nhc
northwest hydraulic consultants

Project: 3000184
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Attention: **Bruce Fischer, P.Eng.**
Via Email: Bruce.Fischer@parsons.com

Subject: **False Creek Ferries**
Hydrotechnical Design Criteria

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1 INTRODUCTION

Parsons is providing marine engineering services to the Canada Mortgage and Housing Corporation (CMHC). As part of this support Parsons is in the process of developing a request for proposals (RFP) for a landing float on Granville Island (Vancouver, British Columbia) for the False Creek Ferries. Northwest Hydraulic Consultants Ltd. (NHC) was retained by Parsons to develop hydrotechnical performance specifications to be included in the RFP. The specifications NHC is to provide are as follows:

- Design water levels
    - high high water large tide and mean tide (HHWLT, HHWMT)
    - low low water large tide and mean tide (LLWLT, LLWMT)
    - 50 year and 200 year return period water levels,
    - expected sea level rise (SLR) to year 2100
- Design waves
    - 50 year and 200 year return periods
    - significant wave height and period
- Design wind velocity and pressure
- Design current speed
- Elevation of the bed at the project site.

This report documents these specifications and their development. The study location is the False Creek Ferry Float shown in the following figure.

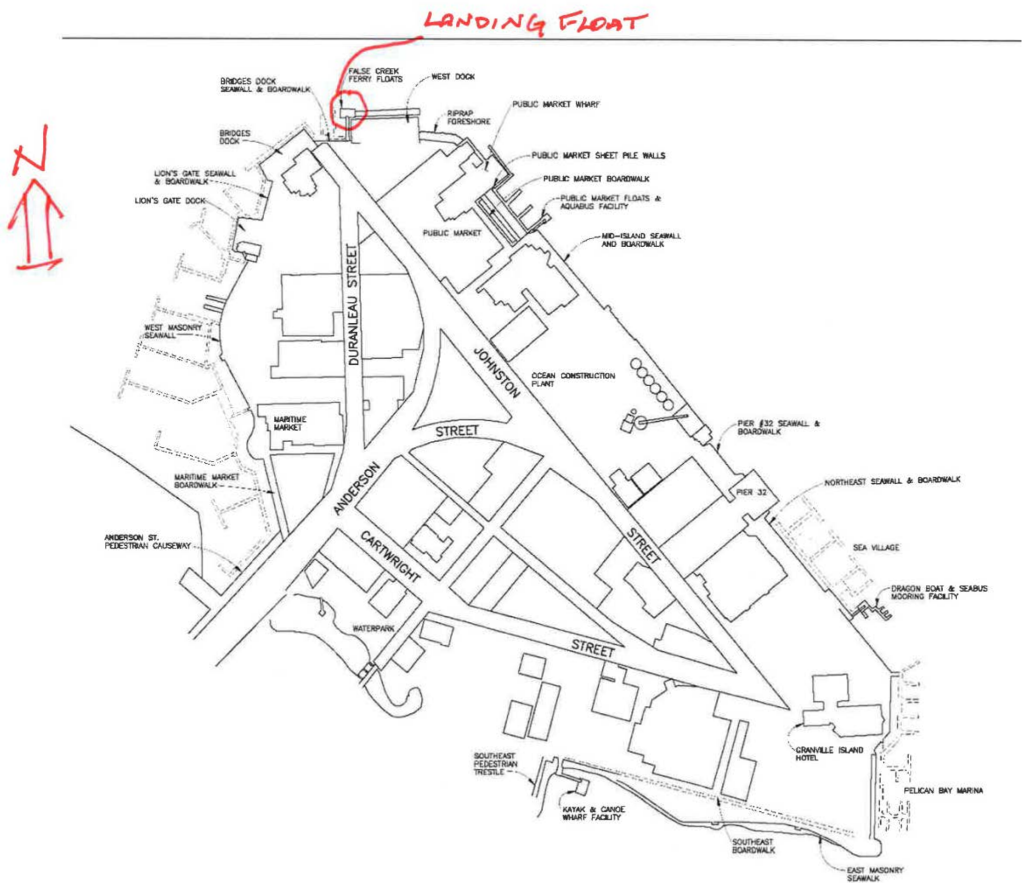


Figure 1. Project location (landing float at south side of False Creek)

2 DESIGN WATER LEVELS

Characteristics of the water levels in False Creek, including typical tides, difference between chart and geodetic datum, and expected sea level rise by 2100 are presented in the following table. In addition, extreme water levels are provided in the table including the highest water level on record and the estimated water levels associated with a 50 and 200 year combined tide and storm surge events.

HHWLT, LLWLT, MWL, Record Extreme High Water and the difference between chart datum (CD) and geodetic datum (GD) are based on information available from the Point Atkinson tide gauge operated by the Canadian Hydrographic Service.

Expected sea level rise by 2100 is based on guidance in the BC Provincial Sea Dike Guidelines (2011).

Water levels associated with a 50 and 200 year combined tide and storm surge events were calculated by applying extreme value theory to a synthesised historical record of water levels in False Creek. Water level measurements from Point Atkinson were used to represent the tidal and external storm surge components of the water level. Local wind generated surge within False Creek was computed using local wind measurements. Wave setup was calculated using the parametric approach to the Direct

Integration Method. The tidal, external surge, local wind surge, and wave setup components were summed to give an estimate of the historical record of water level in False Creek over the last 50 years.

Extreme events were defined by applying the peak over threshold approach of extreme value theory to the synthesized historical record. A threshold of 2.2 m was applied to the data yielding 61 storms for fitting. A Generalized Extreme Value distribution was applied to estimate the water levels associated with the 50 and 200 year return periods. The following table presents the water levels for both Chart Datum (CD) and Geodetic Survey of Canada (GSC).

Table 1. Design water levels at False Creek Ferry Float (m)

Level	Elev. (CD)	Elev. (GSC)
HHWLT	5.1	2.0
HHWMT	4.4	1.3
MWL	3.1	0
LLWMT	1.2	-1.9
LLWLT	0.0	-3.1
Record Extreme High Water	5.6	2.5
Est. 50 Year High Water	5.7	2.6
Est. 200 Year High Water	5.9	2.8
Geodetic Datum	3.1	0
Sea Level Rise (2100)	+1	+1

3 DESIGN WAVES

A non-calibrated two dimensional numerical coastal wave model was used to generate and transform waves to the study site. The model is driven by wind fields derived from measurements at weather stations throughout the Georgia Basin.

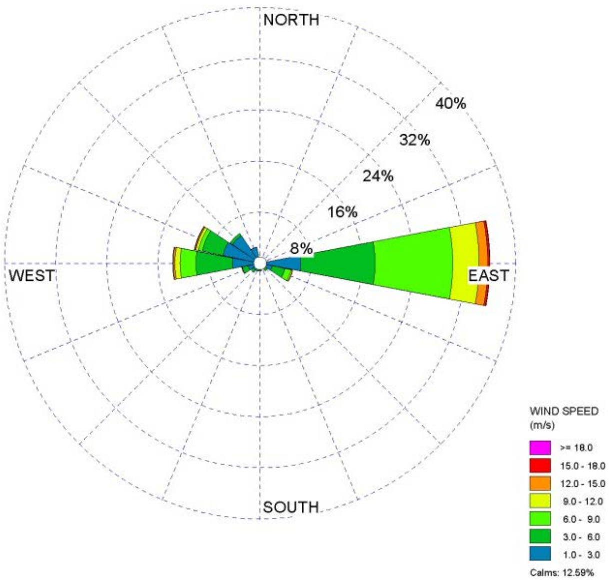
The model was used to hind-cast waves over a 50 year period. Extreme events were defined by applying the peak over threshold approach of extreme value theory to the dataset. The period and direction of the design wave events were specified based on the prevailing relation between significant wave height and these parameters during large events. The following table presents the 50 and 200 year design significant wave heights; with primary wave direction referencing the direction the waves come from.

Table 2. Design wave parameters for 50 and 200-year return period

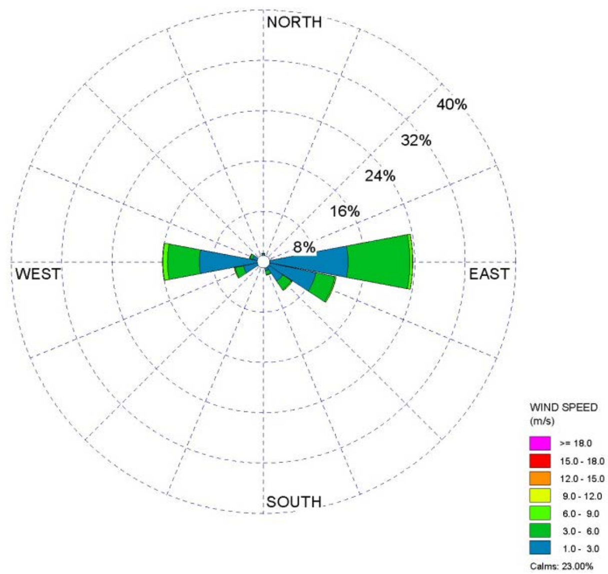
Parameter	50-Yr	200-Yr
Significant Wave Height	0.5 m	0.6 m
Peak Wave Period	2 to 3 s	2 to 3 s
Primary Wave Direction	325^{o}	325^{o}

4 DESIGN WIND VELOCITY

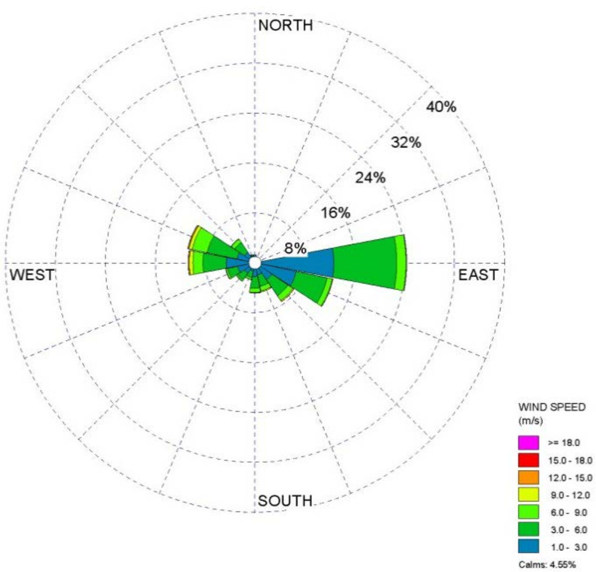
Wind data near the study area is available from Point Atkinson (12 km northwest of the study area), Vancouver Harbour (2.5 km north of the study), and Vancouver International Airport (YVR) (9.5 km southwest of the study area). These climate stations provide hourly climate records as summarised in **Table 3**. **Figure 2** provides wind rose plots of the wind distribution from each station. The plots show the wind predominantly comes from the east.



a) Point Atkinson



b) Vancouver Harbour



c) Vancouver Int’l Airport (YVR)

Figure 2. Wind distribution plots (wind rose)

Table 3. Wind data source from Meteorological Service of Canada

Station	Station ID	Station Location	Period
Point Atkinson	1106200	480768 E 5464953 N	1997–2013
Vancouver Harbour	1108446	491139 E 5460297 N	1976-1988, 1994
Vancouver Int'l Airport	1108447	486744 E 5449149 N	1953–1958, 1961–2013*

*No data is available for the period between 1959 and 1961.

Extreme events were defined by applying the peak over threshold approach of extreme value theory to the historical records. A Generalized Extreme Value distribution was then applied to estimate the wind speed associated with the 50 and 200 year return periods. Design wind events from the Point Atkinson dataset were 5% to 50% greater than those from Vancouver International Airport with the greatest difference from easterly events. Conversely, Vancouver Harbour was an additional15% lower than those from Vancouver International Airport. Due to the amount of shelter at the study site in comparison to the Point Atkinson station and the greater length of record at Vancouver International Airport values were extracted from the Vancouver International Airport dataset.

The maximum gust for Vancouver International Airport was reported as 36 m/s from the west (1957 Nov 25). Similar sized gusts were reported also from the southeast (35 m/s, 1962 October 13).

Table 4. Design hourly average wind speed and direction for 50 and 200-year return period (m/s) based on Vancouver International Airport (data not adjusted from the 4.3 m station height)

Direction	50-Yr	200-Yr
Northeast	15	17
East	15	17
Southeast	18	20
West	26	27
Northwest	22	26

Table 5. Design hourly average wind pressure for 50 and 200-year return period from various directions and maximum gust pressure (N/m^2)

Direction	50-Yr	200-Yr	Record Maximum
Northeast	220	280	
East	220	280	
Southeast	310	390	
West	650	710	
Northwest	470	650	
Maximum Gust			1240

Pressure from the wind was estimated using the design wind speed, an air density of 1.29 kg/m^3 (assuming sea level, 0^{o}C, and high humidity), and a drag coefficient of 1.5 (rectangular plate with a length to width ratio of 20) (Roberson and Crowe, 1985). Pressure should be recalculated once the shape and dimensions of the structure are confirmed and a suitable drag coefficient identified. Wind pressures presented should be considered a minimum design load; municipal or regional bylaws should prevail if greater than the values presented.

5 DESIGN CURRENT SPEED

A two dimensional hydrodynamic model of False Creek was used to compute flow velocities and water levels near the study site. A tidal water level was specified as the boundary condition to the model. On December 17, 2012, Burrard Inlet experienced an extreme high tide often referred to as a king tide. This event was used for the basis of the current modelling.

The calculated 50yr and 200yr tidal residuals (external surge + wind setup) were conservatively assumed to coincide with the high tide event and simulated along with the tidal cycle from December 16 through 17. At the False Creek Ferry Floats, the model predicts peak velocities of 0.2 to 0.3 m/s. A few metres west of the Ferry Floats peak velocities in the channel reached up to 0.5 m/s.

Communications with past and present False Creek Ferry operators suggest that local velocities can be "swirling" and fast enough a couple times a month to make it difficult to hold the vessels to the float. It is estimated that such a condition would occur with a velocity between 0.2 and 0.5 m/s. Due to the lack of local velocity data to calibrate, validate, or verify the model, a design tidal current speed of 0.7 m/s is recommended at the study site as reported in the following table.

Table 6. Recommended design current speed

Parameter	m/s
Design Current Speed	0.7

6 BED ELEVATION

The bed elevation at the edge of the existing float was surveyed using a SonarMite sounder and survey grade Trimble RTK GPS with CanNet correction. The following table presents the survey data in UTM coordinates for five locations along the existing float.

Table 7. Survey data off of existing float (m)

Description	Northing	Easting	Elev. (CD)	Elev. (GSC)
NW Corner	5457841	490100	-2.79	-5.89
N Edge Middle	5457841	490103	-2.72	-5.82
SE Corner	5457837	490111	-2.16	-5.26
NE Corner	5457841	490109	-2.63	-5.73
SW Corner	5457833	490099	-1.79	-4.89

7 CLOSURE

We hope this work meets your immediate needs. However, feel free to contact me by email (dmuir@nhcweb.com) or by phone (604.980.6011) if you have questions.

Sincerely,

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