George Massey Crossing Project

Crossing Cost Report

April 2021

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1 INTRODUCTION

This report sets out the input, basis, scope, and comparisons of costs of the new Immersed Tube Tunnel (ITT) and new Bridge for the Service Delivery Options presented in the Business Case for the George Massey Crossing Project (the Project). The purpose of this report being to provide the basis and scope of the budget for the Crossing component of the Project. This Cost Report does not include the basis and costs for the Corridor Improvements described in the Business Case.

The overall physical scope covered by the estimate is a new eight-lane crossing of the Fraser River with a revised alignment to Highway 99 commencing south of the Steveston Highway Interchange to the Highway 17A Interchange, as shown in Figure 1. Following completion, and transfer of traffic to the new Crossing, the existing George Massey Tunnel (Existing Tunnel) is removed. Further details of the scope and schedule for the ITT and Bridge options are presented in their respective report sections.

Figure 1: Crossing Alignment

The report covers the following:

- The work carried out to date to prepare the estimates to create the budget;
- Methods to retain budget compliance;
- ITT and Bridge cost comparison;
- Basis of estimates that is common to both the ITT and the Bridge estimates;
- Basis and Scope of the ITT estimate; and
- Basis and Scope of the Bridge estimate.

2 DEVELOPMENT AND CONTROL OF THE PROJECT BUDGET

2.1 ESTIMATE METHODOLOGY

The estimates for both the ITT and the Bridge options have been prepared in the same manner as used for previous major projects delivered by the Ministry of Transportation and Infrastructure (the Ministry). The estimate is based on a combination of a resource based (i.e., labour, material, equipment, etc.) estimate where appropriate for the major scope elements, unit rates when more appropriate to the work being carried out, and allowances where there is limited information available at this stage of the Project's design development process.

The estimate accounts for work that reflects direct construction and separately work that reflects schedule, and accounts for the following:

- Temporary works;
- Duration and dependencies between activities;
- Work precedents;
- Labour and equipment requirements;
- Material quantities;
- Construction methodology;
- Logistics;
- Direct management and supervision;
- General management;
- Restrictions; and
- Overhead and profit.

The above factors are applied at differing levels depending on the type of work, from detailed calculations for the work for which there are fewer precedents, to unit rates for simpler work for which there is a higher level of experience, such as roadworks. In elements where there is limited view as the quantum of the work, but it is expected that there will be a need to address the issue, an allowance has been included. Such items include dewatering, casting yard servicing, ancillary minor fit out materials, as examples.

2.2 ESTIMATE CLASSIFICATION

Estimates have been prepared to Class 3 of the Ministry's Project Estimate Classification, which is used for the purposes of establishing the project budget for the Treasury Board submittal, and is the basis of cost control in future phases of a project. Design development of the Service Delivery Options is sufficient at this estimate class to determine the scope and scale of the project, to define key dependencies between major work elements, and to demonstrate achievement of key project requirements.

2.3 MONITORING AND CONTROLLING OF THE PROJECT BUDGET

Following approval of the Project Budget, a more detailed work breakdown structure will be established to further disaggregate the Project scope into discrete elements for the purposes of monitoring and controlling the Project's scope, schedule and costs. As design development and Project activities are advanced, the Project Budget is continuously monitored and additional estimates are made to reflect progress of the Project, changes, quantification of allowances, and new information. Variances of new estimates and the Project Budget are managed through the Project's change management process, including, where appropriate, draws on the Project's contingency if there is no solution to mitigate the contingency draw. In addition to monitoring and controlling of the Project Budget, the Project regularly reviews and updates the risk register for the Project, to actively manage risks, including monitoring of the progress and effectiveness of mitigation measures.

In addition, the procurement process includes the use of an affordability requirement for which a compliant proposal must be within to be eligible for award to deliver the Project. This affordability requirement is based on the Project estimate with an allowance for contractor's risk being transferred from the contingency allowance included within the overall Project Budget. As part of the request for proposal process, proponents are required to make an interim financial submission for the Province to complete an early review with the proponents regarding the proponents' understanding of the Project requirements, and the proponents' cost assumptions with respect to Project requirements. The Province will invite each proponent to discuss any aspect of its interim financial review submittal, including any recommendations for amendment of the Project requirements, if a proponent determines that the Project as described will exceed the affordability requirement.

The above processes have been, and are being used, successfully on the Ministry's past and current major projects, including Kicking Horse Canyon Project – Phase 4, Broadway Subway, Pattullo Bridge Replacement, Evergreen Line, Canada Line and the Sea to Sky Highway projects.

3 BASIS AND SCOPE OF ESTIMATE COMMON TO ITT AND BRIDGE

3.1 BASIS OF THE ESTIMATE

The following basis of estimate are common to the ITT and Bridge options:

1. Procurement is based upon the majority of work being design, build, and finance, with advanced or direct works contracts only being put in place if there is a positive effect of schedule reduction or risk mitigation. The estimate assumes a design, bid, and partial finance form of procurement with engineering and construction management included as a Contractor's cost.

2. Mark-up is included at [redacted]% applied to each major sub-contract contractors' costs; noting this figure does not include any costs or fees outside expected return on the project. All other associated costs such as management, insurance, bonding, risk, inflation, financing, are covered separately. In addition, a further consortium management mark-up of [redacted]% is included on all costs incurred by the Management Contractor.

3. The construction inflation level assumed is assumed at an average of [redacted]% which is comparable with current experience on similar projects. The estimate is calculated in 2021 dollars without inflation, compounded inflation is added for each year the work is anticipated to be carried out.

4. The estimate is based upon an opinion of cost that creates an estimate based on assumptions set out in the scope and basis of estimate.

5. The estimate schedule and cash flows are based on fiscal years commencing on 1st April of each year.

6. The estimates includes all costs associated with the procurement and delivery of the Project from June 2021 to project completion.

7. The construction cost estimates are based on a level of pricing that is expected to be obtained from competitive tenders, with minimal restrictions on construction methodology, and without contract conditions that would create onerous contractual situations that would be reflected in the contract price.

8. The new Crossing will be delivered by Transportation Investment Corporation (TI Corp) using a dedicated project management group, similar to that carried out to implement other major transportation projects in Metro Vancouver. The estimate assumes that the project management group will be of a comparable and composition as those groups currently managing the projects being carried out by TI Corp.

9. The estimates exclude the following:

    a. All financing costs beyond the construction period;

    b. Street works beyond the roadworks set out on the roadwork concepts;

c. Any credit in financing interest due to any interest free grants or subsidies being made available to the project;

d. Re-routing of existing transit services, either temporarily or permanently, due to either construction of the Project, or revised services required on completion;

e. The construction of any special environmental structures;

f. Widening of Highway 99 north and south of the Steveston Highway Interchange and Highway 17A Interchange, respectively;

g. Work to the Highway 17A Interchange;

h. Work to the Steveston Highway Interchange;

i. ITT, Bridge, and maintenance costs related to either the Existing Tunnel or the new Crossing;

j. Temporary bus bridges for pedestrians or cyclists during construction; and

k. GST.

3.2 SCOPE OF THE COMMON WORKS

3.2.1 Roads and Associated Work

This scope item scope reflects work that cannot be carried out as part of the Corridor Improvements, as the work is dependant on the new Crossing being partially or completely in place.

1. *North of the Crossing*
    a. Widening Highway 99 with an additional southbound lane between Westminster Highway and the Steveston Highway Interchange.
    b. Widening and re-aligning Highway 99 between the Steveston Highway Interchange and the new crossing.
    c. Construction of a five metre wide Multi-Use Path (MUP) to the same length as the new highway with connections to existing pathways.
2. *South of the Crossing*
    a. Widening and re-aligning Highway 99 between the new Crossing and the Highway 17 Interchange.
    b. Five metre wide MUP to the same length as the new highway with connections to existing pathways.
3. *Work to Steveston Highway Interchange*
    a. An allowance to cover re-aligning the ramps and merges to Highway 99, together with work to the existing overpass
4. *Work to Existing Railway Bridge*
    a. An allowance for temporary and permanent relocation and replacement of the railway bridge
5. *Replacement of the Rice Mill Road Bridge*

6. *Highway 17A Upgrades*
    a. An allowance to cover upgrades and re-alignment of the connections between Highways 17A and 99
7. *Road Design and Engineering*
    a. Design and Engineering by the Roads Contractor
8. *Roads Construction Management*
    a. The Roads Contractor's construction management

3.2.2 Work to Existing

The estimate includes the following work to existing structures:

- Demolition of the existing Deas Slough bridge;
- The Decommissioning Plan – George Massey Tunnel Vancouver of March 20, 2014 prepared by Ramboll as part of the George Massey Tunnel Replacement Project, adapted for full removal versus partial removal of the Existing Tunnel;
- Environmental clean-up to the Existing Tunnel;
- Partial removal and filling of the Existing Tunnel portals;
- Removal of the Existing Tunnel including crushing, and disposal on land;
- Removal of existing roads;
- Connections of existing roads to the revised Highway 99 alignment;
- Utility relocation, including the relocation of BC Hydro's 230 kV transmission line currently located in the Existing Tunnel to an alternate location;
- Temporary diversions necessary to construct the new Crossing with their associated roadworks;
- Design and Engineering by the Work to Existing Contractors; and
- Construction management by the Work to Existing Contractors.

3.2.3 Consortium Management

All the design, construction, and management will be carried out by specialist and general contractors as part of a special purpose consortium created to construct and deliver the project. These specialist and general contractors will require co-ordination, management, and administration, together with their mark-up covering risk and profit expectation. The estimates of these costs are included within each estimate for element of the work noted above. The Consortium Management includes the following cost to manage and co-ordinate the project:

- Overall management and co-ordination of the project, noting that each specialist contractor includes its owner management costs;
- Insurance and bonding, at a total of [redacted]% of all construction, design, and engineering costs;

- Traffic management; and
- Community relations.

3.2.4 Owner's Costs

Owner's costs are based upon a special purpose project management group, similar to that in place for current TI Corp major projects, based on providing management and engineering.

It is assumed three proponents will be selected to submit a proposal for the Crossing. A stipend of [redacted] is included to be paid to each unsuccessful proponent who submits a compliant proposal.

3.2.5 Project Labour Agreement Costs

The estimate assumes a Project Labour Agreement will be developed to achieve community benefits from the Project. Costs for development and implementation of the Project Labour Agreement are based on [redacted]% of the construction contract value together with the costs to develop the Project Labour Agreement.

3.2.6 Property

Based on estimates for both options provided by the Ministry's Properties and Land Management Branch; contingencies on property acquisition is included within the property estimate. The Property Acquisition will be monitored throughout the preliminary engineering and environmental stages of the project, with the intention that if issues arise that could negatively affect the cost of the project alternate actions could be taken to mitigate this affect.

3.2.7 Financing Interest During Construction

The contractor's estimated interest during construction (IDC) is calculated as (1) the interest accrued on the amount of private financing amount calculated using an annual interest rate of 4.05%, plus (2) the commitment and arrangement fee, minus (3) interest earned on the drawn but unspent private financing. The owner's IDC is estimated based on the interest rate provided by the Ministry.

4 IMMERSED TUBE TUNNEL ESTIMATE

4.1 INTRODUCTION

Initial technical planning in 2019 pertaining to the new ITT was focused on determining the scope and cost of this option, including details regarding, cross-section and key quantities. These studies helped inform the location and configuration of the Crossing, as well as development of a preliminary design basis in consultation with the Ministry's Chief Engineer. This initial technical planning supported early assessment of options, including consultation and engagement activities.

Since then, further analysis relevant to the cost estimate of the ITT option has been undertaken, including:

- Market sounding of general and specialist contractors with experience in the delivery of an ITT crossing;
- A constructability review of the ITT schedule by a specialist ITT immersion contractor;
- Interviews with ITT transportation authorities to understand their experience and lessons learned with respect to ITT projects;
- Review of design and construction of a recent purpose-built casting basin facility in the Pacific Northwest;
- Environmental review and input have been provided, and experience from work currently under construction has been accounted for in the estimate;
- Qualitative and quantitative risk workshops have been carried out;
- Engineering input has continued refining previous design and delivery assumptions; and
- The tunnel element casting basin and yard have been refined to reflect identification of a specific property, and initial optimization of layout and configuration of the casting basin.

4.2 OVERVIEW OF THE ITT SCOPE AND SCHEDULE

The overall scope covered by the estimate is a revised alignment to Highway 99, to the east of the existing Highway 99, commencing close to the south the Steveston Highway Interchange in Richmond, with an eight-lane immersed tube tunnel under the Fraser River, a new bridge crossing over Deas Slough, and a continuation of the revised alignment of Highway 99 to an approximate location north of the existing Highway 17A Interchange. The work includes the de-commissioning and demolition of the Existing Tunnel and removal of the existing Deas Slough bridge and all associated highways and paths no longer required on the new alignment of Highway 99. A rendering of the ITT, including the Deas Slough bridge is should in Figure 2.

Figure 2: Rendering of the ITT Option

The cross section for the eight-lane ITT comprises of two four lane road tubes and one five metre wide bidirectional MUP tube. A typical cross-section of the new ITT crossing, with associated excavation, fills, tunnel protection and ground improvement is shown in Figure 3. Relevant structural details are shown in Figure 4. Due to the relatively large width of the road tubes, the design concept includes post tensioning in top and bottom slabs and the outer walls.

Figure 3: ITT Typical Cross Section

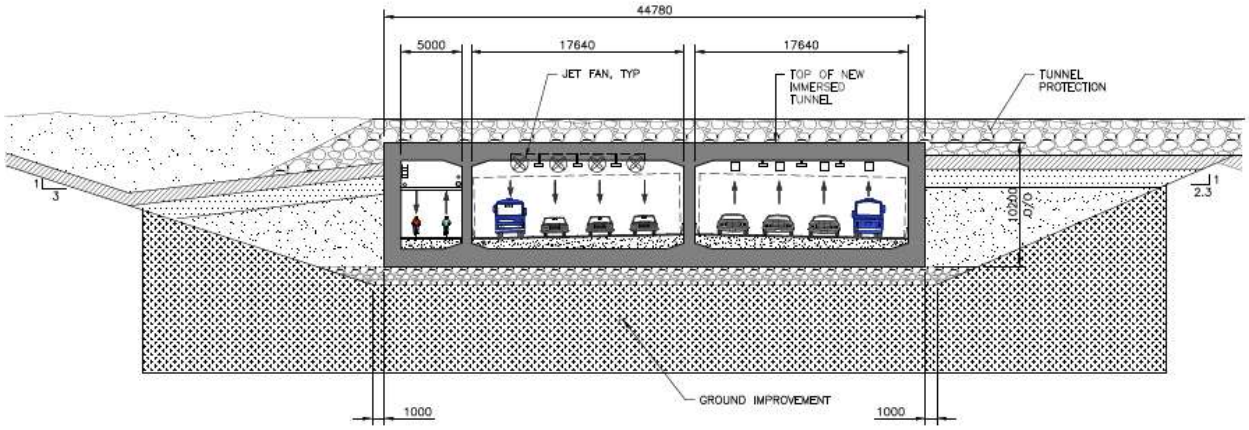
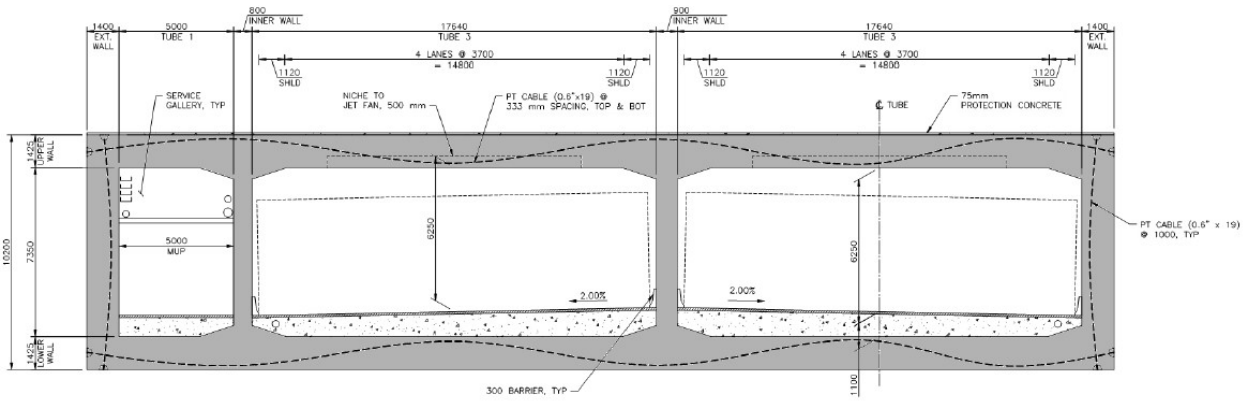


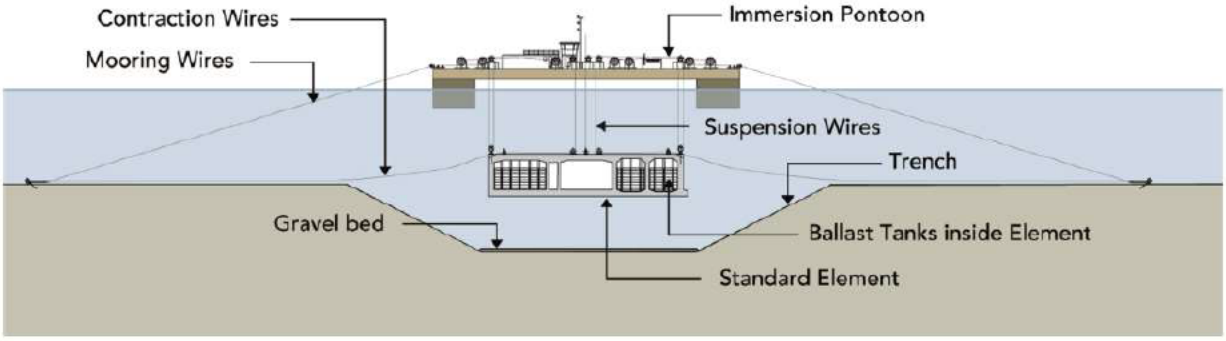
Figure 4: ITT Typical Cross-Section – Structural Details



Essential scope elements of the ITT option include the following:

- The ITT consists of multiple reinforced concrete elements, constructed in the dry in a purpose-built casting basin; the Project requires six elements, each approximately 110 m (L) x 45 m (W) x 10.2 m (H).
- The casting basin is constructed with water access and of sufficient depth to allow for float-out of the tunnel elements after fabrication.
- Temporary steel bulkheads are placed on each end of a tunnel element to enable the sealed element to float for towing transport to the Crossing site. In addition, the ends of each element consist of “Gina” gaskets and “Omega” seals and seismic joint details.
- At the Crossing site:
    - Ground improvement works, such as stone columns, are completed in the footprint of the tunnel and approaches to meet seismic and geotechnical design requirements. These works are completed both instream and uplands.
    - A trench is excavated across the Crossing alignment for the tunnel elements using both land-based excavation and dredging methods in order to meet navigational requirements for vessels.
    - A foundation layer (typically granular) is placed within the trench, and tunnel elements are floated into position with specialized vessels/marine equipment and using a system of riverbed and/or land-based anchorages; each element is immersed using temporary ballasting methods to control the buoyancy of the element. Refer to Figure 5 for an illustration of ITT element immersion works.

Figure 5: Illustration of ITT Element Immersion Works[1]



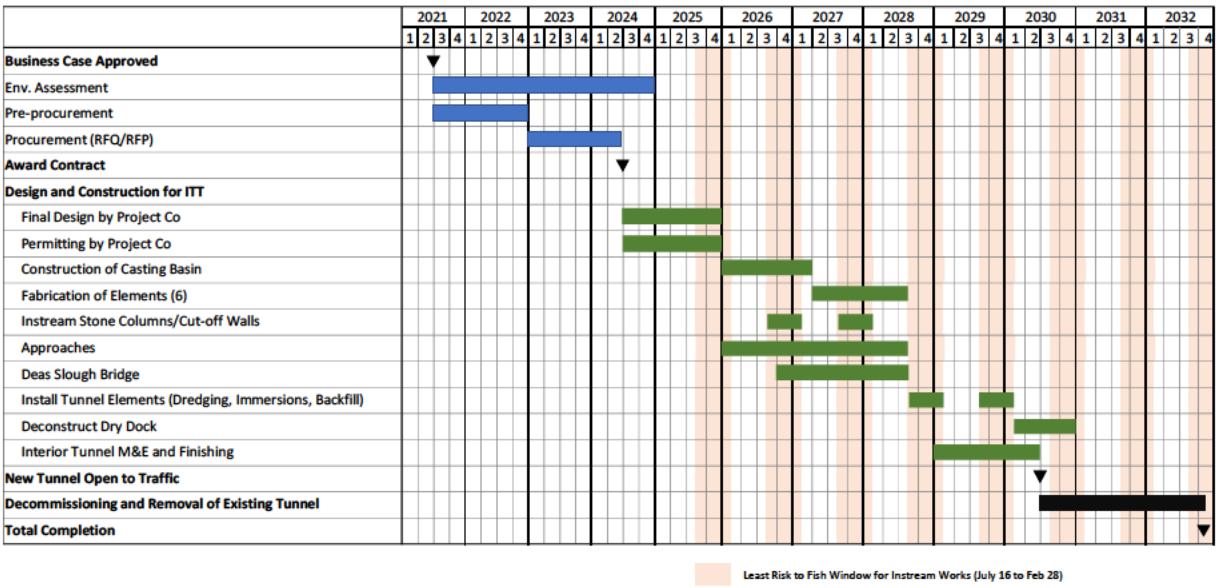
- Following each immersion, fill materials, including tunnel protection are placed over each element.
- Elements are immersed in an advancing sequence, and approximately three to four weeks between immersions is typical.
- Cut and cover tunnels and approaches, and replacement of the Deas Slough bridge with an eight-lane structure complete the Crossing connection.

- Following tunnel fit out and opening of the new ITT to traffic, the Existing Tunnel is removed using a reverse process of the ITT installation, with the removed elements crushed and disposed on land.
- Prior to removal of the Existing Tunnel, BC Hydro's 230 kV transmission line in the Existing Tunnel would be relocated.

The estimated schedule for the new ITT option, including Environmental Assessment and the recommended procurement option is show in Figure 6. Instream stream works are constrained by time periods of least risk to fish in the Fraser River estuary, which are regulated by Fisheries and Oceans Canada. The Existing Tunnel is the boundary of two least risk windows, and it is assumed that the window adjacent and west of the site (i.e. the shorter window, July 16 – February 28) would govern as upstream effects will flow downstream. In addition to this timing constraint, instream works are further constrained by high flows during the annual freshet, which generally peaks in June and attenuate to the annual "low flow" period by August/September.

[1] Femern A/S, Consolidated Technical Report, Draft. December 2011.

Figure 6: ITT Crossing Schedule



Delivery of the ITT is based on procurement delivery model with contract award prior to the expected approval date of the Environmental Assessment Certificate (EAC) for the Project. The purpose being to advance design, engineering with the Contractor / Consortium being in place to assist, advance and provide input for management plans, the EAC and permits. Refer to the Crossing Procurement Options report for further details of the recommended procurement model.

4.3 SUMMARY OF THE ESTIMATE

The estimate for the ITT Crossing is summarized below in Table 1.

Table 1: ITT Crossing Cost Estimate Summary ($ Million, Nominal Dollars)

Cost category	Total
Contractor's construction cost	[redacted]
Design, management and overhead	
Design and engineering	
Construction mgmt..	
Tunnel structure, Deas Slough bridge, fit out, and roadworks	
Structure (tunnel)	
Structure (portals)	
Fit out works	
Deas Slough bridge	
Roadway and associated works	
Work to Existing + Decommissioning of the Existing Tunnel	
Owner's cost	
Project mgmt., project labour agreement and procurement	
Environmental	
Property acquisition	
IDC, bid development and SPV costs (Contractor)[1]	
Contingency / Risks	
Subtotal	
Provincial IDC[2]	
Total	**4,147.9**

NOTES:

1. Includes Contractor's Interest During Construction (IDC) of $[redacted]M estimated by KPMG. The Contractor's estimated IDC is calculated as (1) the interest accrued on the amount of private financing amount calculated using an annual interest rate of 4.05%, plus (2) commission (up-front arrangement fee and commitment fee), minus (3) interest earned on the drawn but unspent private financing.
2. Provincial IDC is estimated based on the interest rate provided by the Ministry.

4.4 BASIS OF ESTIMATE

Indicative quantities for permanent works, including the ITT, cut and cover tunnels/approaches, light attenuation structures and ramps were provided in the George Massey Crossing Assessment 11.5 Immersed Tube Tunnel Technical Summary of 29th September 2020 prepared by COWI North America Ltd; refer to Section 6 – Immersed Tube Tunnel Quantities.

The construction and implementation of the Project is assumed to be a consortium of companies that are experienced in the various aspects of construction related to the project, managed by a separate entity, that may be formed by representatives from the major contractors or by a group formed solely for this purpose. It is anticipated the types of companies could include the following:

a. A construction company skilled in marine construction, including dredging, marine transport, and marine facilities;
b. A precast concrete specialist company, possibly an existing pre-cast concrete supplier, or a contractor with experience on large concrete casting projects;
c. Civil engineering contractor with experience in cut and cover tunnel construction, dewatering and ground improvement;
d. A company well experienced in the immersion of immersed tube tunnel elements;
e. A bridge construction company;
f. A road builder;
g. Demolition contractor;
h. Smaller specialist systems suppliers, installers, and contractors covering safety, controls, and operating systems; and
i. A management contractor, or special purpose company to manage the Consortium to co-ordinate, finance, insure, bond, and cover community relations around the construction of the Project.

[redacted]

4.5 SCOPE OF THE WORK

4.5.1 Temporary Work

The tunnel elements (six) are concurrently cast in a purpose-built casting basin, [redacted]. The casting basin is constructed specifically for this project, with the excavated material from the dock being left in place beside the casting basin, and once the work is complete and the casting basin is no longer required, the excavated material is returned to fill the casting basin, and the site remediated. The estimate includes for the maintenance of the excavated material while being stored on site. For reference, the purpose-built casting basin for the construction of the Existing Tunnel is shown below in Figure 7, this casting basin site is currently the BC Ferries' Fleet Maintenance Unit.

Figure 7: George Massey Tunnel and Casting Basin

The land for the casting basin is included in the Property Budget for a lease period of [redacted] years covering construction of the casting basin, use of the casting basin for fabrication of the ITT elements, and backfilling of the casting basin to return the site to an as-acquired state.

The six 110-metre long elements are fabricated using casting moulds in approximately 20 m long segments to control cracking and ensure water-tightness of the structure. The casting moulds are of a design, and include equipment, that will allow the casting mould to be pushed forward, once the concrete reaches sufficient strength, enabling the subsequent segment to commence concrete pouring.

The casting basin estimate includes a temporary entry lock type gate to allow the basin to be kept dry and filled with water for float out of the ITT elements. In addition, temporary offices and services are provided to service the casting basin facility. The facility will also include an area for, and the costs of, a temporary concrete batching plant and logistic areas. Other equipment assumed includes two tower cranes and two gantry cranes servicing the casting basin area, with other service equipment necessary to facilitate construction.

4.5.2 Tunnel Construction

This scope item scope reflects scope for construction of the 660 metre ITT section of the Crossing, and includes the following activities:

1. *Fabrication of the elements*

   The tunnel elements are constructed of reinforced concrete as follows:

   a. Base slab 1425 mm thick
   b. Roof slab 1425 mm thick
   c. External walls 1400 mm thick
   d. Two internal walls 900 mm thick
   e. Reinforcement density 140 kg per cubic metre
   f. Prestressing density 35 kg per cubic metre

   The immersed tube tunnel length is 660 metres long, consisting of six elements of equal length. Each tunnel element includes "Gina" gaskets, "Omega" seals, together with seismic joints. The tunnel includes a waterproof coating to the sides and top, and steel plate to the base for which an allowance of $[redacted] (2021 dollars) per square metre for both the coating and plate is included. A temporary steel bulkhead is required to seal the tunnel element prior to float out from the casting basin.

2. *Excavation and Backfill*

   a. Ground improvement to the riverbed and shoreline with stone columns;
   b. Dredging the Fraser River to accommodate the tunnel elements, including disposal at sea;
   c. Dredging the shoreline including disposal at sea;
   d. Marine support for instream works;
   e. Excavation in the shoreline to complete preparatory work to the ITT;
   f. Backfill after the tunnel elements are placed;
   g. Rip-rap tunnel protection;
   h. Ballast concrete following tunnel laying;
   i. Fire protection board installation; and
   j. Temporary ground support in areas to the river shoreline to allow for tunnel location and laying in shoreline areas.

   As noted in Section 4.2, instream works, including ground improvement, dredging and placement of backfill or rip-rap tunnel protection is limited to the least risk to fish windows. Dredging the trench for the tunnel elements and placement of backfill and tunnel protection activities are constrained to the least risk to fish window of tunnel element placement due to

the high sediment load of the Fraser River. However, ground improvement activities can take place in an earlier least risk to fish window as these works are at depth and not affected by annual sediment transport of the Fraser River. The estimate assumes day and night shift operations for instream ground improvement, dredging and fill placement activities, with a period of maintenance between shifts.

3. *Placement/Immersion of Tunnel Elements*

    a. Work necessary to float out the tunnel elements and immerse these in place include the following:

        - Fit out jetty for temporary berthing of elements to prepare an element for immersion;
        - Access towers for survey control and access to the sealed element during immersion;
        - Ballast tanks for controlling buoyancy and slope of an element during immersion;
        - Bulkheads for temporary sealing of elements during float out and immersion; and
        - Rental of [redacted] tugboats for [redacted] days for each segment to tow and lower each segment in place. It is assumed that the tugboats can operate on a 24-hour basis for towing purposes.

The tunnel installation estimate includes a specialist ITT contracting group comprising of 30 international specialists, supporting approximately an equivalent number of local labour to carry out the transport, immersion and placement of the tunnel elements. See Figure 8 for an example of equipment required for positioning of an ITT element for immersion.

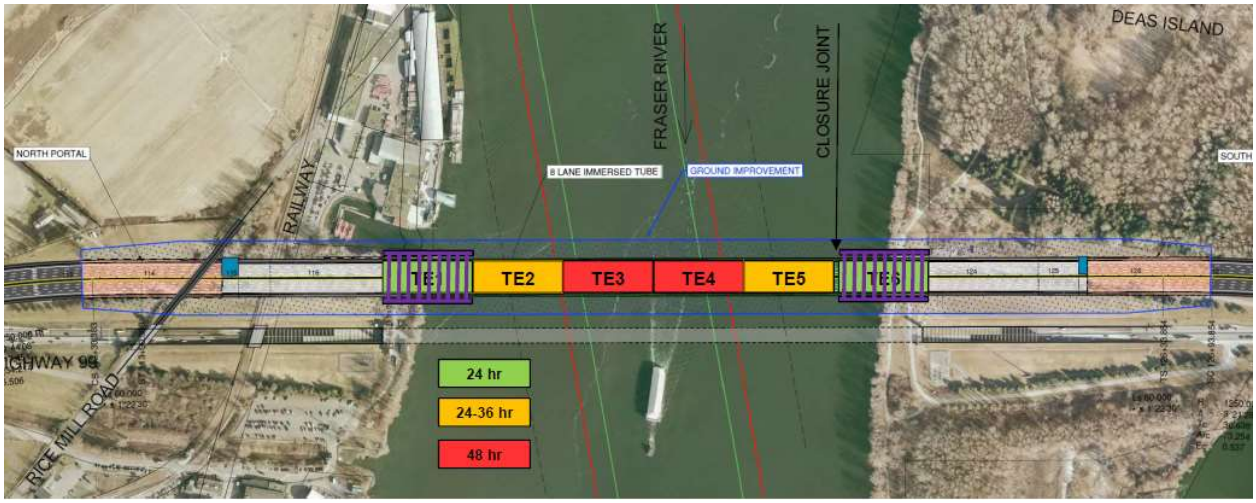
Figure 8: Positioning of an ITT Element for Immersion[2]

[2] International Tunnelling and Underground Space Association, Projects Database, Medway Tunnel (UK).

As noted above, immersion activities for tunnel elements are constrained to the least risk to fish window due to requirement for dredging and placement of backfill to occur within the same window.

The estimate assumes temporary (24-48 hour) closures of the entire navigable channel of the South Arm of the Fraser River and restrictions to navigation in the Crossing area during immersion of each tunnel element. Six closures in total are anticipated, with approximately three to four weeks between each closure. This requirement is primarily driven by safety and the intensity of instream works during these events. Refer to Figure 9 for estimated river closures per element. The estimate assumes 24/7 operations for immersion events.

Figure 9: Estimated River Closures for Immersion of ITT Elements



Additional cost items for this activity include:

- Installation of concrete mats and other scour protection works for the new ITT;
- Design and engineering of the ITT by the Immersed Tube Contractor; and
- The ITT Contractor's construction management.

4.5.3 Portals

This scope item scope reflects scope for construction of the eight-lane reinforced concrete cut and cover tunnel and open portal structures in approaches to the ITT. The cut and cover tunnel to the north of the river consists of a 200 metre long section north of the river. The cut and cover tunnel to the south of the river has a length of 194 metres. The light attenuation structures are 100 metres long on both sides of the river, while the open ramps have lengths of approximately 70 metres to the north and 51 metres to the south. The estimate for this section is broken down into the following:

1. *Construction of the Cut and Cover Tunnels*

The tunnel elements are constructed of reinforced concrete as follows:

a. Base slab 1425 mm thick
b. Roof slab 1425 mm thick
c. External walls 1400 mm thick
d. Two internal walls 900 mm thick
e. Reinforcement density 140 kg per cubic metre
f. Prestressing density 25 kg per cubic metre

2. *Additional activities for Cut and Cover Tunnels*

a. Excavation and backfill with temporary sheet pile support;
b. Stone columns ground improvement under, and adjacent to, the cut and cover tunnels and portals;
c. Breaking out and replacing the existing dykes with temporary work to protect the portal construction from flooding;
d. Temporary relocation of the Rice Mill Road and CN Rail alignments;
e. Waterproofing;
f. Light attenuation as the approach tunnels connect to the portals;
g. Design and engineering of the portal tunnels by the Contractor; and
h. The Cut and Cover Tunnel Contractor's construction management.

4.5.4 Tunnel Operations and Fit Out

Following placement of the ITT elements, and completion of the cut and cover tunnel sections, the following scope is required to make the tunnel fit for traffic operations:

1. *Tunnel Operations Buildings*

Two buildings, one with a floor area of 450 square metres, and the other of 900 square metres, constructed of reinforced concrete with industrial type finishes. The buildings would contain offices, maintenance equipment, and the control centre for the tunnel.

2. *Tunnel Road Surface*

Highway wearing surface of 50 mm asphalt super-pave on 150 mm asphalt, together with edge curbs and paving to the emergency walkway on each side of the roadway tubes. The scope also includes barriers etc. as necessary to safeguard individuals having to use the emergency walkways.

3. *Tunnel Wall Finish*

A heavy duty painted finish, applied directly to the tunnel walls.

4. *Tunnel Soffit Finish*

   None is included in the current estimate.

5. *MUP Finish and Fit Out*

   Emergency evacuation doors from the roadway tube to the MUP, and between the southbound and northbound tubes.

   Floor and wall finishes of an indeterminate design, but assumed to reflect safety issues such as non-slip floors, and light reflective walls, at an allowance of $[redacted] per square metre of finish area.

6. *Maintenance Floor and Fit Out*

   Concrete deck supported on a steel framed floor of 120 kg/m^2 with concrete panels, together with painted light reflective walls

7. *Tunnel Lighting*

   Two continuous rows of tunnel lights per roadway tube at 10 metre centres, changing to wall lights in the open portals.

8. *MUP and Maintenance Floor Lighting*

   Lighting to allow for public access and maintenance.

9. *Tunnel Ventilation*

   Four jet fans per tube at 100 metre centres.

   Fan controls and air monitoring.

10. *MUP and Maintenance Ventilation*

    One jet fan per MUP or maintenance floor at 100 metre centres.

    Fan controls and monitoring.

11. *Tunnel CCTV and Safety Monitoring*

    Four fixed CCTV cameras at 50 metre centres per tube.

    Controls and head end equipment.

12. *MUP and Maintenance CCTV and Safety Monitoring*

    One fixed CCTV camera at 50 metres centres per MUP or maintenance floor.

Controls and head end equipment.

13. *Tunnel Dynamic Signage*

    An allowance to cover the cost of dynamic signage in the tunnel.

14. *MUP and Maintenance Dynamic Signage*

    An allowance to cover the cost of dynamic signage in the MUP and maintenance floors.

15. *Tunnel emergency notification and response equipment*

    An allowance for equipment to alert the tunnel control centres of an emergency, and communications to emergency service providers.

16. *Control and Management Systems*

    An allowance to the control, management, and integration of all the tunnel systems including supervisory control and data acquisition (SCADA), and data storage.

    Connections to the Ministry's Transportation Management Centre, and any modifications within the centre.

17. *Tunnel Drainage*

    Two 300mm diameter ductile iron road drains per roadway tube.

    Catch basins at 50 metre centres on both sides of each roadway tube.

    Pumping systems together with their sumps.

    Emergency pumping systems together with their sumps.

18. *MUP and Maintenance Floor Drainage*

    One 200mm diameter ductile iron drainage per MUP or maintenance floor.

    Catch basins at 100 metre centres on one side of each floor.

    Pumping systems together with their sumps.

    Emergency pumping systems together with their sumps.

19. *Emergency Power Systems*

    Two generators, one in each control centre to provide emergency power as required, together with an Uninterruptable Power System (UPS) for life safety systems.

20. *Fire Suppression*

    A sprinkler system with associated alarms and notification.

    Emergency management system.

21. *Design and Engineering of the Tunnel Systems*

    The Systems Contractor design and engineering.

22. *Tunnel Systems Construction Management*

    The Systems Contractor's construction management.

4.5.5 Deas Slough Bridge

The estimate for the new eight-lane bridge crossing Deas Slough, of a similar design to the existing crossing with instream piers, includes the following scope elements:

1. Seven span girder bridge, 310 metres long and 46 metres wide.
2. The abutments and beams to support the girders include ten 2000 mm diameter caissons 80 metres long, with an average embedment of 70 metres into the riverbed.
3. The estimate includes surfacing, lighting, barriers, and other work to complete the crossing.

4.5.6 Environmental

An allowance discussed with the Environmental Lead, which is based on a probable order of magnitude cost, and the appropriate commitments, obligations, capacity funding, and compensations are accounted for. The allowance includes for 10 hectares of habitat off-setting.

The Environmental scope item includes estimates of First Nation accommodation agreement, which were calculated according to Appendix 4: Guidelines for Capital Project Consultation and Accommodation Budget Envelop Development of the First Nations Consultation and Accommodation Framework: Guidelines for Ministry of Transportation and Infrastructure

4.5.7 Contingencies

The estimate includes contingencies as a separate allowance based upon an assessment of the contingences and risk that could be attributed to each scope element (e.g., ITT, portal, etc.) of the work, [redacted]. This allowance on construction, design, and management estimates is to cover risks and contingency events, associated with working in the river, design development, lack of appropriate resources to carry out the work, unfamiliarity with the proposed construction methodology, procurement, unforeseen ground conditions, third party issues, disposal

restrictions, co-ordination with third parties, commercial risk, procurement and tendering risk, contract reserve during construction, and schedule risk.

5 BRIDGE ESTIMATE

5.1 INTRODUCTION

Estimates for the eight-lane Bridge build upon local depth of experience in long-span bridges, in particular the Ministry's Pattullo Bridge Replacement Project (currently under construction), the Port Mann Highway 1 Bridge (completed in 2012), the Pitt River Bridge (completed in 2009), and the Alex Fraser Bridge (1986). In addition, design development, risk assessments and costs estimates developed for the previous ten-lane George Massey Tunnel Replacement Project (GMTR) were considered in the development of the Bridge option. A rendering of the Bridge option is provided in Figure 10.

Figure 10: Rendering of the Bridge Crossing Option

5.2 OVERVIEW OF THE BRIDGE SCOPE AND SCHEDULE

The overall scope covered by the estimate is a revised alignment to Highway 99, east of the existing Highway 99, commencing close to the south the Steveston Highway Interchange in Richmond, with an eight-lane bridge crossing over the Fraser River, and a continuation of the revised alignment of Highway 99 to an approximate location north of the existing Highway 17A Interchange. Major components of the Bridge crossing include:

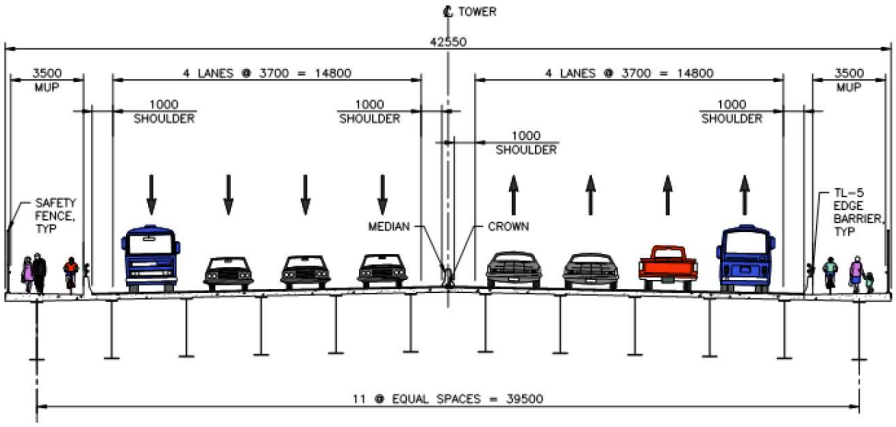
- North Approach Multi-Girder Bridge;
- Cable Stay Bridge with clear span over the Fraser River; and

- South Approach Multi-Girder Bridge, which also accounts for replacement of the Deas Slough crossing.

The work also includes the relocation of BC Hydro's 230 kV transmission line in the Existing Tunnel, de-commissioning and demolition of the Existing Tunnel and removal of the existing Deas Slough bridge and all associated highways and paths no longer required on the new alignment of Highway 99.

The cross section for the eight-lane Bridge comprises of two four lane road tubes and two 3.5 metre wide MUPs, one each side. A typical cross-section of the new Bridge crossing is shown in Figure 11.

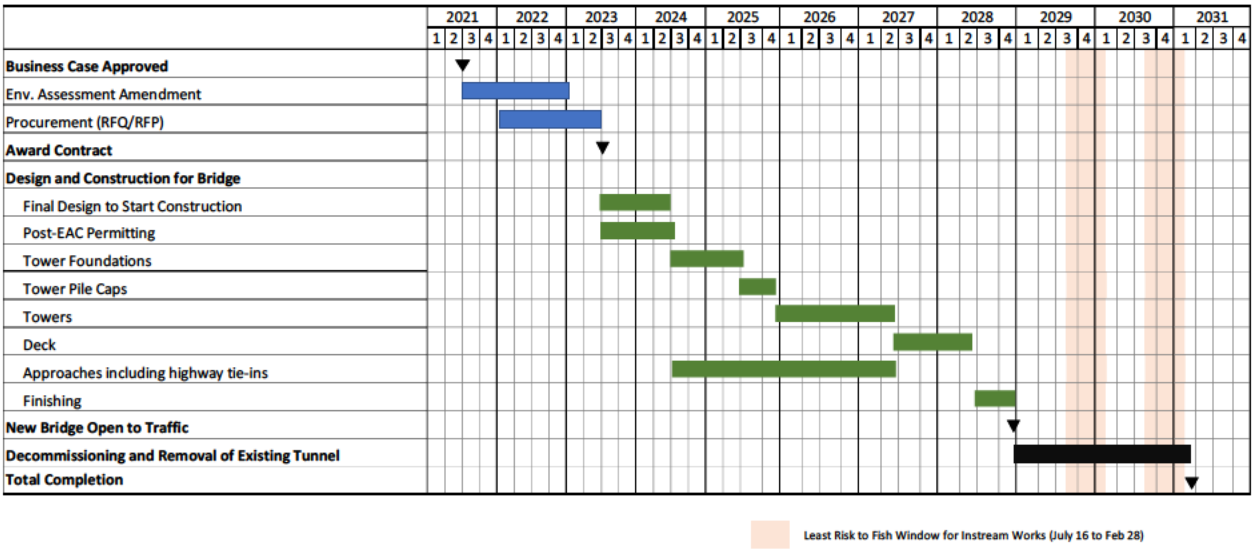
Figure 11: Bridge Typical Cross Section



The estimated schedule for the new Bridge option, including amendment of the GMTR EAC is show in Figure 12. As the piers for the towers of the main span are located outside of the Fraser River, and limited instream works are required, the critical path of constructing the Bridge option is not constrained by fish windows, or freshet conditions. However, the removal of the Existing Tunnel is constrained by these conditions, as shown in Figure 12.

Procurement of the Bridge option assumes technical submissions are received approximately three months following the anticipated timing of the amendment to the GMTR EAC, and a conventional Design Build Finance (DBF) model, similar to the model and timing for the Pattullo Bridge Replacement Project, is utilized for delivery. Procurement resulting in award prior to receipt of the EAC, as recommended for the ITT option in the Business Case, is not utilized for the Bridge option, as the EAC amendment process generally coincides with the EAC amendment process.

Figure 12: Bridge Crossing Schedule



5.3 SUMMARY OF THE ESTIMATE

The estimate for the Bridge Crossing is summarized below in Table 2.

Table 2: Bridge Crossing Cost Estimate Summary ($ Million, Nominal Dollars)

Cost category	Total
Contractor's construction cost	[redacted]
Design, management and overhead	
Design and engineering	
Construction mgmt..	
Bridge structure, fit out, and roadworks	
North Approach Bridge	
Main Span Bridge	
Deas Slough Crossing (South Approach Bridge)	
Roadway and associated works	
Work to Existing + Decommissioning of the Existing Tunnel	
Owner's cost	
Project mgmt., project labour agreement and procurement	
Environmental	
Property acquisition	
IDC, bid development and SPV costs (Contractor)[1]	
Contingency / Risks	
Subtotal	
Provincial IDC[2]	
Total	**4,219.4**

NOTES:

1. Includes Contractor's Interest During Construction (IDC) of $[redacted]M estimated by TI Corp. The Contractor's estimated IDC is calculated as (1) the interest accrued on the amount of private financing amount calculated using an annual interest rate of 4.05%, plus (2) commission (up-front arrangement fee and commitment fee), minus (3) interest earned on the drawn but unspent private financing.
2. Provincial IDC is estimated based on the interest rate provided by the Ministry.

5.4 BASIS OF ESTIMATE

1. The George Massey Crossing Assessment, Business Case Eight Lane Bridge of Option 6th October 2020 prepared by COWI North America Ltd.
2. Drawings and design assumptions included in the awarded design of the Pattullo Bridge Replacement Project, and the design assumptions included in the previous GMTR Project.
3. The construction and implementation of the Project is assumed to be a consortium of companies that are experienced in the various aspects of construction related to the Project, managed by a

separate entity, that may be formed by representatives from the major contractors or by a group formed solely for this purpose. It is anticipated the types of companies could include the following:

a. Smaller specialist systems suppliers, installers, and contractors covering safety, snow removal, and operating systems;

b. A management contractor, or special purpose company to manage the Consortium to co-ordinate, finance, insure, bond, and cover community relations around the construction of the project;

c. A construction company, or companies skilled in bridge construction;

d. A road builder;

e. Demolition contractor; and

f. A management contractor, or special purpose company to manage the Consortium to co-ordinate, finance, insure, bond, and cover community relations around the construction of the project.

5.5 SCOPE OF THE WORK

5.5.1 Bridge Crossing

This scope item scope reflects scope for construction of the Bridge crossing, including the main span and approaches. Each element includes bearings, expansion joints, barriers, super-pave surfacing, preventive bridge fence railings, lighting, maintenance access and support equipment, de-icing equipment to the cable stay bridge, drainage, and lighting. The bridge deck structural steel assumption in the estimate is "weathering" steel.

1. *North Approach*

The north approach for the bridge includes the following:

a. Multi Girder Bridge 766 metres long, and 42.5 metres wide.

b. The bridge deck a structural weathering steel frame weighing 230 kg per square metre, with a 320 mm thick precast reinforced and pre-stressed concrete deck.

c. The deck spans are 80 metres long supported on reinforced concrete bent structures with foundations consisting of 2000mm diameter driven pipe piles 80 metres long, with concrete fill to the top 30 metres.

2. *Main Span (Fraser River Crossing)*

The main span of the bridge includes the following:

a. Cable stay bridge 1170 metres long, and 42.5 metres wide, with a clear span over the Fraser River

b. The bridge deck a structural weathering steel frame weighing 254 kg per square metre, with a 320 mm thick precast reinforced and pre-stressed concrete deck.

c. The deck is supported from the two pylon towers each approximately 195 metres high with 160 cables, and bent structures at the north and south ends of the bridge.

d. The foundations consisting of 2500 mm diameter driven pipe piles 80 metres long, with concrete fill to the top 30 metres, 48 caissons supporting each pylon, and 16 caissons supporting each bent structure.

3. South Approach (Deas Slough Crossing)

The south approach for the bridge includes the following:

a. Multi-Girder Bridge 869 metres long, and 42.5 metres wide.

b. The bridge deck a structural weathering steel frame weighing 242 kg per square metre, with a 320mm thick precast reinforced and pre-stressed concrete deck.

c. The bridge spans vary between 63 and 92 metres long, with a centre span over Deas Slough of 120 metres long supported on reinforced concrete bent structures with foundations consisting of 2000 mm diameter driven pipe piles 80 metres long, with concrete fill to the top 30 metres.

5.5.2 Bridge Operations and Fit Out

The ITT estimate included a section “Tunnel Operations and Fit Out,” covering ventilation, safety, and security measures specific to tunnel operations. As the majority of these elements are not required to operate a bridge crossing, and those remaining such as lighting, structural monitoring systems, access elevators, and maintenance gantries have a much lower cost impact, this element is not shown separately in the Bridge estimate, and all items related to bridge fit out and operations are included within the bridge estimates.

5.5.3 Environmental

An allowance discussed with the Environmental Lead, which is based on a probable order of magnitude cost, and the appropriate commitments, obligations, capacity funding, and compensations are accounted for. The allowance includes for 5 hectares of habitat off-setting for the Bridge option.

Costs for funding of First Nation funding is included with the Environmental scope item. Estimates of First Nation accommodation agreement were calculated according to Appendix 4: Guidelines for Capital Project Consultation and Accommodation Budget Envelop Development of the First Nations Consultation and Accommodation Framework: Guidelines for Ministry of Transportation and Infrastructure.

5.5.4 Contingencies

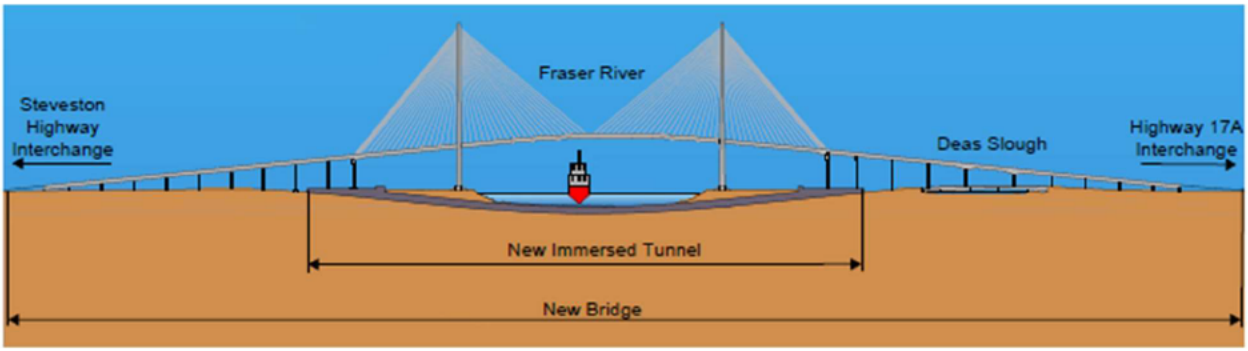
The estimate includes contingencies as a separate allowance based upon an assessment of the contingences and risk that could be attributed to each element (e.g., bridge, portal etc.) of the work, [redacted]. This allowance on construction, design, and management estimates is to cover risks and contingency events, associated with design development, lack of appropriate resources to carry out the work, unfamiliarity with the proposed construction methodology, procurement, unforeseen ground conditions, third party issues, disposal restrictions, co-ordination with third parties, commercial risk, procurement and tendering risk, contract reserve during construction, and schedule risk.

6 DISCUSSION

The estimates for replacing the Existing Tunnel demonstrated comparable costs between ITT and bridge options for an eight-lane crossing. While tunnel construction, including ITT construction is generally perceived to be more costly than bridge construction, the overall dimensions of the two structures are substantially different for the Project.

Primarily based on the navigational clearance requirements for the Fraser River (air and water draft), and acceptable grades for traffic, the total length of the Bridge option (2,805 metres) is approximately three times the length of the ITT option (1,054 metres). Of the approximate one kilometre ITT crossing, only 660 metres make up the section constructed of immersed tunnel elements. The cut and cover tunnels and portals for the approaches represent the remaining length of crossing. Refer to Figure 13 for a comparison of the profiles for the ITT and Bridge crossing options.

Figure 13: Profile of ITT and Bridge Crossing Options



In development of the estimates, the delivery of the ITT section has a greater risk profile than a bridge crossing. [redacted]. The overall contingencies for each option are a reflection of risk/contingency assessment for each major scope element and result in a comparable overall contingency between the options, primarily due to the higher cost of a longer bridge structure versus higher contingency for the shorter and lower cost ITT tunnel section.

The higher risk profile for delivery of the ITT accounts for the significance of the least risk to fish window and river flow constraints on the instream works, as well as risks associated with management of large quantities of excavated materials.

Although an ITT has not been constructed in British Columbia since the Existing Tunnel was completed in 1959, the scale and nature of activities required to construct an ITT, with the exception of the floating and immersion of the tunnel elements ([redacted]), are not unfamiliar to local contractors. Annual maintenance dredging on the Fraser River is on the order of three million cubic metres per year, and fabrication of reinforced concrete structures is performed on many projects each year in the Province, including major structures. Marine/tug operations are consistently performed as part of

operations for the various ports and wharves in Metro Vancouver, and instream and uplands ground improvement have also been completed on recent major projects. Although the tunnel element floating and immersion activities are specialized and not an area of local expertise, these specialist contractors are experienced with international assignments and working with local construction forces to successfully deliver these projects.

7 CASH FLOW FOR BUSINESS CASE RECOMMENDED OPTION

The estimate for the recommended Service Delivery Option, the ITT option, is summarized in Table 3.

Table 3 – Crossing Cash Flow Summary for ITT Option (In million, Nominal Dollars)

Cost category *(Fiscal year ending in March)*	2021-2022	2022-2023	2023-2024	2024-2025	2025-2026	2026-2027	2027-2028	2028-2029	2029-2030	2030-2031	2031-2032	Total
Contractor's construction cost	[redacted]											
Design, mgmt and overhead												
Design and engineering												
Construction mgmt..												
Tunnel structure, Deas Slough channel, fit out, and roadworks												
Structure (tunnel and portals)												
Fit out works												
Deas Slough channel												
Roadway and associated works												
Decommissioning of the Existing Tunnel												
Owner's cost												
Project mgmt., project labour agreement and procurement												
Environmental												
Properties acquisition												
IDC, bid development and SPV costs (Contractor)												
Contingency / Risks												
Subtotal												
Provincial IDC												
Total	[redacted]											**4,147.9**