March 3, 2011

Joost Meyboom

MMM Group,
Suite 600 – 1455 West Georgia Street
Vancouver BC
V6G 2T3

Re: Letter of Understanding for Navigation Envelope Specifications for the Johnson Street Bridge, Victoria British Columbia

Dear Mr. Meyboom:

The purpose of this letter is to confirm our understanding of this project to date pertaining to the navigational clearance envelope for the replacement of the Johnson Street Bridge in the Victoria Inner Harbour. This letter is not an approval to begin works.

Currently, the Johnson Street Bridge consists of a ‘bascule bridge’, which allows for 36.5 metres of horizontal clearance between the existing pier protection works and unlimited vertical clearance. Consultation with affected marine stakeholders has identified that this horizontal clearance is not adequate for current and future navigation uses.

As part of the design process, a navigation assessment report calculated a channel width of 46.7 metre (47m) channel width using international accepted standards for a vessel with a beam of 16.4 metres. Additional analysis identified engineering and maintenance implications for a design to this channel requirement. As a result, an additional assessment of marine operators was conducted using a projected navigational envelope with a 41metre horizontal clearance. The results of this assessment determined that this channel (41m) would most likely address current and future navigation requirements with proper tug assist.

Accordingly, Transport Canada is prepared to accept the conclusions of the navigation assessment report and addendum, and will accept a bridge application for replacement of the Johnson Street Bridge with an understanding the minimum navigation envelope would provide a horizontal clearance of 41metres between any works including any bridge pier protection structures. The project will be reviewed pursuant to section 5(2) of the Navigable Waters Protection Act (NWPA) when a completed application it received.
In addition to a final design, a development plan must be provided with the application that addresses construction related navigation issues that would include but not limited to:
- pre/post and during construction equipment staging areas (no work zones),
- construction timing and methodology,
- pre/post construction hydraulic assessment study information for final design pier placement, will address potential for scour and deposition of material 500 metres up and downstream of the piers,
- development of a communication plan designed to exchange information between affected marine stakeholders and construction contractors.

The above information must address all phases of the new bridge construction and old bridge deconstruction.

Final design submission for this bridge shall also take into account the Navigable Waters Bridge Regulations, of the NWPA, which provide for lighting and marking requirements (such as buoys, beacons and/or racons) for the purposes of safe navigation.

In addition to the above noted requirements, Transport Canada is also responsible for the Public Ports Facilities Regulations, Part 3, Schedule 4. Should there be a need for a channel closure or other such imposition on navigation during bridge construction activities, timely notification will be required at the Victoria Harbour Master’s office.

Should you have any questions or require clarification, please call the undersigned at 604-775-5486.

Yours truly,

[Signature]

Ryan Greville
Navigable Waters Protection Officer
Marine Safety, Transport Canada
Pacific Region

    Russ Tyson, Typlan Consulting Services.
    David Featherby, Victoria Harbour Master’s Office.
    Karen Hall, Transport Canada, Environmental Services.
    Mike Lai, City of Victoria.
July 22, 2011

Joost Meyboom

MMM Group
Suite 600 – 1455 West Georgia Street
Vancouver BC
V6G 2T3

Re: Letter of Understanding for Navigation Envelope Specifications for the Johnson Street Bridge, Victoria British Columbia

Dear Mr. Meyboom:

The purpose of this letter is to confirm our understanding of this project to date pertaining to the navigational clearance envelope for the replacement of the Johnson Street Bridge in the Victoria Inner Harbour. This letter is not an approval to begin works.

We are in receipt of a letter forwarded to our office from TyPlan Consulting (dated July 18, 2011) on MMM Group’s behalf providing our office an update of a general reference concept for the proposed Johnson Street Bridge in Victoria. The updated reference plan provided to us (DWG 2010751-100-C-SKT-0028) identifies that the originally agreed upon envelope will not be met over the entire width of the navigation channel when in the closed position. It is understood, that vertical clearance is unaffected when the bridge is in the open position and that consultations with affected users has concluded that the altered vertical clearance will not significantly affect their operations.

Accordingly, Transport Canada is prepared to accept the provided reference plan and associated envelope for assessment of approval under the Navigable Water Protection Act. To adequately mitigate this alteration to the navigation envelope, a mechanical gauge must be installed and maintained for the life of the bridge that notifies mariners of available clearance based on current water levels.

Should you have any questions or require clarification, please call the undersigned at 604-775-5486.

Best Regards,

Ryan Greville
Navigable Waters Protection Officer
Marine Safety, Transport Canada
Pacific Region

Cc: Jim Fowler MMM Group
    Russ Tyson, Typlan Consulting Services
    David Featherby, Victoria Harbour Master’s Office
    Karen Hall, Transport Canada, Environmental Services
    Mike Lai, City of Victoria
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1 Introduction

The City of Victoria has decided to replace the existing Johnson Street Bascule bridges based on the age of the existing bridges, their seismic vulnerability and risks associated with their worn and obsolete electrical/mechanical systems. The replacement project will be funded by the City as well as through the Building Canada Fund.

In September 2009, TyPlan Planning and Management (TyPlan) prepared a prefeasibility report entitled: Johnson Street Bridge Replacement Project: Navigational Assessment for MMM Group (MMM) on behalf of the City of Victoria (City) The report assessed the preliminary navigational requirements associated with the proposed replacement of the Johnson Street Bridge in Victoria, BC connecting the Inner Harbour with the Upper Harbour, for the purpose of providing input into conceptual design for the proposed bascule bridge.1

In accordance with the World Association for Waterborne Transport Infrastructure (PIANC) Guidelines, a Stage 1: Concept Design Study2 was undertaken to provide preliminary insight into the horizontal and vertical clearance requirements for the proposed replacement project. The results of the Stage 1 Concept Navigational Channel Design Study identified a 47m horizontal channel and an unimpeded vertical clearance of 32m (highest point of the bascule being open) based solely on input parameters identified in the PIANC guidelines.3

The Stage 1 Concept Design Study was undertaken in the absence of a detailed evaluation of design, environmental and cost implications. More detailed information is now available to allow a Stage 2: Detailed Design Study to be undertaken and allow optimization of particular aspects of the navigational channel based on engineering and design realities, modeling and verification.

This addendum report represents an update to the original report presented for this project entitled the: Johnson Street Bridge Navigation Assessment September, 2009 (TyPlan) for the MMM Group.

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1 Much of the supporting data derived for this report is based on existing information referenced from the report entitled: Johnson Street Bridge Replacement Navigational Assessment prepared for the MMM Group September 2009 (TyPlan).
2 During Stage 1: Concept Design initial comments on the overall physical and environmental parameters of the proposed channel should be determined based on readily available data of the waterway.
3 It is noted that by definition guidelines represent a practice that allow leeway in its interpretation, implementation and or use, in which detailed engineering and or constraints impact directly on application.
2 Existing Conditions

The existing Johnson Street Bridges were designed under the direction of Mr. F.M. Preston, City Engineer in 1920. The bridges are Strauss-Bascule-Type Bridges, in which one end rises while a counter weight lowers on the opposite end, and have two separate Bascules, bridges the Railway section and the Highway section.

Based on as-built drawings (refer to Exhibit 2) the navigational channel is 120 feet (36.5m). However the limit of channel, as defined by the clear distance between the existing timber fenders, (utilized to direct errant vessels away from the existing foundations of the bascule bridge) is 39m. In the closed position there is a 5.75m vertical clearance within the new channel as measured between the bascule span soffit and High High Water. In the open position, there is a 32m wide channel width with unimpeded vertical clearance.
Exhibit 1: Johnson Street Bridge: Existing Channel Dimensions

Source: City of Victoria Archives
Although the Stage 1 navigation channel is achievable from a technical perspective, it represents an increase in the project’s design and operational risk profile. Many of these risks are associated with the fact that the new bridges would require one of the largest bascule leafs in North America and Europe.

Some specific design and operational risks and impacts that would be introduced by the Stage 1 navigation channel width include:

- Very large water-based cranes will be required to erect the bascule span. This will increase the risk for disruption and inconvenience to marine users during construction potentially resulting in the need for significant closures of the navigational channel during construction.

- The bridge foundation footprint required for the Stage 1 channel dimensions will be considerably larger than that of the existing bridge. This increases the project’s environmental impact and increases risks associated with contaminated soils in the channel.

- Given the size and weight of the bascule leaf required to accommodate the Stage 1 navigation channel, wear and tear on the corresponding electrical/mechanical equipment would be higher than with a smaller leaf. This leads to a potential reduction in long term reliability of the bridge and significantly higher operating costs for the City.
4 Stage 2 Assessment

Maritime Use within the Upper Harbour

The following identifies the “control vessels” of the maritime users utilizing the navigational channel, as well as commentary from marine users regarding the adequacy of the existing navigation channel at Johnson Street Bridge. As outlined in the Johnson Street Bridge Replacement Navigational Assessment Report the existing channel is limited to a one way channel. Based on the fact that only one way transits are possible TyPlan consulted with the various maritime users within the waterway to confirm the characteristics of vessels utilizing the channel and to ascertain whether the existing navigational channel width was acceptable to maritime operator’s current and future needs. Based on this review, a control vessel associated with each maritime operator was established.

Maritime Operators within the Upper Harbour: Identification of a Control Vessel

When considering horizontal channel width requirements of the proposed Johnson Street Bridge an assessment of current and future marine use is required. Based on information provided in the Johnson Street Bridge Navigational Assessment report as augmented by recent consultations with marine operators the following companies/entities were identified as users affected by the Johnson Street Bridge (See Table 1.)

Table 1: Key Marine Operators using the Johnson Street Bridge, Victoria BC

<table>
<thead>
<tr>
<th>Business Name</th>
<th>Type of Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island Asphalt</td>
<td>Hot mix asphalt paving requiring barging of aggregate products</td>
</tr>
<tr>
<td>Point Hope Maritime</td>
<td>Vessel barge repair and construction</td>
</tr>
<tr>
<td>Salts Sail and Training Society</td>
<td>Owns and operates two tall ships: Pacific Grace and Pacific Swift</td>
</tr>
<tr>
<td>Seaspan International</td>
<td>Tug and barge service catering to the aggregate/ready mix companies within and outside of the Upper Harbour</td>
</tr>
<tr>
<td>Steel Pacific Recycling</td>
<td>Steel Recycling</td>
</tr>
<tr>
<td>United Engineering Ltd.</td>
<td>Steel fabrication and marine shop specifically for marine industry</td>
</tr>
</tbody>
</table>

Source: TyPlan

TyPlan verified and updated the control vessels associated with each operator.

4By definition the design ship or control vessel represents: “The largest vessel capable of navigating the channel today and in the future considering the vessels vertical clearance, beam, length, weight capacity etc.”
Island Asphalt

According to Cory Sangha (Manager) of the Island Asphalt, the company is involved in hot-mix asphalt production. Marine activity associated with the company’s operations is the marine transportation of the asphalt using aggregate barges. The company currently subcontracts all of its marine operations to Seaspan International in Victoria and expects to continue this arrangement in the future.

For the purpose of assessing potential impacts to operations Island Asphalt directed TyPlan to discuss requirements with Seaspan International in Victoria. The results of these discussions are presented under the Seaspan section of this report.

Point Hope Maritime

Point Hope Maritime is known to be one of British Columbia’s oldest maritime operations facilities. They provide services related to:

- Maintenance and refits;
- Vessel retrofits;
- Shipwrights;
- Aluminum and steel welding; and,
- Sand blasting services.

Port Hope Maritime provides services to a variety of users throughout south-western BC.

According to management at Point Hope Maritime, the services above are restricted to the following vessel sizes (e.g., the control vessels outlined in Table 2)

Table 2: Point Hope Maritime: Facility Restrictions

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>Length</th>
<th>Beam</th>
<th>Vertical Clearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tugs</td>
<td>Up to 60m</td>
<td>Up to 15m</td>
<td>Up to 25m</td>
</tr>
<tr>
<td>Barges</td>
<td>Up to 125m</td>
<td>Up to 35m</td>
<td>Up to 35m</td>
</tr>
<tr>
<td>Ferries</td>
<td>Up to 80m</td>
<td>Up to 25m</td>
<td>Up to 35m</td>
</tr>
<tr>
<td>DND /CCGs</td>
<td>Up to 60m</td>
<td>Up to 20m</td>
<td>Up to 30m</td>
</tr>
<tr>
<td>Misc vessels /Yachts</td>
<td>Up to 60m</td>
<td>Up to 20m</td>
<td>Up to 25m</td>
</tr>
</tbody>
</table>

Source: Point Hope Maritime: Hank Bekkering General Manager

Note: DND/CCG Department of National Defence and Canadian Coast Guard
Point Hope Maritime indicated that the vessels identified above in Table 2 represent the optimum (or maximum) beam that could be handled in the shipyard and acknowledged that occurrence of having such large vessels at the Point Hope shipyard was negligible, most likely a one off opportunity.  

Hank Bekkering (General Manager: Point Hope Maritime) indicated that he wanted the opportunity to service larger vessels if such an opportunity arose in the future. He acknowledged that when larger vessels do transit the bridge to gain access to the shipyard, tug assist is commonly utilized.

Mr. Bekkering noted that maintenance of the existing channel width is important. Further, he indicated that any additional width that could be provided as a result of the bascule bridge replacement would be welcome and appreciated by marine operators.

As part of the organizations business planning process the potential to service some of the BC Ferries has been identified. As part of this review, BC Ferries was contacted to obtain the vessel characteristics within their entire fleet to ascertain which vessel classes could be accommodated within the Point Hope Shipyard.

It is noted that only certain vessels within the BC Ferries fleet could be accommodated at Point Hope shipyard due to vessel size constraints.

According to Francois Cambron, BC Ferries Fleet Technical Engineering, the following vessels could be accommodated within the Point Hope Shipyard. He notes that the larger vessels are restricted due to the size of vessel and drafts. According to Mr. Cambron those vessels that can be accommodated include:

Table 3: BC Ferries Fleet of Vessels that could be accommodated at Point Hope Shipyard

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Length(m)</th>
<th>Beam Extreme (m)</th>
<th>Draft Max (incl. propeller Dip) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalka</td>
<td>54.72</td>
<td>14.18</td>
<td>1.52</td>
</tr>
<tr>
<td>Kiltsa</td>
<td>47.43</td>
<td>12.25</td>
<td>2.143</td>
</tr>
<tr>
<td>Kupper</td>
<td>49.54</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Kwana</td>
<td>71.63</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Mill Bay</td>
<td>36.58</td>
<td>9.94</td>
<td>2.134</td>
</tr>
<tr>
<td>Nicola</td>
<td>33.53</td>
<td>11.92</td>
<td>1.981</td>
</tr>
<tr>
<td>Nimpkish</td>
<td>33.53</td>
<td>12.50</td>
<td>2.057</td>
</tr>
</tbody>
</table>

5 Widths by economic sector of the economy were provided by Hank Bekkering. In discussions with his office TyPlan could not identify a barge that had a beam of 35m however Hank indicated that a key opportunity in the future was to potentially service BC Ferries which was identified as a current and future opportunity for the shipyard.
Johnson Street Bridge  
Navigational Assessment: Addendum Report  
Vertical and Horizontal Clearance Requirements

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Length (m)</th>
<th>Beam Extreme (m)</th>
<th>Draft Max (incl. propeller Dip) (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Island Princess</td>
<td>61.04</td>
<td>17.96</td>
<td>3.27</td>
</tr>
<tr>
<td>Quadra Queen Two</td>
<td>48.62</td>
<td>13.21</td>
<td>2.6</td>
</tr>
<tr>
<td>Tachek</td>
<td>49.54</td>
<td>14.69</td>
<td>3.017</td>
</tr>
<tr>
<td>Tanaka</td>
<td>46.18</td>
<td>13.21</td>
<td>2.44</td>
</tr>
<tr>
<td>Howe Sound Queen</td>
<td>73.46</td>
<td>18.45</td>
<td>3.264</td>
</tr>
</tbody>
</table>

Source: BC Ferries Magna Carta. It is noted that the BC Fleet vessels ability to be serviced by Point Hope Shipyard is limited by the infrastructure available at Point Hope Shipyard

Lafarge

Lafarge Cement now transports its own aggregate to and from the Upper Harbour. According to Maureen Allen, Shipping Coordinator Richmond Plant, Lafarge Canada and Ted Graham, Shipping Coordinator Lafarge Seattle USA, the largest vessel currently used by Lafarge to service Victoria Harbour is the Warrior. Both Ted Graham and Maureen Allen were contacted to determine the dimensions of the Warrior as noted in Table 4.

**Table 4: Lafarge Cement Control Vessel Characteristics: The Warrior**

<table>
<thead>
<tr>
<th>Vessel characteristics</th>
<th>Measurements (ft.)</th>
<th>Measurements (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>196</td>
<td>59.7</td>
</tr>
<tr>
<td>Beam</td>
<td>49</td>
<td>14.9</td>
</tr>
<tr>
<td>Draft</td>
<td>16.6</td>
<td>5.06</td>
</tr>
<tr>
<td>Height</td>
<td>35</td>
<td>10.66</td>
</tr>
</tbody>
</table>

Source: Lafarge Cement Maureen Allen Vancouver

When queried in regard to the use of future vessels that Lafarge would consider operating in the Upper Harbour, Maureen Allen indicated that unless existing maritime law was revoked (specifically the Jones Act) the Warrior would represent the largest vessel in operation in the Upper Harbour. Section 27 of the Merchant Marine Act of 1920 (also known as the Jones Act) regulates commercial maritime commerce within US waters and Ports. The Act prohibits US vessels being used for commercial activities within Canadian sovereign waters thereby prohibiting the ability of Lafarge (USA) to utilize some of its sister ships registered in the US from operation in Canada.  

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The **Merchant Marine Act of 1920** (P.L. 66-261) is a United States **Federal statute** that regulates **maritime commerce** in U.S. waters and between U.S. ports.

Section 27, also known as the **Jones Act**, deals with cabotage (i.e., coastal shipping) and requires that all goods transported by water between U.S. ports be carried in U.S.-flag ships, constructed in the United States, owned by U.S. citizens, and crewed by U.S. citizens.
Seaspan

Both Kevin Ashley of Seaspan (Superintendent, Victoria Operations), and Ron Skinner (Retired General Manager) both confirmed that if existing channel dimensions are maintained, Seaspan’s current and future operations would not be affected. Both noted however that any additional horizontal width would be appreciated.

Seaspan International represents the key maritime operator within the Upper Harbour, services many of the maritime users in the Upper Harbour and is responsible for the majority of transits at the Johnson Street Bridge. Aggregate barges (defined as the Flat Deck Barges) are those most utilized for transits according to Seaspan International and should be considered as the “control vessel” for the Upper Harbour as the others are not frequently utilized. Seaspan uses tug assist, as required with larger vessels.

The vessel types most likely utilized within the Upper Harbour by Seaspan are described in Table 6.

Table 6: Seaspan Fleet Listing by Vessel Category and Control Vessel (by Beam)

<table>
<thead>
<tr>
<th>Fleet Listing by Type</th>
<th>Vessel Name Barge Number</th>
<th>Short Tonne Capacity</th>
<th>Hull Size (Length, Width, Height in ft.)</th>
<th>Hull Size (Length, Width, Height in m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Carriers</td>
<td>Barge Nos. 201, 202, 203, 204</td>
<td>5500</td>
<td>261 x 65 x 18</td>
<td>79.5 x 19.8 x 5.5</td>
</tr>
<tr>
<td>Chip Barges</td>
<td>Barge Nos. 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22</td>
<td>2600</td>
<td>200 x 45 x 18.1</td>
<td>61 x 13.7 x 5.5</td>
</tr>
<tr>
<td>Combination Chemical Covered Barges</td>
<td>Consume River and Gold River</td>
<td>3500 Pulp</td>
<td>244 x 54 x 15.5</td>
<td>74.4 x 16.4 x 4.7</td>
</tr>
<tr>
<td>Covered Barges</td>
<td>Cape Flattery</td>
<td>4350</td>
<td>226 x 60 x 22</td>
<td>68.8 x 18.2 x 6.7</td>
</tr>
<tr>
<td>Flat Deck Barges</td>
<td>Barge No. 175, 176</td>
<td>3200</td>
<td>200 x 54.1 x 13.1</td>
<td>61 x 16.4 x 3.9</td>
</tr>
</tbody>
</table>

U.S. citizens and U.S. permanent residents. The purpose of the law is to support the U.S. Maritime industry. In addition, amendments to the Jones Act, known as the Cargo Preference Act (P.L. 83-644); provide permanent legislation for the transportation of waterborne cargoes in U.S.-flag vessels. The Merchant Marine Act of 1920 has been revised a number of times, the most recent and thorough revision was the re-codified version of 2006.

In an email sent from Kevin Ashley of Seaspan International to Russ Tyson of TyPlan, forwarded on January 14th of 2011, Kevin stated:

“Good Morning Russ, if the new bridge at least stays the same or slightly larger horizontal channel is incorporated, this would meet the requirements for tug and barge transit with the equipment we use now.”

Kevin Ashley
Superintendent
Vancouver Island Marine Operations
As noted above, the flat deck barges and covered barges with a beam of 16.4m are the most frequent users of the channel. It is important to note that the larger vessels identified in Table 6 are not utilized in the Upper Harbour but are part of Seaspan’s larger fleet utilized throughout British Columbia and are based out of Vancouver. Regardless such vessels could navigate the channel if required with tug assist.\(^8\)

**Ocean Cement (A Division of Lehigh Cement)**

Rockie Collins (Supervisor, Ocean Cement in Victoria) was contacted to ascertain the vessel characteristics of the barges transiting the Johnson Street Bridge. He indicated that currently he has no problem navigating the Johnson Street Bridge and does not have any concerns for his operations in the future if the existing navigation channel is maintained.

Wayne Dean (Ocean Cement head office) confirmed that the Evco 60 and Evco 61 are the largest cement barges that Ocean Cement plans to use in the channel at the Johnson Street Bridge. The Evco 55 is also used in the Upper Harbour (beam of 18.3m). The Evco 55 accommodates 50% of total transits between all of the larger vessels identified in this report.

The Ocean Cement vessel characteristics are as follows:

**Table 7: Ocean Cement Control Vessels: Evco 60 and Evco 61**

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Vessel (Length x Width x Height) in ft.</th>
<th>Vessel (Length x Width x Height) in m</th>
<th>Vertical Walls (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evco 60</td>
<td>256 x 62 x 16</td>
<td>78 x 18.9 x 4.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Evco 61</td>
<td>256 x 62 x 16</td>
<td>78 x 18.9 x 4.9</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Source: Ocean Cement

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\(^8\) Conversation with Seaspan International Victoria
The Ocean Cement barges can be accommodated within the existing channel, in Ocean Cement’s case the control vessels has a beam of 18.9m.\(^9\)

**Sail and Life Training Society (SALTS)**

SALTS operate two tall ships moored within the Upper Harbour. SALTS transit the Johnson Street Bridge approximately 54 times per annum. The key issue associated with navigation from this operator’s perspective is that unimpeded vertical clearance must be provided to accommodate the tall ships’ shrouds so that they do not collide with the bascule bridge when opened. The vessel characteristics are provided in Table 8.

**Table 8: SALT Tall Ships Vessel Characteristics**

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Vessel (LWH) in ft.</th>
<th>Vessel (LWH) in m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt Training Tall Ship 1</td>
<td>138.7 x 22 x 115</td>
<td>42.3 x 6.7 x 35</td>
</tr>
<tr>
<td>Salt Training Tall Ship 2</td>
<td>111 x 20.5 x 88</td>
<td>33.8 x 6.2 x 26.8</td>
</tr>
</tbody>
</table>

Source: SALTS

The key operational issue associated with SALTS is the provision of a clear vertical clearance that would accommodate at least the beam of the vessels at a continuous vertical clearance that accommodates the vessels’ shrouds at 6.7m.

**Pacific Steel Recycling**

Steel Pacific Recycling conformed that they utilized barges approximately 30 times per year. The identified control vessel is presented in Table 9.

\(^9\) Dave Warner of Leigh Cement indicated in an email to TyPlan on Thursday, January 13, 2011:

Hi Russ,

As per our discussion on the phone, the current width of the span for transit of the Johnston Street Bridge is acceptable for the barges we run through. This I however consider a minimum and anything wider would only increase the safety of barges transiting the bridge.

David Warner
Aggregate Distribution Maintenance Superintendent
Lehigh Materials, a division of Lehigh Hanson Materials Limited
Table 9: Pacific Steel Recycling Control Vessel

<table>
<thead>
<tr>
<th>Vessel characteristics</th>
<th>Measurements (Ft)</th>
<th>Measurements (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>236</td>
<td>72</td>
</tr>
<tr>
<td>Beam</td>
<td>54</td>
<td>16.4</td>
</tr>
<tr>
<td>Height</td>
<td>35</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Source: Pacific Steel Recycling

As identified a beam of 16.4m represents the control vessel for Pacific Steel Recycling

Summary of Control Vessels by Marine Operator

Based on discussions with marine operators within Victoria’s Upper Harbor and follow-up discussions with management undertaken as part of this review the control vessels (for both current and future use) are identified in Table 10.

Table 10: Control Vessel Characteristics by Commercial Marine Operation Victoria Upper Harbour

<table>
<thead>
<tr>
<th>Business Operation</th>
<th>Vessel and Vessel Beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island Asphalt</td>
<td>Seaspan Aggregate Barges 16.4m beam</td>
</tr>
<tr>
<td>Point Hope Maritime</td>
<td>BC Ferries up to 25m / Barges up to 35m</td>
</tr>
<tr>
<td>SALTS</td>
<td>Tall ships: Pacific Grace and Pacific Swift which require an unrestricted vertical clearance of 6.7m</td>
</tr>
<tr>
<td>Seaspan International</td>
<td>Aggregate Barges with a beam of 16.4m</td>
</tr>
<tr>
<td>Steel Pacific Recycling /United Engineering</td>
<td>Barges with a beam of 16.4m</td>
</tr>
<tr>
<td>Ocean Cement</td>
<td>Aggregate Barge of 18.9m beam</td>
</tr>
</tbody>
</table>

Source: TyPlan

Based on the findings of this review, the following observations are presented:

1. All maritime operators in Victoria’s Upper Harbour have acknowledged that maintenance of the existing navigation channel width is acceptable although a slightly wider channel would be preferable.

2. Tug assist is common throughout the Upper Harbour and will remain necessary in the future.

3. The most frequent bridge transits are for aggregate transports that use a barge with a 16.4m beam. These barges represent the key control vessel.
4. There is some indication that certain operators would like to cater to larger vessels and provided tug assist is maintained the larger vessels noted in this review can be accommodated with the existing navigational channel.

5. From a vertical clearance perspective provided the Salts Tall ships (whom have a vertical clearance of 35m and a vertical beam of 6.7m (to accommodate the shrouds) is accommodated they will retain unimpeded access.
5 Channel Design (Vertical and Horizontal Clearance Requirements)

In Canada, the “Canada Coast Guard Navigational Impact Assessment Guidelines (“CCG NIAG”) provides guidance regarding minimizing interference with navigation. The CCG NIAG provides a model upon which a navigational channel can be conceptually designed.

Alternatively, the International Navigation Association (PIANC) report entitled: “Design of Approach Channels (Volume 2)” provides an accepted methodology for design of navigational Channels.

Both references represent the industry standards associated with designing navigational waterways.

Canada Coast Guard (CCG) Navigational Impact Assessment Guidelines (NIAG)

The CCG NIAG’s are intended to preserve the rights and safety of navigators by initially restricting the degree of interference created by “works” (as defined by the NWPA) in navigable waterways. The allowance for navigation channels is based on established criteria and the inclusion of other factors and restrictions as outlined in the CCG NAIG which enables the Navigable Waters Protection Program Officers (NWPO) to arrive at reasonable decisions regarding requirements for present and future waterways for navigational purposes. All applications made to NWPP regarding navigable waterways should address the principles and design parameters outlined in the NIAG.


The International Navigation Association (PIANC) is a professional organization offering access to worldwide trends and challenges in port and waterway development and management. The design of an approach channel encompasses a number of disciplines including ship handling and maritime engineering in order to design waterways to a desired level of navigability and safety. Approach channel design involves designing the layout and dimensions of a port’s main water area with reference to:

- The alignment and width of approach channels and port entrances;
- The depth of approach channels; and,
- The size and shape of manoeuvring spaces within the port, with particular reference to the stopping and swinging areas.

The design process is based on two specific stages:

1. **Stage 1**: Concept Design Study, based on initial physical and environmental data, the identification of a design ship or control vessel required to undertake detailed engineering and other requirements derived from commercial considerations and forecasts. Once physical data has been reviewed and the design ship or control vessel has been identified this leads to:
2. **Stage 2:** Detailed Design Study, involving development and validation of particular aspects of the navigational channel based on engineering modeling and verification.

### 5.1 Concept Design Parameters

Concept design generally considers the physical and environmental characteristics associated with the waterway in relation to the vessels that utilize the waterway. In addition, some common sense approach to alignment, width and depth requirements are identified and aids to navigation and marine traffic and risk are identified. Physical data and the identification of a control vessel are critical starting points in concept design.

The following factors are considered, and corresponding “ratings” are required (and provided as part of this report) as inputs into the PIANC model when designing the navigational channel:

- Control vessel identification (inclusive of length, width and draft of vessel)
- Vessel speed
- Vessel manoeuvrability
- Vessel density
- Traffic lane assessment
- Bank suction effect
- Bottom surface
- Cross current
- Wind Effect
- Channel depth
- Channel alignment

The ratings associated with the Johnson Street Bridge are outlined below.

**Control Vessel**

The required width of a channel is conveniently expressed as a multiple of the width of the beam of a ship with bend radii expressed as multiples of its length. The identification of a design ship or control vessel is critical and essential for detailed design. By definition the design ship or control vessel represents:

> “The largest vessel capable of navigating the channel today and in the future considering the vessels vertical clearance, beam, length, weight capacity and frequency of transits etc.”

---

4 As defined by TyPlan based on Port Mann Navigational Clearance Assessment and discussions with NWPP officers regarding assessment requirements.
The “design ship” or “control vessel” is required to assist the NWPPO in determining the navigational requirements for the waterway as well as in the design process in which engineering models are used to determine channel alignment width and depth to promote safety and efficiency along the navigable waterway. As defined the control vessel, based on the frequency of transits is the Seaspan aggregate barge with the following characteristics:

- DWT 4200 tonnes
- 100 m length
- 16.4 m beam
- 5 m draught

This report acknowledges that both the Evco 60 and 61 vessels (with a beam of 18.9m) are utilized by Leigh Cement (Ocean Cements’ parent company) and have been recently introduced into the Upper Harbour once Leigh Cement decided to undertake their maritime operations internally (no longer using Seaspan). They are utilized infrequently in comparison to total transits throughout the Upper Harbour. Also table 6 identifies other vessels within Seaspan’s fleet that have a wider beam than the control vessel but as mentioned they are not utilized in the Upper Harbour.

Conversations with management indicated that the use of such barges is not impacted by the current navigational channel width and the frequency of transits is light (transits are limited to one to two per week), which has been confirmed via email (see footnote 9 of this report) As such for the purpose of this report we have retained the original control vessel to run the PIANC model in determination of the recommended channel width based on guidelines and a more detailed review of the PIANC parameters.

**Vessel Speed**

According to Transport Canada’s Traffic Scheme for Victoria Harbour, the maximum speed of transit is not to exceed 5 knots.5

**Vessel Manoeuvrability**

Rating associated with vessel manoeuvrability is deemed to be “good” for the Johnson Street Bridge. This is based on regular usage of tug assist; the characteristics of tugs in use have adequate propulsion, and adequate navigational aids to assist mariners.

**Traffic Density**

Based on discussions with marine users and a review of newspaper articles with the bridge operator (Saanich News) the number of requested swings is estimated to remain the same. As a result the rating selected for traffic density is “light”.

**Traffic Lanes**

Due to existing topographic constraints in the waterway it is impossible to create at two way channel. Therefore provisions for a “one way channel” have been chosen.

---

5 Transport Canada has a Traffic Scheme for all of the Victoria Harbour which defines a 5 knot maximum speed
Bank Suction Effect
According to Canadian Hydrographic Chart 3412 (as illustrated in Exhibit 3) the bottom of the channel is mud and correspondingly the bank suction effect is rated as “low”.

Exhibit 3: Bank Suction Effect

![Bank Suction Effect](source: CHS Nautical Chart 3412)

Bottom Surface
The bottom surface is mud as identified on Chart 3412 and a rating and a “smooth and soft” was identified.

Cross Currents
Little if any cross current exists in this portion of the waterway and as such, a “negligible” rating (0.2) has been applied. The Canadian Hydrographical Chart 3412 indicates a maximum flow of 0.5 knots parallel to the navigational channel and no cross-current is evident.

Exhibit 4: Cross Currents

![Cross Currents](source: CHS Nautical Chart 3412)
Navigation Aid/Pilot age

The existing channel has well established aids (see Exhibit 5) to navigation and tug assist is a regular occurrence in the harbour based on discussions with marine users. A rating of “good” has been applied.

Exhibit 6: Navigational Aids

![Exhibit 6: Navigational Aids](source: CHS Nautical Chart 3412)

Cross Winds

A report by McNeal and Associates (February 2009) indicated average wind speeds of 3 to 7 knots with gusts between 20 to 30 knots. December winds from the south are the strongest reaching 17 to 21 knots up to 12% of the time. May has southwest winds of 11 to 17 knots door 20% of the time. Based on this information, a “mild cross wind” rating/parameter has been chosen.

Channel Depth

The depth draught is the ratio between the design depth and the maximum vessel draft. The design depth is 5.2m (CHS datum) which is 13% greater than the draught of the design vessel of 4.6m. The depth draught effect is 1.3. While a middle rating was identified, discussions with Seaspan International regarding channel depth and the use of the channel for the aggregate barge transits indicated that channel depth and vessel draft is not a critical issue and if required periods of either slack tide or high tide could be utilized to accommodate transits if warranted. As a result, this parameter has been reduced from 1.2 to greater than 1.5.

Horizontal Channel Alignment Design

Based on the above parameters the PIANC model reveals that a horizontal width of 40.18m would be satisfactory provided the factors utilized in the determination of the horizontal channel provided herewith are acceptable (Table 11).
### TABLE 11: Victoria Harbour: Horizontal Channel Design Recommendations

<table>
<thead>
<tr>
<th>Design Vessel</th>
<th>Tug and Barge</th>
<th>Rating</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Aggregate Barge</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td>100 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam</td>
<td>16.4 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Draught</td>
<td>5 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed</td>
<td>5 knots maximum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel Width Parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vessel Manoeuvrability</td>
<td>Good</td>
<td>1.50</td>
<td></td>
</tr>
<tr>
<td>Traffic Density</td>
<td>Light</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Traffic Lanes</td>
<td>One</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Bank Suction Effect</td>
<td>Low</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>Bottom Surface</td>
<td>Smooth and Soft</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Cross Current Effect</td>
<td>Negligible</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Cross Wind Effect</td>
<td>Mild</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Cargo Hazard</td>
<td>Low</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Navigational Aid /Pilot age</td>
<td>Good</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Depth Draft Effect</td>
<td>Greater than 1.5</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Total Factors</td>
<td></td>
<td></td>
<td>2.45</td>
</tr>
<tr>
<td><strong>Recommended Horizontal Channel Width</strong></td>
<td>16.4m</td>
<td>16.4m x 2.45</td>
<td>40.18m</td>
</tr>
</tbody>
</table>

Source: CCG NAIG and PIANC

Notes: Refer to main report for assessment details and rationalization of parameters chosen.

Based on the PIANC channel design methodology a horizontal channel width is recommended to be 40.0m.
6 Navigational Envelope Recommendations

Based on a review of existing and future vessels anticipated to transit the navigational channel connecting the Inner Harbour to the Upper Harbour in Victoria, BC, the following vertical and horizontal channel requirements are recommended to accommodate a one way navigational channel:

1. An unobstructed vertical clearance width of 34m

2. A horizontal channel width of 41m (which provides an additional 2m of channel width based on the existing timber piles in the channel)

The recommended navigational channel dimensions are shown on the following Exhibit 2.
Exhibit 2: Johnson Street Bridge Replacement Proposed Channel Dimensions
While the 41m channel is adequate to accommodate both current and future use, navigating this channel does require confirmation and approval from the Navigable Waterway Protection Program (NWPP) as well as an update to the Canadian Hydrographic Services (CHS) nautical mapping. Marine operators and the Harbour Masters office should confirm protocols associated with the request for Tug Assist (currently utilized) for transiting the channel once the new structure is in place.

It is noted that a detailed assessment of the frequency of transits has not been undertaken as part of this review and will be required during detailed design of the bridge structure to determine design loads.

**General Overview of NWPP Approval Terms and Conditions**

While this memo provides recommendations associated with the vertical and horizontal clearance requirements associated with the proposed Johnson Street Bridge Replacement Project for NWPP consideration, it is also acknowledges that proponents bidding on the construction and demolition of the existing structure should also be made aware of the general terms and conditions that NWPP will require, to assist proponents bid on this project.

Such terms and conditions will be mandatory for the selected proponent and the proponent will incur costs to meet the NWPP obligations. Such general terms and conditions are outlined below; however detailed terms and conditions will be outlined in the NWPP “Letter of Understanding” regarding the projects implementation.

- The most important component of the terms and conditions will be the proponent’s responsibility to establish and lead a communication and safety committee. The committee shall be comprised of members of marine stakeholders affected by construction and placement of the bridge and should include but is not limited to the proponent, construction contractors, Canadian Coast Guard, Marine Communications and Traffic Services, local commercial users and the Harbour Master. The committee shall be led by the proponent and or contractor and will take place on a regular basis or at intervals agreed to by the participants. Issues to be discussed include but are not limited to:
  - Communication Strategy;
  - Construction phasing and schedule;
  - Tug assist; and,
  - Issues impacting navigation during construction.

The proponent shall provide a meeting facility, prepare agendas, take and issuance of meetings and action items, document control and referencing and maintain an ongoing communications protocol throughout the entire construction and demolition process.
In addition, the proponent will be responsible for:

- All temporary piles, false works, debris, etc. are to be removed at or below the bed of the waterway (mud line) upon completion of construction and or demolition.

- The old bridge structure must be removed at completely

- Structures associated with the demolition of or construction of the bridge structure will not encroach on the navigational channel beyond the limits of the foundations works.

- Bridge footings should so far as possible not to protrude above the natural bed of the waterway. If temporary footings show above the waterway they will show above the water at all stages of the tide.

- Bridge works and protection works are to be constructed in accordance with the construction management plan.

- Debris control and removal will be the responsibility of the contractor during construction and deconstruction activities. After completion of the project, the owner shall be responsible for debris control.

- During construction warning signs shall be placed at appropriate locations in the water around the construction zone that advice small craft of work in progress.

- The proponent owner shall ensure that a qualified person is at the bridge site at all times during construction to immediately address navigational safety issues.

- The proponent shall have available a vessel capable of providing tug assist for commercial users that may require it while construction and demolition activities are ongoing.

- Prior to construction beginning and upon completion of the entire project, the proponent will conduct a multiband bank to bank survey over a distance of 200m upstream and downstream of the bridge to ascertain any impacts on deposition and/or scour in the navigable waterway. Each survey will be conducted in accordance with the Canadian Hydrographical Service Exclusive Order standards. The survey results will be reported to TC NWPP and the Victoria Harbour Master.
JOHNSON STREET BRIDGE REPLACEMENT PROJECT (JSBRP)

Marine Communication Plan (MCP)

Prepared for:
City of Victoria
Johnson Street Bridge Project

Prepared by:
TyPlan
Planning and Management
1461 IOCO ROAD
PORT MOODY, BC
V3H 2X3
SEPTEMBER 08, 2011
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1.0 PURPOSE AND SCOPE

Marine activities related to the demolition/construction of the Johnson Street Bridge Replacement Project (the Project or JSBRP), connecting the Inner and Upper Harbour’s in Victoria, British Columbia have the potential to impact on navigation during demolition/construction.

It is noted that all marine activity within the Port of Victoria are governed by the Port of Victoria Traffic Scheme (PVTS).

The JSRBP project location and traffic scheme is presented on Exhibit 1 below.

Exhibit 1: Johnson Street Bridge Project Location

The marine community, interested stakeholders and approving authorities must be made aware of and kept informed of related demolition/construction activities (the “named works” as defined by the Navigable Waters Protection Program (NWPP) of Transport Canada (TC) under the Navigable Waters Protection Act (NWPA)) potentially impacting navigation.

Demolition/construction activities are expected to commence during the fall of 2011 and continue until the fall of 2015.
This Marine Communication Plan (MCP) is intended to provide users, interest groups and regulatory approving authorities an outline of the recommended marine communication protocols between marine users, the contractor (yet to be determined), owner (City of Victoria) and the owner’s engineer (MMM Group).

The goal of the MCP is to avoid conflict between demolition and construction activities and marine navigation.

The implementation of the MCP is the responsibility of the selected contractor(s).

This MCP was prepared by TyPlan Consulting Ltd. and is based on similar MCP’s prepared for other bridge demolition/construction projects in British Columbia (i.e. the Golden Ears Bridge, the Pitt River Bridge and the Port Mann Bridge, all of which have been approved by the NWPP of TC). Discussions with officers of the NWPP as part of this process have confirmed that a similar format as outlined herewith is acceptable for the JSBRP.

This MCP acknowledges that all mariners and contractors must adhere to all the rules and regulations governing navigation within Victoria Harbour as presented on the PVTS prepared by TC.

This document represents a work in progress as details associated with selected contractor(s), marine contractors/operators; types of construction methods and equipment are to be determined. The selected contractor(s) will be responsible for the implementation of this plan.

Matters pertaining to the revision or implementation of the plan should be referred to:

Russ Tyson MPI, MCIP, PLE
TyPlan Consulting Ltd
Phone 604 461 6664 Fax 604 461 6668

russ@typlan.ca
2.0 BRIDGE DESIGN FINALIZATION

While a bridge “Reference Concept” has yet to be prepared for the Project, preliminary plans defining navigational requirements have been reviewed by NWPP and a letter of understanding has been issued.

While the letter of understanding is not an approval for demolition/construction or any works associated with the Project, the reference concept will provide a general indication of the plan and profile of the proposed bridge and defines the navigational channel which the bridge design must adhere to.

The reference concept is to be utilized by the selected contractor to develop a final design. The MMM Group (the Owners Engineer) is currently working towards a 30% complete design plan (reference concept). Exhibit 2 provides a general profile of the proposed bridge.

Exhibit 2: General Profile

All requirements associated with the bridge design and the projects construction must address all identified requirements as will be outlined by the NWPP approval for this Project.
Ongoing design updates will be required by the contractor(s) as the bridge design becomes more detailed. Submission and review of such drawing will be coordinated between the Contractor(s) and NWPP.

3.0 DEMOLITION / CONSTRUCTION SCHEDULING AND PHASING

The report entitled: Johnson Street Bridge Vertical and Horizontal Clearance Requirements Johnson Street Bridge Navigational Impact Assessment: TyPlan 2011 defines the navigational channel requirements for the JSBRP.

The NWPP supports the navigational requirements outlined in the above mentioned report (i.e. vertical and horizontal width characteristics as supported by NWPP TC) and is confirmed in the letter entitled: Letter of Understanding for Navigational Envelope Specifications for the Johnson Street in Victoria, BC (dated March 3rd, 2011) by NWPP of TC.

Throughout project demolition/construction certain “works” may infringe upon the publics’ right to navigation within this defined navigational channel. As part of this MCP, construction scheduling and related activities are considered in context to potential impacts to navigation. The selected contractor will be responsible for maintaining open and ongoing communications with marine operators and suppliers associated with demolition/construction related activities and users of the waterway.

Exhibit 3 (below) illustrates the general schedule of the demolition/construction phases of the JSBRP:

- Phase 1- TELUS duct work and removal of the rail bridge
- Phase 2- Construction of the new bridge; and,
- Phase 3- Removal of the old vehicle bridge.

A general outline of the Project phases and schedule are presented on Exhibit 3.
It is acknowledged that the selected contractor(s) will be responsible for more detailed schedules as the JSBRP related demolition/construction activities are undertaken.

Detailed weekly schedules will be required by the selected contractor(s), this MCP provides users with an overview of the demolition/construction schedule. As discussed in Section 7 of this MCP, the issuance of Notices to Shipping will provide ongoing and weekly information to marine users related to demolition/construction activities.
4.0 DEMOLITION/CONSTRUCTION STAGING AREAS

This MCP plans to limit obstructions and interferences to navigation by establishing construction staging areas. The construction staging areas are to be utilized by the selected contractor(s) during any in water works.

Exhibit 4 illustrates general areas in which the contractor(s) should attempt to direct in water works and in water barge locations to support demolition/construction.

Exhibit 4: Construction Staging Area

5.0 PERIODS PROHIBITED FROM ANY DEMOTION/CONSTRUCTION ACTIVITIES

The selected contractor(s) should be aware of the extensive number of scheduled events occurring within Victoria Harbour on an annual basis. The contractor(s) will be responsible for consulting with the Greater Victoria Harbour Authority (GVHA) and the Harbour Masters office (Transport Canada) regarding such events and confirm whether related demolition/construction activities will impact such events. According to the GVHA web site those events include (refer to Table1):
Table 1: Greater Victoria Harbour Authority: Sample Event Schedule

<table>
<thead>
<tr>
<th>EVENT</th>
<th>DATES</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCYBA Floating Boat Show</td>
<td>April 28 - May 1</td>
<td>Ship Point/Causeway</td>
</tr>
<tr>
<td>Massive Outdoor &amp; Marine Garage Sale</td>
<td>April 30</td>
<td>Ogden Point - Pier A</td>
</tr>
<tr>
<td>Opening Day Sail Past (Victoria Day Weekend)</td>
<td>May 19 - 23</td>
<td>Inner Harbour</td>
</tr>
<tr>
<td>Swift sure Int. Yacht Race</td>
<td>May 28 - 30</td>
<td>Inner Harbour</td>
</tr>
<tr>
<td>Boat for Hope</td>
<td>June 4</td>
<td>Inner Harbour</td>
</tr>
<tr>
<td>Blessing Ceremony - Land and Sea Mural</td>
<td>June 4</td>
<td>Ogden Point</td>
</tr>
<tr>
<td>International Cycling Festival</td>
<td>June 10-12</td>
<td>Ship Point</td>
</tr>
<tr>
<td>Van Isle 360</td>
<td>June 15 - 17</td>
<td>Inner Harbour</td>
</tr>
<tr>
<td>Performance On A Sailboat</td>
<td>June 16 - 18</td>
<td>Ship Point</td>
</tr>
<tr>
<td>Int’l Buskers Festival</td>
<td>July 15 - 24</td>
<td>Ship Point</td>
</tr>
<tr>
<td>Symphony Splash (BC Day Weekend)</td>
<td>July 31</td>
<td>Inner Harbour</td>
</tr>
<tr>
<td>Dragon Boat Festival</td>
<td>August 12 - 14</td>
<td>Ship Point</td>
</tr>
<tr>
<td>Classic Boat Festival (Labour Day Weekend)</td>
<td>September 2 - 5</td>
<td>Causeway</td>
</tr>
</tbody>
</table>

Source: Greater Victoria Harbour Authority

Discussions with GVHA confirmed that the key events the contractor should consider are the Symphony Splash and International Cycling Festival; however the contractor(s) will be responsible for consulting on a regular basis with the GVHA.

6.0 ASSIST TUG

The potential need to establish tug assist during demolition/construction activities to maintain commercial navigation has been identified. Securing services for such potential support is the responsibility of the contractor(s).

In instances during demolition/construction in which works either adjacent to or within the navigational channel occur that result in an infringement/restriction to navigation, a tug assist may be requested by commercial operators to enable commercial transits to occur.

The tug assist is intended to be utilized to:
1. avoid potential conflicts that may endanger the contractor’s personnel, equipment or bridge structure; as well as,

2. avoid restricting commercial navigation.

It will be critical to co-ordinate such activities with existing commercial operators operating in the area.

(Name- to be determined) has been retained by the contractor(s) as the company responsible for providing tug assists.

The typical response time of one (1) hour has been identified as adequate and it is the responsibility of the marine users to provide such advance notice to (Name).

All assists will require prior approval by the contractor(s), but such requests will not be unreasonably withheld (refer to table 2).

Table 2: Tug Assist

<table>
<thead>
<tr>
<th>Company</th>
<th>Name</th>
<th>Position</th>
<th>Dispatch Number</th>
<th>Cell Phone</th>
<th>24 Hour Home</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Dispatch number provides 24 hour service

In the unlikely event that (Name) cannot be contacted, (Name) should be contacted. The contact is:

- 
- 
-
7.0 NOTICE TO MARINERS AND NOTICE TO SHIPPING

In support of ongoing marine communications there will be a requirement for the contractor(s) to provide both a “Notice to Mariners” and “Notice to Shipping” to the marine community to inform marine users of demolition/construction activities and schedules within and or abutting to the navigational channel.

The “Notice to Mariners” provides a more general overview of construction related works, usually associated with construction activities over a longer period of time.

The “Notice to Shipping (Not ships)” provides specific construction related activities. Correspondingly, when major construction activities related to the JSBRP are scheduled that have the potential to impact navigation within or adjacent to the navigational channel, a “Notice to Shipping” will be advertised.

Such notices, when submitted to Marine Communications and Traffic Services (MCTS) of the Canadian Coast Guard (CCG) will be published in the western edition of the Department of Fisheries and Oceans: Notices to Mariners; Western Publication, published monthly by the Canada Coast Guard.

The frequency of such “Notice to Shipping” will be dependent upon construction activities but in general will be provided weekly during such active demolition/construction periods.

During periods of construction within or adjacent to the navigational channel occur, placement of “No Wake” signs will be mandatory on all construction equipment in the wetted areas.

8.0 RECREATIONAL USER POSTING REQUIREMENTS

The selected contractor will be responsible for posting demolition/construction notices at all public wharfs and marinas within the Port of Victoria’s jurisdictional boundaries informing users of activities which may potentially impact navigation throughout the demolition/construction period.

9.0 MARINE CONSTRUCTION CONTRACTOR

In the event that either tug assist operator is unavailable the contractor(s) should be contacted directly at the following numbers (refer to table 3):

**Table 3: Marine Construction Contractor Contact Information**

<table>
<thead>
<tr>
<th>Company</th>
<th>Name</th>
<th>Position</th>
<th>Number</th>
<th>Cell Phone</th>
<th>24 Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
10.0 MARINE CONSTRUCTION METHODS AND RELATED EQUIPMENT

It is expected that the following types of marine construction methods will be utilized in the demolition/construction of the bridge:

- 
- 
- 

The types of marine construction methods will be presented to stakeholders as part of the MCP.

11.0 RADIO COMMUNICATIONS

VHF marine radios will be monitored on Channel 18A by the Harbour Master's office for operations within Victoria Harbour.

For vessels requesting a lift of the Johnson Street Bridge the City of Victoria Bridge Operator maintains an open channel on VHF Channel 12 during the hours of: 09:00-16:00.

The bridge does not open from 07:00-09:00 and 16:00-18:00 to accommodate vehicular traffic.

If marine users request an opening when the operator is not working the marine operator should call the City of Victoria at 1 250 385 5717.

The contractor will be responsible for identifying a channel to monitor as it relates to interfacing demolition/construction activities with ongoing marine operations, especially commercial marine operations.

The contacts are presented below.
### Table 4: Radio Communications for the JSBRP

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact/Position</th>
<th>Call Sign</th>
<th>Phone Number</th>
<th>24 Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Harbour Masters Office</strong></td>
<td>Dave Featherby</td>
<td>18A</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bridge Operator</strong></td>
<td>City of Victoria</td>
<td>16</td>
<td></td>
<td>(24 hours)</td>
</tr>
<tr>
<td><strong>Bridge Operator</strong> (after hours)</td>
<td>Transport Canada</td>
<td>18A</td>
<td>250-385 5717</td>
<td></td>
</tr>
<tr>
<td><strong>Contractor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 12.0 AIDS TO NAVIGATION

As part of the construction of the JSBRP ongoing discussions with MTCS of the DFO will be required to confirm the navigational aids.

### 13.0 JOHNSON STREET BRIDGE MARINE COMMUNICATIONS GROUP (JSBMCG)

It is the intent of the MCP to provide marine users with a clear and ongoing indication of restrictions to navigation throughout the demolition/construction period. Monthly meetings and updates of such demolition/construction activities and work schedules will be required and presented to the marine community via the creation of a Johnson Street Bridge Marine Communication Group (JSBMCG).

The JSBMCG will meet monthly throughout the demolition/construction period or at regular intervals agreed to by the JSBMCG. The ongoing JSBMCG is intended to inform users of such demolition/construction related activities impacting navigation.

Details associated with the JSBMCG and its participants will be formalized via discussions and monthly meetings to be initiated in October 2011. Representatives from the following groups are suggested to be included in the JSBMCG:

1. Harbour Masters Office Port of Victoria Transport Canada
2. City of Victoria (owner)
3. Navigable Waters Protection Division (NWPD)
4. Representative from the selected Contractor
5. Ministry of Transportation
6. Seaspan Victoria
7. Point Hope Shipyard
8. Lefarge Cement
9. Ocean Cement

The contractor will be responsible for communicating with a larger user group to ensure a comprehensive and inclusive list of users are included on the JSBMCG.

14.0 CLOSURE

This document was prepared as a component of the approval documentation for the JSBRP. The content of this document is based on the experience of TyPlan in regard to the preparation and implementation of MCP and the development of Policy Position papers for NWPP.

As more site-specific information about local marine conditions, related response procedures, and design/construction activities becomes available, this MCP will be updated.

It will be necessary to modify and reissue the document, as it currently represents a work in progress. It is acknowledged that this MCP forms part of the eventual approval from NWPP for approval of the project it should be subsequently circulated to approving agencies and regulatory agencies that will comment on the MCP.

Revision and redistribution of the MCP will be carried out as specified by the document control system in the contractors Project Quality Plan.

City of Victoria

Approved by:

______________________________ 
Date
July 18th 2011

Re: Design Update for the Johnson Street Bridge Project

Dear Sir:

As a follow up to your letter dated March 3, 2001 re: Letter of Understanding for Navigation Envelope Specifications for the Johnson Street Bridge, Victoria, British Columbia, we are writing to provide your office an update on the evolving design of the proposed Johnson Street Bridge for the purpose of providing the potential contractors ultimately bidding on the construction of the bridge a reference concept upon which detailed design will be undertaken.

Accordingly, we provide the following exhibit entitled: Johnson Street Bridge Replacement: L10 Johnson Street Bridge Profile Clearance Envelope, for your review, comment and files.

As noted on the exhibit, the design continues to provide for a 41m horizontal clearance and an unimpeded vertical clearance when the bascule is opened, however we note that while the design provides for a 5.75m air draft clearance when closed (measured from the centreline of the navigational channel to the western rest pier), the structural design of the bridge requires a slight structural curvature for the pedestrian walkway on the southside of the bridge, impacting the vertical clearance of the bridge in a closed position from the centreline of the navigational channel to the eastern bascule pit structure (see exhibit and refer to finished profile grade bascule which provides for an existing closed vertical clearance of 5.586m and a proposed vertical clearance of 5.75m at the western fender (immediately east of station 10+321.899), 5.75m mid channel and 4.828m at the extreme eastern portion of the channel, the site at which the bascule bridge is raised, measured a HHLW (1.522m)).
While it is not anticipated that this design impacts navigation channel nor interfere with the public’s right to navigation, we have undertaken a number of consultations with the key marine users to verify that the design as proposed does not impact current or future navigational requirements. The comments received by various users are provided in the table below for your reference:

### Exhibit 1: User Comments Re: Proposed Johnson Street Bridge Bascule in a closed Position

<table>
<thead>
<tr>
<th>User</th>
<th>Contact</th>
<th>Comment Provided by Operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seaspan</td>
<td>250.920.7924</td>
<td>Seaspan was contacted and provided a copy of the exhibit. Upon review he confirmed that this would not impact Seaspan operations (confirmation 07/07/2011)</td>
</tr>
<tr>
<td></td>
<td>Kevin Ashley</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Superintendent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vancouver Island Marine Operations</td>
<td></td>
</tr>
<tr>
<td>Ocean Cement</td>
<td>(250) 382-8121</td>
<td>Rocky was contacted and provided a copy of the exhibit. Upon review he indicated that his operations would not be impacted (confirmation via phone 07/07/2011)</td>
</tr>
<tr>
<td></td>
<td>Rocky Collins,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operations Manager</td>
<td></td>
</tr>
<tr>
<td>Lafarge Cement</td>
<td>250-388-4181</td>
<td>Dale indicated all of his operations require a lift of the Johnson Street Bridge and no impacts would result in a closed position (confirmation provide 07/07/2011)</td>
</tr>
<tr>
<td></td>
<td>Dale Neilson</td>
<td></td>
</tr>
<tr>
<td>SALT</td>
<td>(250) 383-6811</td>
<td>As the company operates two tall ships a lift is required regardless of the vertical clearance of the Johnson Street. No impacts identified. (call made 06/07/2011)</td>
</tr>
<tr>
<td>Pacific Steel Recycling</td>
<td>250-381-5865</td>
<td>Pacific Steel Recycling utilizes Seaspan’s fleet of barges for operations and deferred to Seaspan</td>
</tr>
<tr>
<td>Point Hope Maritime</td>
<td>250 385-3623</td>
<td>Hank indicated that the closed vertical clearance would not impact his operations (call made 06/07/2011)</td>
</tr>
<tr>
<td></td>
<td>Hank Bekkering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Manager</td>
<td></td>
</tr>
<tr>
<td>Greater Victoria Harbour Authority</td>
<td>Ian Crocker, Manager of Operations 250.383.8300 ext. 223</td>
<td>Ian was provided a copy of the exhibit and confirmed by phone that the design would not impact marina operations upstream of the proposed Johnson Street Bridge Replacement (call made 06/07/11)</td>
</tr>
</tbody>
</table>
As illustrated above it would appear that the design as illustrated on the attached exhibit does not impact nor infringe on neither the public navigation nor the commercial operators right to navigation.

Accordingly, we would respectfully request written confirmation from your office acknowledging this design modification (attached exhibit) is acceptable to your office and that no anticipated navigational concerns have been identified by the users.

As outlined the purpose of requesting such a letter from your office is to provide contractors certainty in relation to undertaking detailed design, as the construction process evolves.

If you have any questions please do not hesitate to contact the undersigned at 604 461 6664.

Yours truly,

Russ Tyson, M.PI, MCIP, PLE
TyPlan Consulting Ltd.

Attached

CC:
Joost Meyboom: Dr.sc.tech., P.Eng., Practice Lead - Western Canada, Project Delivery and Management
Partner
Jim Fowler, P.Eng: Project Manager, MMM Group
Mike Lai: City of Victoria
VEssel-Bridge Collision Risk And Associated Forces
Johnson Street Bridge, Victoria, BC

July 14, 2011

By
Ricardo O. Foschi, P.Eng
3806 West 36th Ave.
Vancouver, BC

1. Introduction

The methodologies for the determination of the expected number of collisions per year, between vessels and the bridge piers, and for the resulting collision forces, are specified both in the Code AASHTO (2010) as well as in CSA-S6 (2010). Both Codes essentially contain the same provisions, differing in the system of units used in the prescribed equations. The methodologies followed here agree with those specified in AASHTO (2010), with modifications as described in the sections where implemented. These modifications refer to the specific introduction of a probabilistic approach for the calculation of geometric probability of collision, for the estimation of the probabilistic distribution of collision forces and the bridge collapse probability. Both AASHTO (2010) and CSA-S6 (2010) allow the possibility of using such a probabilistic approach rather than their calculation equations.

2. Expected Number of Collisions/year

Following AASHTO (2010), the expected number of collisions per year, or annual frequency AF, is calculated as follows:

\[
AF = N P_A P_G
\]

in which

\[N = \text{number of a vessel trips per year (traffic) or crossings at the bridge location;}\]

\[P_A = \text{probability of aberrancy, or the probability that a vessel will be out of control and likely to be involved in a collision incident;}\]

\[P_G = \text{geometric probability that an out of control vessel vessel will collide with a pier.}\]

The number N is obtained from traffic data for the different types of vessels involved. The probability of aberrancy \(P_A\) is calculated according to

\[P_A = R R_B R_C R_{XC} R_D\]
in which, according to AASHTO (2010):

\[ R = \text{basic rate of aberrancy, specified as } R = 1.2 \times 10^{-4} \text{ for barges and } R = 0.6 \times 10^{-4} \text{ for ships (tall ships in this report);} \]

\[ R_B = \text{adjusting coefficient for location of the bridge and the alignment of the navigation channel. For a transition zone location, applicable to this bridge,} \]

\[ R_B = 1.0 + \theta^\circ/90^\circ, \theta^\circ \text{ being the angle of the transition in degrees;} \]

\[ R_C = \text{adjusting coefficient for current parallel to the vessel transit path,} \]

\[ R_C = 1.0 + \frac{V_C}{10.0}, V_C \text{ being the current velocity parallel to the vessel transit path, in knots, at the time of the collision. Although this velocity varies randomly with the tides, the coefficient } R_C \text{ is calculated for the velocity corresponding to high tide.} \]

\[ R_{XC} = \text{adjusting coefficient for cross-currents, perpendicular to the vessel transit path,} \]

\[ R_{XC} = 1.0 + V_{XC}, V_{XC} \text{ being the cross-current velocity in knots.} \]

\[ R_D = \text{adjusting coefficient which depends on the traffic density. The value used here for this coefficient is } R_D = 1.0, \text{ corresponding to low density traffic, for which vessels rarely meet, pass or overtake each other in the immediate vicinity of the bridge.} \]

The conditional probability \( P_G \) corresponds to the geometric possibility of collision with a pier, given the distance between the pier and the centreline of the navigation channel, the pier dimensions and the vessel’s length and beam. Here \( P_G \) is calculated with the probabilistic treatment described in Section 2.1. The procedure utilized here takes into account the possibility of the vessel approaching the pier at an angle to the navigation channel direction.

The annual collision frequency \( AF \) is calculated for each pier, for a set of different scenarios, each associated with a vessel type, navigation up-channel or down-channel.

For up-channel (towards the north) or down-channel (towards the south) travel, the bridge is located in a transition zone according to AASHTO (2010). The angle \( \theta^\circ \) for down-travel is \( \theta^\circ = 45^\circ \), and for up-travel \( \theta^\circ = 90^\circ \), resulting in corresponding coefficients \( R_B = 1.5 \) and \( R_B = 2.0 \).

The maximum tide current velocity is 0.5 knot. Thus the coefficient \( R_C = 1.05 \). There is negligible cross-current at the bridge location, thus \( V_{XC} = 0.0 \) and \( R_{XC} = 1.0 \).
2.1 Geometric Probability $P_G$

The following describes the probabilistic approach to calculating $P_G$, implementing the objective in AASHTO (2010). Figure 1 shows a vessel of length $L$ and beam $B$ near the pier. The distance between the edge of the pier and the centreline of the channel is $Z$. At the time of crossing, the vessel position is identified by the coordinate $s$ and the angle $\alpha$. The distance $s$ is measured between the centre of the vessel and the centreline of the navigation channel.

![Figure 1. Vessel and Pier Locations to Determine Geometric Probability $P_G$](image)

From Figure 1, the vessel will not collide with the pier if it is completely to the left of the vertical line at a distance $Z$ from the channel centreline. The probability of colliding is then calculated by

$$P_G = 1.0 - P_{\text{not colliding}}$$

(3)

The calculations were implemented in the general reliability software RELAN (Foschi, 2000), and were obtained for each type of vessel or collision scenario.

The probability $P_{\text{not colliding}}$ is obtained by using RELAN with the performance function $G$,

$$G = s + \frac{L}{2}\sin \alpha + \frac{B}{2}\cos \alpha - Z$$

(4)

which satisfies $G < 0$ when there is no collision.
Random variables are the vessel location \( s \) and the angle \( \alpha \). The distribution of \( s \) is assumed Normal, with mean = 0 and a standard deviation equal to the length of the vessel, \( L \). The latter follows recommendations in AASHTO (2010). The angle \( \alpha \) is also assumed Normal, with a mean = 0 (straight-on crossing) and a standard deviation of 10° (approximately equivalent to assuming that 95% of the time the angle \( \alpha \) will be between –20° and +20°). The absolute value of the angle is used in Eq.(4).

The distance \( Z \) is
- For all vessels except SALTS tall ships, \( Z = 20.5 \text{m} \) (half of the navigation channel width of 41m).
- For the SALTS tall ships, the PG is calculated using a distance \( Z = 13.5 \text{m} \) (distance from the centreline of the channel to the tip of the open bridge, allowing for an unimpeded vertical clearance channel width of 34.0m). The with B for the SALTS tall ships corresponds to that for which there must be an unimpeded vertical clearance to avoid collisions between the open bridge tip and the ship superstructure, including the mast and the mast shrouds).

3. Probability Distribution of Collision Force \( F \), Conditional on a Collision Taking Place

The collision force was estimated using the AASHTO (2010) equation

\[
F = 8.15 V (DWT)^{1/2}
\]

in which \( DWT \) is the dead weight tonnage of the vessel (in tonnes), and \( V \) is the vessel collision velocity (relative to the pier) in ft/sec. The constant 8.15 calibrates the units of \( F \) to Kips.

The approach followed here is to use Equation (5) for each vessel but considering the randomness in the velocity \( V \). Let the vessel velocity relative to the pier be \( V_T \) when navigating along the centreline of the channel, and let current velocity be \( V_C \). If \( V_W \) is the vessel’s velocity with respect to the water, then \( V_T = V_W + V_C \). The velocity \( V_C \) corresponds to tidal effects, varying between a maximum of 0.844 (0.5 knots) and a minimum of -0.844 ft/sec (-0.5 knots). It is assumed that navigation could take place either with or against the tide, with no restrictions. Both CSA-S6 (2010) and AASHTO (2010) allow that the actual vessel velocity \( V \) at the time of crossing varies with the random position \( s \) of the vessel (shown in Figure 1), between a maximum \( V_T \) and a minimum equal to the current velocity \( V_C \). This variation is shown in Figure 2, where \( X_C \) is half of the navigation channel's width. Here, the navigation channel width is 41.0 m. The Codes assume that the minimum velocity \( V_{MIN} \) is reached if the vessel’s path is 3L away from the channel’s centreline. \( V_{MIN} \) is equal to the current velocity \( V_C \), and \( s \) has the same probability distribution used for the calculation of \( P_G \). In order to apply the velocity reduction shown in Figure 2, however, the distance \( s \) must be within the zone leading to a collision.
The software RELAN was utilized to obtain the probability that the force $F$ will exceed a level $F_0$ (all in Kips), conditional on a collision having occurred for a given scenario. The calculation implemented Eq.(5) into the performance function $G$, 

$$ G = F_0 - 8.25(DWT)^{1/2} f(s) $$ (6)

in which $f(s)$ is defined as follows, from Figure 2,

$$ f(s) = \begin{cases} V_T & \text{if } s < X_C \\ V_T + \frac{V_C - V_T}{3L-X_C} (s-X_C) & \text{if } X_C < s < 3L \\ V_C & \text{if } s > 3L \end{cases} $$ (7)

$V_W$ was considered a random variable, Normally distributed, with a mean value of 3.85 knots (6.5 ft/sec) and a standard deviation of 0.385 knots (0.65 ft/sec). Thus, the “maximum” speed is $V_W = 5.0$ knots (8.44 ft/sec), calculated at the mean + 3 standard deviations, agreeing with
maximum speed requirements by Transport Canada for the Victoria Harbour. To maintain steerage, however, it was assumed that $V_W$ has a minimum of 2.5 knots (4.2 ft/sec).

4. **Total Probability Distribution of Collision Force $F$.**

Equation (6) represents the performance function used in RELAN to obtain the probability with which $F > F_0$, for different values of $F_0$. This probability, $P_E (F > F_0)$, correspond to the conditional case that a collision event has taken place. To obtain the probability of the force $F$ exceeding $F_0$ in a time $T$, $P_T (F > F_0)$, the event probability $P_E (F > F_0)$ must be modified to take into account the likelihood that a collision event will occur in time $T$, given by the frequency $AF$ and the exposure $T$ in years. The Codes offer the following equation to achieve the modification:

$$P_T (F > F_0) = AF T P_E (F > F_0)$$

(10)

This calculation is performed for each collision scenario $i$ ($i = 1, \ldots, N$), resulting in a total probability of the maximum force $F$ exceeding the level $F_0$ in $T$,

$$P_T (F > F_0) = \sum_{i=1}^{N} AF_i T P_{E_i} (F > F_0)$$

(11)

Each of the terms in Equation (11) corresponds to the contribution from each scenario to the total probability over the time $T$. The terms can also be used to identify a “design or controlling condition” as that combination with the largest contribution.

The results shown here assume an exposure of $T = 1$ year and are, therefore, *annual probabilities of exceedence of the level $F_0$*. In particular, a force with a 10000 year-return period can be obtained by calculating that force level with an exceedence probability of $1.0 \times 10^{-4}$, as required by AASHTO (2010), and also CSA-S6 (2010), for *critical or essential bridges*.

In the calculations here, the value $F_0$ was varied, calculating each time the annual exceedence probability $P_T (F > F_0)$, until the level $F_0$ corresponding to a desired exceedence probability could be interpolated.

5. **Probability of bridge collapse**

Applying a load $F$ greater than the pier capacity $C$ does not necessarily produce total collapse but intermediate states of damage, so that the probability of total collapse is generally less than 1.0. Thus, $F = C$ designates a situation separating no collapse from levels of damage of
increasing severity, approaching an actual collapse when the capacity \( C \) is much smaller than the load \( F \).

This is recognized by the Codes. Thus, AASHTO (2010) and CSA-S6 (2010) include a graph to estimate the probability of total collapse should the pier capacity \( C \) be less than the demand \( F \). This graph shows that: 1) when \( F = C \), or \( C/F = 1.0 \), the probability of collapse is 0.0; 2) if the load \( F \) is greater than the capacity \( C \), that is, when the ratio \( C/F \) is less than 1.0, the probability of total collapse increases, reaching 0.1 when the ratio \( C/F \) is 0.1; 3) if a larger force \( F \) is applied, or when \( C/F \) is less than 0.1, the probability of total collapse continues to increase until, as the ratio \( C/F \) approaches 0.0, that probability approaches 1.0. This graph can be seen to represent a conditional probability of collapse, given a capacity \( C \) and a force \( F \) under the condition that \( F > C \).

Using this conditional probability, the total probability of collapse for the bridge, for a given \( C \), is obtained by integration over all possible \( F > C \), given \( C \):

\[
P_{\text{collapse}} = \left\{ \int (P_{\text{collapse}} | C > F) \cdot f(F)_{F>C} \cdot dF \right\} \cdot P(F > C)
\]  

(12)

In which \( P_{\text{collapse}} | C > F \) is the conditional probability of collapse from the Code, and \( f(F)_{F>C} \) is the probability density function for the force \( F \) on the condition that \( F > C \).

The probability that the force \( F \) will exceed a level \( C \), \( P(F > C) \), was calculated with RELAN using a performance function

\[ G = C - F \]  

(13)

from which, after calculating this probability for different levels \( C \), according to Sections 3 and 4 of this Report, the distribution \( F(F) \) of the force \( F \) was obtained. This distribution was represented by an Extreme Type I with parameters \( a \) and \( b \), as follows

\[ F(F) = \exp\left\{- \exp\left[- a(F - b) \right]\right\}
\]  

(14)

The probability density \( f(F) \) can be obtained from Eq.(14) by differentiation with respect to \( F \). The censored distribution to be used in Eq.(12) is obtained from

\[ f(F)_{F>C} = \frac{f(F)}{1.0 - F(C)} \]  

(15)

The Extreme Type I distribution obtained by fitting the collision force results is shown in Figure 3, with the parameters
The probability of pier collapse, $P_{\text{collapse}}$, was calculated with Eq.(12) (via numerical integration) for different values of the capacity $C$. The required design capacity was obtained in correspondence with a probability of collapse of $1.0 \times 10^{-4}$, as required by either AASHTO (2010) or CSA-S6 (2010) for this type of bridge.

6. SALTS tall ships

The AF results are shown for each vessel in Table 1 and correspond to the annual probability that a collision could occur. In the case of SALTS tall ships, this probability is related to the possibility that the vessel could be beyond 13.5m from the centerline of the channel, or outside the 34.0 width of the unimpeded vertical clearance zone. Thus, for Case 11, for the Pacific Grace ship travelling north, the probability of colliding with the tip of the open bridge is $0.0029$ (a 345-year return event), and for the same vessel travelling south, $0.0022$ (a 454-year return event).
return event). The Codes do not specify a tolerable exceedence probability for this case, but it would appear that these events are associated with sufficiently long return periods.

7. Results and Conclusions

The different collision scenarios are shown in Table 1. Cases 11 and 12 correspond to the SALTS tall ships and are not included in the estimation of collision loads, and only in the estimation of violating a required, unimpeded vertical clearance to avoid collisions between the tip of the open bridge and the vessel. Table 1 also shows the traffic data, segregated into travelling up (towards the north, U) or down (towards the south, D). This distinction has to be made because the coefficient $R_B$ in Eq.(2) changes with the direction of travel. The geometric probability of collision, $P_G$, is a conditional probability in case the vessel is out of control. As shown in Table 1, these probabilities are fairly high, reflecting the relative narrowness of the navigation channel in relation to the length and beam of the vessels. Finally, Table 1 shows the annual frequencies $A_F$, according to Eqs. (1) and (2).

Table 2 shows the collision loads (considering all first 10 scenarios) at three exceedence probability levels. The scenario that contributes the most at each probability level is shown as the “controlling scenario”. At higher exceedence probabilities, scenario 3 controls (the Seaspan barge travelling north (with a sharp bend in the navigation channel)), which, although it does not have the largest DWT has a large annual number of trips. At the lower exceedence probabilities, leading to higher loads, the scenario 5 controls (the EVCO 60-61 also travelling north). This barge, has a much larger DWT even if the number of annual trips is smaller than those for the Seaspan.

The bridge collapse probability has been estimated using the procedure allowed in both AASHTO (2010) and CSA-S6 (2010), as previously described in Section 5. Table 3 presents the results for the bridge lateral load capacity at a collapse probability of $1.0 \times 10^{-4}$, required by the Codes for critical or essential bridges. It is seen that lateral capacity does not have to be designed according to the $1.0 \times 10^{-4}$ collision load from Table 2 (5,743 Kips) but for a lower capacity of 3,990 Kips.

8. References:


Table 1. Collision Scenario Cases, Traffic Data, Geometric Probability $P_G$, Annual Frequencies $AF$

<table>
<thead>
<tr>
<th>Case</th>
<th>Vessel Type</th>
<th>Vessel Type</th>
<th>DWT (tonnes)</th>
<th>Length $L$ (m)</th>
<th>Beam $B$ (m)</th>
<th>Travelling Direction</th>
<th>N/year</th>
<th>$P_G$</th>
<th>AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lafarge Warrior Aggregate barge</td>
<td>2800</td>
<td>59.8</td>
<td>14.9</td>
<td>U</td>
<td>55</td>
<td>0.4400</td>
<td>0.0061</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Lafarge Warrior Aggregate barge</td>
<td>2800</td>
<td>59.8</td>
<td>14.9</td>
<td>D</td>
<td>55</td>
<td>0.4400</td>
<td>0.0046</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Seaspan Flat deck barge</td>
<td>3200</td>
<td>60.9</td>
<td>16.5</td>
<td>U</td>
<td>1095</td>
<td>0.4468</td>
<td>0.1232</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Seaspan Flat deck barge</td>
<td>3200</td>
<td>60.9</td>
<td>16.5</td>
<td>D</td>
<td>1095</td>
<td>0.4468</td>
<td>0.0925</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Ocean Cement EVCO 60-61 Aggregate barge</td>
<td>5500</td>
<td>78.0</td>
<td>18.9</td>
<td>U</td>
<td>52</td>
<td>0.4706</td>
<td>0.0062</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ocean Cement EVCO 60-61 Aggregate barge</td>
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<td>9</td>
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<td>30</td>
<td>0.4588</td>
<td>0.0035</td>
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<td>11</td>
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<td>6.7</td>
<td>U</td>
<td>54</td>
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<td>0.0029</td>
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<tr>
<td>12</td>
<td>SALTS Pacific Grace Tall ship</td>
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<td>D</td>
<td>54</td>
<td>0.4318</td>
<td>0.0022</td>
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Notes:
- Beam $B$ for SALTS Pacific Grace corresponds to width for unimpeded vertical clearance to avoid collision with the bascule bridge when opened.
- $P_G$ is the conditional probability that the vessel, out of control, would be beyond 20.5m from the centreline of the navigation channel. For the SALTS Pacific Grace tall ship, $P_G$ is the conditional probability that this vessel, out of control, would be beyond 13.5m from the centreline of the channel with the bridge open.
- $AF$ is the annual frequency or probability for a vessel being at risk of collision.
Table 2. Collision Force (Kips, MN) at Annual Exceedence Probabilities of $1.0 \times 10^{-2}$, $1.0 \times 10^{-3}$ or $1.0 \times 10^{-4}$

<table>
<thead>
<tr>
<th>Collision Force</th>
<th>Exceedence Probability</th>
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<td>$1.0 \times 10^{-2}$</td>
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<tr>
<td>Kips</td>
<td>4008.0</td>
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<tr>
<td>MN</td>
<td>17.8</td>
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<td>Controlling Scenario</td>
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</table>

Table 3. Required Capacity (Kips, MN) at Annual Collapse Probability of $1.0 \times 10^{-2}$, $1.0 \times 10^{-3}$ or $1.0 \times 10^{-4}$

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Collapse Probability</th>
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</thead>
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<tr>
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<td>$1.0 \times 10^{-2}$</td>
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<tr>
<td>Kips</td>
<td>1316.0</td>
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<tr>
<td>MN</td>
<td>5.8</td>
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</table>

(*) = Level required by AASHTO 2010 for critical or essential bridges.

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