forests adjacent to open land and close to both a food source and groundwater seeps. The project corridor does not provide such suitable areas.

8. The project corridor is not large enough to meet the criteria for area-sensitive bird habitat breeding nor was any of the listed indicator species observed. Furthermore, there is no suitable marsh breeding bird habitat within the project corridor, although suitable habitats are present within the visible cattail portion of the Greater Cataraqui Marsh to the north.

9. The west side lands, in particular are dominated by urban land uses but no cultural heritage properties or ELC community types. As such, the C-NHPEP represents an opportunity for restoring the extensive environmental disturbance that has occurred, and enhancing the area as a naturalized landscape. This in turn could further serve to enhance both the ‘ribbon of life’ along the shoreline and visitor experience of the Canal.

10. The east side lands, in particular:

    a) Demonstrate anthropogenic-based disturbances, including: i) historic agricultural land uses; ii) the trails and off-leash dog park on the Gore Road Library property, which have fragmented the forest block; iii) non-native and some invasive plant species; and v) surrounding urban land uses.

    b) Generally lack the key characteristics of an old-growth forest, even though there are some very large mature trees. Moreover, none of the trees observed in publicly accessible areas are listed under the ESA or SARA, although it is recognized that Butternut Trees may be present on privately owned lands.

    As such, the significant functions of the forested block on the east side lands are restricted to the provision of shoreline and fish habitat protection as well as in forming part of the ‘ribbon of life’. Ultimately, the C-NHPEP represents an opportunity for ecological compensation following project construction by restoring and enhancing the naturalized landscape in this area. This in turn could also further serve to enhance both the ‘ribbon of life’ along the shoreline and visitor experience of the Canal.

2. Potential Noise Effects on Humans and Terrestrial Wildlife

The construction and operation of the bridge will generate environmental noise impacts on both humans and terrestrial wildlife. For this reason, noise assessments were conducted, focusing on:

1. Potential noise impacts on human receptors within the project corridor from (a) bridge construction; and (b) bridge operations (i.e. traffic).
2. Potential noise impacts on (a) birds and reptiles from bridge construction (i.e. impact pile driving); and (b) birds from bridge operations (i.e. traffic).

The supporting reports are included in **Appendix L** and **Appendix M**.

(A) Noise Impact Assessment on Human Receptors

The MTO Noise Guide outlines requirements for noise assessments and mitigation relating to the construction of new or the expansion of existing Provincial highways, and is often referenced for municipal roadway projects. Mitigation is warranted when increases in sound levels over the future ‘no-build’ ambient sound levels are either 5 A-weighted decibels (dBA) or greater; or greater than 65 dBA at the Outdoor Living Areas (OLA) of Noise Sensitive Areas (NSA). Mitigation measures should achieve at least 5 dBA of attenuation, averaged over the first row of noise-sensitive receivers.

As shown on **Drawing 9.1.2.1**, 15 noise receptors represent the NSA within the project corridor, which is consistent with the NSA defined during the Class EA. There are approximately 324 NSA in the following general areas:

1. Six existing residential areas.
2. An existing day care centre on the south side of John Counter Boulevard just west of Montreal Street.
3. A vacant privately owned lot adjacent to the Gore Road Library property to the north that could potentially accommodate a future residential development.
4. The Gore Road Library, though it is not strictly considered a NSA by the MTO Noise Guide.

The noise assessment then compared future ‘build’ ambient sound levels (i.e. projected traffic volumes for the 2034 horizon year with the 2-lane bridge in place) versus the future ‘no-build’ ambient sound levels. Critical inputs in this analysis are as follows:

1. The OLA have been evaluated as per the MTO Noise Guide, but assessed at a more conservative height of 1.5 m (not 1.2 m), as per the MOECC Environmental Noise Guideline (NPC-300).

Drawing 9.1.2.1: Noise Sensitive Areas (NSA)

2. The expected percentage of heavy vehicles is assumed to be split evenly between 'heavy trucks'[5] and 'medium trucks'[6].

3. The daytime and nighttime (D / N) breakdown of the traffic volume has assumed consistency with the Ontario Road Noise Analysis Method for Environment and Transportation (ORNAMENT).

Table 8.1.2.1 summarizes the vehicle class and D / N breakdowns used in the analysis.

Table 9.1.2.1: Summary of Vehicle Class and D / N Breakdowns

Intersection	Automobile (A) / Medium Truck (M) / Heavy Truck (H)				D / N (%)
	Eastbound (%)	Westbound (%)	Northbound (%)	Southbound (%)	
John Counter / Montreal	A: 95.0 M: 2.5 H: 2.5	A: 92.5 M: 3.75 H: 3.75	A: 92.5 M: 3.75 H: 3.75	A: 92.5 M: 3.75 H: 3.75	D: 90.0 N: 10.0
John Counter / Ascot	A: 92.5 M: 3.75 H: 3.75	A: 92.5 M: 3.75 H: 3.75	A: 99.0 M: 1.0 H: 1.0	A: 99.0 M: 1.0 H: 1.0	D: 90.0 N: 10.0
Gore Road / Point St. Mark	A: 92.5 M: 3.75 H: 3.75	A: 92.5 M: 3.75 H: 3.75	A: 99.0 M: 1.0 H: 1.0	A: 99.0 M: 1.0 H: 1.0	D: 90.0 N: 10.0
Gore Road / Highway 15	A: 92.5 M: 3.75 H: 3.75	A: 95.0 M: 2.5 H: 2.5	A: 95.0 M: 2.5 H: 2.5	A: 95.0 M: 2.5 H: 2.5	D: 90.0 N: 10.0

[5] MTO defines 'heavy trucks' as all vehicles having 3 or more axles and designed for the transportation of cargo. Generally, the gross vehicle weight is greater than 12,000 kilograms (kg). Intercity buses are also included in this category.
[6] MTO defines 'medium trucks' as all vehicles having 2 axles and 6 wheels designed for the transportation of cargo. Generally, the gross vehicle weight is greater than 4,500 kg but less than 12,000 kg. City buses are also included in this category.

4. In addition:

a) Speed limits have been assumed at 60 km/hr within the project corridor (50 km/hr elsewhere) on proposed road elevations with a pavement type having 'average' acoustic absorption.

b) Traffic has been assumed to be predominantly free-flowing and has not considered the acoustic effects of vehicles accelerating or decelerating at flow control devices.

c) Regarding the future 'no-build' scenario, it should be noted that, in addition to the future 'build' scope of the enclosed Report, the majority of the project corridor extends over the Cataraqui River, where no major noise sources currently exist. As such, the analysis conservatively has assumed that the first-row NSA would all be subject to a minimum 5 dB increase under the future 'no-build' scenario.

With the above context in mind, **Table 8.1.2.2** shows the future 'build' versus future 'no-build' comparison.

Table 9.1.2.2: Projected 2034 Sound Levels (Unmitigated)

Receptor Location	NSA	Unmitigated Future 'No-Build' (dBA)	Unmitigated Change From Project (dB)	Unmitigated Future 'Build' (dBA)
NR1 (Briceland Street Residential)	25	45 – 50	≤ 5	50
NR2 (Day Care)	1	50 – 55	≤ 5	58
NR3 (Montreal Street Residential)	10	55 – 60	≤ 5	62
NR4 (River Park Subdivision West)	72	50 – 55	≥ 5	61
NR5 (River Park Subdivision East)	72	40 – 45	≥ 5	65
NR6 (Village On The River Apartment)	50	40 – 45	≥ 5	53
NR7 (Kenwood Crescent Residential)	15	40 – 45	≥ 5	56
NR8 (Kenwood Crescent Residential)	15	40 – 45	≥ 5	51

Table 9.1.2.2: Projected 2034 Sound Levels (Unmitigated)

Receptor Location	NSA	Unmitigated Future 'No-Build' (dBA)	Unmitigated Change From Project (dB)	Unmitigated Future 'Build' (dBA)
NR9 (Kenwood Crescent Residential)	15	40 – 45	≥ 5	56
NR10 (Barker Drive Residential)	10	45 – 50	≥ 5	61
NR11 (Gore Road Library)	-	50 – 55	≥ 5	60
NR12 (Barker Drive Residential)	15	55 – 60	≤ 5	60
NR13 (McLean Court Residential)	12	50 – 55	≤ 5	55
NR14 (McLean Court Residential)	12	50 – 55	≤ 5	56
NR15 (Vacant Land-Potential Residential)	-	45 – 50	≤ 5	51

The results show that noise mitigation is required for certain NSA within the project corridor. Potential mitigation measures in this regard could include:

1. Changes to horizontal alignments: Horizontal changes in alignment can result in increases or decreases in sound levels at NSA by moving the roadway closer or further away. However, the changes that result are limited since the distance to the roadway must be doubled for a 3 dB to 5 dB decrease in sound level. This is not feasible at the project corridor as the alignment is constrained by the location and width of the existing rights-of-way, and by the proximate locations of the NSA.

2. Changes to vertical alignments: Vertical changes in alignment can affect sound levels at NSA by affecting the line-of-sight between the roadway sources and the receiver. Line-of-sight changes influence ground attenuation and barrier effects of the surrounding topography. For example, placing the roadway at the bottom of a shallow in-cut can create a natural barrier effect at the edge of the excavation. On the other hand, elevated roadways located on embankments or structures may also have reduced sound levels, as the structure can act as a barrier for ground level receptors, blocking the line-of-sight for roadway lanes on the 'far side' of the road from the receptor in question. However, these scenarios are not feasible at the project corridor as the alignment is constrained by the location and width of the existing rights-of-way, and by the proximate locations of the NSA.

3. Sound-reducing pavement: For vehicles travelling at highway speeds, the majority of the sound produced is due to interactions between the tires and pavement surface. Sound-reducing asphalts such as 'open-graded friction course' or 'stone mastic asphalt' may cost twice as much as conventional mixes, and by themselves, rarely achieve the required 5 dB reduction in sound level on their own.

4. Sound barriers: Barriers reduce sound levels at protected receptors by blocking the path of sound waves from the source towards the receiver, and by absorbing or reflecting the incident sound energy away. Therefore, a sound barrier must at least break the line-of-sight between the source (i.e. the roadway) and the NSA. Sound barriers, which can be formed of earthen berms, engineered walls, or a combination of the two, can achieve the required 5 dB reduction in sound level.

Based on the above and consistent with the Class EA, sound barriers are the preferred method of noise mitigation resulting from bridge use:

1. As shown on **Drawing 9.1.2.2**, regarding the use of sound barriers for the identified NSA on the west side lands:

    a) For Barrier BR04 (River Park Subdivision West) a 2.6 m high by 140 m long sound barrier wall, earthen berm or a combination is recommended on the north side of John Counter Boulevard up to Ascot Lane.

    b) For Barrier BR05 (River Park Subdivision East), a 2.6 m high by 113 m long sound barrier wall, earthen berm or a combination is recommended on the north side of John Counter Boulevard up to Ascot Lane.

2. As also shown on **Drawing 9.1.2.2**, regarding the use of sound barriers for the identified NSA on the east side lands:

    a) For Barrier BR07 (Kenwood Crescent Residential) a 1.5 m high by 340 m long sound barrier wall is recommended extending west from the south side of the Gore Road / Point St. Mark Drive intersection onto a portion of the bridge deck.

Drawing 9.1.2.2: Sound Barriers

b) For Barrier BR10 (Barker Drive Residential) a 2.75 m high by 205 m long sound barrier wall is recommended extending east from the south side of the Point St. Mark Drive / Gore Road intersection to Highway 15.

Generally, the sound barriers are limited to either within or along the boundary of the rights-of-way with limited return legs extending roughly perpendicular to the main lengths of the sound barriers beyond the right-of-way. As shown earlier on **Drawing 9.1.2.2**, a portion of Barrier BR07 on the east side lands is staggered, in that a portion of it is shifted from the north side of the multi-use path to the south side of the multi-use path ahead of the Gore Road / Point St. Mark Drive intersection. This layout, which should be further reviewed during the detail design phase, is recommended as part of the current project design phase for the following reasons:

1. It prevents an obstruction between the multi-use path and the Gore Road / Point St. Mark Drive intersection.

2. Typically, the boulevard on a road will slope from the property line to the road. If the sound barrier is placed on the south side, the design can maintain a standard drainage pattern from the barrier back to the curb. If the sound barrier is completely on the north side of the multi-use path, then the design would have to slope runoff south from the barrier down the slope. This is not ideal from a stormwater management perspective.

In addition, it is also anticipated that the bridge may serve as an emergency detour route for Highway 401, should an accident or event cause it to be closed in the vicinity of Kingston. In this instance, traffic volumes on the bridge can be expected to increase, likely to the point of causing congestion and reduced vehicle speed since the bridge would be exceeding its capacity. Such congestion events generally produce reduced sound levels from road traffic since wheel sound is largely limited by the reduced speed of the vehicles. Normally, wheel sound created by the interaction of tires with the road surface creates a large portion of traffic sound levels, which tends to increase with increasing speed. As a result, emergency detours over the bridge are expected to produce lower sound levels than under more free-flow conditions. This could also extend to emergency situations on the bridge itself, which are expected to result in decreased sound levels due to restricted traffic movements.

Finally, sound from bridge construction activities would also be generated at the project corridor, which will be temporary and vary temporally and spatially as construction progresses. Sound levels from construction at a given NSA will also vary over time as different activities take place and change location. Though construction sound would be largely unavoidable, the use of construction grade noise attenuation measures as well as adherence to guideline and Code of Practice requirements will be critical to minimize potential effects on NSA. In this latter regard, the City Noise By-Law (No. 2004-52), as amended, prohibits the following:

1. The operation of any item of construction equipment without an effective exhaust muffling device that is in good working order and in constant operation.

2. The operation of construction equipment or performing any action relating to construction between 1900 hours (7:00 PM) of one day to 0700 hours (7:00 AM) of the next day, with no construction on Sundays and statutory holidays.

However, it is also important to note that under Schedule 'C' to the City Noise By-Law, the operation of municipal and utility service vehicles and related equipment is exempt, which could apply to bridge construction activities. Despite this, a protocol has been put in place for other past major municipal infrastructure projects to notify the City in advance if the Contractor has deemed it necessary to perform construction works outside of the allowable time periods listed above. This protocol has given the City the opportunity to consider whether any conditions should be imposed on proposed works.

Furthermore:

1. As shown in **Table 9.1.2.3**, the MOECC Model Municipal Noise Control By-Law (NPC-115) stipulates the following sound emissions limits from individual items of construction equipment:

Table 9.1.2.3: Construction Equipment Sound Emission Levels

Type of Unit	Maximum Sound Level (dBA)	Distance From NSA (m)	Power Rating [kilowatt (kW)]
Excavation Equipment	83	15	less than 75 kW
	85	15	more than 75 kW
Pneumatic Equipment	85	7	not applicable
Portable Compressors	76	7	not applicable

2. The MOECC Publication NPC 119 on blasting also sets blast vibration limits, as shown below in **Table 8.1.2.4**:

Table 9.1.2.4: Maximum Blast Vibration Levels		
Vibration Source	**Cautionary (Unmonitored Blasts)**	**Peak (Monitored Blasts)**
Concussion (air overpressure)	120 dB	128 dB
Ground-borne Vibration	1 centimetre / second (cm/s)	1.25 cm/s

(B) Noise Impact Assessment on Terrestrial Wildlife

Noise can negatively affect wildlife by: causing loss of hearing sensitivity, either temporarily or permanently; increasing stress levels by altering the production of stress hormones, causing negative physiological effects to cardio-vascular systems; masking important signals from predators or prey; and interfering with acoustic communications, which can further interfere with mating or how animals select foraging locations. Wildlife responses to noise is usually related to the type of noise, the sound level, the frequency structure of noise relative to the hearing ability of the animal, and the distance of the noise source from the animal.

Based on the fieldwork activities undertaken during the Class EA, 59 bird species and one snake species were identified as species of interest for the noise impact assessment on terrestrial wildlife[7]. Birds are a keystone species used to describe the effects of human-generated noise on wildlife. This is due to the fact that the inner structures of all vertebrate ears are similar; birds and humans share many of the same environments; and the hearing range of birds and humans is also similar. On the other hand, snakes have long been considered deaf or insensitive to sound because they lack outer ears. However, recent research has demonstrated that: snakes perceive sound as well as vibration through their skin cells (also known as somatic hearing) and inner ear; and bird and reptile hearing share a number of similarities.

With the above context in mind:

[7] The potential noise impacts on turtles are addressed later in this Report.

1. A similar approach has been used to guide the assessment of noise impacts from bridge construction on birds and snakes, namely:

   a) In-air acoustic sound propagation was calculated using JASCO's Impulse Noise Propagation Model (INPM)[8]. The INPM has conservatively assumed that bridge construction would be facilitated by impact pile driving activities, as this method generates more in-air noise than either vibratory pile driving or rock socket drilling.

   b) The modelling location within the project corridor was roughly centered between the west shore and the mid-point of the Cataraqui River, where the in-river sediment is thickest (and which could require more pile driver strikes), and the typical nesting and perching habitat associated with the visible cattail portion of the Greater Cataraqui Marsh north of John Counter Boulevard is most proximate.

The results indicate the following:

1. Overall, the risk of auditory injury to birds and snakes due to impact pile driving is low, but not negligible:

   a) Auditory injury in birds could occur at levels about 125 dBA, which corresponds to a location within 20 m of the pile driving location.

   b) Auditory impairment in birds could occur at levels greater than 93 dBA, which corresponds to a maximum distance of 113 m from the pile driving location.

   c) Auditory masking and behavioural disturbance could occur at levels greater than 55 dBA, which corresponds to a maximum distance of 2.3 km from the pile driving location.

   d) Auditory impairment in snakes could occur at levels greater than 104.5 dBA, which corresponds to a maximum distance of 37 m from the pile driving location (i.e. close to shore).

   Despite the above however, it is equally critical to note the following:

[8] The INPM computes acoustic fields by modelling transmission loss along evenly spaced radial traverses covering a 360 degree swath from the source.

a) The preferred method for pile installation is drilling, not impact pile driving, which generates noise emissions below established thresholds.

b) Additional proposed mitigation measures discussed later in this Report will either further reduce or eliminate potential negative effects.

2. The potential effects of traffic noise from bridge operations have only been considered for birds, since the available information on received sound levels was restricted to ambient-weighted metrics which, although applicable to birds, is not appropriate to assess the hearing sensitivity of snakes. With this in mind, the results indicate the following:

a) Similar to humans:

i. auditory injury to birds is not expected to result from traffic noise exposure since anticipated sound levels will not exceed levels that are considered high enough to cause injury even at very close distances from the sound sources; and

ii. although auditory impairment to birds could occur when received sound levels exceed 93 dBA, this level is unlikely to be reached anywhere within or near the project corridor.

b) Anticipated traffic noise is in frequencies that hearing for both birds and humans will be unaffected. Furthermore, the aforementioned proposed transportation noise mitigation measures which would lower the potential risk of noise impact on humans would similarly lower the potential risk of noise impact on birds.

3. Potential Viewscape Effects

The bridge represents a major piece of infrastructure at the project corridor. As such, its on-land visual impacts on the community and Canal would not be completely eliminated. Therefore, in light of the DIA scope and surrounding contextual landscape, it is critical that the project design not only accommodate existing topographic conditions on-shore, but also mitigate on-land visual impacts.

Based on the key viewshed limits at the project corridor and surrounding area:

1. As shown earlier on **Figure 4.4.1**, the project corridor is not visible from Highway 401.

2. **Figure 8.1.1**, which provides a bridge profile view from the Elliott Avenue Parkette on the west side of the Cataraqui River, shows the gradual rise in bridge clearance over the water west-to-east that remains at or below the tree line on the east side of the river.

3. **Figure 8.1.4**, which provides a bridge profile view from the Point St. Mark residential neighbourhood on the east side of the Cataraqui River during winter, shows the gradual descent in bridge clearance over the water east-to-west and its integration into the urban landscape on the west side of the river, with the Village On The River Apartments and John Counter Place noted prominently in the background. It should also be noted that the landscape improvements on the west side lands provide an opportunity for the bridge to be below the ‘future’ tree line in this area when viewed during non-winter periods from both the water and land on the east side.

9.2 The In-Water Effects

As discussed below, prior to mitigation, the project has the potential to negatively impact the natural and cultural heritage of the marine environment during the construction and operation phases. These potential project effects are outlined below. In certain cases, specific DIA area conditions or project design mitigation considerations are discussed for ease of reference.

1. Potential Effects on Marine Archaeological Resources

As noted earlier, no in-water cultural heritage materials were located as part of the fieldwork during the Class EA or current project design phase. The paleo-environment of the project corridor is a ‘marsh environment’, akin to its designation as the Greater Cataraqui Marsh PSW. As such, the project corridor exhibits a low archaeological potential for encountering either prehistoric or historic cultural remains. This should not be interpreted to mean however, that marine archaeological resources are not present within the project corridor, and will not be potentially encountered during the construction and operation phases of the project.

2. Potential Effects on River Hydrology

The installation of piers could change water levels and flows. This is due to the partial blockage of water flow from the in-water works which causes upstream water levels to increase to force the flow through the restricted openings and around the obstructions. Typically, hydraulic bridge design is based largely on the flow-generated conditions at the bridge location, as these conditions generate the largest local velocities. Though wind speed and water flow velocities vary within the watercourse over time, as previously noted, the lower Cataraqui River reach is not a typical reach, in that it is wide and flow-generated velocities, especially at the project corridor, are low, at roughly 0.4 m/s. As such, the physical characteristics of the lower Cataraqui River reach are similar to a lake-like setting.

Due to the reduced importance of the hydrologic conditions at the project corridor, six environmental forcing scenarios reflecting a range of temporal changes in water flow and wind speeds were modeled during the Class EA phase to assess potential project impacts from the v-piers on river hydrology. The scenario conditions are summarized in **Table 8.2.1**.

Table 9.2.1: Class EA Hydraulic Modelling Scenarios

Scenario	Water Flow (m^3/s)	Wind Speed (m/s)	Wind Direction
High (100 Year) Condition	50	20	North
Moderate I Condition	50	4.5	North
Moderate II Condition	10	20	North
Moderate III Condition	10	4.5	North
Moderate IV Condition	4.5	20	South
Low Condition	0	4.5	North

The modelling results generally show that the worst case scenario is the ‘High (100 Year) Condition’ model. Under this scenario, the piers would generate the most impact on water levels and flow-generated velocities. But these impacts are considered minor and localized, especially in light of the current design optimizations in support of the inverted U-frame pier design, in that:

1. The highest increase in water levels was modeled to be only 4 mm in the vicinity of the v-piers, which was due to the resistance to flow generated by the piers and the increase in flow-generated velocity between the v-piers. In addition, the highest increase in flow-generated velocity was modeled to be only 0.035 m/s, which was found between the spans of each V-pier. It is anticipated that these minimal impacts will be reduced even further with the inverted U-frame pier design, given that the comparative in-water footprint has been reduced from 5,000 m^2 to 4,200 m^2 through design optimization.

2. The above-noted impacts would be under worst case conditions, which would not be expected to persist for any significant period of time. As such, flow-generated velocities and their related effects would be reduced even further under more normal conditions.

In addition, general and local scour estimates were prepared based on the hydraulic modelling and as per the CHBDC requirements with guidance from MTO’s Drainage Management Manual. Given the width of the watercourse and limited flow-generated velocities at the project corridor, the general scour estimates are in the order of 2 N/SM, which is considered negligible. In terms of local scour, estimates suggest a local scour depth allowance of 7.5 m. This potential undermining of the pier footings would be prevented if the piles were socketed directly into the bedrock.

Finally, the potential for any of the bridge concepts to influence ice jamming on the Cataraqui River is also considered to be negligible. As stated earlier, the ice generally melts in place due to the limited flow-generated velocities. This is not expected to change with the construction of the bridge.

Floodplain compensation management is prescribed by the CRCA and filling within the floodplain is generally not permitted unless a floodplain storage compensation (cut and fill) study is completed to adjust the floodplain boundary. Construction of the bridge will involve impacts in the floodplain due to installation of the piers as well as near shore activities. The modification of the pier structure from V-shape to inverted U-shape has reduced the footprint substantially, but the impacts on the floodplain cannot be completely eliminated. On land, there is a balance between accommodating existing near shore underground infrastructure, necessary new stormwater management features, maintaining similar public access to the waterfront, providing an accessible pathway networks with gentle slopes and placement of the bridge abutments. Infringing into the floodplain on land is necessary in a limited sense.

The CRCA has stated that the Cataraqui River floodplain elevation is recognized at the 76.3 m elevation. In addition, the 100 year water level elevation is at 76.0 m and a 0.3 m wave uprush is recognized as the difference in between these two elevations. The CRCA has communicated that, within the Cataraqui River at the proposed location of the bridge, the placement of fill may be considered within the wave uprush allowance (between 76.0 m and 76.3 m) without the need for storage compensation.

Further discussions have identified that within the Cataraqui River floodplain and upstream of the proposed bridge corridor there are limited opportunities for floodplain compensation to make up for the filling of the floodplain. However, in this area, the impact of filling is minimized by the types of natural and built environment that could potentially be affected. In essence, between the bridge location and Kingston Mills Locks, examples of areas that could be potentially affected would be the built up areas along the CN rail and Highway 401 corridors and the natural wetland vegetation found throughout this area.

Permanent bridge piers and associated rock scour protection that may be required will potentially amount to 3000-4000 m^2 of impacted floodplain area. On shore, within the current design, 1000-2000 m^2 of impacted floodplain is expected. With modifications to the design near the waterfront, it is possible that the total impact on east and west shorelines could be reduced to less than 1000 m^2. Therefore, in total, the impacted area is predicted to be less than 5000 m^2. The CRCA has recommended that a Hydrology and Hydraulics review be undertaken to demonstrate the potential effects (if any) of the 5000 m^2 impact area within the 1.5 million m^2 upstream area during a 1:100 year flood event. This work should be deferred to the detail design phase when the permanent bridge pier design and associated rock scour protection measures are further refined and confirmed.

Lastly, fluctuating water levels in the Great Lakes and St. Lawrence River due to the adoption of Plan 2014 by the International Joint Commission, in comparison to the infrequent occurrence of impacted floodwaters caused by the infilling described above, may be expected to be of greater concern.

3. Potential Effects on Watercraft Navigation

As noted earlier, the bridge clearance above the water is 12 m over the navigable channel and adjacent rowing lanes. This exceeds the 6.7 m Federally regulated navigable requirement for the Canal. In addition, the 145.6 m arch span pier-to-pier over the navigable channel provides unencumbered through-navigation for the rowing course. However, proper advance safety mitigation measures, in conjunction with required regulatory approvals, will be required to protect the public in support of any bridge construction or subsequent maintenance activities that may need to occur over the navigable channel or adjacent rowing lanes during the navigation season.

4. Potential Effects on Geophysical Conditions

For seismic design purposes, and as also noted earlier, the bridge will have a classification of an irregular 'Major-Route Bridge' and a Site Class of D based on the site properties. Based on the fundamental period, the bridge is within Seismic Performance Category 2 and as such the seismic design will be based on the Performance Based Design method for the following performance levels: 475 years event, 975 years event, and 2475 years event (as further described in **Section 3.2.3**).

In addition, as discussed earlier, there are two possible in-water fault zones within the project corridor where low resistivity is observed within the bedrock beneath the river, centered at distances of 320 m and 970 m. These areas are most likely associated with the Frontenac Axis. The bedrock cores recovered from boreholes within these zones do not suggest that the boreholes were drilled through a historical fault. However, bridge foundation construction may encounter a fault or highly fractured bedrock within these zones or closer to the shorelines at a transition from the gneissic bedrock in the Cataraqui River to the limestone bedrock at the east shore and the dolostone bedrock at the west shore. At these locations, the design may require modification to accommodate a reduced axial geotechnical capacity, either with deeper rock sockets or through the use of post-grouting to improve the side wall shear resistance.

Finally, in regards to other bridge foundation design considerations, the potential geophysical effects are as follows:

1. In terms the in-water bridge foundations, due to the significant length of the caissons required to reach the bedrock and depth below the Cataraqui River, it may not be feasible to dewater and clean the base of the caisson and, as such, full end-bearing support may not be developed. Thus:

    a) The axial geotechnical resistance for rock socketed caissons would need to be based on the side-wall (shaft) resistance of the rock socket, rather than end-bearing.

    b) The use of a liner or casing would also be required to advance the caissons through the overburden with minimal loss of ground. The casing should be extended so that it is seated a minimum of 300 mm into the bedrock.

    c) Casing installation through the glacial till containing cobbles and boulders (where encountered) may be difficult. Churn drilling and possibly rock coring techniques would be required to advance the caissons through potential boulder deposits. Moreover, since the bedrock at the project corridor is strong-to-very-strong, the caisson sockets would likely have to be advanced by rock coring (and possibly supplemented with a down-hole hammer) and/or chisel drilling.

2. The in-water test holes put down as part of the current project design phase were advanced at selected pier locations based on the previous 14-span V-pier arrangement. As discussed earlier, the refined bridge arrangement maintains the same abutment locations and overall bridge length, but now comprises 19 inverted U-frame piers. As such, most of the test holes are no longer within the footprint of the inverted U-frame pier locations. Though the relevance and applicability of the geotechnical assessments to the refined bridge arrangement is re-confirmed, additional field investigations should be carried out during the detail design phase to confirm bedrock surface elevation and founding soil and bedrock conditions at the proposed U-frame pier locations.

5. Potential Effects on Substrate Disturbance

Should in-river sediment material be brought to land during construction, the portion taken at depths greater than 1.3 m below the top of the sediment does not meet MOECC Table 1 (R/P/I/I/C/C) standards for metals. Overall however, the metals and polycyclic aromatic hydrocarbons (PAHs) were generally non-detectable or lower than the most conservative sediment quality guidelines issued by the CCME for the protection of aquatic life. Where exceedances did occur, they were relatively small or localized, and not indicative of wide-spread contamination from the direct deposit of industrial waste. Rather, the sediment quality is consistent with the low energy depositional environment which may have been influenced by fall out from the nearby City and industries.

Furthermore, most of the sediment from the project corridor would be acceptable for re-use on land for a residential use and some sediment, with higher concentrations, on lands with an industrial use. However, this re-use would likely not be practical, as the material itself is very high in organic peat content and thus, will likely be disposed of as waste following dewatering. It should also be noted that the anticipated sediment removal requirements have been significantly reduced through project design and constructability innovations and optimizations.

Despite the above, bridge construction activities will still disturb this substrate. If proper mitigation measures are not in place, this disturbance could cause sediment re-suspension, the dispersion of associated contaminants, potential changes in sedimentation dynamics, and increased turbidity in the water column.

6. Potential Effects on Fish and Fish Habitat

In-water bridge construction activities could potentially lead to: i) restriction of fish movement; ii) species mortalities or avoidance of the area; iii) the loss of aquatic vegetation and fish habitat; iv) erosion along the shoreline; v) the spread of invasive species from vessels brought in from areas outside the Great Lakes system; and vi) accidents and malfunctions from equipment use. It is the cumulative effect of all of these potential impacts which can result in a 'Harmful Alteration Disruption or Destruction' (HADD) to fish and fish habitat.

The Class EA context in which dredging was recommended as the preferred in-water bridge construction option has subsequently evolved, as highlighted below:

1. UK confirmed an alternative route for the proposed watermain that was originally intended to be located within the dredged channel.

2. Based on more in-depth fieldwork activities, the composition of the dredgeate could lead to severe suspension and sloughing of in-river sediment during construction; and changes in sediment dynamics and increased turbidity in the water column after construction.

3. Critical outcomes from specific consultations with Parks Canada during the current project yielded the following:

    a) The context of the bridge corridor within the Greater Cataraqui Marsh PSW ecosystem, particularly its role as a coastal wetland, and its status as one of Parks Canada's larger protected heritage areas.

    b) The proposed 4.3 ha impact area from the dredging option, which is significantly larger than the proposed 0.6 ha impact area from the temporary work bridge option. Furthermore, the impact area from the temporary work bridge option would be a patchwork of small areas that cumulatively add up to 0.6 ha, as opposed to a large linear area. Localized excavation of the riverbed will still be required, but only at the v-pier locations, which will significantly minimize the overall impact footprint. As such, these smaller patches would be anticipated to rebound faster post-disturbance, and will not pose a barrier to habitat access.

c) With minimal anticipated impacts on habitat fragmentation and no expected long term changes to sediment dynamics or turbidity, the lower risk concerning the potential long-term effects from the temporary work bridge option on the Cataraqui River substrate, vegetation, habitat and water quality.

Based on the above considerations as well as the aforementioned extensive bridge constructability assessments by the JLR Project Team in consultation with City staff, the current project is recommending the temporary work bridge as the preferred in-water bridge construction option, which as noted earlier, is supported by Parks Canada.

In addition, regarding the permanent bridge:

1. Although the span arrangement would increase from 14-to-19-spans, the overall environmental footprint from the U-frame piers would still be lower compared to the initial V-pier design.

2. The bridge deck would ultimately have a total shore-to-shore area of approximately 20,000 m^2.(measured abutment to abutment) In addition to the use of the bridge, in order to ensure its long term safety and viability, operational maintenance will also be required. With these factors in mind, the potential direct impacts associated with bridge operations could include: i) the loss of aquatic vegetation and fish habitat due to shading from the bridge; and ii) accidents and malfunctions from bridge operations and maintenance. These impacts are considered minor relative to the following:

   a) The bridge clearance above the water, which as noted earlier, is approximately 4 m near its westerly portion and then gradually rises to over 11 m over the navigable channel and then descends to approximately 9 m at the east shore, should contribute only partial bridge deck shading on the marine environment.

   b) The proper safety mitigation measures that will be put in place by the City to address accidents and malfunctions from bridge operations and maintenance.

During construction, fish and fish habitat are to be further protected in areas near the temporary work bridge. Containment measures, including silt curtains and cofferdams will be installed and monitored to prevent habitat access.

7. Potential Noise Effects on Marine Wildlife

The aforementioned negative effects of noise on terrestrial wildlife are equally applicable to the marine environment (i.e. loss of hearing sensitivity; increased stress levels by altering the production of stress hormones; masking important signals from predators or prey; and interfering with acoustic communications). As such, based on the fieldwork activities undertaken during the Class EA, 24 fish species and five turtle species were identified as species of interest for the noise impact assessment on marine wildlife. The goal of this assessment was to predict the extent of ensonification from pile driving and assess the potential effects on fish, turtles, fish eggs, and fish larvae from underwater noise, based on currently applied sound level thresholds for auditory injury and behavioural disturbance. The supporting report is included in **Appendix N**.

Fish are classified based on their hearing capabilities, which are typically determined by whether a swim bladder is present and, if it is, whether it is directly involved in hearing. All of the fish species present within the project corridor have swim bladders and many have additional adaptations that provide pressure sensitivity and extend the hearing frequency range. In addition, recent research on sea turtles suggested similar criteria and thresholds to fish. This Report acknowledges there are no sea turtles present within the project corridor, but no other criteria are available for turtles exposed to sound underwater.

With the above context in mind, a similar approach has been used to guide the assessment of noise impacts from bridge construction on birds and snakes, namely:

1. Acoustic sound propagation was calculated using JASCO's Pile Driving Source Model (PDSM)[9] and Full Waveform Range-dependent Acoustic Model (FWRAM)[10] to estimate sound levels that would be radiated into the environment by impact pile driving activities and the propagation of sound through the water column and riverbed.

---

[9] The PDSM is a physical model of pile vibration and near-field sound radiation which is used in conjunction with wave equation modelling to obtain an equivalent pile source signature consisting on a vertical array of discrete point sources.

[10] The FWRAM is a time-domain acoustic model that determines received levels as a function of depth, range and azimuth. It accepts as input a PDSM-generated array of point sources representing the pile and computes synthetic pressure waveforms via Fourier synthesis, from which several metrics – sound pressure level, peak pressure level and sound exposure level – can be obtained.

2. The PDSM and FWRAM have conservatively assumed that bridge construction would be facilitated by impact pile driving activities, as this method generates more in-air noise than either vibratory pile driving or rock socket drilling.

3. The modelling location within the project corridor was roughly centered between the west shore and the mid-point of the Cataraqui River, where the in-river sediment is thickest (and which could require more pile driver strikes), and the typical nesting habitat associated with the visible cattail portion of the Greater Cataraqui Marsh north of John Counter Boulevard is most proximate.

The results indicate the following:

1. The peak pressure thresholds for mortal and recoverable acoustic injury to fish and for mortal injury to fish eggs, fish larvae and turtles occurred within 2 to 3 m of the source.

2. The sound-exposure-level-over-24-hour thresholds for mortal acoustic injury to fish (with a swim bladder), fish eggs, fish larvae and turtles occurred within 5 to 6 m of the source.

3. The sound-exposure-level-over-24-hour thresholds for recoverable acoustic injury to fish (with a swim bladder) occurred within 7 m of the source.

4. Turtles within tens of metres of the pile are at high risk of recoverable injury, and fish eggs and larvae are at moderate risk of recoverable injury within this range. The relative risk is low for distances of hundreds-to-thousands of metres.

5. Adult fish with a swim bladder (either involved or not involved in hearing) and turtles are at high risk of behavioural disruption within tens of metres of the pile.

6. Larval fish are at moderate risk of behavioural disruption within tens of metres of the pile.

Despite the above however, it is equally critical to note the following:

1. The preferred method for pile installation is drilling, not impact pile driving, which generates noise emissions below established thresholds. Additional proposed mitigation measures discussed later in this Report will either further reduce or eliminate potential negative effects.

2. The riverbed bathymetry and its compositional properties are the most important environmental factors governing propagation of sound from pile driving activities. A portion of the sound generated from the driven pile is radiated directly into the riverbed, and in such a shallow environment, there are multiple sound wave bottom interactions or ‘bounces’. Thus, sound transmission into deeper sediment and rock layers and attenuation within the riverbed becomes significant loss factors for waterborne energy. Since the top sediment layer at the riverbed surface is composed of fine, water-saturated sediments, it allows for a high penetration of acoustic energy, which provides effective noise attenuation.

3. Underwater vegetation is also present throughout the water column, which can play a role in both scattering and attenuating sound.

8. Potential Viewscape Effects

Similar to the potential on-land visual impacts from the bridge, the potential on-water visual impacts would also not be completely eliminated. Therefore, in light of the DIA scope and surrounding contextual landscape, it is equally critical that the project design not only accommodate Federally regulated navigable requirements, but also mitigate on-water visual impacts.

Based on the key viewshed limits at the project corridor and surrounding area:

1. As shown earlier on **Figure 4.4.1**, the project corridor is not visible from the water at or near Highway 401 and, as such, the visible cattail marsh, near continuous overhanging tree canopy and shrub understory would still dominate the natural landscape.

2. **Figure 8.1.2** shows that as boaters proceed southward at roughly 1 km north of the Inner Harbour entrance near Belle Island and enter the open vista of the Cataraqui River, the bridge would be in full view along with the City’s emerging urban landscape, but most of the rising silhouette of the bridge would be below the tree line along the north shore of Belle Island and Belle Park. Furthermore, **Figure 8.1.3** shows contemporary and elegant roadway lighting with accent lighting that highlights key bridge corridor components in a subtle, yet aesthetically pleasing effect at night.

3. As discussed earlier, views of the project corridor south of Belle Island are blocked by the tree line along the northern portion of Belle Park and Belle Island as well as by the extension of the eastern shoreline whereon the Gore Road Library, Point St. Mark

residential neighbourhood and Rideau Marina are located. Views of the project corridor are similarly blocked by these features for boaters proceeding from the LaSalle Causeway northward. This includes the protected views related to Fort Henry and Kingston fortifications in the southern portion of the DIA area.

Figure 8.1.6 shows that as boaters proceed northward from the LaSalle Causeway and round the tip of Belle Island at roughly 1 km south of the project site location, the sense of the urban-to-natural landscape transition begins with all but the east end of the bridge being visible (the east end is blocked from view by the Rideau Marina and shoreline) and its rising silhouette either at or below the tree line of the natural landscape that emerges in the background further north.

9.3 The Carbon Life Cycle Assessment

One of the main objectives of the Sustainability Charrette was to establish sustainability priorities for this project. This objective reflects the role of sustainable development in the City as a critical lens through which development in general, and this project in particular, must proceed.

The Project Team conducted a Carbon Life Cycle Assessment (LCA) focusing on mitigation measures resulting from anticipated energy use and greenhouse gas (GHG) emissions outputs from the construction phase of the project. Granted, it is acknowledged that a whole-project LCA would estimate carbon emissions caused by materials extraction and processing, transportation of materials to be used during construction and operation, and project maintenance and operation, including vehicle traffic. Although the boundary of this LCA is limited to the construction phase, its relationship to a whole project LCA has also been explored to demonstrate context and relationship of this analysis to the energy and carbon impacts that may be performed for other phases of the project.

The LCA is summarized below. The full LCA report is included in **Appendix O.**

The United States Federal Highway Administration (FHWA) Infrastructure Carbon Estimator (ICE) tool was selected for the LCA because it provides approximate energy use and emissions outputs for projects that have not progressed to more detailed levels of design and construction planning[11]. All available facility and project types in the ICE tool are shown in **Table 9.3.1**, with ones applicable to this project highlighted in green boxes.

Table 9.3.1: FHWA ICE Tool Facility and Project Types

Category	Facility Type	Project Type
Roadways	Rural interstates Rural principal arterials Rural minor arterials Rural collectors Urban interstates / expressways Urban principal arterials Urban minor arterials / collectors	Roadway construction: • New facility • Re-alignment Construct additional lane: • Lane widening • Shoulder improvement Roadway rehabilitation • Re-construct pavement • Resurface pavement
Parking	Surface parking Structured parking	New construction
Bridge Structures	Single-span Two-span Multi-span (over land) Multi-span (over water)	New construction Reconstruction Land addition
Rail	Light rail Heavy rail Rail station	New construction (underground) New construction (elevated) New construction (at grade) Convert / Upgrade existing facility
Bus Rapid Transit (BRT)	BRT lane or right-of-way BRT station	New construction Convert / Upgrade lane

[11] FHWA's ICE tool is designed to allow users to create ballpark estimates of energy and greenhouse gas emissions using data collected from state transportation departments, a nationwide database of construction bid documents, and consultation with transportation engineers and lifecycle analysis experts. The calculation methodologies, including energy and emissions factors embedded in the tool are based on empirical data gathered from a broad sample of projects throughout the United States.

Table 9.3.1: FHWA ICE Tool Facility and Project Types		
Category	**Facility Type**	**Project Type**
Bicycle	Off-street paths On-street bicycle lanes	New construction Replacing Restriping (on-street)
Pedestrian	Off-street paths On-street sidewalks	New construction Replacing Restriping (off-street)

The LCA results are expressed with an upper and lower limit to the energy and emissions calculation. The upper limit (or Unmitigated) result represents the energy consumption and emissions associated with standard practice [i.e. the worst case scenario as informed by Ontario Province Standard Specifications (OPSS)]. The lower limit (or Mitigated) result represents the energy and emissions calculated when various mitigation strategies have been applied. None of the mitigation strategies pose a risk to the structural performance of the bridge.

The Unmitigated and Mitigated condition assumptions are described below and summarized in **Table 9.3.2**. **Table 9.3.2** also summarizes the ICE Threshold condition assumptions:

1. The OPSS do not address the use of hybrid or biofuel construction vehicles. Therefore, the Unmitigated condition assumes that 0% of construction vehicles will be hybrid, use B20 fuel, use B100 fuel, or be combined hybrid / alternative fuel vehicles. The Mitigated condition was assumed, conservatively, to be 10% use of each vehicle type.

2. At this current project design phase, it has not been determined how much cold-in place recycling or full-depth reclamation of existing roadway will be used. The Unmitigated condition was therefore assumed to be 0% and the Mitigated condition was assumed to be 50%.

3. Warm Mix Asphalt (WMA): The MTO specified 10% WMA on all of its contracts in 2011. For the Mitigated condition, it is assumed that in 2018 it will be possible to use at least 20% WMA.

4. The OPSS state that values up to a certain percentage of Reclaimed Asphalt Pavement (RAP), Recycled Concrete Material (RCM), and cementitious material substitutes are allowed, which means that the minimum amount of recycled and reclaimed materials that would be incorporated into a standard project is 0%. This was used as the Unmitigated condition, or the worst case energy and emissions scenario for the incorporation of recycled and reclaimed materials.

Table 9.3.2: Emissions Mitigation Practices			
Strategy	**Unmitigated**	**Mitigated**	**ICE Threshold**
Alternative Fuels and Vehicle Hybridization:			
Hybrid construction vehicles and equipment – as a percentage of all construction vehicles/equipment	0%	25%	44%
Switch from diesel to B20 in construction vehicles and equipment – as a percentage of total fuel used by construction vehicles	0%	10%	100%
Switch from diesel to B100 in construction vehicles and equipment – as a percentage of total fuel used by construction vehicles	0%	10%	100%
Combined hybridization/B20 in construction vehicles and equipment – as a percentage of all construction vehicles/equipment	0%	10%	44%
In-Place Roadway Recycling:			
Cold In-place recycling – the percentage of total roadway resurfacing and BRT conversion lane miles that are resurfaced using cold in-place recycling	0%	50%	99%
Full depth reclamation – the percentage of total roadway resurfacing and BRT conversion lane miles that are reconstructed using full depth reclamation	0%	50%	99%
Warm Mix Asphalt:			
Warm Mix Asphalt – the percentage by mass of	0%	20%	100%

Table 9.3.2: Emissions Mitigation Practices			
Strategy	**Unmitigated**	**Mitigated**	**ICE Threshold**
warm mix asphalt used in the project			
Recycled and Reclaimed Materials:			
Use recycled asphalt pavement as a substitute for virgin asphalt aggregate – the percentage by mass of recycled aggregates used in the project	0%	25%	25%
Use recycled asphalt pavement as a substitute for virgin asphalt bitumen – the percentage by mass of bitumen used that comes from recycled asphalt pavement	0%	30%	40%
Use industrial byproducts as substitutes for Portland cement – the percentage by mass of Portland cement substitutes are used (e.g. fly ash, blast furnace slag, silica fume)	0%	25%	33%
Use recycled concrete aggregate as a substitute for base stone – the percentage by mass of aggregate that comes from recycled concrete	0%	50%	100%

Energy use and greenhouse gas emissions were measured in millions of British Thermal Units (MMBTU) and metric tons of carbon dioxide [CO_2 equivalent (MT CO_2e)], respectively. The energy and emissions savings associated with each mitigation strategy were first evaluated separately and then a combined impact was calculated, as shown in the scenarios below:

1. Scenario 1: Unmitigated Baseline Performance
2. Scenario 2A: Mitigated (Alternative Fuels Only)
3. Scenario 2B: Mitigated (In-Place Roadway Recycling Only)
4. Scenario 2C: Mitigated (Warm Mix Asphalt Only)
5. Scenario 2D: Mitigated (Recycled and Reclaimed Materials Only)
6. Scenario 3: Mitigated (All Mitigations Combined)

The Unmitigated, or worst case scenario energy and GHG emissions outputs are summarized in **Table 9.3.3** and **Table 9.3.4**, respectively.

Table 9.3.3: Unmitigated Construction Phase Energy Use					
Energy (MMBTU)	**New Road Construction**	**Road Rehabilitation**	**Bridges**	**Rail, Bus, Bike, Pedestrian**	**Total**
Upstream: Materials	1,505	1,508	13,787	3,487	20,287
Direct: Construction Equipment	618	412	5,501	584	7,115
Total	2,123	1,920	19,288	4,071	27,402
Percent Contribution	7.7%	7.0%	70.4%	14.9%	-

Table 9.3.4: Unmitigated Construction Phase GHG Emissions					
GHG Emissions (MT CO2E)	**New Road Construction**	**Road Rehabilitation**	**Bridges**	**Rail, Bus, Bike, Pedestrian**	**Total**
Upstream: Materials	96	97	1,405	201	1,799
Direct: Construction Equipment	45	30	401	43	519
Total	141	127	1,806	244	2,318
Percent Contribution	6.1%	5.5%	77.9%	10.5%	-

A summary of the energy and GHG emissions outputs of the Unmitigated condition, each individual Mitigation category, and the impact of all Mitigations combined are summarized in **Table 9.3.5** and **Table 9.3.6**, respectively.

Table 9.3.5: Energy Use and Percentage Savings by Mitigation Scenario

Energy (MMBTU)	Unmitigated	Alternative Fuels	In-Place Road Recycling	Warm Mix Asphalt	Recycled / Reclaimed Materials	Combined Mitigations
Upstream: Materials	20,287	20,287	20,261	20,232	16,571	16,489
Direct: Construction Equipment	7,115	7,449	6,975	7,115	7,115	7,303
Total	27,402	27,736	27,236	27,347	23,686	23,792
Percent Savings	-	-1.2%	0.6%	0.2%	13.6%	13.2%

Table 9.3.6: GHG Emissions Outputs and Percentage Savings by Mitigation Scenario

GHG Emissions (MT CO2E)	Unmitigated	Alternative Fuels	In-Place Road Recycling	Warm Mix Asphalt	Recycled / Reclaimed Materials	Combined Mitigations
Upstream: Materials	1,799	1,799	1,797	1,794	1,519	1,512
Direct: Construction Equipment	519	452	509	519	519	443
Total	2,318	2,251	2,306	2,313	2,038	1,955
Percent Savings	-	2.9%	0.5%	0.2%	12.1%	15.7%

A summary of the energy and GHG emissions outputs by project component from all combined Mitigations combined are summarized in **Table 9.3.7** and **Table 9.3.8**, respectively.

The LCA results indicate the following:

1. Overall unmitigated energy use and emissions for the construction phase are dominated by the contribution of the bridge portion of the scope (70% and 78%, respectively). This is to be expected since the bridge comprises the largest portion of the scope of work and associated materials. As such, the mitigation measures that have a large impact on the bridge materials and transport greatly influence the overall energy and emissions outputs for the project. Ultimately, the combined mitigations for the bridge component comprise over 47% of the total energy savings and over 62% of the total emissions reduction.

2. Mitigation 2D (Recycled and Reclaimed Materials Only) has the most significant impact to energy use and emissions (13.6% and 12%, respectively). The decreased need for extraction and transport of virgin materials leads to this significant decrease in Upstream Materials energy and emissions for all project components.

3. Mitigation 2A (Alternative Fuels Only) also contributes 2.9% to overall emissions reduction (likely due to lower emissions factors for biofuels and electricity), which is significant because even though this mitigation only influences the Direct emissions from construction vehicles, it still has the second largest impact overall. Interestingly, the switch to alternative fuel vehicles appears to increase energy outputs marginally (possibly due to lower energy intensity of biofuel and electricity). When broken down by project component, all of the scenarios see this increase in energy consumption for Construction Equipment, except for Roadway Rehabilitation. This is attributable to significant energy use reduction resulting from Mitigation 2B (In-Place Roadway Recycling Only).

4. Mitigation 2B has a noticeable impact on the Direct (Construction Equipment) energy and emissions of the Roadway Rehabilitation portion of the project, but has comparatively little impact to reducing energy and emissions overall (0.6% and 0.5%, respectively).

5. Mitigation 2C (Warm Mix Asphalt Only) has the smallest contribution to energy and emissions reduction (0.2%, and 0.2%, respectively). It is important to note that a relatively small amount (20%) of warm mix asphalt was assumed for the Mitigated condition, compared to the maximum amount allowed by the ICE tool. However, even if this percentage were increased to 90%, the overall impact of this Mitigation on the project would still be less than 1%.

6. The use of recycled materials has an impact on energy use and emissions. The project specifications should encourage the use of these materials, without compromising structural performance, by providing specific percentage minima for such content.

Table 9.3.7: Energy Use and Percentage Savings by Project Component

Energy (MMBTU)	Combined Mitigations Energy Use (MMBTU)					Combined Mitigations (Percentage Savings by Category)				
	New Road Construction	Road Rehabilitation	Bridges	Rail, Bus, Bike, Pedestrian	Total	New Road Construction	Road Rehabilitation	Bridges	Rail, Bus, Bike, Pedestrian	Total
Upstream: Materials	1,112	1,087	11,821	2,469	16,489	26.1%	27.9%	14.3%	29.2%	18.7%
Direct: Construction Equipment	647	285	5,760	611	7,303	-4.7%	30.8%	-4.7%	-4.6%	-2.6%
Total and Percentage Savings By Category	1,759	1,372	17,581	3,080	23,792	17.1%	28.5%	8.9%	24.3%	13.2%
Percentage Contribution to Overall Savings						10.1%	15.2%	47.3%	27.5%	-

Table 9.3.8: GHG Emissions Output and Percentage Savings by Project Component

GHG Emissions (MT CO2E)	Combined Mitigations GHG Emissions (MT CO2E)					Combined Mitigations (Percentage Savings by Category)				
	New Road Construction	Road Rehabilitation	Bridges	Rail, Bus, Bike, Pedestrian	Total	New Road Construction	Road Rehabilitation	Bridges	Rail, Bus, Bike, Pedestrian	Total
Upstream: Materials	71	71	1,228	142	1,512	26.0%	26.8%	12.6%	29.4%	16.0%
Direct: Construction Equipment	39	17	350	37	443	13.3%	43.3%	12.7%	14.0%	14.6%
Total and Percentage Savings By Category	110	88	1,578	179	1,955	22.0%	30.7%	12.6%	26.6%	15.7%
Percentage Contribution to Overall Savings						8.5%	10.7%	62.8%	17.9%	-

7. Means of transportation, fuels used, and emissions factors influence emissions for material transport and construction equipment operation, even if the total energy consumption is not significantly reduced. As construction means and methods progress, the focus should be on minimizing distance travelled and using fuels with low emissions factors.

8. WMA and in-place roadway recycling have energy and emissions benefits, but the emissions for the project are not very sensitive to these practices, and can be emphasized less.

9. As part of the detail design phase, it is recommended that a more detailed LCA be performed based on estimates of material quantities, raw material source and manufacturing locations, use of recycled materials, transportation distances, and anticipated transportation modes, and likely construction means, methods, and equipment.

10.0 MITIGATION MEASURES

The assessment of the project and its potential effects is useful in further exploring the interactions of the project during each stage of its design life (i.e. construction, operation and decommissioning). This can assist in identifying best management practices and mitigation measures required to either reduce or eliminate the potential negative effects of specific project activities.

As discussed earlier, the Federal EIA process is part of the scope of this current project design phase, and shall continue into future project phases leading up to construction. Given the nature of the project and the sensitivity of the project area, Parks Canada's Director of Waterways has determined that the DIA framework is to be used for the Federal EIA. The DIA is the most comprehensive level of assessment, intended for complex projects that require applied analysis of project interactions with valued components that may affect a particularly sensitive environmental setting or threaten one or more sensitive valued components.

Parks Canada, in consultation with the City and Project Team, prepared a Scoping Document for the DIA, which is included in **Appendix B**. The Scoping Document provides guidance on the following phases of the project that shall be addressed in the DIA:

1. Site preparation.
2. Construction.
3. Site restoration and rehabilitation.
4. Operation.

It is acknowledged that decommissioning is discussed in this Report, but it is not part of the scope of the DIA, since it is anticipated that the bridge will have a life span of more than 100 years. If and when decommissioning and rehabilitation are required at the project corridor, it is anticipated that such works would be assessed as part of a Decommissioning Plan and regulatory impact assessment provisions current to that time.

Based on the above context, the DIA shall describe and assess potential interactions (including timing, frequency, duration, residual effects, cumulative effects and mitigation) between the phases of the project noted above and various environmental components, focused within the project corridor. The environmental components are categorized as:

1. Valued Components, which represent the main focus of the DIA based on Parks Canada's mandate.
2. Secondary Components, which represent the secondary focus of the DIA, but are also reflective of Parks Canada's mandate.

Highlights of the C-NHPEP to this point of the Report have focused on design measures which will restore and enhance the landscape following the construction phase, in accordance with the aforementioned Mission Statement, Vision and Values for the project. In addition, the CAP, which was also introduced earlier in this Report, establishes protocols for use by the City for notifying the general public of any service interruptions and addressing public issues both prior to and during bridge construction activities as well as during the subsequent use and maintenance of the bridge.

This Section of the Report further incorporates provisions in both the C-NHPEP and CAP by focusing on best management practices that will serve to protect the cultural and natural heritage landscape within the project corridor during the construction (which groups the DIA phases focusing on site preparation, construction, and site restoration and rehabilitation as noted and applicable below to minimize duplication), and operation phases of the project. These are outlined below.

1. As part of the construction phase:
    a) Continue to consult with Parks Canada and other applicable review agencies and stakeholders in further refining the C-NHPEP, CAP and LCA as part of the detail design phase for subsequent implementation during all construction sub-phases.
    b) Ensuring all equipment during all construction sub-phases:
        i. is maintained in good working condition through regular maintenance and inspections;
        ii. includes industry-standard emissions treatment and noise-suppression systems that meet applicable Provincial guidelines current at that time; and
        iii. operates and re-fuels only in designated areas.

c) Employing dust suppression techniques such as watering on project site access roads and sweeping at project site entrances during all construction sub-phases.

d) Employing detailed protocols are in place during all construction sub-phases for employees/contractors regarding equipment maintenance and inspections procedures for minimizing both the duration and severity of any accidents or malfunctions as well as emergency response procedures.

e) In advance of on-land excavation works during the site preparation sub-phase, installing sediment fencing along the riverbanks to prevent sediment movement and erosion outside of the work area for the duration of the construction phase.

f) Installing silt fencing for spoil stockpiling or fill materials during the site preparation sub-phase and maintaining it for the duration of the construction phase, and further ensuring that such areas are at least 30 m off-shore.

g) Ensuring during all construction sub-phases that spill kits are located on-site and storing construction materials and debris as well as fuel, lubricants and other hazardous materials in designated areas away from high-traffic areas and the Cataraqui River.

h) Suspending in-water activities during all construction sub-phases during periods of heavy rain and high wind events.

i) Unless otherwise necessary, undertaking activities during all construction sub-phases during daylight hours in accordance with the City's Noise By-Law and to avoid potential effects of noise and artificial night lighting on the natural environment.

j) Conducting advance inspections in affected areas during all construction sub-phases in order to assess the presence of sensitive vegetation and tree species as well as wildlife species and the feasibility of relocating affected species to other hospitable environments and/or establishing buffers to protect affected species and to restrict access.

k) Scheduling activities during all construction sub-phases:

i. to avoid confirmed or assumed habitats as well as breeding/spawning seasons and over-wintering periods for:

(a) American Eel and other fish from March 15 to July 15;

(b) Barn Swallow from May through the end of August;

(c) Common Nighthawk from the end of April through mid-October;

(d) Bats from early April through the start of September (maternity roosting) and October through April (hibernating);

(e) Spring and Fall for migratory waterfowl;

(f) Eastern Milk Snake from May to late September and the Fall-Winter months;

(g) Blanding's and other turtles from October through March (over-wintering) and late May through early July (nesting);

unless advance inspection and exclusion provisions, in conjunction with applicable permits and approvals being in place, have ensured that there will be no potential species impacts; and

ii. in consultation with Parks Canada, DFO, TC and the Kingston Rowing Club to ensure that either:

(a) the navigable channel and/or adjacent rowing lanes remain open during the site preparation and construction sub-phases and the arch span installation in particular occurs during when the navigable channel and/or adjacent rowing lanes are officially closed to watercraft; or

(b) proper advance safety mitigation measures, in conjunction with required regulatory approvals, are in place to protect the public in support of any activities that may need to occur during the site preparation and construction sub-phases over the navigable channel and/or adjacent rowing lanes during the navigation season.

l) In regards to the Gore Road Library property:

i. in advance of the site preparation sub-phase:

(a) documenting the condition of historic structures in advance of site preparation works and during construction activities to ensure that any adverse effects are promptly addressed;

(b) ensuring that the historic structures are protected from direct impact by vehicles during site preparation and construction activities;

(c) assessing the condition of trees and plantings along the southern boundary of the property and avoiding or relocating those specimens having historical significance to other suitable locations on the property, as feasible and appropriate;

(d) documenting the section of the dry stone wall to be relocated, both for historical purposes and to facilitate site reconstruction;

ii. during the site preparation sub-phase:

(a) relocating as little of the dry stone wall as possible in order to facilitate the widening of Gore Road and to meet safety and traffic requirements in road construction;

(b) ensuring the relocated section of the dry stone wall is reconstructed by a qualified heritage stonemason and that it is rebuilt as a continuation of the existing wall, but at right angles and heading eastward on a parallel to Gore Road (the latter as per the request of representatives of the Kingston Heritage Advisory Committee); and

(c) assessing the condition of the remaining dry stone wall by a qualified heritage stonemason; and

(d) preparing an interpretive plan that both documents and presents the known history of the Gore Road Library property in situ.

m) In advance of the site preparation sub-phase:

i. documenting and removing archeological site BbGc-127 through archaeological excavation in order to mitigate the risk of the site being damaged during the project construction phase; and

ii. documenting and temporarily removing the survey marker for subsequent reinstatement in situ during the site restoration and rehabilitation sub-phase.

n) Ensuring proper in situ conservation or excavation and removal measures as well as notification protocols are in place during all construction sub-phases regarding the discovery of previously undocumented cultural heritage and archaeological resources.

o) Sorting construction debris during all construction sub-phases for recycle or disposal for hauling off-site by licensed operators to approved facilities.

p) Using licensed personnel during all construction sub-phases to:

i. handle hazardous materials; and

ii. provide regular pump-out and haulage services of temporary on-site effluent holding tanks to an approved water pollution control plant for disposal and treatment.

q) Ensuring during all construction sub-phases that proper on-site construction signage and controls are installed for designated areas and traffic lanes to ensure safe and efficient circulation on-land and in-water.

r) Installing:

i. temporary ditches and permanent stormwater drainage and management facilities during the site preparation sub-phase to drain all temporary project site access roads to permanent on-land stormwater management facilities for treatment (sediment removal) and release in accordance with regulatory requirements; and

ii. permanent stormwater drainage facilities during the construction sub-phase to drain all roadway and bridge deck areas to on-land stormwater management facilities.

s) Conducting analyses of sediments in advance of and following all excavation activities both on-shore and in-water during the site preparation and construction sub-phases in order to:

i. determine sediment contamination levels; and

ii. further ensure appropriate protocols are in place for:

(a) control measures (work stoppage and agency notification); and

(b) excavated material disposal to an approved landfill facility in accordance with regulatory requirements.

t) Ensuring that during the site preparation and construction sub-phases:

i. on-land excavation works meet applicable Provincial blasting vibration guidelines current at that time;

ii. proper construction equipment noise ramp-up procedures are in place to enable wildlife to either adapt their behaviour to the affected area or avoid it entirely;

iii. multiple underwater noise generating activities are either minimized or sequenced to minimize their duration; and

iv. hydro-acoustic monitoring is in place to confirm that noise levels at close range to the in-water pile installation work in particular, are either below the injury threshold for fish and aquatic wildlife or that additional mitigation measures need to be considered.

u) Purging the ballasts of all in-water vessels during the site preparation and construction sub-phases, should they originate from outside the Great Lakes system, in order to minimize the risk of introducing invasive species into the Cataraqui River.

v) Minimizing the removal of shoreline and riparian vegetation during the site preparation and construction sub-phases and ensuring that permitting from the City is in place regarding the removal of any trees.

w) In advance of in-water removal of aquatic vegetation or substrate during the site preparation and construction sub-phases, installing:

i. silt curtains and/or turbidity barriers around in-water work areas and ensuring such measures remain in place until the sediments within the affected area have settled; and

ii. cofferdams around localized excavation works at the v-pier locations (and monitoring of such provisions) to both facilitate construction of the footings and restrict habitat access to these work areas.

x) Regularly monitoring:

iii. river water quality north and south of the project corridor during all construction sub-phases for turbidity, suspended soils, nutrients and contaminants; and

iv. shoreline erosion and sediment control measures and: modifying/enhancing such measures, as required; and further ensuring such measures are not removed until the terrestrial vegetation is re-established as part of the site restoration and rehabilitation sub-phase.

2. As part of the project operation phase:

a) Preparing and employing an Operations and Maintenance (O&M) Manual that contains detailed protocols for employees/contractors regarding the CAP, stormwater management system and maintenance equipment inspections and maintenance procedures for minimizing both the duration and severity of any accidents or malfunctions as well as emergency response procedures.

b) Ensuring all maintenance equipment is in good working condition through regular maintenance and inspections.

c) Continuing to regularly monitor:

i. shoreline erosion and sediment control measures and ensuring such measures are not removed until the terrestrial vegetation is re-established as part of the landscape improvement works; and

ii. Cataraqui River water quality north and south of the project site location for turbidity, suspended soils, nutrients and contaminants.

d) Maintaining and monitoring those works that are included in the C-NHPEP.

e) Implementing dust suppression measures as part of maintenance activities.

f) Using only non-chlorinated de-icing agents on the bridge deck.

g) Ensuring the stormwater drainage and management facilities are in good working condition through regular maintenance and inspections.

h) Suspending in-water maintenance activities during periods of heavy rain and high wind events.

i) Conducting advance inspections in areas slated for maintenance activities in order to assess the presence of sensitive vegetation and tree species as well as wildlife species and the feasibility of relocating affected species to other hospitable environments and/or establishing buffers to protect affected species and to restrict access.

j) Ensuring that the historic structures are protected from direct impact by maintenance equipment.

k) Scheduling maintenance activities:

   i. to avoid confirmed or assumed habitats as well as breeding/spawning seasons and over-wintering periods for:

      (a) American Eel and other fish from March 15 to July 15;

      (b) Barn Swallow from May through the end of August;

      (c) Common Nighthawk from the end of April through mid-October;

      (d) Bats from early April through the start of September (maternity roosting) and October through April (hibernating);

      (e) Spring and Fall for migratory waterfowl;

      (f) Eastern Milk Snake from May to late September and the Fall-Winter months;

      (g) Blanding's and other turtles from October through March (over-wintering) and late May through early July (nesting);

   unless advance inspection and exclusion provisions, in conjunction with applicable permits and approvals being in place, have ensured that there will be no potential species impacts; and

   ii. in consultation with Parks Canada, DFO, TC and the Kingston Rowing Club to ensure that either:

      (a) the navigable channel and/or adjacent rowing lanes remain open during the operational phase; or

      (b) proper advance safety mitigation measures, in conjunction with required regulatory approvals, are in place to protect the public in support of any maintenance activities that may need to occur over the navigable channel and/or adjacent rowing lanes during the navigation season.

l) Monitoring future traffic conditions by the City in order to further:

   i. optimize the coordination of traffic signals to maximize efficient traffic flows; and

   ii. address any issues of short-cutting through the Point St. Mark residential neighbourhood on the east side lands.

The project description and potential project effects, when read in conjunction with the proposed mitigation measures, provides further perspective on the effects of the project on the Valued and Secondary Components for the DIA. In order to avoid duplication, this is summarized for the construction and operations phases of the project in **Table 10.1** and **Table 10.2**, respectively. Note the significance of the residual effects on each Valued and Secondary Component is categorized as follows:

1. **Magnitude:** the typical effects of the impact i.e. low (L), medium (M) or high (H).
2. **Geographic Extent:** where the effect occurs i.e. immediate (I), local (L) or regional (R).
3. **Duration:** the duration of the effect i.e. short term (S) or long term (L).
4. **Frequency:** the frequency of the effect i.e. intermittent (I) or continuous (C).
5. **Reversibility / Irreversibility:** whether an effect can be reversed (R) or is irreversible (I).
6. **Ecological Context:** an estimate of the ecological value of the area in which the effect occurs i.e. low (L) or high (H).

Table 10.1: Project Effects on Valued and Secondary Components: Construction Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Greater Cataraqui Marsh PSW	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Waste Management Systems Malfunctions and Accidents	Loss of structure and function	L/M	I	S	I	R	H	The short-term residual environmental effect will be Low/Medium and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; and the proposed project design and mitigation measures.
Surface Water Quality and Quantity	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Waste Management Systems Malfunctions and Accidents	Soil erosion and sediment loading Accidental spills	H H	I I	S S	I I	R R	H H	The residual environmental effect will be Minimal given the proposed mitigation measures. The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Hydrologic Processes	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Changes to water flow	L/M	I	L	C	R	H	The short-term residual environmental effect will be Low/Medium and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Fish / Aquatic Habitat Quality	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Change in diversity Accidental spills	H H	L I	S S	I I	R R	H H	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; and the proposed project design and mitigation measures. The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.

Table 10.1: Project Effects on Valued and Secondary Components: Construction Phase									
Component	**Interaction**	**Potential Environmental Effect Before Mitigation**	**Residual Effects Evaluation Criteria**						**Significance of Residual Environmental Effects**
			Magnitude	**Geographic Extent**	**Duration**	**Frequency**	**Reversibility / Irreversibility**	**Ecological Context**	
Fish / Aquatic Wildlife / SAR and Vegetation	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Sensory disturbance	L	I	S	I	R	H	The residual environmental effects will be Minimal given the proposed mitigation measures.
		Loss and fragmentation	L/M	I	S	I	R	H	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; and the proposed project design and mitigation measures.
		Mortality risk	L/M	I	S	I	R	H	The residual environmental effect will be Low to reflect 100 percent mortality avoidance is not possible in relation to the short-term duration of construction and the proposed mitigation measures.
		Accidental spills	H	I	S	I	R	H	The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Submerged Cultural Resources	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Loss and fragmentation of Archaeological Site BbGc-127 and the stone survey marker	H	I	L	I	R	H	The short-term residual environmental effect will be Low/Medium and the mid-to-long-term residual environmental effect will be Minimal to reflect: the short-term duration of construction; and the proposed project design and mitigation measures.
		Loss and fragmentation of previously undocumented resources	L	I	S	I	R	H	The residual environmental effect will be Minimal given: the characteristics of the project corridor; and the proposed mitigation measures.

Table 10.1: Project Effects on Valued and Secondary Components: Construction Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria: Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	Significance of Residual Environmental Effects
Surrounding Cultural Landscape Canal's Commemorative Integrity Canal's Outstanding Universal Value Visitor Experience and Recreation Aesthetic Values	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Loss and fragmentation	H	L	S	I	R	H	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; and the proposed project design and mitigation measures.
Navigation	Site Preparation Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Waste Management Systems Malfunctions and Accidents	Level of service Accidents	L/M H	I I	S S	I I	R R	H H	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Groundwater Quality and Quantity	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Waste Management Systems Malfunctions and Accidents	Groundwater should not be encountered	L	I	S	I	R	H	The residual environmental effect will be Minimal given: the characteristics of the project corridor; the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.

Table 10.1: Project Effects on Valued and Secondary Components: Construction Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Terrain, Geology and Soils	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Waste Management Systems Malfunctions and Accidents	Soil erosion and sediment deposition	H	I	S	I	R	H	The residual environmental effect will be Minimal given: the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
		Uncover contaminated soils and accidental spills	H	I	S	I	R	H	
Terrestrial Wildlife / Migratory Birds / SAR	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Sensory disturbance	L	I	S	I	R	H	The residual environmental effects will be Minimal given the proposed mitigation measures.
		Loss and fragmentation	L/M	I	S	I	R	H	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; the characteristics of the project corridor; and the proposed project design and mitigation measures.
		Mortality risk	L/M	I	S	I	R	H	The residual environmental effect will be Low to reflect 100 percent mortality avoidance is not possible in relation to the short-term duration of construction and the proposed mitigation measures.
		Accidental spills	H	I	S	I	R	H	The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.

Table 10.1: Project Effects on Valued and Secondary Components: Construction Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Terrestrial Vegetation / Habitat	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Change in diversity	H	L	S	I	R	L	The short-term residual environmental effect will be Low and the mid-to-long-term residual environmental effect will be Positive to reflect: the short-term duration of construction; the characteristics of the existing vegetation; and the proposed project design and mitigation measures.
		Accidental spills	H	I	S	I	R	L	The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Air Quality and Climate Change	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Diesel exhaust emissions	M	I	S	I	R	H	The residual environmental effect will be Low to reflect: existing land uses in relation to weekday construction activities; the short-term duration of construction; the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
		Airborne dust	M	I	S	I	R	H	
		Noise emissions	M	I	S	I	R	H	
		High noise events	M	I	S	I	R	H	

Table 10.2: Project Effects on Valued and Secondary Components: Operations Phase									
Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Greater Cataraqui Marsh PSW	Road / Water Use Maintenance Malfunctions and Accidents	Loss of structure and function	H	I	L	I	R	H	The residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
Surface Water Quality and Quantity	Road / Water Use Maintenance Malfunctions and Accidents	Soil erosion and sediment deposition	H	I	L	I	R	H	The residual environmental effect will be Minimal given: the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Hydrologic Processes	Road / Water Use Maintenance Malfunctions and Accidents	Changes to water flow	M	I	L	C	I	H	The will be Positive to reflect: the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Fish / Aquatic Habitat Quality	Road / Water Use Maintenance Malfunctions and Accidents	Change in diversity Accidental spills	M H	I I	L L	I I	R R	H H	The residual environmental effect will be Positive to reflect the proposed project design and mitigation measures. The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Fish / Aquatic Wildlife / SAR and Vegetation	Road / Water Use Maintenance Malfunctions and Accidents	Sensory disturbance Loss and fragmentation Mortality risk Accidental spills	M H	I I	L L	I I	R R	H H	The short-term residual environmental effect will be Positive to reflect the proposed project design and mitigation measures. The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Submerged Cultural Resources	Road / Water Use Maintenance Malfunctions and Accidents	Loss and fragmentation	H	I	L	I	I	H	The residual environmental effect will be Minimal to reflect: the characteristics of the project corridor; and the proposed project design and mitigation measures.

Table 10.2: Project Effects on Valued and Secondary Components: Operations Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Surrounding Cultural Landscape Canal's Commemorative Integrity Canal's Outstanding Universal Value Visitor Experience and Recreation Aesthetic Values	Site Preparation Temporary Facilities and Lay-Down Areas Superstructure Construction Bridge Deck Construction Utility Installations Site Restoration and Rehabilitation Malfunctions and Accidents	Loss and fragmentation	H	L	L	I	I	H	The residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
Navigation	Road / Water Use Maintenance Malfunctions and Accidents	Level of service Accidents	M H	I I	S S	I I	R R	H H	The residual environmental effect will be Positive to reflect: the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Groundwater Quality and Quantity	Road / Water Use Maintenance Malfunctions and Accidents	Groundwater should not be encountered	H	I	L	I	R	H	The residual environmental effect will be Minimal given: the characteristics of the project corridor; the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Terrain, Geology and Soils	Road / Water Use Maintenance Malfunctions and Accidents	Soil erosion and sediment deposition	H	I	L	I	R	H	The residual environmental effect will be Minimal given: the proposed project design and mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.

Table 10.2: Project Effects on Valued and Secondary Components: Operations Phase

Component	Interaction	Potential Environmental Effect Before Mitigation	Residual Effects Evaluation Criteria						Significance of Residual Environmental Effects
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility / Irreversibility	Ecological Context	
Terrestrial Wildlife / Migratory Birds / SAR	Road / Water Use Maintenance Malfunctions and Accidents	Sensory disturbance	M	I	L	I	R	H	The short-term residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
		Loss and fragmentation	M	I	L	I	R	H	The short-term residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
		Mortality risk	M	I	L	I	R	H	The short-term residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
		Accidental spills	H	I	L	I	R	H	The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Terrestrial Vegetation / Habitat	Road / Water Use Maintenance Malfunctions and Accidents	Change in diversity	M	I	L	I	R	H	The residual environmental effect will be Positive to reflect the proposed project design and mitigation measures.
		Accidental spills	H	I	L	I	R	H	The residual environmental effect will be Minimal given: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
Air Quality and Climate Change	Road / Water Use Maintenance Malfunctions and Accidents	Diesel exhaust emissions	L/M	I	L	C	I	H	The residual environmental effect will be Low to reflect: the proposed mitigation measures; and the projected infrequent occurrence of malfunctions and accidents.
		Airborne dust	L/M	I	L	C	I	H	
		Noise emissions	L/M	I	L	I	R	H	
		High noise events	L/M	I	L	I	R	H	

10.1 Effects of the Environment on the Project

This section of the Report outlines the effects of climatic fluctuations and extreme events on the project that could occur in the area.

1. Climatic Fluctuations

Climatic fluctuations cannot be accurately predicted. As such, it is considered highly unlikely that any fluctuations that affect long-term weather trends would significantly affect the project, particularly since the design features of the project will need to meet the CHBDC.

2. Extreme Events

Potential extreme weather events that could affect the project include wind, earthquake, lightning and fire. Firstly, an extreme wind event is defined as winds in the range of 100 km/hr to 140 km/hr. Extreme wind events are rare but have been known to occur in the area. Wind data from the Kingston Airport suggests that most of the winds are from the southwesterly quadrants. The largest contributions are from due south and due west, caused mainly by the effects of Lake Ontario. Probable hourly wind speeds aggregated annually suggest that high winds can be experienced from any direction. But 100 year wind speeds are roughly 20 m/s (or 72 km/hr), which falls well below the criteria for an extreme wind event.

Secondly, as also noted earlier, for seismic design purposes, the bridge will have a classification of an irregular ‘Major-Route Bridge’ and a Site Class of D based on the site properties. Based on the fundamental period, the bridge is within Seismic Performance Category 2 and as such the seismic design will be based on the Performance Based Design method for the following performance levels: 475 years event, 975 years event, and 2475 years event (as further described in **Section 3.2.3**).

There are also two zones within the project site location where low resistivity is observed within the bedrock beneath the river, centred at distances of 320 m and 970 m along the alignment. These areas are most likely associated with the Frontenac Axis. As discussed earlier, the in-water test holes put down as part of the current project design phase were advanced at selected pier locations based on the previous 14-span V-pier arrangement. Although the refined bridge arrangement maintains the same abutment locations and overall bridge length, it now comprises 19 inverted U-frame piers. As such, most of the test holes are no longer within the footprint of the inverted U-frame pier locations. Though the relevance and applicability of the geotechnical assessments to the refined bridge arrangement is re-confirmed, additional field investigations should be carried out during the detail design phase to confirm bedrock surface elevation and founding soil and bedrock conditions at the proposed U-frame pier locations.

Thirdly, during the spring and summer seasons, thunderstorms and electrical storms can occur in the area. In the event of a lightning strike that hits the bridge, the built-in grounding system should prevent any severe damage and reduce the risk of fire.

Furthermore, in regards to a potential extreme flooding event (during construction), flooding may occur at the bridge location and mitigation / protection measures should be used such as: extending the cofferdams / caisson liners above the high water level; and constructing the temporary work bridge to ensure that it is also above the high water level. Erosion and sediment control measures both on-land and in-water will need to be monitored throughout the project for their effectiveness and modified or reinforced as required.

In addition, regarding bridge operations, it should also be noted that the current design for roadway drainage can accommodate more than the 10 year storm event which exceeds current best practices. Cyclists that are on the bridge during rainfall events which exceed the 10 year storm event would be able to use an area clear of flooding within the traffic lane or the multi-use pathway.

Given the design features of the project, which will need to meet the CHBDC, a significant environmental effect due to extreme events is unlikely to occur.

10.2 Cumulative Effects

In addition to the impacts of the project on the Valued and Secondary Components, this Report must also consider the cumulative environmental effects of the project in conjunction with existing and future activities or projects. Cumulative effects are defined as effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out. Cumulative effects are limited to those effects that are likely and for which measureable or detectable residual effects are predicted. A measureable change is defined as a change that is real, observable and detectable compared with existing (baseline) conditions. A predicted change that is negligible or indistinguishable from background conditions is not considered to be measureable.

In addition, the proposed refinements to the preferred bridge, roadway and landscape concept further reinforce the potential of the project to provide an overall community benefit to the City:

1. The identified roadway improvement works should maintain the flow of traffic along this critical mid east-west arterial corridor at an acceptable LOS over the long-term. This analysis has also demonstrated that short-cutting of traffic through the Village On The River Apartments on the west side is not anticipated. Furthermore, additional traffic calming alternatives have been proposed at the reconfigured Point St. Mark Drive-Gore Road Intersection, which should prevent short-cutting of traffic through the Point St. Mark residential neighbourhood on the east side.

2. The purpose of the active transportation provisions on the bridge and on-land is to connect with, and thereby enhance, existing non-automotive networks on both sides of the Cataraqui River.

3. The recommended best management practices in the C-NHPEP and CAP will protect the cultural and natural heritage landscape within the project corridor during the construction and operation phases of the project. This is considered a ‘triple win’, in that:

   a) The temporary work bridge is preferred over the dredged channel from an environmental impact and protection perspective with regards to construction methodology (first win).

   b) Although the span arrangement would increase from 14-to-19-spans, the overall environmental footprint from the U-frame piers would still be lower compared to the initial V-pier design. This alternative pier design, in conjunction with the temporary work bridge, also yields a more reasonable cost estimate that is commensurate with the City’s current financial resources (second win).

   c) From functional and aesthetic perspectives, the functionality of the bridge would not be compromised due to the alternative pier design, and the bridge deck features would be retained to enhance user experiences along the Canal; and aesthetically, the inverted U-frame piers would still provide a cohesive overall rhythm towards the arch span as the focal point of the bridge (third win).

4. Further to the above, the intent of the preferred bridge concept, in conjunction with on-land and in-water design provisions in the C-NHPEP, is to enhance the cultural and natural heritage landscape within the project corridor and as part of the broader Canal context. As such, the overall project design satisfies the aforementioned:

   a) Statement of Outstanding Universal Values for the Rideau Canal UNESCO World Heritage Site (UNESCO).

   b) Commemorative Integrity Statement for the Canal (Parks Canada).

   c) Heritage Values and Guiding Principles for the Cataraqui River Sector of the Rideau Canal (Parks Canada).

   d) Bridge Design Guidelines (Parks Canada).

   e) DIA Scoping Document for the Federal EIA (Parks Canada) up to this current project phase.

   f) Mission Statement, Vision and Values for the project (City and Project Team).

11.0 NEXT STEPS

The following activities will remain from the completion of the current project to the start of construction:

1. Continue stakeholder and First Nations consultations.

2. Finalize the Federal EIA with Parks Canada.

3. Confirm the need to prepare addenda to the ESR in light of current bridge design and constructability refinements.

4. Determine the preferred project delivery model.

5. Determine project financing.

6. Prepare final design drawings and specifications for construction.

7. Prepare detailed construction phasing, scheduling and cost estimates.

8. Obtain all permits and approvals required for construction.

9. Execute the land lease and construction agreement(s) with Parks Canada.

10. Obtain property easements and acquisitions for the project.

11. Procure the project (Pre-qualification, Proposal / Tendering, Agreements).

Additional studies that should be conducted during the detailed design stage include, but are not limited to, the following:

1. **Geotechnical Investigations:** The in-water test holes put down as part of the current project design phase were advanced at selected pier locations based on the previous 14-span V-pier arrangement. As discussed earlier, the refined bridge arrangement maintains the same abutment locations and overall bridge length, but now comprises 19 inverted U-frame piers. As such, most of the test holes are no longer within the footprint of the inverted U-frame pier locations. Though the relevance and applicability of the geotechnical assessments to the refined bridge arrangement is re-confirmed, additional field investigations should be carried out during the detail design phase to confirm bedrock surface elevation and founding soil and bedrock conditions at the proposed U-frame pier locations.

   Performing a borehole investigation at each inverted U-frame pier location is recommended as it reduces the risk of unforeseen conditions occurring during construction which can significantly delay construction.

2. **Scour Study:** The effects of scour on bridge piers should be developed more fully during the detailed design process based on local bed conditions as well as refinements to the proposed pier design, pier construction and riverbed restoration techniques. The proposed pile-supported piers to bedrock would prevent undermining of the pier footings, but exposure of any significant length of the piles should be accounted for in the structural design considerations, or appropriate scour protection should be provided as required to accommodate structural capacities.

3. **Ice Study:** An investigation should be conducted on the effect that the ice will have on the v-pier footing and the optimal pier nosing / ice breaker design to reduce the ice loading.

   As part of the preliminary design, ice impact load was considered at two different locations, the high elevation of 74.9 m which corresponds to the maximum of the average water levels between the months of December to April; and the low elevation of 73.0 m which corresponds to the ice loading on the footing. Due to the adoption of the inverted U-shape pier for majority of the piers, it is anticipated that ice loading can be minimized. However, it is recommended that refined studies be carried out during detailed design to refine ice loading at the inverted U-shape and the V-piers that frame the arch. Consideration should be given to using pier nosing / ice breaker design and cut-water to minimize ice loading.

4. **Hydrology and Hydraulics Review:** The permanent bridge piers and associated rock scour protection that may be required will potentially amount to 3000-4000 m^2 of impacted floodplain area. On shore, within the current design, 1000-2000 m^2 of impacted floodplain is expected. With modifications to the design near the waterfront, it is possible that the total impact on east and west shorelines could be reduced to less than 1000 m^2. Therefore, in total, the impacted area is predicted to be less than 5000 m^2.

   The CRCA has recommended that a Hydrology and Hydraulics review be undertaken to demonstrate the potential effects (if any) of the 5000 m^2 impact area within the 1.5 million m^2 upstream area during a 1:100 year flood event. This work should be deferred to the detail design phase when the permanent bridge pier design and associated rock scour protection measures are further refined and confirmed.

5. **Archaeological Investigations:** Visual examination of the west side lands suggests that virtually all lands within the existing John Counter Boulevard right-of-way have been disturbed to the extent that any archaeological testing in those areas is almost certain to be futile. On the other hand, the private lands on either side of John Counter Boulevard do not appear to have been extensively disturbed and may contain areas where archaeological potential still remains. Since archaeologists have no right of access to conduct archaeological testing on private lands, further assessment of the west side lands continues to be suspended, and should be resumed if the project proceeds to the detail design phase, and the affected private lands are acquired by the City.

   Regarding the east side lands, archeological site BbGc-127 and the identified survey marker should be further documented, and appropriate protocols put in place in advance of the project construction phase for:

   a) The removal through archaeological excavation of archeological site BbGc-127.

b) The temporary removal of the identified survey marker for subsequent reinstatement in situ during the site restoration and rehabilitation sub-phase.

6. **Geo-Environmental Investigations:** Additional sampling and analyses of sediments both on-shore and in-water should be undertaken in order to further determine sediment contamination levels and ensure appropriate protocols are in place for both management and disposal measures in accordance with regulatory requirements.

7. **Natural Heritage Investigations:** Additional fieldwork of natural heritage resources (terrestrial and marine) should be undertaken to both further confirm the presence of sensitive natural heritage features and identify necessary design refinements to the C-NHPEP.

8. **Traffic Calming:** Typically, consideration would be given to implementing the traffic calming options noted herein for the Point St. Mark Drive-Gore Road intersection in a progressive manner. However, the feedback received to date from Point St. Mark residents indicates concern that the least intrusive options would not solve the issue, whereas the most intrusive options would be too severe. As such, it is recommended that the City and Point St. Mark residents continue to advance collaborations on traffic calming options during the future detail design stage.

9. **Coordination with Highway 15 Upgrades:** Preliminary drawings have been developed for the three intersections within the project corridor, excluding the Gore Road-Highway 15 intersection, which is being determined under a separate Class EA study. As part of the Third Crossing Preliminary Design project, lane arrangements selected for the Gore Road-Highway 15 intersection have been co-ordinated with the Highway 15 Class EA work to ensure a cohesive design for this intersection. As such, it is recommended that collaborations continue to advance in this regard during the future detail design stage.

10. Other studies and investigations as deemed necessary by those authorities having jurisdiction.

www.jlrichards.ca

Ottawa

864 Lady Ellen Place
Ottawa ON Canada
K1Z 5M2
Tel: 613 728-3571
E-mail: ottawa@jlrichards.ca

Kingston

203-863 Princess Street
Kingston ON Canada
K7L 5N4
Tel: 613 544-1424
E-mail: kingston@jlrichards.ca

Sudbury

314 Countryside Drive
Sudbury ON Canada
P3E 6G2
Tel: 705 522-8174
E-mail: sudbury@jlrichards.ca

Timmins

201-150 Algonquin Blvd. East
Timmins ON Canada
P4N 1A7
Tel: 705 360-1899
E-mail: timmins@jlrichards.ca

North Bay

200-175 Progress Road
North Bay ON Canada
P1A 0B8
Tel: 705 495-7597
E-mail: northbay@jlrichards.ca

Hawkesbury

326 Bertha Street
Hawkesbury ON Canada
K6A 2A8
Tel: 613 632-0287
E-mail: hawkesbury@jlrichards.ca

Guelph

107-450 Speedvale Ave W
Guelph ON Canada
N1H 7Y6
Tel: 519 763-0713
E-mail: guelph@jlrichards.ca

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS