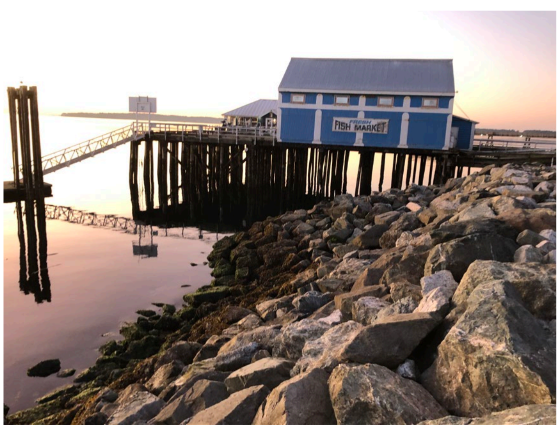
SNC·LAVALIN

BEACON WHARF

Surveys & Feasibility Study

Town of Sidney



Infrastructure

Document Number: 667543-1000-4PER-0001

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SNC • LAVALIN

CLIENT: Town of Sidney

PROJECT: Beacon Wharf Surveys and Feasibility Study

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REVISION INDEX

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1 INTRODUCTION

1.1 Background

Beacon Wharf in Sidney, British Columbia is a timber structure which has been in place for over 50 years. The wharf has required a number of repairs in recent years in order to remain serviceable and is believed to have a remaining design life of less than 10 years. In 2018, the Town of Sidney ("Sidney") completed its Downtown Waterfront Vision which considers how the area in the vicinity of Beacon Wharf may be developed in future.

Sidney engaged SNC-Lavalin (SNCL) to assess the feasibility of rebuilding Beacon Wharf as a rock reclamation or piled structure. In addition, Sidney requested that SNCL assess the feasibility of an intertidal rock reef at adjacent Glass Beach. The study includes undertaking surveys, a technical feasibility assessment and a high-level cost estimate of potential options.

1.2 Scope of Study

The scope of this assignment includes the following:

- Geotechnical Assessment: Desktop Review;
- Environmental Survey: Desktop Review, Intertidal Survey, Subtidal Survey;
- Feasibility Assessment: Design Criteria, Options Analysis, Cost Estimate.

1.3 References

The following documents make up the background information for this assignment.

[1.] Downtown Waterfront Vision, Town of Sidney, April 2018
[2.] Interim Flood Construction Level, Policy and Procedures, Town of Sidney, June 2019
[3.] District of North Saanich Flood Construction Level Study, Study, SNC-Lavalin, May 2016
[4.] Flood Hazard Area Land Use Management Guidelines, British Columbia, January 2018
[5.] Guidelines for Management of Coastal Flood Hazard Land Use, Ausenco, January 2011

SNCL acknowledges the contribution provided by the District of North Saanich (DNS) in granting SNCL the permission, on behalf of Sidney, to utilize the relevant archived data and, if necessary, use the archived models produced for DNS Flood Construction Level Study [3.], which includes an extensive assessment of the wave climate in this area.

2 EXISTING FACILITY

The existing Beacon Wharf structure is located at the eastern end of Beacon Avenue and is shown in Figure 1. The wharf is closed to vehicles but open to pedestrians. It currently supports two buildings, a café and a fish market. The shoreline at the wharf is a rock armoured revetment, which also extends north to the nearby marina, and on the south side, transitions into Glass Beach. At the abutment, a small separate ramp on the north side of the primary wharf slopes down to the fish market, allowing trucks to back up and be level with the loading bay, as indicated in Figure 2.

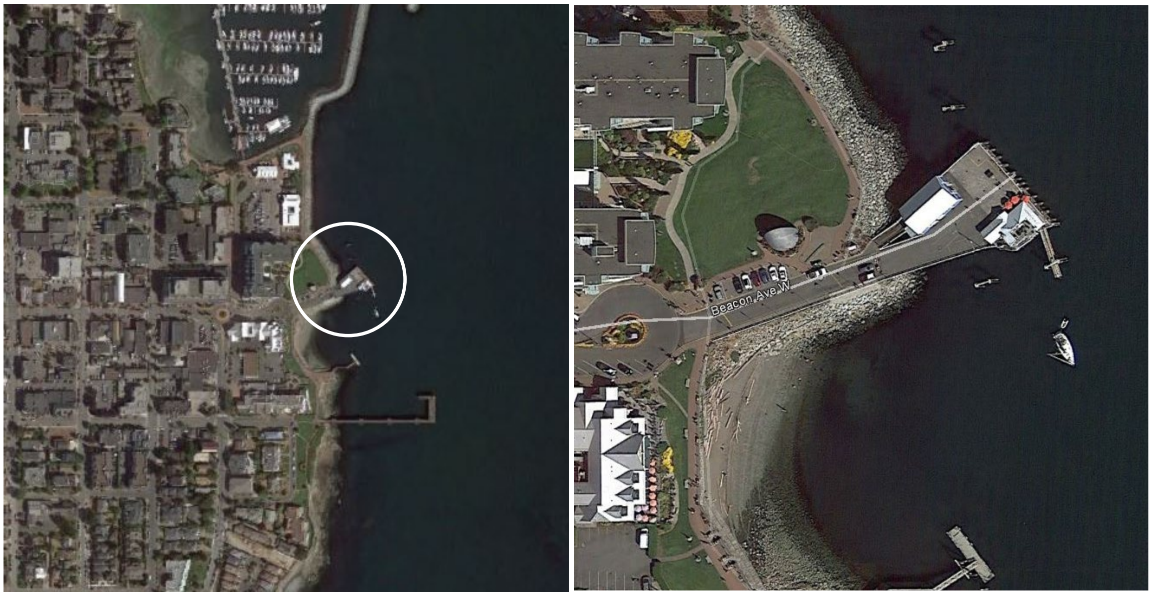


Figure 1 - Existing Beacon Wharf location and arrangement

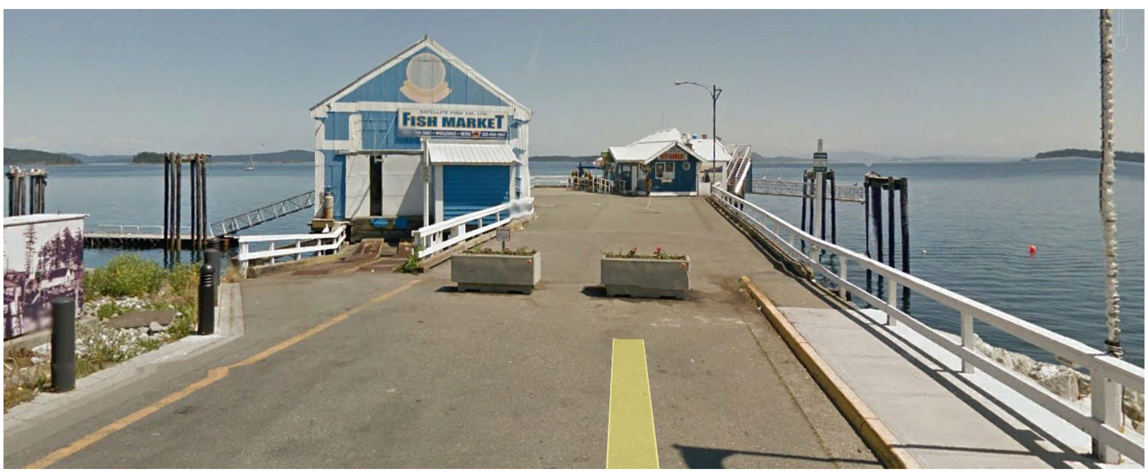


Figure 2 - Beacon Avenue looking towards Beacon Wharf

There are a number of free-standing piles to the north and south of the wharf. Those on the north side are used to moor a float during summer, which is used by a small ferry to the Sidney Spit. In winter, the float is removed to avoid storm damage. There is a gangway supported by piles on the southern side of the wharf (Figure 2), which is understood to be currently unused.

Record images (Figure 3) show that piled structures were previously much more extensive, both to the north and to the south of Beacon Wharf. These include a timber breakwater / wave screen to the north. While the structures are no longer in place, it is unknown whether timbers below the sea bed have been removed and these areas have a risk of yielding buried obstructions for any future piling works.

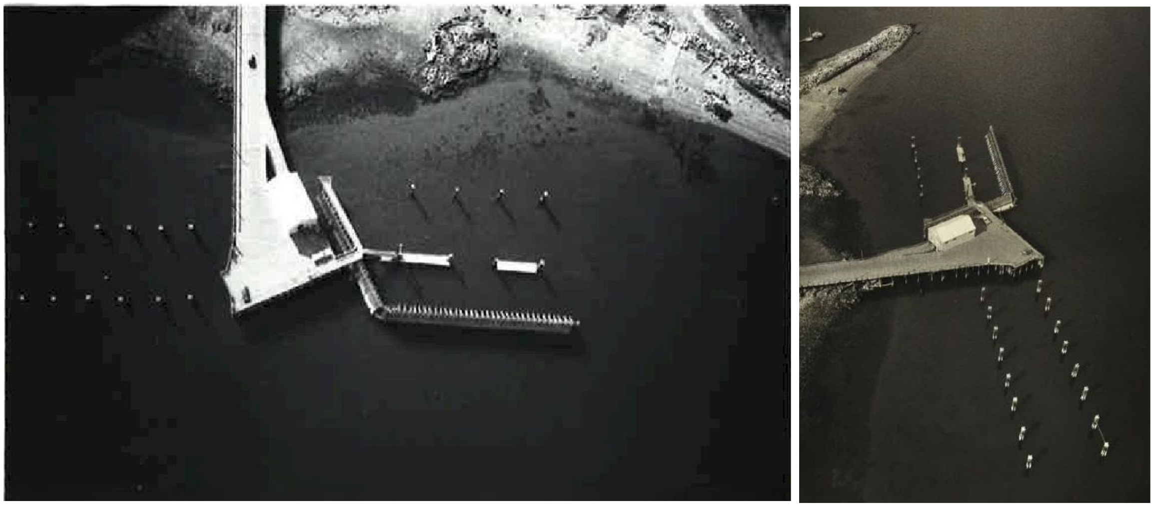


Figure 3 – Historical Image of Beacon Wharf & Original Timber Breakwater (Google)

3 DESIGN CRITERIA

To assess the engineering feasibility of implementing infrastructure required to achieve Sidney's vision for the Beacon wharf, SNCL established the technical requirements of the facility described in a Design Criteria Memo, Appendix A. The Design Criteria memo includes aspects such as: the facility design life, operational requirements for access, design vehicle loadings, design vessels for berthing and mooring, design environmental conditions and other requirements defined by Sidney.

3.1 Functional Requirements

The functional requirements of the Beacon Wharf are based on Sidney's Downtown Waterfront Vision [1.] which includes Beacon Wharf as a central component of the waterfront's redevelopment. The following are the key functional requirements:

- Design Life: All infrastructure is to be 50 years, except for timber floats and replaceable items (such as handrails) which are to be designed for 25 years.
- Buildings: The wharf shall accommodate a leased lot(s) on top of the deck for commercial buildings.
- Pedestrian access: The wharf will be a public area and requires pedestrian access to all areas of the wharf, around any buildings on top of the wharf and any additional facilities such as floats or the nearby Glass Beach. Edges of public spaces which present a potential fall risk shall be protected with suitable handrails/barriers. Walkways, roads and gangways shall have a maximum grade of to 1:20 without handrail and 1:12 with handrail.
- Vehicle access: The wharf shall give pedestrians priority with vehicle access to any buildings on the wharf down a central lane. Vehicle barriers shall be provided in areas directly alongside an edge. Vehicles shall include: delivery trucks (CL3-W), maintenance vehicles (F350 pickup or similar), and forklifts.
- Services: Building power, water and sewer shall be provided to the buildings on the wharf. Site lighting is requested in all public area. Fire protection shall be provided to the wharf.
- Floats: Vessel mooring spaces will be provided only on floats and shall be for short term/ temporary mooring. As such, no services shall be provided to the floats. Float layouts and requirements for permanent moorage year-round are dependent on the coastal conditions and shelter provided by the layout of the wharf. Float vessel details, and marina wave conditions are further discussed in the Design Criteria Memo in Appendix A.

3.2 Coastal Conditions

As part of the DNS study [3.], an analysis of storm conditions and water levels was undertaken near the northern and southern boundaries of the Town of Sidney. This study established the expected storm surge and wave conditions during the Designated Storm at particular zones of the shoreline, which was based on a storm that has an average annual probability of being equalled or exceeded (Annual Exceedance Probability, AEP) of 1/500, or a 0.2% chance of occurring in any given year. This level of probability was selected based on guidance in the Provincial Guideline documents [4.] to minimize and equalize risk to exposed high value shoreline properties around the peninsula.

Previous detailed modelling work undertaken by SNC-Lavalin for the DNS study [3.] included the shoreline in front of Sidney and specifically the Beacon Wharf area. These results defined the expected significant wave height during the 1:500 year storm for the present sea level, for a 0.5m sea level rise and for 1.0m a sea level rise.

While this information is sufficient to provide an estimate of flood construction levels (FCLs) for the purpose of assessing conceptual arrangements and top-of-wharf elevations, additional modelling is likely to be required to:

› Accurately define the top of wharf level once the preferred option has been selected,
› Define wave conditions at the wharf during an annual expected storm for assessing pedestrian safety, and
› Define the 1:100 AEP storm conditions for wave loading design criteria.

3.2.1 Tidal Range

The water levels for Sidney from the 2019 CHS tidal tables are given in Table 1:

Table 1 – Beacon Wharf CHS Tidal Range (2019)

Tidal Condition	Water Level (m CD)
Observed Historical Extreme High Water	4.4
Higher High Water Large Tide, HHWLT	3.5
Higher High Water Mean Tide, HHWMT	3.1
Mean Water Level, MWL	2.1
Lower Low Water Mean Tide, LLWMT	0.8
Lower Low Water Large Tide, LLWLT	-0.3
Observed Historical Extreme Low Water	-0.5

3.2.2 Storm Surge

Storm surge elevations are defined for the Sidney area in Ausenco Guidelines [5.]. The expected storm surge elevations for this area are summarized in Table 2:

Table 2 – Storm Surge Elevations

Annual Exceedance Probability	Storm Surge Elevation (m above astronomical tide)
Annual Expected Storm	0.73
1/100 AEP Storm	1.2
1/200 AEP Storm	1.25
1/500 AEP Storm	1.3

3.2.3 Sea Level Rise

Recommended allowances for sea level rise:

Table 3 – Sea Level Rise Allowance

Design Life	Sea Level Rise Allowance (m)
50 years	0.8*

Recommended allowances for sea level rise, related to ongoing climate change, are outlined in BC Guidelines [4.] based on Ausenco Guidelines [5.]. The minimum recommended allowance for a 50-year service life circa 2070 is 0.8 m. The guidance for sea level rise (SLR) planning outlined in the BC Guidelines recommends that this allowance should be reviewed every 10 years or sooner, if there is significant new scientific information. Scientific information released since 2011 suggests that 0.8m of SLR might be realized sooner than 2070.

3.2.4 Winds

During a severe SE storm, with an AEP of 1:500, the area offshore of the Beacon Wharf is likely exposed to SE winds with a speed of 65 knots (33.4 m/s) during the future Designated Storm event.

SNCL performed a preliminary investigation of winds and waves on behalf of the DNS in 2019 for the DNS shorelines to the north and south of the project area. The results are indicative only of conditions during the Designated Storm. The archived model results have been provided by DNS for this study; however, the available studies do not include conditions during all storms and are yet to be validated for the Sidney waterfront area.

3.2.5 Wave Climate

The DNS wave climate results indicate a 4.5m significant wave height at the limits of Sidney's water lot. Incident waves will run up the armour rock slope of the reclamation, with a steeper slope causing more runup. For instance, this seastate and an armour rock slope of 3:1 (H:V) could produce a wave runup requiring a top of deck elevation above 11.1 m CD (including SLR = 0.8m). However, for a rock mound wharf structure located closer to the shoreline, waves will interact with a shallower seabed and dissipate energy prior to arriving at the wharf structure, which reduces the required top of deck elevation. In the case of a suspended deck wharf on piles, waves can pass underneath the structure and thus reduce some of the additional elevation required to accommodate wave run up.

3.2.6 Flood Construction Levels (FCLs) & Elevations

Elevations described in this report are relative to Chart Datum (CD) and in some cases were converted from Geodetic Datum (CGVD28). The conversion between these two datums at this site is:

0 m CGVD28 = +2.1 m CD.

Differences between existing infrastructure, shoreline and topography are described in Appendix B. A summary of the existing elevations and FCLs at Beacon Wharf is provided in Table 4.

Table 4 – Summary of FCLs & Deck Elevation Review

Item	Elevation (CD)
Existing Top of Wharf	+5.5 m CD
Beacon Wharf St Roundabout Curb	+6.9 m CD
Sidney's Interim FCL	+7.1 m CD
Recommended Replacement Wharf FCLs	+8.0 m CD to +11.1 m CD

FCLs are determined as the sum of the following considerations from the BC Guidelines [4.]:

- Allowance for future SLR to the end of Design Life;
- Allowance for regional uplift, or subsidence to the end of Design Life;
- Higher high water large tide (HHWLT);
- Estimated storm surge for the Designated Storm, with an AEP of 1:500;
- Estimated wave effects associated with the Designated Storm; and
- A minimum freeboard of 0.3 m.

An illustration of this calculation is presented in Figure 4.

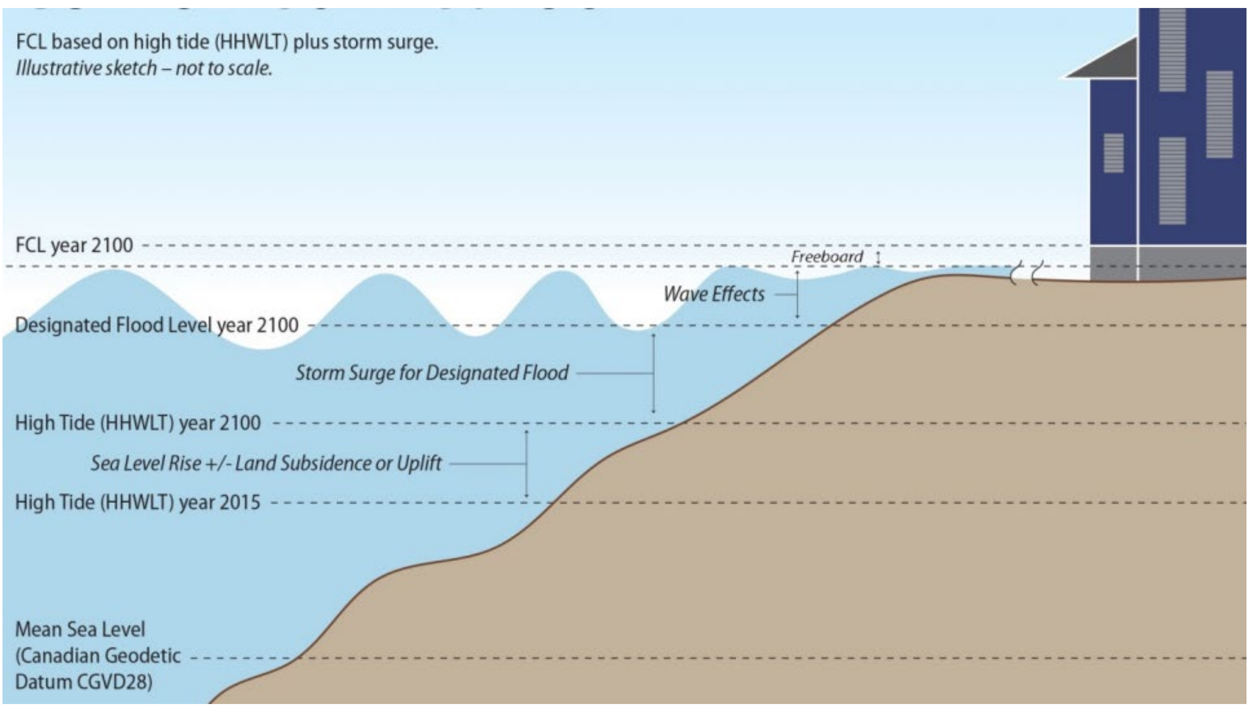


Figure 4 – Combined Method – BC Guidelines (2018)

During the detailed design phase, further consideration is required to set the appropriate freeboard and address any three-dimensional interaction between waves and the wharf geometry; most notably the corners of the wharf that are exposed to storms from the south-east.

3.2.7 Balanced Coastal Flood Risk

SNC-Lavalin recommends adopting an approach of “balanced risk” with respect to coastal flooding. This approach stems from two opposing considerations:

1) **Coastal risk will increase over time.** Sea level rise (SLR) and increased storminess will mean that the risk of coastal flooding is greatest towards the end of a facility’s design life,

2) **Total risk is a function of exposure time**. All facilities have a probability of failure in any given year, with the total risk being the summation of all the years of exposure. This means that the risk of a structure encountering a 1:500 AEP event in the last year of its expected service life is much lower than it is for a structure planned to be in place for 50 years.

If a structure was designed for the full 1:500 AEP event occurring at the very end of its design life, the facility is likely to be overdesigned at the start of its design life when the SLR allowance has not yet occurred. The balanced risk approach aims to maintain a more consistent standard of protection throughout the design life. This is achieved by considering the following two cases:

- **At the start of the design life.** A 1:500 AEP event, without sea level rise, with an exposure period of 50 years, and
- **At the end of the design life.** SLR and increased storminess combined with a reduced AEP event in order to provide a standard of protection commensurate with the first case, when considered over a reduced exposure period of one or two years.

3.2.8 Flood Risk and Land Use

The requirements for Flood Construction Levels, as discussed above, are well defined for buildings and, with buildings on the proposed wharf, these criteria are likely to govern the design. However, developments without buildings should still consider coastal flood risk. The level of risk depends on the sensitivity of the land use, with the two main considerations being safety to the public and risk of damage to property:

Safety

- **Whether the space is inhabited/occupied or not.** Inhabited spaces are those where people work, eat and sleep. Public spaces like parks and picnic areas can reasonably be assumed to be unoccupied during extreme weather events.
- **Public or private access.** The rate of wave overtopping that is considered acceptable will vary depending on the types of people expected to be in the area at the time. Trained staff who are expecting to get wet can tolerate a lot more overtopping than unsuspecting members of the public.
- **Land use.** Roadways will have different requirements than pedestrian access areas. Anticipated vehicle speed is a factor, with slower-moving vehicles able to tolerate more overtopping. The setback from the seawall is also important with risk decreasing as setback increases.

Damage to property

- **Damage to property.** Structures can de damaged by wave loading, standing flood water, flow-induced water velocities and scour and other effects. Industrial structures which have been designed to withstand wave loads can withstand more wave overtopping than a typical building, however it is likely to come with a cost premium and some architectural penalties.

These considerations may be relevant at future project stages as it is understood that the proposed usage of the wharf is not necessarily restricted to only restaurant buildings, as currently proposed. Building a restaurant on the wharf would require adhering to the requirements for Building FCL's. However, if Sidney were to not include permanent buildings then the sensitivity to flooding would decrease and lower crest levels may be sufficient. For example, if the wharf area was used for seasonal food trucks instead, the safety and property risks would be reduced as the trucks could relocate in a storm.

4 GEOTECHNICAL ASSESSMENT

The geotechnical assessment of the area found that it is feasible to build a rock fill wharf in the location of the existing Beacon Wharf. It was observed that the onshore soil composition is soft sediment, which is consistent with the silts, clays and glacial tills mapped and reported in the general area. Settlement of 1.0m is anticipated for any rock fill options. This settlement has been accounted for in the comparative cost estimates. The geotechnical report can be found in Appendix C.

Following completion of the geotechnical investigation, and after coastal risk aspects are considered, the possibility of replacing the wharf with a piled structure has been given more serious consideration. The presence and successful performance of the existing piles, and many other timber piles in previous years, confirms that piles can be driven to at least a depth where they are stable within the present footprint. However, there are known to be rock outcrops nearby, and bedrock levels can vary significantly in this area. If a piled wharf replacement option is to be taken forward in future, till and bedrock levels within the piled footprint should be confirmed in order to assess pile drivability and geotechnical risk.

5 ENVIRONMENTAL SURVEY

An environmental survey was undertaken to characterize marine habitat in the Beacon Wharf area and within the marine footprint of the developments proposed in Sidney's Waterfront Vision [1.], which includes the new wharf and an intertidal reef. The desktop survey indicated that species at risk, biological resources, and fisheries resources either occur or potentially occur in the project area. The field survey determined that the project area contains numerous diverse intertidal and subtidal habitats. The environmental survey report is included in Appendix D.

The proposed infrastructure work to replace the Beacon Wharf is expected to result in "harmful alteration, disruption or destruction of fish habitat (HADD)" as defined by the *Fisheries Act*. An Authorization under the Act may be required, and any impact to fish or fish habitat is required by the Act to be avoided, mitigated, and/or offset. Offsetting involves creating new marine habitat or enhancing existing habitat, either onsite or elsewhere, which is of equivalent biological productivity to that being altered by the Project. There is a broad range of possible habitat enhancement work that can be used to offset a development. The requirements for, and scope of, any additional habitat studies – and related offsetting – would be determined in coordination with the Department of Fisheries and Oceans Canada (DFO) after reviewing the proposed project. It is expected that the extent of offsetting for the reclamation options would be more than for the piled wharf options, due to the increased footprint area of the development.

It is important to note that any proposed environmental offset, such as a reef or similar, will need to be considered 'in addition to' the core project scope of replacing the wharf. DFO typically does not consider elements of the project itself to be an offset. As an example, habitat created by the rock revetment, though valuable, would not offset the loss of seabed habitat when the area is reclaimed. However, a separate reef undertaken primarily for the purpose of creating habitat could be used to offset the reclamation.

The environmental report in Appendix D describes the environmental permits and authorizations required to implement a wharf development like that in Sidney's Waterfront Vision.

6 OPTIONS ASSESSMENT

To assess the feasibility of Beacon Wharf replacement options, the following process was undertaken:

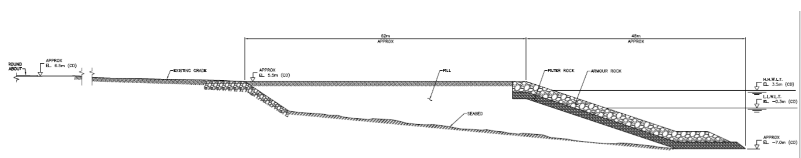
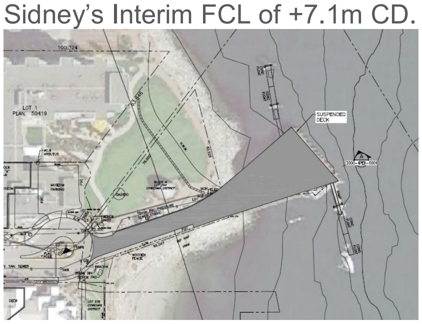
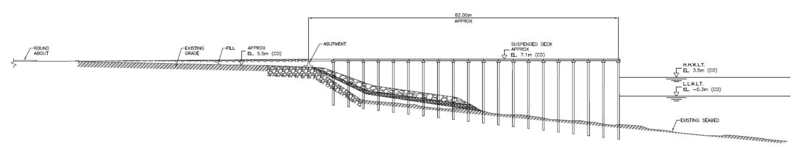
1) Develop a full spectrum of possible options. Design options included both reclamation and suspended decks, as well as the inclusion of a breakwater.
2) Assess the relative merits of each of the options with respect to:
    a. Coastal flooding and wave overtopping risk;
    b. Comparative costs;
    c. Footprint and impact to seabed; and
    d. Integration to the existing shoreline.
3) Compile a shortlist of the most feasible options for future consideration.

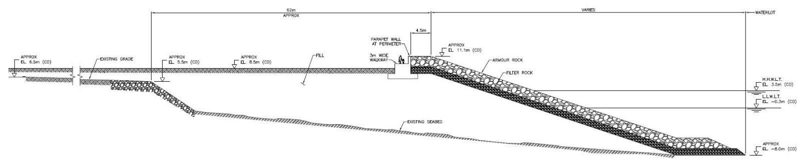
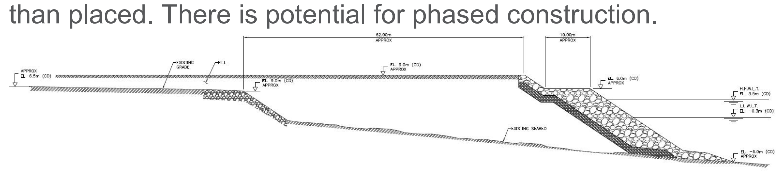
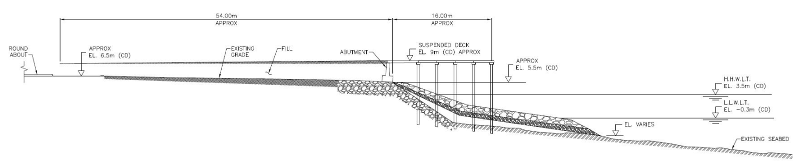
As coastal risk was assessed to be the principal consideration governing the arrangement and elevations of the development, high level option screening has given priority to this aspect.

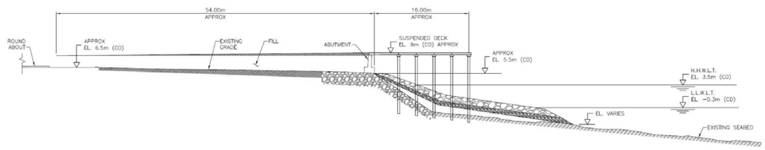
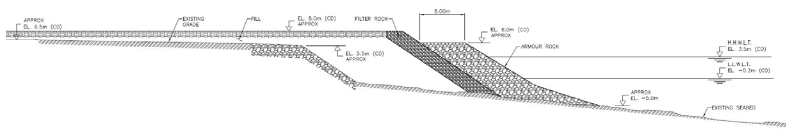
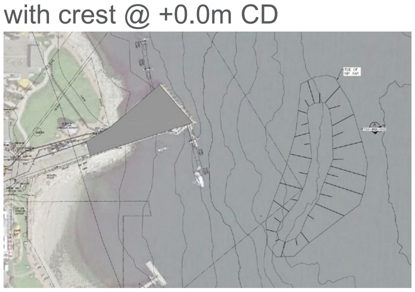
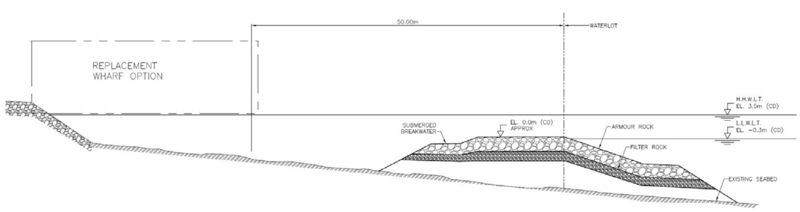
6.1 High-Level Conceptual Wharf Options

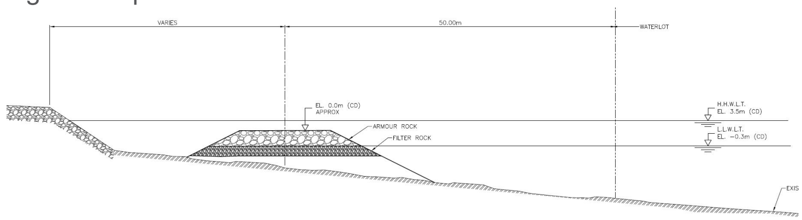
Table 5 includes a brief description of the options considered. Sketches of the options are included in Appendix E, and a detailed summary of the option assessment can be found in Appendix F.

Table 5 - High-Level Wharf Options Summary

Option and Description	Assessment Summary
Option 1 - Rubble mound wharf at existing wharf elevation +5.5m CD. 	1.4 m below Beacon Avenue roundabout. Not advisable for 50-year consideration period, due to flooding and overtopping risks. 
Option 2 - Suspended deck at Sidney's Interim FCL of +7.1m CD. 	Approximately level with Beacon Avenue roundabout. Not advisable for 50-year consideration period, due to flooding and overtopping risks. 

Option and Description	Assessment Summary
Option 3 - Rubble mound revetment @ +11.1m CD, parapet/retaining wall for lower top of wharf elevation @ +8.5m CD. Walkway at the perimeter of the wharf. 	Requires large amount of fill and revetment and therefore expected to have larger cost. Crest level is very high for integration into surrounding waterfront. Public space at wharf is more separated from the water by raised perimeter. It may be feasible if considered as a phased construction, however other options are likely to be more preferable. 
Option 4 - Reclamation @ +9.0m CD and a berm revetment @ +6.0m CD. 	"Berm" revetment includes a horizontal bench and more armour rock. Preferable to traditional revetment as it dissipates more wave energy, facilitating lower crest levels. Cheaper to construct because, while armour is thicker, it can be steeper and uses smaller rock with a wider grading, allowing it to be dumped rather than placed. There is potential for phased construction. 
Option 5A - Marginal wharf suspended deck parallel to shore with the same area as the original Beacon Wharf @ +9.0 m CD. 	Meets required FCLs for buildings and requires a smaller seabed footprint than the reclamation options. 

Option and Description	Assessment Summary
Option 5B - Marginal wharf suspended deck parallel to shore but smaller deck area than the original Beacon Wharf @ +9.0 m CD. 	Meets required FCLs for buildings and requires a smaller seabed footprint than the reclamation options. Similar merits to 5A but with lower cost due to reduced footprint. 
Option 6 - Marginal wharf parallel to shore with reclamation @ +8.0m CD and a berm revetment @ +6.0m CD. 	Developing along the shoreline rather than out to sea reduces the reclamation volume and is expected to reduce the design wave size. Expected to be lower cost that extending out into deeper water. 
Breakwater Options	
Option 7 - Submerged breakwater with crest @ +0.0m CD 	The breakwater function would be to break waves from SE storms, facilitating the wharf to be built at a lower level than would otherwise be possible. Low crest does not obstruct views. Will also have environmental benefits. 

Option and Description	Assessment Summary
Option 8 - Intertidal rock reef with crest at +2.0m CD. 	Reef is closer to the beach and is primarily to provide environmental benefits by creating new habitat. Offers no significant protection to the wharf. 

Two breakwater concepts have been considered (Options 7 and 8). These are not wharf options in their own right but may be included as optional additions to the other wharf development options considered.

6.2 Comparative Cost Estimates

Cost estimates are Class D and are based on conceptual-level engineering. Cost are presented for assessing relative costs for the purpose of option screening only. Further engineering would be required to establish a cost estimate suitable for budgeting.

Table 6 – Comparative Cost Estimates of Options Assessment

Option	Comparative Cost
Wharf Options	
Option 1 - Rubble Mound Wharf (+5.5m CD)	$13,710,000
Option 2 - Suspended Deck at Sidney Interim FCL (+7.1m CD)	$8,540,000
Option 3 - Reclamation at Water Lot Extent with Elevated Crest & Parapet Pedestrian Walkway (+11.1m CD)	$20,760,000
Option 4 - Reclamation with Elevated Crest (+9.0m CD) & Berm Revetment (+6.0m CD)	$14,170,000
Option 5A - Marginal Wharf Suspended Deck Oriented Parallel to Shore with Same Deck Area (+9.0m CD)	$8,680,000
Option 5B - Marginal Wharf Suspended Deck near Shore with Smaller Deck Area (+9.0m CD)	$6,290,000
Option 6 - Marginal Wharf Reclamation Oriented Parallel to Shore (+8.0m CD) & Berm Revetment (+6.0m CD)	$14,130,000
Breakwater Options	
Option 7 - Submerged Breakwater Combined with wharf (crest +0.0m CD)	$9,770,000
Option 8 – Intertidal Rock Reef (crest at +2.0m CD)	$1,230,894

The cost estimates not include any applicable taxes or inflation allowance. A contingency allowance of 25% has been included, as has a 10% allowance for engineering, supervision and other owner costs.

6.3 Option Screening

6.3.1 Key conclusions

The options in Section 6.1 were assessed based on their vulnerability to coastal risks; their environmental impact to the seabed; ease of integration to the existing shoreline; and their comparative costs. Key conclusions from option assessment are:

- Crest levels and coastal risk:
  - Options with top of deck elevations at current Sidney Interim FCLs or lower are not considered feasible recommended or advisable for the design life due to an unacceptable (high) level of risk of flooding and overtopping.
  - Reclamation options utilizing the existing Beacon Wharf layout require a higher top of deck elevation due to the larger wave run up effects in deeper water where incident waves are larger.
  - Options closer to shore are expected to have reduced design wave conditions and can have slightly lower top of deck elevation than those extending further out.
- Reclamation and revetments:
  - The armour rock size for a traditional revetment or breakwater would be quite large, and there is expected to be an issue sourcing the volume of material required from local quarries.
  - Berm revetments differ from traditional revetments in that they use a greater thickness of armour rock, but the rock can be smaller, with a wider gradation and can be places on a steeper slope, which reduces the seabed footprint. They also have a horizontal berm or shelf near the top which helps to dissipate wave energy, allowing for a lower crest level. Berm revetments are expected to be preferable to traditional revetments in terms of both cost and performance.
  - There are a number of opportunities for phasing the reclamation options to increase the standard of protection in future when it is required.
- Breakwaters
  - A full height conventional breakwater to protect the wharf would be a very large structure and would obstruct views out to sea. This has not been considered.
  - A submerged breakwater can reduce the design wave height at the wharf. However, the size and cost of this type of structure is still large.
  - The estimated cost of the breakwater is considered large relative to the benefit of lowering the wharf level by approximately 1 m.
  - A smaller breakwater located closer to shore (to protect Glass Beach) would provide environmental benefits but provides no protection to the wharf.
  - It is likely that a breakwater would only form part of the preferred scheme if the environmental benefits are considered essential to the feasibility of the scheme.

- Suspended deck wharf options
    - Suspended deck option costs are relatively insensitive to the final deck level compared to a reclamation where the fill volume and cost increases significantly with raised crest levels.
    - Comparative costs suggest that a piled wharf may be preferable to reclamation.
- Connection to shoreline:
    - There is a large difference between some of the wharf levels proposed and the existing waterfront, creating a challenge to integrate the development with the existing waterfront.

6.3.2 Shortlisted Options

Given the above conclusions for the option assessment, the following are recommended to be shortlisted for future consideration:

- Option 4: Reclamation with Elevated Crest & Berm Revetment (+9.0m CD)
- Options 5A & 5B: Marginal Wharf Suspended Deck Parallel to Shore (+9.0 m CD)
- Option 6: Marginal Wharf Reclamation Oriented Parallel to Shore (+8.0m CD) & Berm Revetment (+6.0m CD)

6.4 Limitations of Assessment

Options screening has considered technical, constructability and cost aspects of the site only. All options will have ramifications for the broader area, and a range of other aspects which will need to be considered by others such as planning, transport, social considerations, etc.

7 SHORTLISTED OPTIONS

7.1 Reclamation with Berm Revetment

Shortlisted options from the option assessment that include reclamation with a berm revetment are:

- Option 4: Reclamation with Elevated Crest & Berm Revetment (+9.0m CD)
- Option 6: Marginal Wharf Reclamation Oriented Parallel to Shore (+8.0m CD) & Berm Revetment (+6.0m CD)

The general arrangement of this type of wharf is composed of a reclamation fill protected by armour rock. The armour rock has a thick outer layer forming a horizontal berm and then a filter layer to prevent fill material washing out. Fill is typically sand which is retained by the rock perimeter and built up in stages. The berm design allows for a steeper outer slope, which reduces the footprint on the seabed. The berm will dissipate wave energy because the thick layer of armour rock creates a very porous matrix that absorbs a significant amount of wave energy. The berm toe apron on the seabed provides an allowance for expected scour at the toe of the berm.

A significant benefit of this type of revetment is that smaller armour rock can be used than would be required for a traditional revetment. This material can be readily sourced from local quarries. The berm can also be constructed by simple end dumping of the rock materials, whereas a traditional revetment requires careful placement of each individual layer to ensure interlocking of armour rock within the layers.

Construction could be undertaken either using land-based or marine equipment. Construction from land would involve more equipment and haul trucks moving through Sidney which may be undesirable, but it would avoid the cost of marine equipment. Constructing from the water only would allow material to be barged to site in larger loads but requires marine equipment. It is quite likely that the preferred approach would be to barge rock and fill directly to site from the quarry and use the minimum amount of marine equipment for unloading, together with land-based cranes or excavators for placing and trimming the material.

The environmental impact of a reclamation option will be greater than that of a suspended deck. As all developments are expected to require environmental offsetting, the amount of environmental offsetting (and associated costs) required by DFO will be greater for the reclamation options. The area of offsetting can be estimated once a preferred arrangement is selected.

7.2 Suspended deck

Shortlisted options from the option assessment that include a suspended deck wharf are:

- Option 5A – Marginal Wharf Suspended Deck Parallel to Shore with Same Footprint (+9.0m CD)
- Option 5B – Marginal Wharf Suspended Deck with Smaller Footprint (+9.0m CD)

A suspended deck wharf is composed of an abutment where the wharf interfaces with the shoreline, and a deck supported by bents of piles and pile caps. The shoreline is typically protected by a revetment to prevent scour and landside erosion. Suspended deck options considered for replacement of Beacon Wharf aim to provide similar deck area as the existing wharf. Wharf layouts that are closer to shore and orientated along the shoreline are expected to reduce the design wave height and required deck level of the wharf. The wharf would be designed to allow waves to pass under the deck rather than attracting lateral or upward wave loads.

The environmental impact of a suspended deck option will be less than that of a reclamation. The wharf will overshadow its footprint which will cause changes to the habitat, but the only benthic habitat lost is the area of the piles themselves. Some environmental offsetting is still anticipated.

A suspended deck of this type, designed for light vehicle loads and buildings, would typically be constructed of steel piles, concrete pile caps and precast concrete deck panels. However, if there is a desire to maintain the timber appearance of the wharf, this would also be possible. Timber piles treated with creosote can last indefinitely, while other waterborne treatment methods are typically less durable. Creosote timber piles are still in use, however our recent local experience is that they are less preferable environmentally as they are not used by herring for spawning. It would be an option to use steel piles with a timber deck.

Construction of the suspended deck could also be undertaken either from land or from the water. Land based construction would involve working forward “end over” where the crane tracks over the wharf spans as they are completed. This method is typically used for long jetties where temporary works can be reused in a repetitive fashion on identical bays of the structure. There is a cost saving in avoiding marine equipment. The drawback of this option for a lightly-loaded wharf is that the construction loads may govern the design resulting in a heavier structure and is also not well suited to small or irregular shaped structures. It is considered more likely that marine piling equipment would be used for construction of wharf elements beyond the highwater mark. Marine plant would consist of a barge-mounted crane for installing piles, together with support tugs and delivery/storage barges.

Pile driving may be a potential noise issue for residents or local business during construction. Work is likely to take place during acceptable working hours, as permitted by Sidney’s bylaws. Noise is usually an issue for impact driving rather than installation with a vibro-hammer. If the piled wharf option proceeds, geotechnical investigation would allow consideration of the extent and type of driving likely to be required.

As mentioned in Section 2, it is possible that there may be timber piles from historic structures cut-off at seabed level which would cause obstructions for pile installation. New pile installation would be set out to minimise the risk of obstructions.

7.3 Phasing of Construction

7.3.1 Reclamation Phasing

A significant advantage of the reclamation options is that they may be phased to progressively add coastal risk mitigation measures in the future as required. A possible phasing sequence for the reclamation option is shown in Figure 5. The reclamation option is well suited to this approach as most of the potential future protection measures do not require the initial reclamation construction level to change.

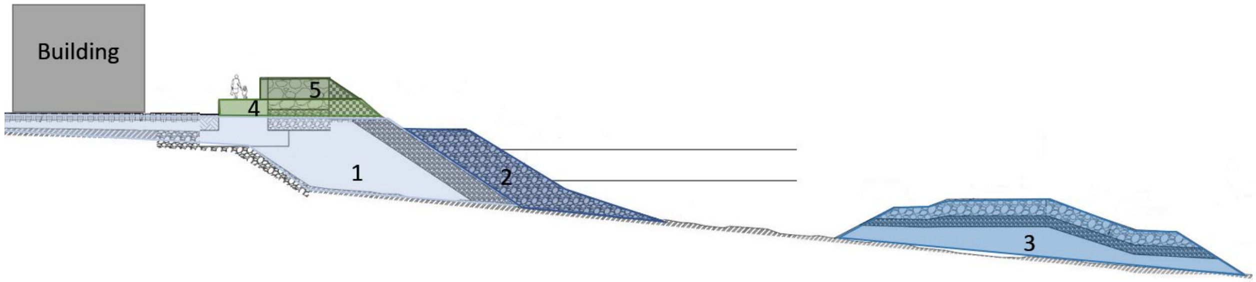


Figure 5 - Possible phasing of future increased coastal protection for reclamation

It would also be possible to simply raise the entire reclamation in the future. However, this would require buildings to be constructed at a higher level with ramps/stairs as required for the interim until the site is raised. Each time the site is raised, the useable footprint will be slightly smaller due to the revetment side slopes. This approach is illustrated in Figure 6.

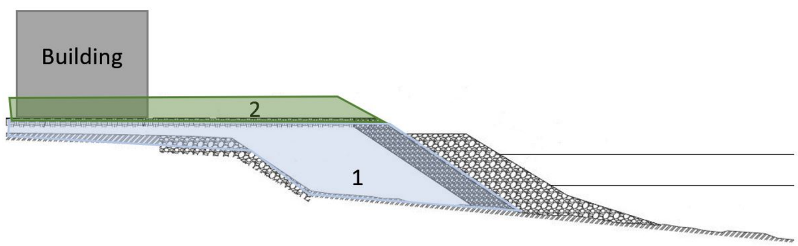


Figure 6 - Future site-wide level raising

7.3.2 Suspended Deck Phasing

Phased construction of a suspended deck could involve future construction of a protective breakwater. Other phasing possibilities are technically possible but not as straightforward as the reclamation option. Designing the suspended deck for lateral loads from a perimeter wave wall would make it much heavier and would also mean designing for vertical wave loads to the deck. Raising the deck in future is expected to be a technical and construction challenge and may cost a large fraction of the original construction cost. As the cost of the wharf is not very sensitive to the deck level, it is recommended that a suspended deck be constructed at a level suitable for the full design life.

7.4 Additional Infrastructure Elements

7.4.1 Intertidal Rock Reef

As part of this assignment, SNCL assessed the feasibility of an intertidal rock reef installed south of Beacon Wharf to protect Glass Beach. The requirements for this structure are its ability to withstand the coastal conditions, and its ability to create a marine habitat.

Provided the breakwater is constructed using armour rock heavy enough to prevent excessive damage during the design storm, there are no technical issues with installation of a breakwater.

There are local precedents for rock reefs like this to be very successful in creating new and diverse marine habitat if set in the appropriate location and level, and built in such a way that there are enough voids between the rocks to allow for marine life to flourish. However, the footprint of the proposed rock reef would be relatively large. The net benefit of an environmental installation like this decreases if it is installed in an area which already has good marine habitat.

Sidney has indicated that reef balls have been previously installed in the area south of Beacon Wharf. Reef balls are smaller, discrete installations intended to increase habitat without covering the full seabed. This type of installation has a number of benefits over a submerged breakwater in that the cost is significantly less, and habitat gains can be achieved without as much loss of existing habitat. If more reef balls were to be considered for this development, further study is likely to be warranted to assess the reef balls for coastal considerations i.e. to determine if the reef balls are likely to be stable and robust enough for the expected storms, and whether the reef would provide any coastal protection benefits.

Also considered in this study is a larger breakwater which would act to protect the wharf and allow a lower deck/reclamation level. While potentially effective, the full-sized breakwater is considered likely to be cost prohibitive when considered relative to the incremental cost of a slightly higher wharf. As can be seen from the comparative cost estimates in Table 6, the cost of the breakwater increases significantly with increases in length and water depth.

7.4.2 Floats & Gangway

The requirement to provide floats is primarily intended to provide a mooring spot for the Sidney Spit seasonal ferry service and a temporary mooring location for recreational vessels. More detailed requirements for the float are provided in the Design Criteria in Appendix B. The floats may be either timber or concrete deck with floatation billets underneath. They would be moored using mooring piles (timber or steel). Access to the float would be via a steel or aluminum gangway fixed to the wharf. Floats must be located such that they can accommodate the maximum design vessel draft at all states of the tide.

Key considerations and conclusions regarding the small craft mooring provisions are summarised below:

- **Permanent vs removable floats.** Marinas for year-round vessel mooring typically must provide sufficient protection for vessels during a storm to ensure that the vessels and floats are not damaged. If no additional protection from waves is provided, it is only considered feasible to install floats seasonally and remove them in winter when storms typically occur, as is currently understood to be the case.
- **Additional protection from waves.** If a reclamation option proceeds, it may be feasible to implement permanent floats by locating them on the north side of the reclamation where they will be partially protected by the wharf, and by using larger concrete floats and steel piles, which can tolerate more severe environmental conditions. Installing a wave screen would also be an option to provide increased protection. The feasibility of permanent floats would need to be further considered once a preferred scheme has been selected.
- **Differences between options.** It is believed to be feasible to incorporate mooring floats into either a suspended deck, or a reclaimed wharf. However, with the water-lot boundary to remain

unchanged, the size of the reclamation berm footprint means that the location of the floats may have a bearing on the wharf plan arrangement in order to fit the necessary components within the available area. This consideration may require the reclamation to extend further to the east and south in order to leave sufficient area to the north for the floats. This is much less of an issue for the suspended deck option where there will be ample deep water alongside the wharf to accommodate the floats.

- **Access to floats.** Floats will require a gangway for access . The necessary length of the gangway is governed by the elevation of the fixed upper end and the tidal range it must accommodate. As the wharf elevations are considerably higher than existing, there will be an associated increase in gangway length in order for the maximum slope to remain reasonable. The berm revetment will also push the floats further out from the wharf necessitating a longer span. Once a preferred option for the wharf and floats is selected, a suitable gangway arrangement will need to be developed. The factors above may require a short fixed span to limit the gangway to a reasonable length. The gangway could also potentially be connected to the existing shorefront rather than the new wharf if this becomes preferable.

7.4.3 Stepped Access to Glass Beach

The Waterfront Vision [1.] includes stepped access to Glass Beach using granite blocks. The purpose is understood to be providing connectivity from the road to the beach, while achieving an aesthetically pleasing public realm area that is robust enough for the environmental conditions.

As design coastal conditions for a 50-year design life are somewhat more severe than for the existing infrastructure, it is likely there will be an increase in the size of rock armour required. Granite block steps are expected to be less porous and more sensitive to block movement than a conventional revetment would be, increasing the size of block required and the amount of resulting overtopping. If the project proceeds, it is recommended that the feasibility of stepped blocks be considered at the inner end of the approach roadway to connect the roundabout area with Glass Beach. If blocks are not considered feasible, traditional stairs and/or a beach ramp could be incorporated to provide access to the beach.

Stepped access is part of a broader consideration of how the wharf development will interface with the surrounding waterfront at the time of development and also in the future. Once a preferred approach is selected, this will need to be considered in detail as there are a number of technical, planning and public-realm aspects to be assessed.

8 CONCLUSIONS & RECOMMENDATIONS

8.1.1 Conclusions of Study

This study has consisted of a high-level assessment of proposals to replace Beacon Wharf, and in doing so has identified key drivers to be considered for the anticipated area development. The study also explored possible constraints. Conclusions from the various aspects considered during the study are summarised in Table 7.

Table 7 – Summary of Conclusions

Item	Assessment	Conclusions
Coastal Conditions	The Designated Storm is based on 1:500 AEP, storm surge of 1.3m and SLR over 50 years of 0.8m. The expected sea state in these conditions is a significant wave height of 4.5m at the water lot boundary.	Design environmental conditions are relatively severe for this area due to particulars of the exposure to the SE. These criteria should be evaluated in more detail prior to final design.
Geotechnical Survey	Soil conditions appears to be silts, clays and glacial tills. Soft sediments observed as top layer.	Rockfill wharf is feasible and, at this time, 1m settlement allowance is included.
Environmental Survey	Numerous species at risk, biological resources, and fisheries resources either occur or potentially occur in the project area.	The project is likely to require habitat offsetting. Environmental permits and authorizations will be a key consideration.
Flood Construction Levels	Buildings proposed for the wharf must comply with Flood Construction Level (FCL) requirements. Current Beacon Wharf is at +5.5m CD. Sidney Interim FCL is +7.1 CD. Expected FCL's for wharf options are above +8m to +9m CD.	New infrastructure with a design life of 50 years will need to be higher than the existing waterfront. How much higher will depend on the type of wharf and intended use. FCL's for the wharf should be revisited during detailed design.
Options Assessment	A range of wharf options was considered, including reclamation and suspended deck wharves. Option assessment considered coastal risk, environmental impact to the seabed, comparative costs, and ease of connectivity to the existing shoreline.	Options closer to shore reduce risk from coastal conditions. Suspended deck options are believed to be cheaper than reclamation, but less adaptable to future protection measures.
Shortlisted Options	Preferred options for reclamation and suspended deck were identified.	Shortlisted options are 4, 5A & 5B and 6.
Breakwaters / Intertidal Rock Reef	Breakwater or an intertidal rock reef is technically feasible.	A breakwater can provide protection and lower wharf crest level. However, the cost for a full-size breakwater is significantly more than would be required to only provide ecological enhancement.

Floats & Gangway	Permanent floats will require adequate protection from extreme environmental conditions.	Seasonal floats (as per existing) can be incorporated into any scheme. Permanent floats are likely to require protection from either the reclamation or a new breakwater structure.
Stepped Access to Glass Beach	Stepped rock access to the beach would need to be designed considering stability under design waves and wave runup effects.	Granite blocks are unlikely to be feasible in all areas other than the landward end of the wharf approach road. Feasibility of rock steps down to Glass Beach near the roundabout should be considered, along with conventional stairs or a ramp.

8.1.2 Recommendations

It is hoped that the high-level design drivers, considerations and constraints discussed in this study will inform the Town of Sidney's planning activities and may have implications beyond the footprint of the development considered. Recommendations for progressing the project are summarised below.

Confirmation of the proposed wharf land use. Marine infrastructure normally entails a significant cost premium relative to comparable infrastructure built on land. As a result, most marine infrastructure developments are undertaken to satisfy a particular marine-specific needs that cannot be achieved on land. This may include providing mooring space for boats, or loading materials, vehicles or people on and off vessels. In this particular case, the primary purpose of the wharf replacement is to provide a general public amenity value with a range of facilities, including waterside restaurants, public realm areas, and small craft mooring facilities. It is assumed that the order-of-magnitude costs associated with the types of development considered for the wharf will need to be weighed against the benefits achieved by the development, and other existing or future land-based facilities. It is noted that there are already open public realm areas, fishing jetties and a marina for mooring boats in the local area of the site. Confirmation of the land use will be necessary in order to progress the design.

Coastal risk planning. In order for the wharf development project to be consistent with the rest of Sidney's waterfront vision, all aspects of the waterfront area will need to be approached with a common understanding of coastal risk mitigation priorities and options. This is expected to require further coastal work to accurately define the risks, confirm FCL's, consider mitigation measures and how the necessary mitigation measures can be incorporated into Sidney's Waterfront Vision. It is expected that coastal risk planning is likely to need to adopt a phased approach allowing for increased and strategic levels of protection to be implemented in future.

Development of wharf design. Once the potential Beacon Wharf development has been aligned with Sidney's broader Waterfront Vision and the land use confirmed, technical details of the project can be developed to establish a preliminary arrangement and design. This is expected to require coastal modelling and validation of wave behaviour in the local area, and geotechnical investigation to ascertain bedrock levels. Architectural aspects will need to be considered, including lines of sight from neighbouring properties. Connectivity with the existing waterfront will remain a central consideration.

END OF REPORT

APPENDIX A – DESIGN CRITERIA

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DESIGN CRITERIA

SNC·LAVALIN
Engineering, Design, Project Management

TO:	Jenn Clary (Town of Sidney)	**DATE:**	29 November, 2019
C.C.:	Dave McWalter	**FROM:**	Patrick Devlin, John Readshaw, Adam Dijkerman
PROJECT:	667543 Beacon Wharf	**REVISION:**	PC
SUBJECT:	Design Criteria and Input Summary	**DOCUMENT NO:**	667543-1000-4PEC-0001

1.0 INTRODUCTION

The Town of Sidney (Sidney) intends to replace the existing wharf at Beacon Avenue, Sidney, Vancouver Island with a new facility. The vision for the marine facilities is described in Town of Sidney, Downtown Waterfront Vision (2018). Sidney has engaged SNC-Lavalin (SNCL) to undertake surveys around the Beacon Wharf and assess the feasibility of the wharf redevelopment, along with an intertidal rock reef at the adjacent Glass Beach. This document describes the design requirements for the facility in order to inform the feasibility assessment, conceptual design and costing.

2.0 DESIGN LIFE

Design life of all infrastructure is to be 50 years, except for timber floats and replaceable items (such as handrails) which are to be designed for 25 years.

3.0 FUNCTIONAL REQUIREMENTS

3.1 Access

- Public pedestrian access is required to all areas of the wharf and around the two buildings.
- Public pedestrian access is to be facilitated to all areas of floats and floating breakwater.
- Edges of public spaces shall be protected with suitable handrails/barriers wherever feasible to do so. Where there is a fall risk, barriers shall have maximum 100 mm gaps as per NBC.
- Pier surface shall be generally asphalt except where other surface finishes are necessary.

3.1.1 Vehicle access

- The facility shall give pedestrians priority with vehicle access to the buildings down a central lane.
- Removable bollards to control vehicle access should be provided to prevent public vehicle access.
- Vehicle barrier are only required where trafficable areas are directly alongside an edge.

Vehicle access shall be provided for:

- **Delivery trucks** – For each of the buildings suitable access shall be provided to allow a CL3-W Truck (TBC)

- **Maintenance vehicles** – Access for a maintenance vehicle shall be provided, including a F350 pickup truck or similar and for a forklift vehicle.

The vehicle lane shall generally be at the center of the pier, however where vehicle lanes are directly alongside the edge of the pier, vehicle barriers shall be provided.

3.2 Vessels

- Vessel mooring spaces will be provided only on the floats, there will be no provision for berthing or moorage directly on the rock pier.
- Mooring on floats is to be for short term / temporary / day-use only, no permanent moorings.
- Floats are to remain in place year-round.
- Mooring space shall be provided for the following design vessels:

Table 1 – Float Vessel Details

Float Vessel Type	Quantity	Length [m]	Beam [m]	Draft [m]
Small private power boat	4	6.1	2.8	0.9
Medium private power boat	1	9.1	3.4	1.2
Small yacht	4	10.0	2.5	2.0
Floating Breakwater Vessel Type	**Quantity**	**Length [m]**	**Beam [m]**	**Draft [m]**
Sidney Spit Ferry	1	15.2	5.9	1.3

3.3 Services

The following services shall be provided:

- Building services (power, water and sewer),
- Site lighting,
- Fire protection for pier and floats,
- No services for floats.

3.4 Buildings

Buildings will require public washrooms to be incorporated into the facility.

3.5 Marina Wave Conditions

The target wave height at small craft moorings shall be less than H_s = 0.3 m in an annual expected storm event in accordance with a “Class A” marina.

3.6 Intertidal Rock Reef

The purpose of the intertidal rock reef is:

- To create marine habitat, potentially as offsetting for the pier development, and
- To facilitate recreational uses such as snorkeling and diving.

There are existing “reef balls” providing habitat around the fishing pier to the south of the site.

4.0 GEOMETRIC REQUIRMENTS

4.1 Wharf Deck Level

Wharf deck level will need to be set to satisfy flood construction level requirements for the buildings. Buildings are assumed to be single storey only, similar to existing.

Crest level of revetments/seawalls shall limit overtopping to safe levels for public pedestrians in an annual storm event, and for damage to buildings in a 1:200 or 1:500 Annual Exceedance Probability (AEP) storm event, including an allowance for climate change such as: sea level rise (SLR), wave components from more frequent and intense storms.

A balanced-risk approach shall be considered over service life of the project to maintain a uniform standard of protection. This involves considering:

- Initial case: 1:500 AEP event with no SLR or increased storminess, with an exposure period of 50 years; and
- End of life case: A reduced AEP event, with SLR and increased storminess over a reduced period to give a similar standard of protection as the initial case.

4.2 Grades

Pavement areas shall have a maximum grades of:

- 1:20 without handrail,
- 1:12 with handrail.

Gangway grades shall be limited to 1 to 12.

It is assumed that rock steps will form the southern side of the pier, with geometry of the steps to suit public access (e.g. rise 0.3 m, run 1 m).

Consideration shall be given to a ramp to the beach.

5.0 ENVIRONMENTAL

5.1 Topography

Existing topographic survey should be performed during detail design.

5.2 Bathymetry

The bathymetry is as per CHS chart 3479 (offshore) and the available soundings, the area of the project site is shown in Figure 1:

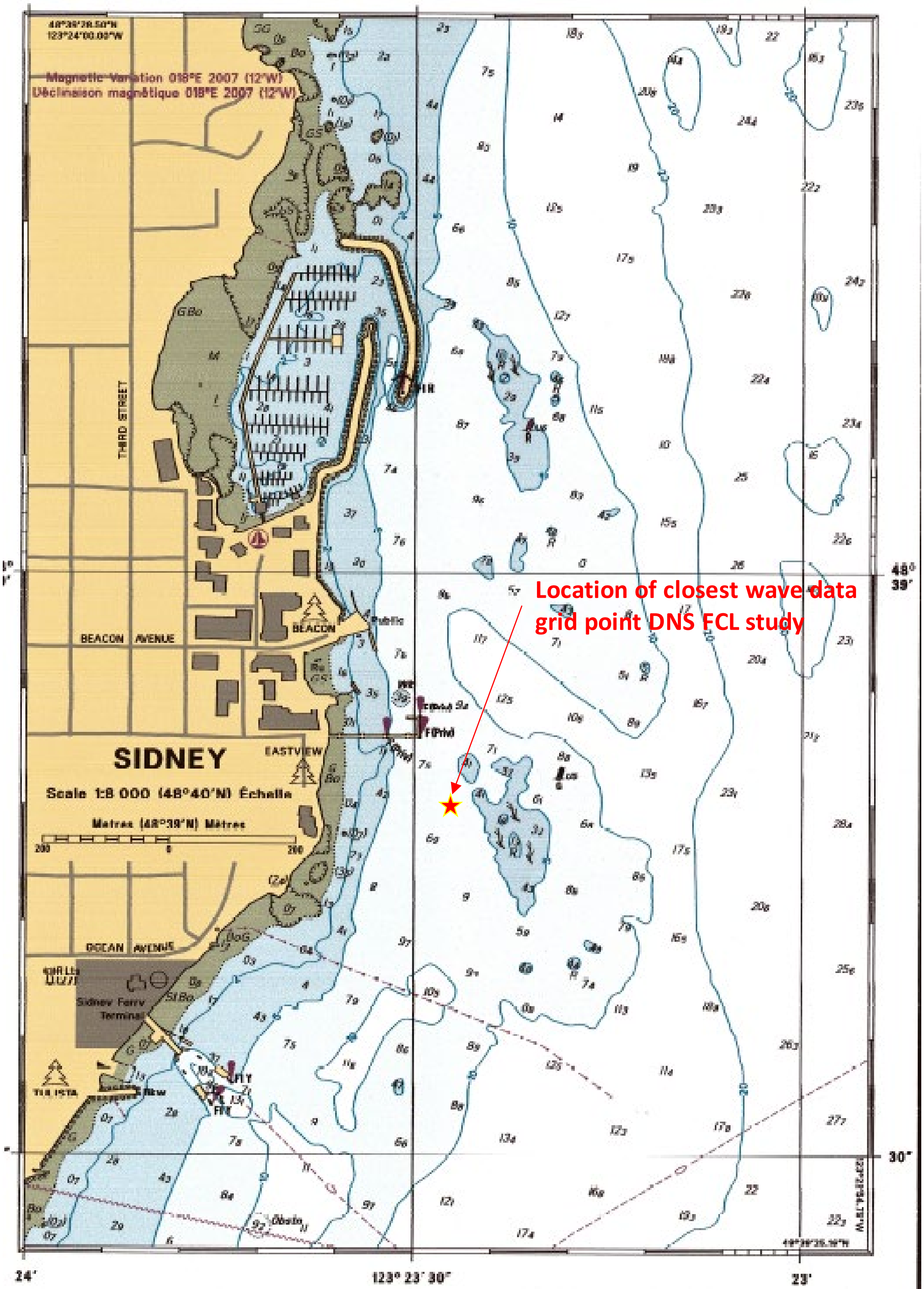


Figure 1 – Site Location with Bathymetry
image source: CHS Chart 4937 – positions converted using NRCAN TRX for NAD 83(CSRS)

5.3 Water Levels

5.3.1 Tidal Range

Design water levels for Sidney from the 2019 CHS tidal tables are given in Table 2 relative to Chart Datum.

Table 2 – 2019 CHS Tidal Range - Beacon Wharf

Tidal Condition	Water Level [m CD]
Observed Historical Extreme High Water*	4.4
Higher High Water Large Tide, HHWLT	3.5
Higher High Water Mean Tide, HHWMT	3.1
Mean Water Level, MWL	2.1
Lower Low Water Mean Tide, LLWMT	0.8
Lower Low Water Large Tide, LLWLT	-0.3
Observed Historical Extreme Low Water*	-0.5
* : based on Fulford Harbour (closest Reference Port). These are the observed maximum and minimum total water levels recorded over the period of record. They may have been observed several times during the record and should not be used as design water levels.	

5.3.2 Storm Surge

Storm Surge elevations are defined for the Sidney area in Ausenco Sandwell (2011).

The expected storm surge elevations for this area are summarized in Table 3.

Table 3 – Storm Surge Elevations (above astronomical tide)

Annual Exceedance Probability	Storm Surge Elevation [m above astronomical tide]
Annual Expected Storm	0.73
1/100 AEP Storm	1.2
1.200 AEP Storm	1.25
1/500 AEP Storm	1.3

5.3.3 Sea Level Rise

Recommended allowances for sea level rise, related to ongoing climate change, are outlined in BCMOE 2018 based on Ausenco Sandwell 2011. The minimum recommended allowance for a 50 year service life (circa 2070) is 0.8 m.

The guidance for sea level rise planning outlined in BCMOE 2018 recommends that this allowance should be reviewed every 10 years or sooner, if there is significant new scientific information. Scientific information released since 2011 suggests that 0.8 m of sea level rise might be realized sooner than 2070.

5.4 Winds

The site is exposed to gale and occasionally storm force winds from both the NE and the SE directions. A detailed wind and wave hindcast investigation, which includes measurement of both overwater winds and waves, is warranted before the detailed design of any options for the replacement of the Beacon Street Wharf.

A preliminary investigation of winds and waves was made by SNCL on behalf of the District of North Saanich (DNS) in 2017 for the DNS shorelines to the north and south of the project area. The model results included the Sidney shoreline area; however, the results are indicative only of conditions during a Designated Storm defined for the development of a proposed DNS Flood Construction Level Bylaw. The archived model results have been provided by DNS for this study; however, the available studies do not include conditions during all storms and remain to be validated for the Sidney waterfront area.

The DNS studies found that during a severe SE storm, with an AEP of 1:500, the area offshore of the Beacon Wharf is likely exposed to SE winds with a speed of 65 knots (33.4 m/s).

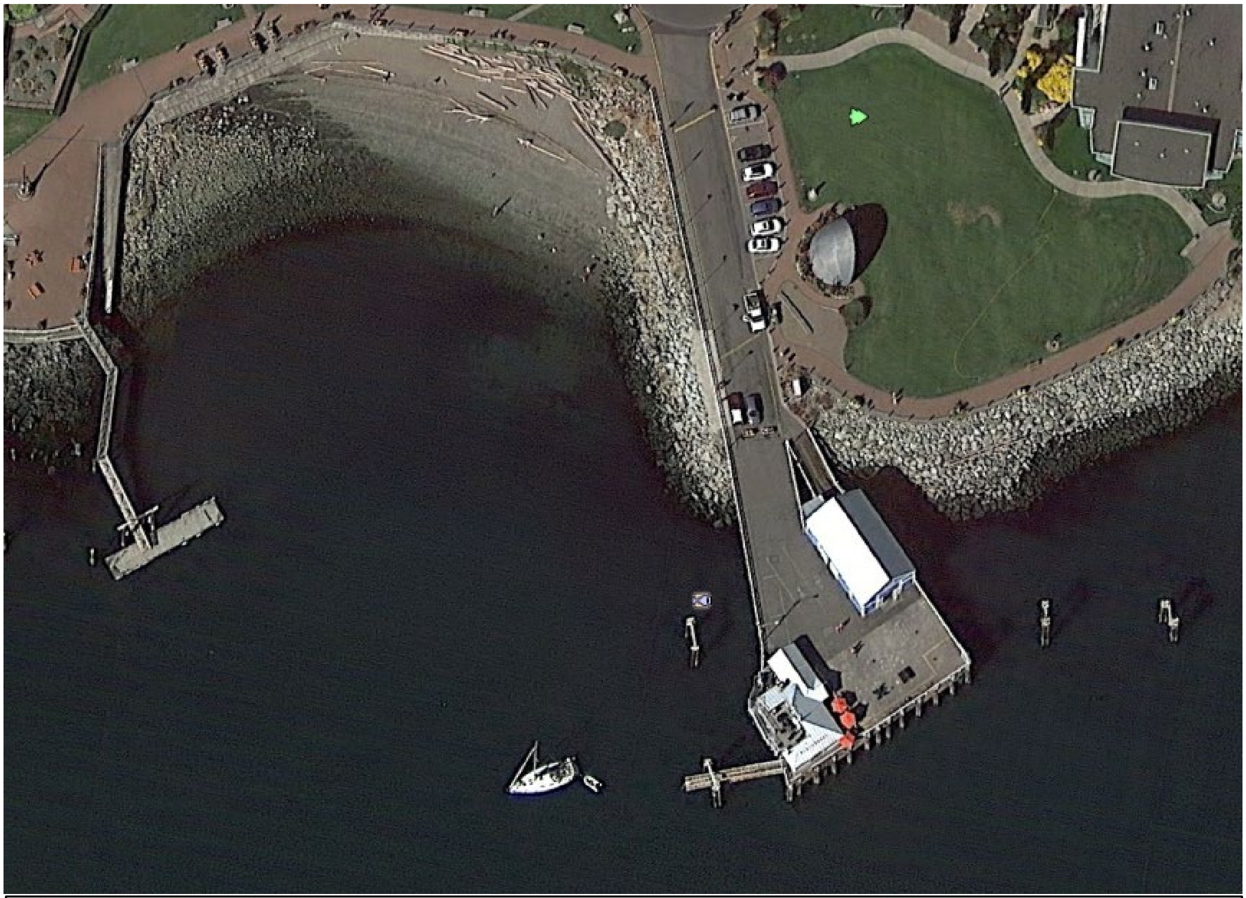
5.5 Wave Climate

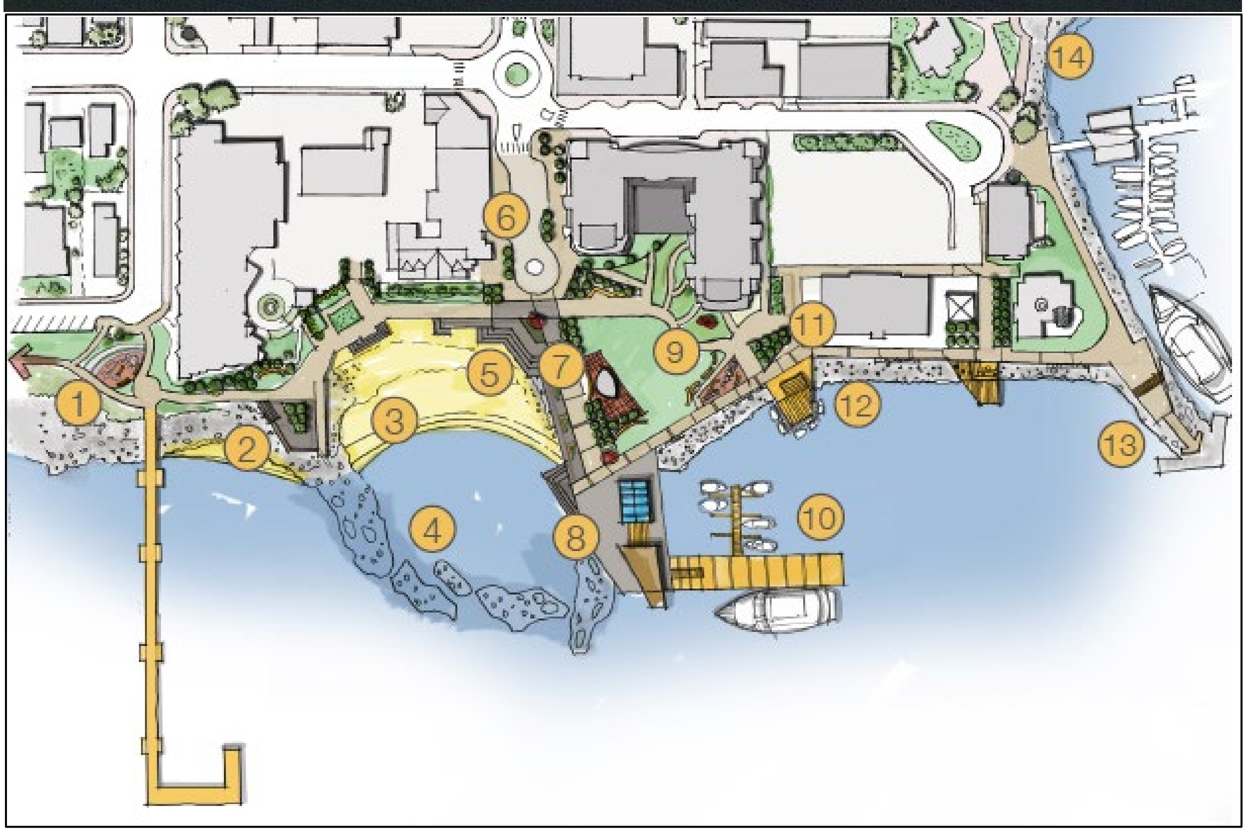
The DNS study archived results include sea state estimates (H_s) for a model grid point located approximately 300 m SSE of the Beacon Wharf, Figure 1, in 8 m water depth (CD). The grid point is located inshore of an extensive reef, Figure 1 and the results at this grid point are likely influenced by the reef bathymetry and by wave breaking on the extensive reef area, including a rocky area with a shallowest depth of 1.3 m at low tide.

6.0 SEISMIC REQUIREMENTS

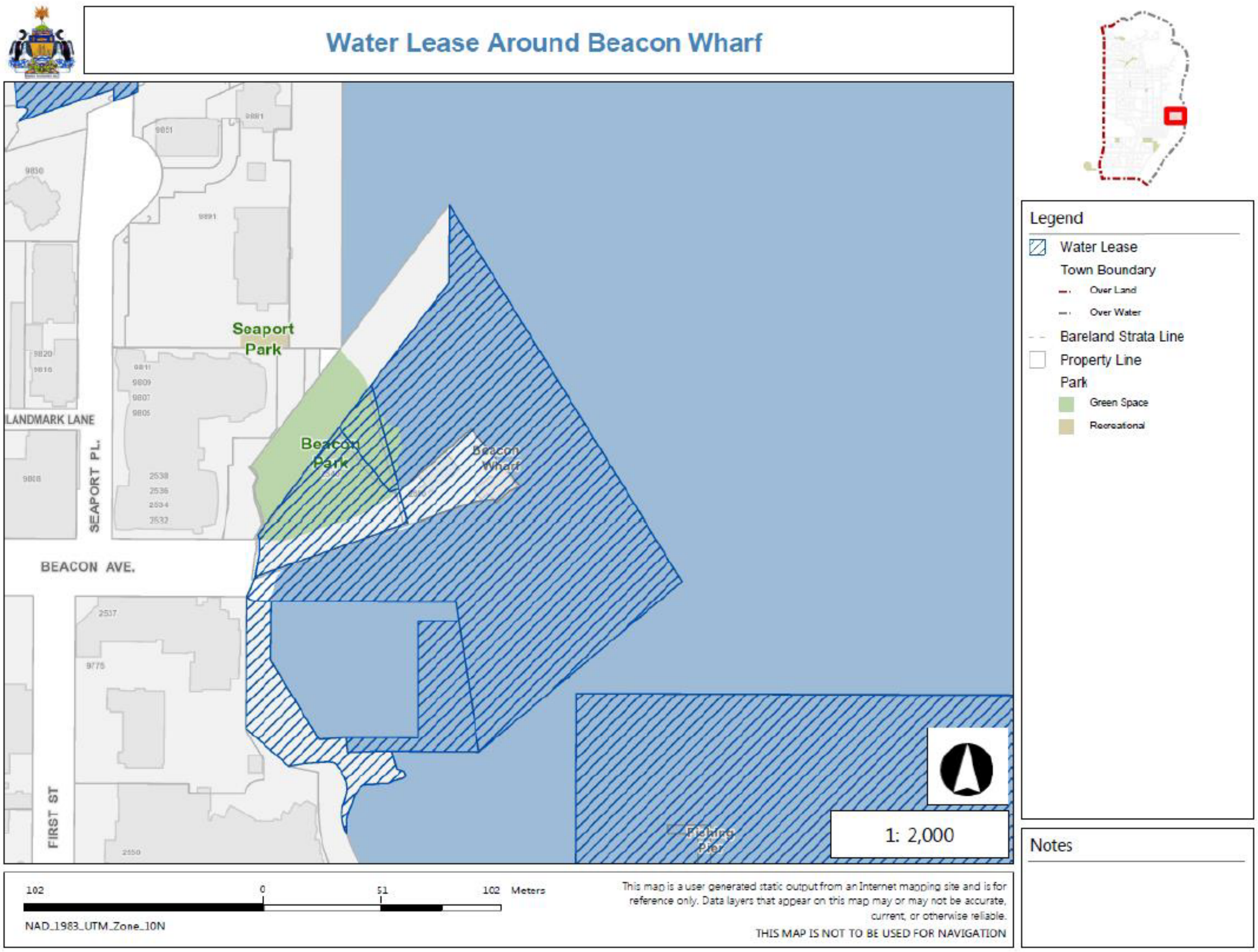
Design of infrastructure will be to CSA S6 for infrastructure and NBC 2015 for buildings and will provide life safety in a 2475 yr event.

Attachment 1 – Aerial photo of existing arrangement, and plan of Preferred Vision





Attachment 2 – Water lot lease boundary



APPENDIX B – ELEVATIONS & FCL MEMORANDUM

SNC-LAVALIN Inc.
745 Thurlow Street.
Vancouver, BC
Canada V6E 0C5
T: 604-662-3555

Certified ISO 9001

MEMORANDUM

Engineering, Design, Project Management

TO:	Town of Sidney	**DATE:**	24th October, 2019
C.C.:	Dave McWalter, John Readshaw, Patrick Devlin	**FROM:**	Adam Dijkerman
PROJECT:	667543 Beacon Wharf	**REVISION:**	PB
SUBJECT:	Elevations and Flood Construction Levels	**DOCUMENT NO:**	667543-0000-4PEN-0002

INTRODUCTION

This document summarizes the findings from desktop review of information available to SNCL to determine the existing elevations of Beacon Wharf and the recommended Flood Control Level for a replacement wharf.

REFERENCES

[1.] Sidney Approach Renewal, Drawing No 2-16, Public Works, July 1969

[2.] Beacon Wharf – Waterfront Park Curb Design, Drawing No 606A, Town of Sidney, February 2007

[3.] Interim Flood Construction Level, Policy and Procedures, Town of Sidney, June 2019

[4.] District of North Saanich Flood Construction Level Study, Study, SNC-Lavalin May 2016

CONVERSION: CHART DATUM - GOEDETIC

- CGVD28 = CD - 2.1 m

TOWN OF SIDNEY

- Existing top of wharf elevation is: +3.4 m Geodetic equivalent to +5.5 m CD (18.0’ in Figure 1).

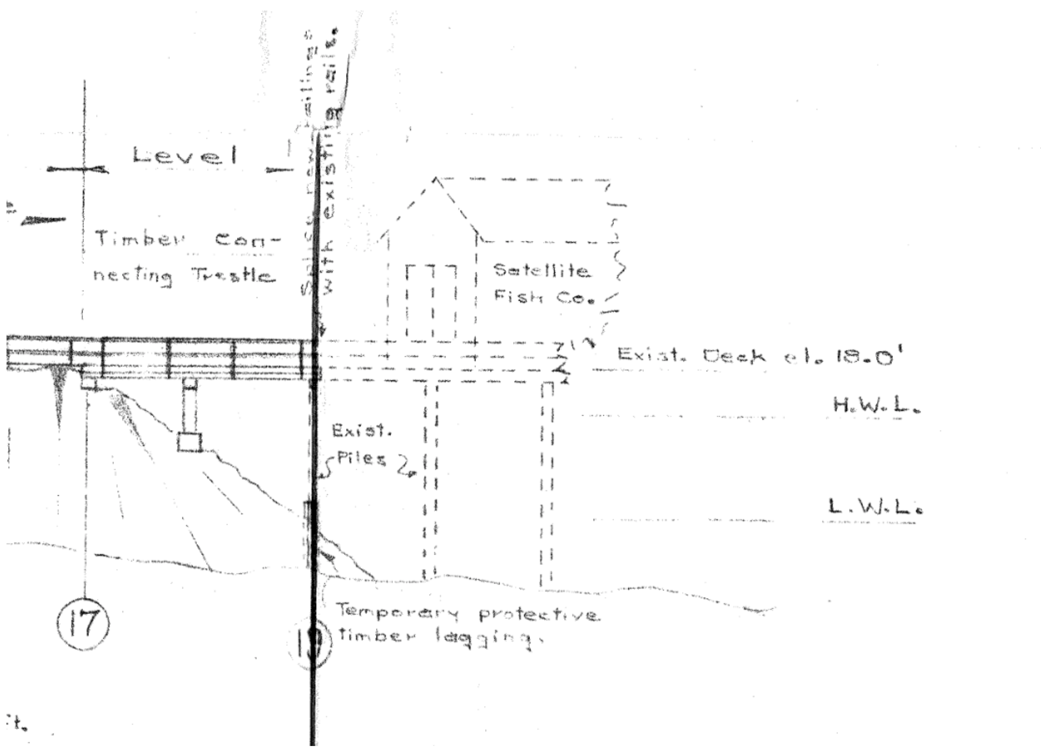


Figure 1 – Top of Wharf Elevation in Chart Datum (Ref 1)

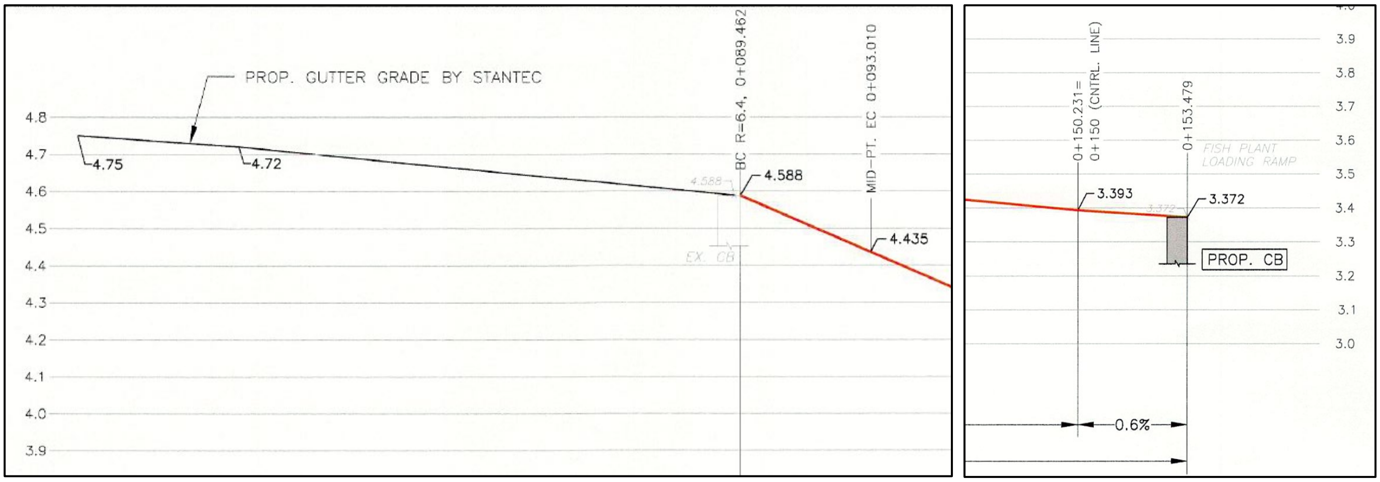


Figure 2 – Approach and Top of Wharf Elevation in Geodetic (Ref 2)

- Town of Sidney Interim Flood Construction Level: +5.0 m Geodetic (ref 3) equivalent to +7.1 m CD.

DISTRICT OF NORTH SAANICH WAVE CLIMATE SNCL

- Seastate of Hs = 4.5 m at limits of town's water lot due to the following conditions:
  - Severe Storm AEP of 1:500 storm event, SE winds (65 knots)
  - SLR of 0.8 m
  - Bathy elevation at toe of revetment of -8 m CD
- Top of recommended crest elevation (no freeboard allowance) at Beacon Wharf:
  - +9.0 m Geodetic equivalent to +11.1 m CD

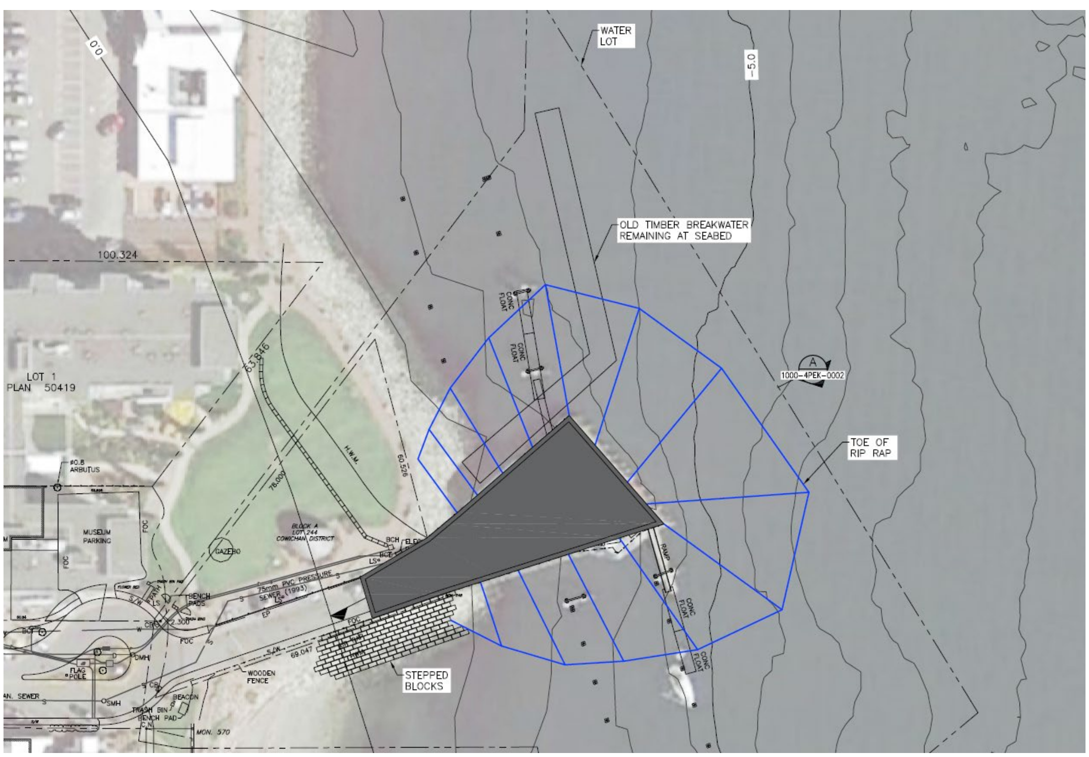


Figure 3 – Sketch of Bathymetry and Wharf Layout (Toe to be determined)

- FCL Study of DNS (Ref 4) located on the shoreline North and South of Beacon Wharf:
  - 10 L/m/s Overtopping crest level +6.3 m to +7.9 m Geodetic equivalent to +8.4 m to +10 m CD
  - 100 L/m/s Overtopping Threshold +4.5 m to +5.4 m Geodetic equivalent to +6.6 m to +7.5 m CD

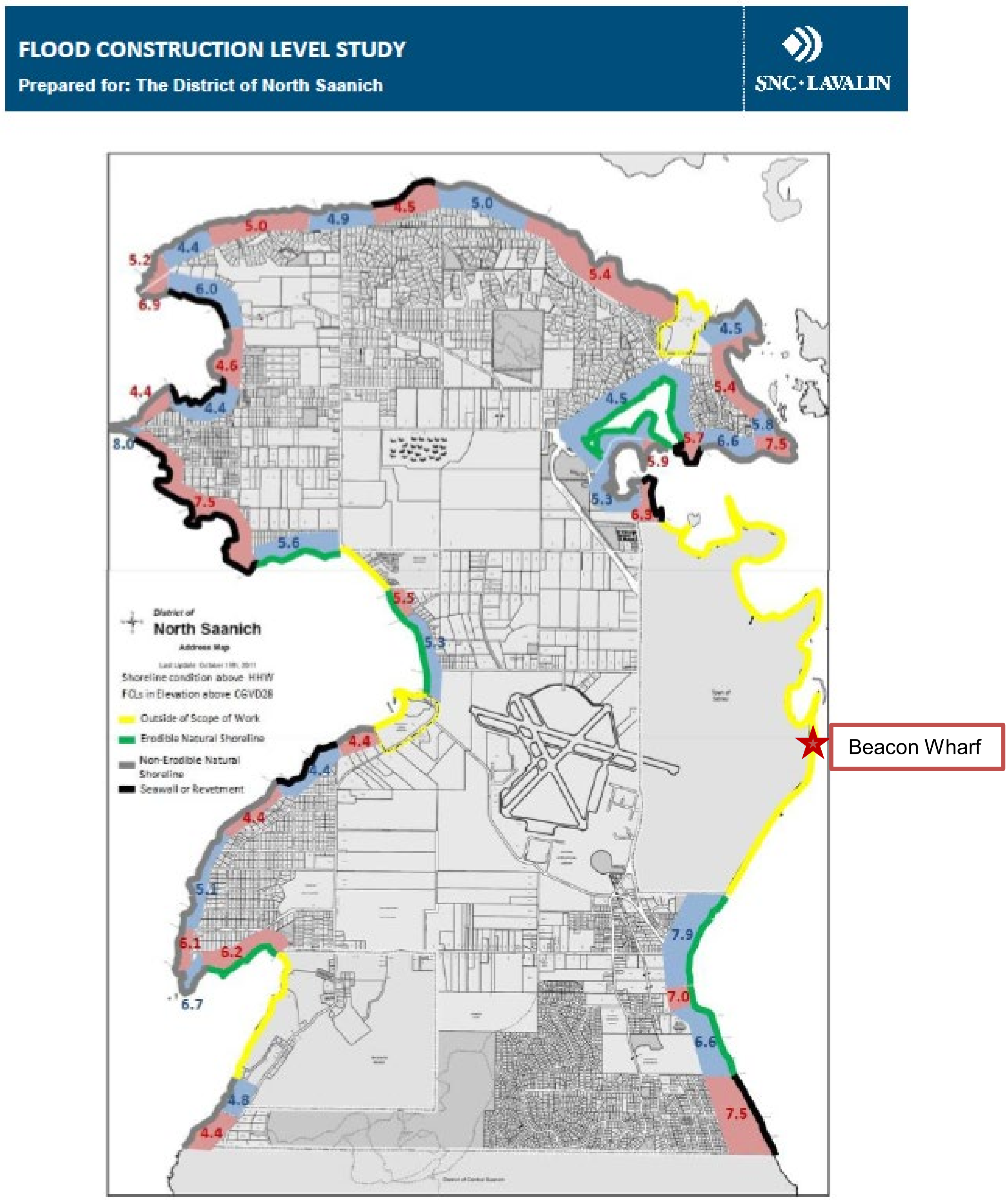


Figure 4 – FCL's for a 10 L/m/s Overtopping Threshold for DNS located North and South of Beacon Wharf (Ref 4).

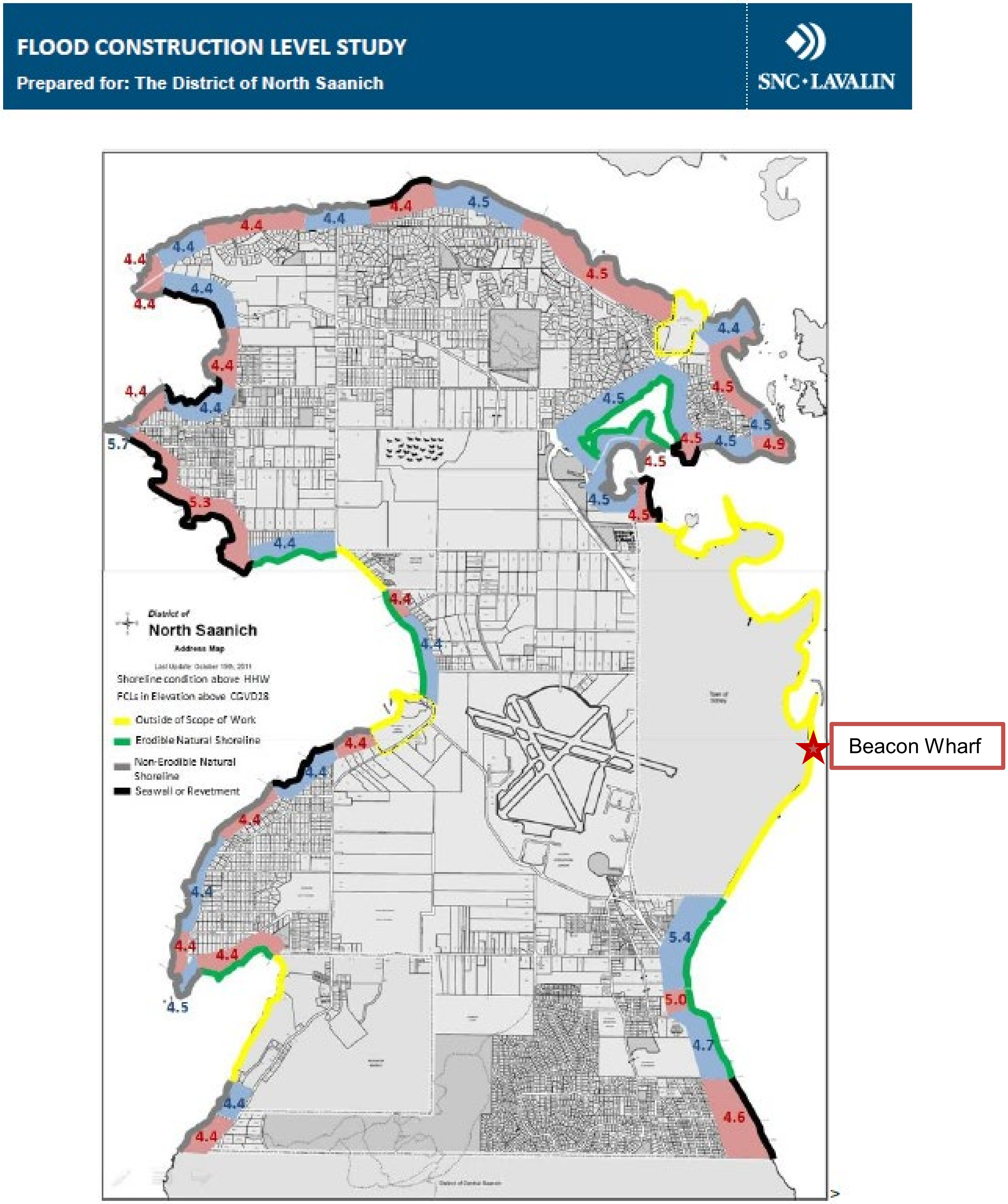


Figure 5 – FCL's for a 100 L/m/s Overtopping Threshold for DNS located North and South of Beacon Wharf (Ref 4).

CONCLUSION

The top of deck elevation for the replacement of the Beacon Wharf shall be determined using a balanced risk approach composed of requirements for the service life of the project, the buildings and considerations for climate change such as sea level rise and wave components from more frequent and intense storms.

The current top of wharf elevation of +5.5 m CD is lower than the Town of Sidney's current Interim Flood Construction Level of +7.1 m CD. However, considering the seastate assessed by SNCL for the DNS, options for replacement should consider FCLs that are in the range of +8.5 m CD to +11.1 m CD depending on location, type and configuration of the replacement wharf. Options will be developed to consider how coastal risk aspects can be incorporated into the proposed development.

APPENDIX C – GEOTECHNICAL ASSESSMENT

SNC-Lavalin Inc.
#202 - 3440 Douglas Street
Victoria, British Columbia, Canada V8Z 3L5
250.385.5028 604.515.5150

MEMORANDUM

To:	Town of Sidney	**Date:**	October 31, 2019
Attention:	Dave McWalter		
cc:	File		
From:	Damien Engelbrecht, P.Eng.	**Project:**	667543
Reviewed:	Jeremy Zandbergen, P.Eng.		
Subject:	Sidney Wharf Upgrade Feasibility Study, Sidney, BC Geotechnical Engineering Desktop Study – Revision 1		

Introduction and Project Scope

SNC-Lavalin Inc. (SNC-Lavalin) was contracted by the Town of Sidney to perform a feasibility study for the proposed replacement of the Beacon Wharf located in Sidney, BC. The geotechnical portion of the project scope included a desktop study and a geotechnical opinion regarding the feasibility of the project.

Following the desktop review, SNC-Lavalin probed the seabed to estimate the thickness of soft sediment above the anticipated bearing strata.

This memorandum provides the result of our desktop study, the factual result of the seabed probing, and our comments regarding the feasibility of the project. It should be noted that the scope of this memorandum is limited to the geotechnical aspects of the project and does not include any investigations, analytical testing or assessments of possible soil and groundwater contamination, biological considerations, archeological considerations and/or sediment control measures.

This memorandum should be read in conjunction with the "**Notice to Reader**" which is attached following the text. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this memorandum. The Town of Sydney along with other government agencies, as the regulatory authorities are authorized users of this memorandum and may rely upon this memorandum.

October 31, 2019

Desktop Review

SNC-Lavalin reviewed several reports to obtain background geology information pertaining to the proposed Beacon Wharf project. The reports reviewed included those provided by the Town of Sidney as well as reports that were readily available on the internet.

Reports included in our desktop review are indicated below along with relevant geology information which was obtained from the report.

The Brief in Support of Breakwater (1968) indicated that:

- There are near shore rocky shoals present;
- Bottom material was comprised of “fluffy” fine grained material underlain by clay-like material with no indications of granular material; and
- Rock was observed near shore.

The Tsehum Harbour Report (1981) indicated that:

- The shore zone was classified as mixed irregular shore-zone type characterized by rocky headlands and embayments.

The Physical Shoreline Analysis of the Saanich Peninsula, MOE Technical Report 9 (1979) indicates that:

- The shoreline is comprised of thick, gently undulating glaciomarine silt overlying till.

The Regional Groundwater Potential for Supplying Irrigation Water North Saanich, B.C. (1986) indicated that:

- The area southwest of Beacon Wharf is underlain by silt, clay, or till overlying bedrock.

Site Observations

On August 28, 2019 SNC-Lavalin inspected the site and performed probing of the seabed utilizing a 10 mm (3/8”) steel rod to determine the thickness of the soft sediment near the existing Beacon Wharf.

The site was inspected during low tide and it was observed that the visible shoreline had bedrock outcroppings. In addition, the sediments observed adjacent to the outcropping were comprised of loose silts and sands with scattered cobbles. Below the soft silts and sands the material appeared to contain some firm clay with some gravels.

The tide at the time the measurements were taken was approximately -1.4 m below existing sea level. The locations along with the depth of water at the time the measurement was taken, and thickness of the soft sediment are presented in the below Table 1:

Table 1 – Seabed Depth and Soft Sediment Estimated Thickness at Time of Measurement

Latitude	Longtitude	Time (GMT)	Depth of Water (m)	Thickness of Soft Sediment (m)
48.64903104	-123.392820	2019-08-28T17:09:54Z	3.89	0.3
48.64899499	-123.392987	2019-08-28T17:11:29Z	2.94	0.3
48.64919297	-123.392628	2019-08-28T17:14:01Z	3.91	0.0
48.64935902	-123.392634	2019-08-28T17:17:29Z	5.49	0.0
48.64948902	-123.392850	2019-08-28T17:19:17Z	4.57	0.0
48.64968399	-123.393074	2019-08-28T17:24:01Z	4.04	0.5
48.64961802	-123.393084	2019-08-28T17:25:21Z	3.28	0.0
48.64954300	-123.392978	2019-08-28T17:26:05Z	3.51	0.0
48.64962900	-123.392992	2019-08-28T17:27:02Z	4.29	0.9
48.64973403	-123.393020	2019-08-28T17:28:02Z	3.66	0.0
48.64975004	-123.393022	2019-08-28T17:28:37Z	4.67	0.9
48.64946899	-123.393063	2019-08-28T17:31:39Z	5.00	0.3
48.64943999	-123.393108	2019-08-28T17:33:01Z	2.82	0.3

Discussion

Due to the constant reworking of sediments due to wave action and rising and falling tides, it is not clear if the observed sediments on the shoreline were in an undisturbed state. It should however be noted that the observed material was consistent with the anticipated materials from the desktop review. Below the soft sediment observed onshore the soil composition appears to be consistent with the silts, clays, and glacial tills mapped and reported in the reviewed documents within the general area.

Based on the desktop study and the observed materials as well as the general consistency of the material observed during the seabed probing it is the opinion of SNC-Lavalin that a rockfill wharf is feasible in this location to replace the existing Beacon Wharf suspended deck structure. For planning and budgeting purposes and based on the soft sediment thicknesses observed it is our opinion that planning displacement of up to 1.0 m of soft sediment during the placement of the rock foundation should be anticipated, with the potential of thicker pockets.

It is also our opinion that during the design stages of the project that a geotechnical drilling investigation of the seabed should be performed to confirm the observations and assumptions made during this feasibility level study. At a minimum, planning and budgeting should be made for three (3) boreholes to be drilled, one on each of the water sides of the present wharf.

Attachment

1: Notice to Reader

C:\USERS\BACHR\DESKTOP\667543\20191031_667543_MEM_SIDNEY WHARF.DOCX

Attachment 1

Notice to Reader

Notice to Reader

This memorandum has been prepared and the work referred to in this memorandum has been undertaken by the Engineering, Design, and Project Management business unit of SNC-Lavalin Inc. (SNC-Lavalin) for the use of Town of Sydney (the Client), who has been a party to the development of the scope of work and understands its limitations. The methodology, findings, conclusions, and recommendations in this memorandum are based solely upon the scope of work and subject to the time and budgetary considerations described in the proposal and/or contract pursuant to which this memorandum was issued. Any use, reliance on, or decision made by a third party based on this memorandum is the sole responsibility of such third party. SNC-Lavalin accepts no liability or responsibility for any damages that may be suffered or incurred by any third party as a result of the use of, reliance on, or any decision made based on this memorandum.

The findings, conclusions and recommendations in this memorandum (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this memorandum. No other warranties, either expressed or implied, are made with respect to the professional services provided to the Client or the findings, conclusions and recommendations contained in this memorandum. The findings and conclusions contained in this memorandum are valid only as of the date of this memorandum and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered or project parameters change, modifications to this memorandum may be necessary.

This memorandum must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final version of this memorandum, it is the final version that takes precedence. Nothing in this memorandum is intended to constitute or provide a legal opinion.

The contents of this memorandum are confidential and proprietary. Other than by the Client, copying or distribution of this memorandum or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of the Client and SNC-Lavalin.

APPENDIX D – ENVIRONMENTAL SURVEY

Beacon Wharf Surveys and Feasibility Study

Marine Habitat Assessment
Town of Sidney

September 18, 2019

Internal Ref: 667543

Table of Contents

Table of Contents (cont'd)

In-Text Figures

In-Text Tables

1. Introduction

As part of its Downtown Waterfront Vision, the Town of Sidney ("Town" or "Sidney") is undertaking surveys around the Beacon Wharf to guide future investment and decision-making in the area. Currently, Sidney is assessing the feasibility of rebuilding Beacon Wharf on a rock base and constructing an intertidal rock reef at Glass Beach. The existing conditions in the project site are shown on Figure 1, with the preferred Downtown Waterfront Vision shown on Figure 2.

SNC-Lavalin was retained by the Town to complete an environmental survey to provide information about the vegetation and seafloor life in the vicinity of Beacon Wharf.

Figure 1: Existing Conditions at the Downtown Sidney Waterfront.

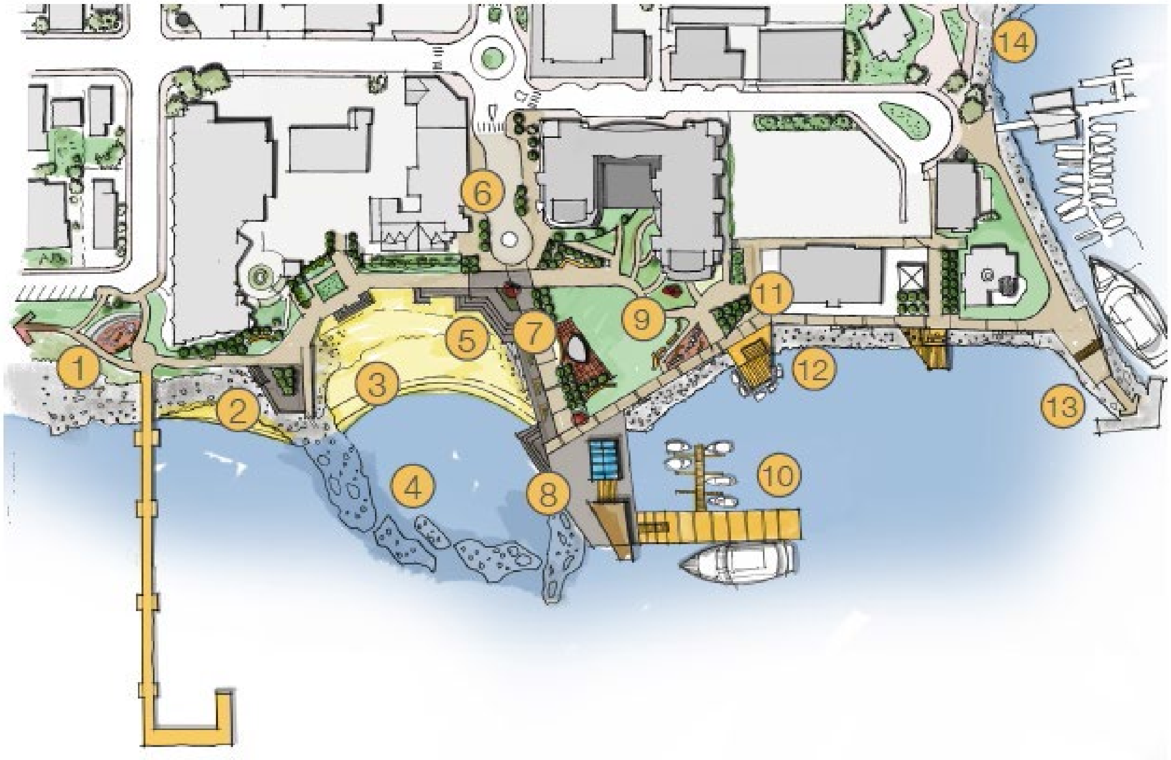


Figure 2: Preferred Downtown Sidney Waterfront Vision

1.1. Scope of Work

This environmental survey is intended to characterize marine habitat in the Beacon Wharf area and the marine footprint of Sidney's Downtown Waterfront Vision via desktop studies and field surveys. The environmental survey characterizes the biophysical environment in the marine footprint of Sidney's Downtown Waterfront Vision, including:

- a desktop review of fisheries and biological resources in the area using available literature and databases, including characterization of potential species at risk occurring in the project area
- intertidal and subtidal field surveys to determine substrates, habitat type, species presence, including dominant species, and presence of sensitive species such as kelp forests and eelgrass beds
- preparation of a habitat map(s) to show the habitat types, kelp forests and eelgrass beds in the marine footprint of Sidney's Downtown Waterfront Vision.

2. Habitat Assessment

2.1. Methods

2.1.1. Desktop Review

The fisheries resources, biological resources, and species at risk were characterized in the project area through desktop review. As part of the desktop review, the following sources were queried:

- British Columbia Ministry of Environment—BC Species and Ecosystem Explorer;
- British Columbia Ministry of Environment— Fisheries Inventory Data Queries;
- British Columbia Coastal Resource Information System (CRIMS); and,
- Fisheries and Oceans Canada—Herring Geographical Bulletin.

Primary literature was also reviewed, and citations are provided.

2.1.2. Field Surveys

Field surveys were completed on August 27 (intertidal field survey) and August 28 (subtidal field survey), 2019.

2.1.2.1. Intertidal Survey

The intertidal survey was conducted as the tide was receding on August 27, 2019, to coincide with the lowest tide of the day (0.4 m at 0837 h). Nine survey transects were established perpendicular to the foreshore using a measuring tape that extended from the riparian zone to the waterline (Figure 3). Photographs were recorded along the entire length of each transect and GPS coordinated recorded at each end of the transect as well as at changes in predominant habitat type. Each transect was then surveyed by a qualified environmental professional (QEP) who walked the length of the transect to observe habitat bands. Note: the intertidal zone in the pacific northwest shows strong 'vertical zonation' in the form of habitat bands. Habitat bands are defined as *repeatable assemblages of intertidal biota that usually have a unique colour signature and intertidal position* (Howes, 2001). The start and end of each habitat band was recorded and the habitat within the band was characterized by substrate type present (see Table A), as well as the presence of vegetation/algae and invertebrates. Habitat bands were used to create a habitat map of the surveyed area.

Table A: Substrate Classification Categories for Field Surveys

Substrate Type	Definition
Bedrock	Solid, continuous rock
Boulder	Rocks greater than ~25 cm in diameter
Cobble	Moderate to small-sized rocks, ~6 to 25 cm in diameter
Gravel	Small stones between ~2 mm and 6 cm in diameter
Fines	Fine deposits < 2 mm, including mud, clay and shell fragments
Shell Hash	Dominant presence (>50%) of shell fragments in substrate
Wood	Dominant presence (>50%) of wood in substrate

2.1.2.2. Subtidal Survey

Subtidal field surveys were conducted by deploying an underwater camera (GoPro Hero 7 Silver) programmed to take video of the seabed which was attached to a line and weight and lowered to the seabed surface. The camera was deployed from a boat in the project footprint (see Figure 4 for observation points). During boat surveys, video was recorded of the seabed throughout the project area, with the goal of encompassing the project footprint and beyond. The GPS position was tracked throughout the survey so that the location where video was recorded could be determined. Pre-mapped transects were difficult to follow in the subtidal area due to winds and currents.

The underwater video was reviewed by an SNC-Lavalin marine biologist. Marine habitat was characterized by recording the substrate type as well as the presence of vegetation/algae, eelgrass, kelp, invertebrates and fish. Habitat types were used to create a habitat map of the surveyed area.

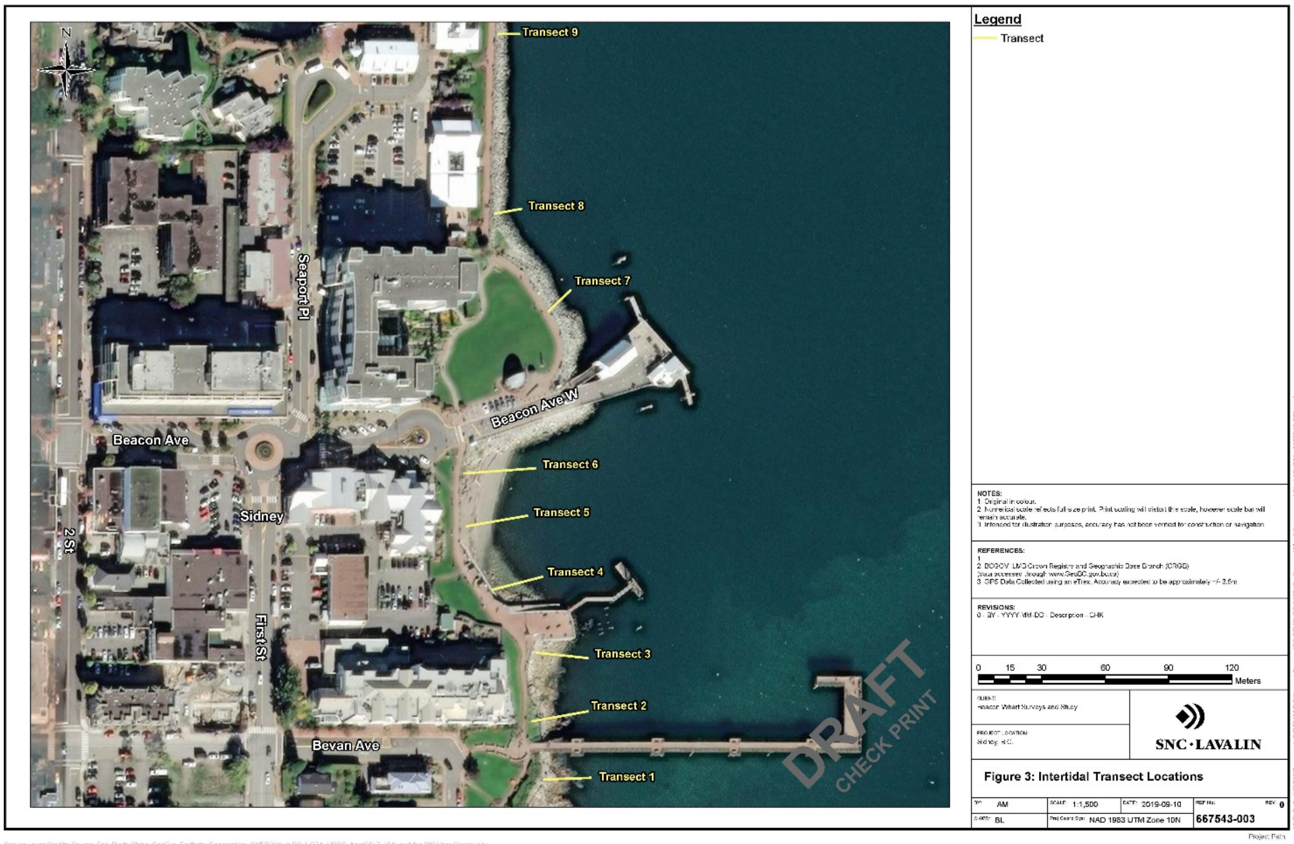


Figure 3: Intertidal Transect Locations

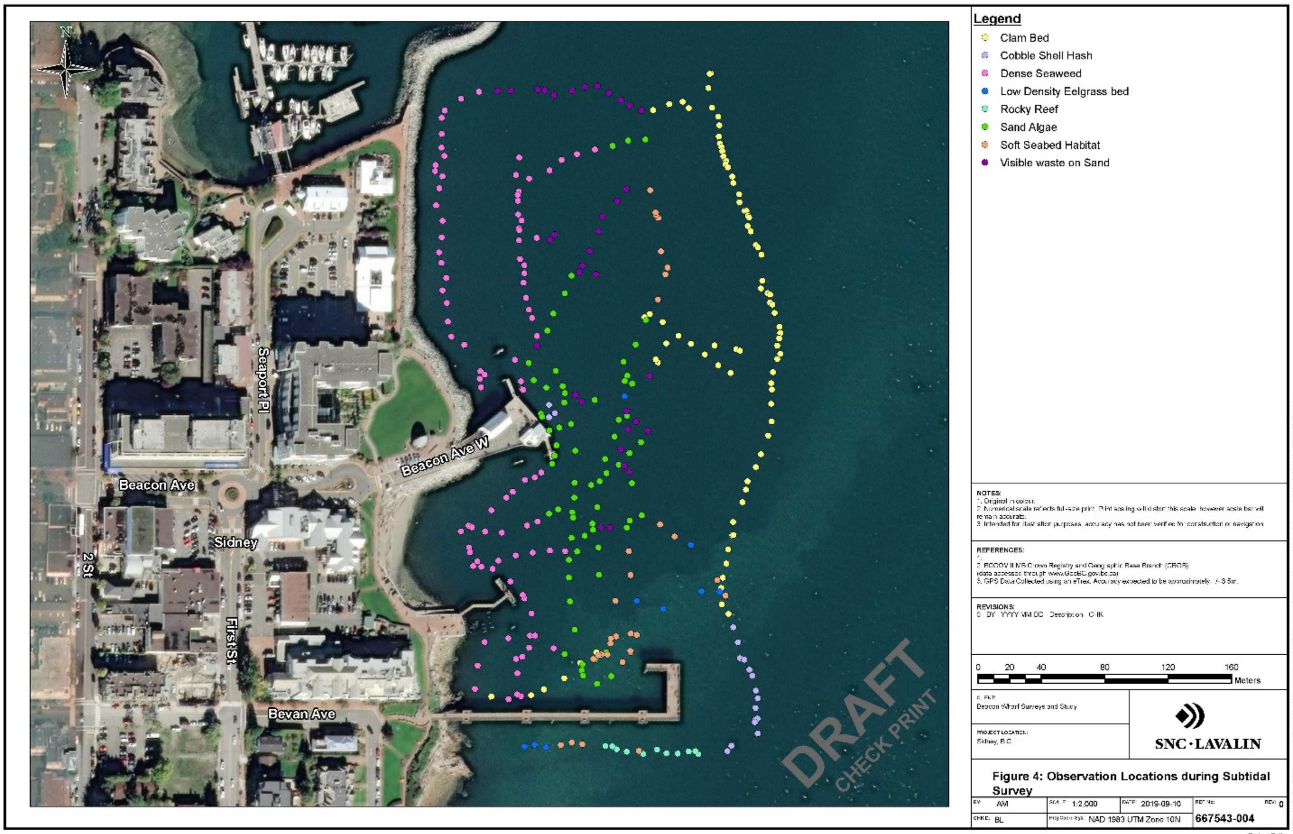


Figure 4: Observation Locations during Subtidal Camera Survey

2.1.3. Data Analysis

Data recorded during the intertidal and subtidal surveys were used to create a habitat maps (Figure 5).

2.2. Results

2.2.1. Desktop Review

The desktop review focussed on known distributions of species at risk, biological resources, and fisheries resources with the potential to occur in the project area.

2.2.1.1. Species at Risk

Species at risk include those that are listed as endangered, threatened, or special concern by either the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), or under the federal *Species at Risk Act* (SARA), or those species that are listed under the British Columbia *Wildlife Act*.

Federally, species at risk are covered by the *Canada Wildlife Act* and are ranked by COSEWIC as follows: extinct (X), endangered (E), extirpated (XT), threatened (T), special concern (SC), not at risk (NAR) and data deficient (DD). COSEWIC rankings are recommendations to the federal government, following which the government then decides on whether or not the species will be listed under the SARA. Species listed in Schedule 1 of SARA are species officially at risk in Canada and are protected under the SARA.

Schedule 2 and 3 species are not officially protected under SARA and are not considered in this section of this report.

Provincially, the red list includes any indigenous species that is extirpated, endangered, or threatened in British Columbia (BC CDC 2017). The blue list includes any indigenous species that is of special concern in British Columbia. The yellow list includes uncommon, common, declining and increasing species. Yellow list species are not considered in this section of this report.

Table B shows a list of marine species at risk that have the potential to occur in the project area. While any project in the area has the potential to impact these species, impacts can very likely be avoided or mitigated though appropriate environmental management planning. Moreover, these species are expected to only occur in the project area infrequently and the potential for impact is expected to be low.

Table B: Species at Risk Potentially Occurring Near Sidney

Species	Conservation Status*		
	BC Status	**COSEWIC Status**	**SARA Status**
Grey Whale	Blue-2006	SC-2004	1-SC-2005
Harbour Porpoise	Blue-2006	SC-2016	1-SC-2005
Humpback Whale	Blue-2006	SC-2011	1-SC-2017
Killer Whale (Southern Resident)	Red-2011	E-2008	1-E-2003
Killer Whale (Transient)	Red-2011	T-2008	1-T-2003
Sea Otter	Blue-2015	SC-2007	1-SC-2003
Stellar Sea Lion	Blue-2013	SC-2013	1-SC-2005
Northern Abalone	Red-2002	E-2009	1-E
Olympia Oyster	Blue-2003	SC-2011	1-SC-2003
Great Blue Heron (fannini subspecies)	Blue-2009	SC-2008	1-SC-2010
Marbled Murrelet	Blue-2015	T-2012	1=T-2003
Double-crested Cormorant	Blue-2015	NAR-1978	–
Brandt's Cormorant	Red-2015	–	–
Common Murre	Red-2015	–	–
Purple Martin	Blue-2015	–	–
Caspian Tern	Blue-2015	NAR-1999	-
Tufted Puffin	Blue-2015	–	–

* from BC Species and Ecosystem Explorer, accessed August 2019.

2.2.1.2. Biological Resources

While numerous species with biological significance occur in the project area, it should be noted that only those with significant ecological, importance are discussed in this section. These species are described in Table C. Note: species with significant commercial, recreational or aboriginal significance are discussed in section 2.2.1.3.

Table C: Biological Resources Potentially Occurring Near Sidney

Species	Description
Pacific Herring	Pacific herring are an important food source for a variety of species in the project area including pacific salmon (coho and chinook, and other fish, birds and marine mammals (DFO, 2018). Pacific Herring (*Clupea pallasii*) is a pelagic species that migrates between nearshore spawning and offshore feeding areas of the North Pacific Ocean (DFO, 2018). In the project area, spawning typically occurs in early spring (March or April; Hay 1985). Herring spawn has not been reported in the Project area (Hay et al. 1989, revised 2015), with the nearest known herring spawn site occurring in Shoal Harbour, which is over 2 km away (CRIMS 2019; Hay et al. 1989, revised 2015). The spawning sites that occur on Shoal Harbour are in the lowest 25% of spawning site importance (Hay et al. 1989, revised 2015). Project interactions with spawning herring are expected to be limited.
Pacific Salmon	All five species of Pacific salmon (*Oncorhynchus spp.)* are found in the waters around Sidney. These include: pink (*O. gorbuscha*), chum (*O. keta*), chinook (*O. tshawytscha*), Coho (*O. kisutch*); and sockeye (*O. nerka*). The species which occur nearest the project area is coho, which have been recorded in Raey Creek approximately 2.2 km to the south of the project (FIDQ 2019). In general, all juvenile salmon species undergo long distance seasonal migrations as they travel from their natal streams towards deep waters of the north Pacific. Seasonally, juvenile out-migrating salmon and returning adult spawners will transit through the nearshore waters of the project area, however, project interactions with salmon are expected to be limited.
Eelgrass	Eelgrass (*Zostera marina*) is an extremely important component of marine ecosystems in the Pacific northwest as it provides multiple ecosystem functions (Philips 1984). Specifically, eelgrass stabilizes sediments and prevents erosion, provides direct and indirect food sources to numerous invertebrates and fishes, and acts as a nursery area for numerous marine species (Philips 1984). No eelgrass beds are known to occur within the project footprint (CRIMS 2019). Eelgrass does occur in the area, with large eelgrass beds occurring to the north of Port Sidney Marine (Pers. Obs. Lynch, 2019) and large eelgrass beds occurring 3.5 km away at Sidney Spit (CRIMS 2019).
Kelp	Kelp forests in the project area generally consists of *Macrocystis* (giant kelp) and/or *Nereocystis* (bull kelp). Kelp forests provide critical habitat, including nursery and feeding habitat for numerous invertebrates and fishes (Wheeler 1990). Kelp forests are known to occur within the project area (CRIMS 2019).

2.2.1.3. Fisheries Resources

Various fisheries operate around the project footprint at different times of the year including commercial, recreational and Aboriginal fisheries. Table D describes the main commercial fisheries species that occur around the project footprint.

Table D: Summary of Primary Commercial Fisheries Species Near Sidney

Fishery	Fishing Season	Details
Pacific Herring	Food and Bait: Nov. to Jan.[1] Roe Herring: Feb. to Mar. Spawn on Kelp: Mar. to Apr.	Pacific Herring are harvested commercially in BC for food and bait, spawn-on-kelp products, and roe (DFO, 2018). First Nations traditionally harvest whole herring and herring spawn-on-kelp for food, social and ceremonial purposes (DFO, 2018). There are no documented herring fisheries within 10 km of the project site (CRIMS 2019).
Pacific Salmon	Species dependent	There are no known commercial finfish fishing areas within 5 km of the project site (CRIMS 2019). There are two documented locations where recreational fin fishing occurs within 5 km of the project area (CRIMS 2019): southwest of coal island (approx. 3.5 km away from the project site) and Sidney Spit (approximately 3 km from the project site).
Other Finfish	Species dependent	There are no known commercial finfish fishing areas within 5 km of the project site (CRIMS 2019). There are two documented locations where recreational fin fishing occurs within 5 km of the project area (CRIMS 2019): southwest of coal island (approx. 3.5 km away from the project site) and Sidney Spit (approximately 3 km from the project site).
Crab	Year round	Dungeness crabs (*Cancer magister*) is harvested commercially from within 3.5 km of the Project area, with the nearest harvesting locating located off the northern tip of Sidney spit (CRIMS 2019). In addition, recreational harvest of Dungeness crabs and red rock crabs (*C. productus*) occur from the project area via the Bevan Fishing Pier (*Pers. Obs*. Lynch 2019).
Bivalve Shellfish	Year round	There are no known commercial bivalve fishing areas within 5 km of the project site (CRIMS 2019). The project area is open to recreational fishing[2] of Littleneck Clam, Manila Clam, Mussels, and Oysters.
Prawn, Shrimp and other Invertebrates	Year round	There are no known commercial invertebrate fishing areas within 5 km of the project site, except for sea cucumbers which are harvested in Haro Strait (CRIMS 2019). The project area is open to recreational fishing[2] of shrimp, prawns, barnacles, limpets, octopus, squid, sea cucumber, sea urchin, and sea stars among other invertebrate species. Abalone fishing is prohibited. Recreational harvest of spot prawns (*Pandalus platyceros*) occur from the project area via the Bevan Fishing Pier (*Pers. Obs*. Lynch 2019).

[1] http://www.pac.dfo-mpo.gc.ca/fm-gp/commercial/pelagic-pelagique/herring-hareng/index-eng.html

[2] https://www.pac.dfo-mpo.gc.ca/fm-gp/rec/tidal-maree/a-s19-eng.html

2.2.2. Field Surveys

2.2.2.1. Intertidal Zone

The intertidal zone within the proposed project footprint can be divided into three distinct areas:

- **Riprap Breakwater:** found predominantly in the northern half of the project area; 3 survey transects were surveyed in this habitat type.

Photo 1. Riprap breakwater found in the northern part of the project area.

- **Glass Beach:** a beach located in the middle of the projects area; 3 survey transects were surveyed in this habitat type.

Photo 2. Glass Beach.

- **Rocky Intertidal:** found predominantly in the southern part of the project area; 3 survey transects were surveyed in this habitat type.

Photo 3. Rocky intertidal zone found in the southern part of the project area.

2.2.2.1.1. Riprap Breakwater Habitat

Strong 'vertical zonation' in the form of habitat bands was observed in the surveys of riprap breakwater habitat in the project area. The following bio bands were observed:

- **Unvegetated Riprap Band**: The unvegetated riprap Habitat Band was located along breakwater fronting much of the Sidney seawall in the supra-littoral zone. Substrate consisted of riprap boulders. Vegetation was sparse with only some lichen present. No invertebrates were observed in this habitat band.
- **Rockweed Band**: The rockweed habitat band was located along the breakwater fronting much of the Sidney seawall, between the unvegetated riprap band and the sea lettuce band in the mid intertidal zone. Substrate consisted of riprap boulders. Rockweed (*Fucus gardneri*) was the dominant alga in this band though other species of algae were present in this band including Turkish washcloth leafy and crustose phases (*Mastocarpus papillatus*), filamentous red seaweed (*Polysphonia spp.*) and sea lettuce (*Ulva sp*.) Invertebrates observed included acorn barnacles (*Balanus glandula*) periwinkles (*Littorina spp.*), and limpets (*Lottia spp*. and *Tectura spp*.).
- **Sea Lettuce Band**: The sea lettuce habitat band was located along the breakwater fronting much of the Sidney seawall below the rockweed band in the low intertidal zone. Substrate consisted of riprap boulders. Sea lettuce (*Ulva sp*.) was the dominant alga in this band though other species of algae were present in this band including coralline algae (*Corallina spp.)*, Turkish washcloth leafy and crustose phases (*M. papillatus*), filamentous red seaweed (*Polysphonia spp.*), sargassum (*Sagassum sp*.), purple laver (*Porphyra sp.*), sea sacs (*Hallosaccion sp.*), sugar kelp (*Laminaria sp.*) and rockweed (*F. gardneri*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), limpets (*Lottia spp*. and *Tectura spp*.), ochre seastars (*Pisaster ochraceus*), mottled seastars (*Evasterias troschelii*), brittle stars (*Ophiopholis aculeata*), and unidentified tubeworms and sponges.

Photos 4, 5 and 6. Unvegetated riprap habitat band (left); rockweed habitat band (middle); and sea lettuce habitat band (right) found on the riprap breakwater.

2.2.2.1.2. Glass Beach

The following bio bands were observed in the survey of Glass Beach:

- **Gravel Beach Habitat Band**: The gravel beach habitat band was located on Glass Beach in areas where substrates were thick gravels in the high intertidal zone. No vegetation occurred in this band though beach wrack (washed up organic material such as dead seaweed) was noted. Invertebrates observed were limited to beach hoppers (unidentified amphipods).
- **Cobble Beach Habitat Band**: The cobble beach habitat band was located on Glass Beach in areas where substrates consisted of gravels and cobbles in the mid intertidal zone. Sea lettuce (*Ulva sp.*) was the dominant alga in this band though other species of algae were common including Turkish washcloth leafy and crustose phases (*M. papillatus*), sugar kelp (*Laminaria sp.*) and rockweed (*F. gardneri*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), limpets (*Lottia spp*. and *Tectura spp*.), and unidentified amphipods. Fish were commonly found underneath intertidal rocks in pools and included rock prickleback (*Xiphister mucosus*) and black prickleback (*X. atropurpureus*).
- **Boulder Cobble Seaweed Beach Habitat Band**: The boulder cobble seaweed beach habitat band was located on Glass Beach in areas where substrates consisted of cobbles and boulders in the low intertidal zone. Sea lettuce (*Ulva sp.*) was the dominant alga in this band though other species of algae were common including Turkish washcloth leafy and crustose phases (*M. papillatus*), purple laver (*Porphyra sp.*), and rockweed (*F. gardneri*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), limpets (*Lottia spp*. and *Tectura spp*.), mottled seastars (*Evasterias troschelii*), shore crabs (*Hemigrapsus nudus* and *H. oregonensis*), juvenile red rock crabs (*Cancer productus*) and unidentified amphipods. Fish were commonly found underneath intertidal rocks in pools and included rock prickleback (*X. mucosus*) and black prickleback (*X. atropurpureus*).

Photos 7, 8 and 9. Gravel beach habitat band (left); cobble beach habitat band (middle); and boulder/cobble seaweed habitat band (right) found on Glass Beach.

2.2.2.1.3. Rocky Intertidal

The following eight bio bands were observed during surveys of rocky intertidal habitat found in the southern portion of the site:

- **Riparian Habitat Band**: The Sidney seawall occurs at the uppermost limit and is fronted by retaining walls and/or landscaping so marine riparian vegetation was absent or very limited. Where riparian vegetation did occur it consisted of grasses, shrubs and bushes. No trees were noted in the area fronting the project.
- **Supra-Littoral Habitat Band**: the supra-littoral habitat band occurred below the riparian band, but above the splash zone with no obvious signs of past seawater inundation. This area consisted of bedrock colonized by mosses and weeds.
- **Splash Zone Habitat Band**: The splash zone bio-band occurred in the uppermost area of the intertidal zone. Sparse vegetation, in the form of lichen, occurred here.

Photos 10, 11 and 12. Riparian habitat band (left); supra-littoral habitat band (middle); and splash zone habitat band (right) found in the rocky intertidal zone.

- **Barnacle Habitat Band**: The barnacle habitat band was located in rocky intertidal transects between the Splash Zone Band and the Rockweed Band in the mid-high intertidal zone. Substrates consisted of bedrock and boulders. Algae occurring in this band included somewhat sparse assemblages of Rockweed (*F. gardneri*), and Turkish washcloth leafy and crustose phases (*M. papillatus*). Invertebrates observed included acorn barnacles (*B. glandula*) periwinkles (*Littorina spp.*), dogwinkles (*Nucella spp.)* and limpets (*Lottia spp*. and *Tectura spp.*).
- **Rockweed Habitat Band**: The rockweed habitat band was located in rocky intertidal transects between the barnacle and the sea lettuce in the mid-low intertidal zone. Substrate consisted of bedrock. Rockweed (*F. gardneri*) was the dominant alga in this band though other species of algae were common including coralline algae (*Corallina spp*.), Turkish washcloth leafy and crustose phases (*M. papillatus*), filamentous red seaweed (*Polysiphonia sp.*), and sea lettuce (*Ulva sp.*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), limpets (*Lottia spp*. and *Tectura spp*.), mottled seastars (*E. troschelii*), shore crabs (*H. nudus* and *H. oregonensis*), dogwinkles (*Nucella spp.),* mossy chiton *(Mopalia muscosa),* and unidentified amphipods. Fish were commonly found tidepools and included tidepool sculpin (*Oligocottus maculosus*).
- **Sea Lettuce Habitat Band**: The sea lettuce habitat band was located in rocky intertidal transects between the rockweed band and the waterline in the low intertidal zone. Substrate consisted of bedrock. Sea lettuce (*Ulva sp*.) was the dominant alga in this band though other species of algae were present in this band including coralline algae (*Corallina spp.)*, Turkish washcloth leafy and crustose phases (*M. papillatus*), filamentous red seaweed (*Polysphonia spp.*), sargassum (*Sagassum sp*.), sea sacs (*Hallosaccion sp.*), and rockweed (*F. gardneri*). Invertebrates observed included acorn barnacles (*B. glandula*), limpets (*Lottia spp*. and *Tectura spp*.), and unidentified

amphipods. A single white lined dirona nudibranch (*Dirona albolineata*) was observed just below the waterline.

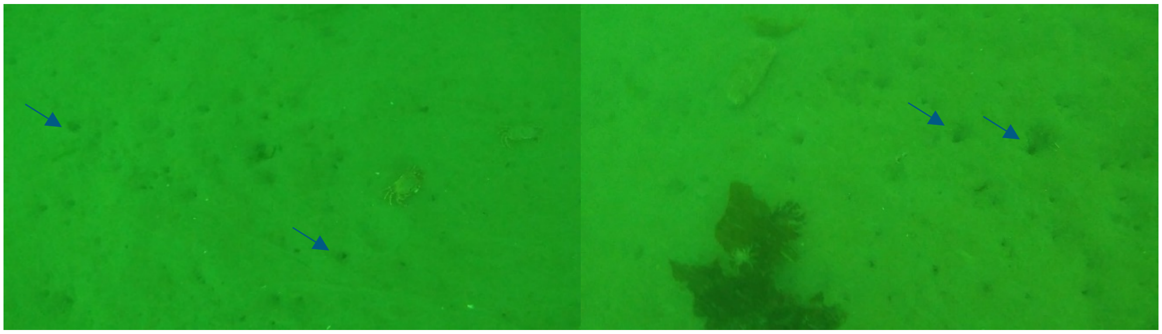
Photos 13, 14 and 15. Barnacle habitat band (left); rockweed habitat band (middle); and sea lettuce habitat band (right) found in the rocky intertidal zone.

- **Cobble Beach Habitat Band**: The cobble beach habitat band was located in rocky intertidal transects in the mid- intertidal zone. Substrate consisted of cobble and gravel on soft sediments. Algae present in this habitat type included Rockweed (*F. gardneri*), Turkish washcloth leafy and crustose phases (*M. papillatus*), Turkish towel (*Chondracanthus exasperatus*), sugar kelp (*Laminaria spp*.), filamentous red seaweed (*Polysiphonia sp.*), and sea lettuce (*Ulva sp.*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), and shore crabs (*H. nudus* and *H. oregonensis*).
- **Boulder Cobble Seaweed Beach Habitat Band**: The boulder cobble seaweed beach habitat band was located in rocky intertidal transects in the low intertidal zone. Substrate consisted of boulders, cobble and gravel on soft sediments. Algae present in this habitat type included Rockweed (*F. gardneri*), Turkish washcloth leafy and crustose phases (*M. papillatus*), Turkish towel (*C. exasperatus*), and sea lettuce (*Ulva sp.*). Invertebrates observed included acorn barnacles (*B. glandula*), periwinkles (*Littorina spp.*), shore crabs (*H. nudus* and *H. oregonensis*), dogwinkles (*Nucella spp.),* isopods *(Idotea wosnesenskii),* and unidentified amphipods.

2.2.2.2. Subtidal Zone

The subtidal areas within the proposed project footprint can be divided into 8 habitat types:

- **Shellfish Bed Habitat**: this habitat type is described as soft sediment colonized by shellfish (likely Horse clams, Geoducks, and/or cockles). In this habitat type, substrates consisted sand and silt. Where hard substrates were available to grow upon (e.g. rocks), the following seaweeds occurred din low densities: sea moss (*Endocladida sp*.), sugar kelp (*Laminaria spp*.), filamentous red seaweed (*Polysiphonia sp.*), and sea lettuce (*Ulva sp.*). Invertebrates observed include Dungeness crabs (*Cancer magister*), red rock crab (*C. productus*), kelp crab (*Pugettia spp*.), and geoducks (*Panopea generosa*). One great sculpin (*Myoxocephalus polyacanthocephalus*) was observed in this habitat.

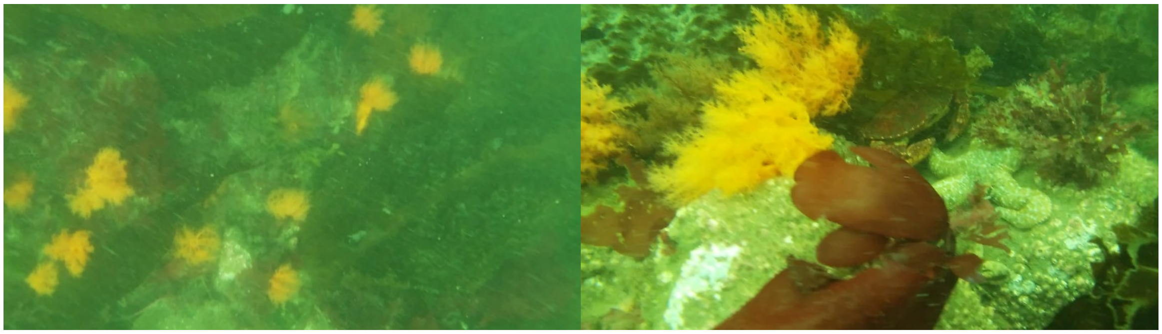


Photos 16 and 17. Shellfish bed habitat type; shellfish siphon holes (see arrows) and Dungeness crabs (left); shellfish siphon holes (see arrows) and Kelp crab on sugar kelp, note discarded bottle (right).

- **Soft Seabed Habitat**: this habitat type was similar to the shellfish bed habitat type but with far fewer shellfish siphon holes observed. In this habitat type, substrates consisted sand and silt. Where hard substrates were available to grow upon (e.g. rocks), the following seaweeds occurred din low densities: sea moss (*Endocladida sp*.), sugar kelp (*Laminaria spp*.), splendid iridescent seaweed (*Mazzaella splendens*), red spaghetti seaweed (*Gracilaria sp*.), and sea lettuce (*Ulva sp.*). Invertebrates observed include Dungeness crabs (*C. magister*) and geoducks (*Panopea generosa*).

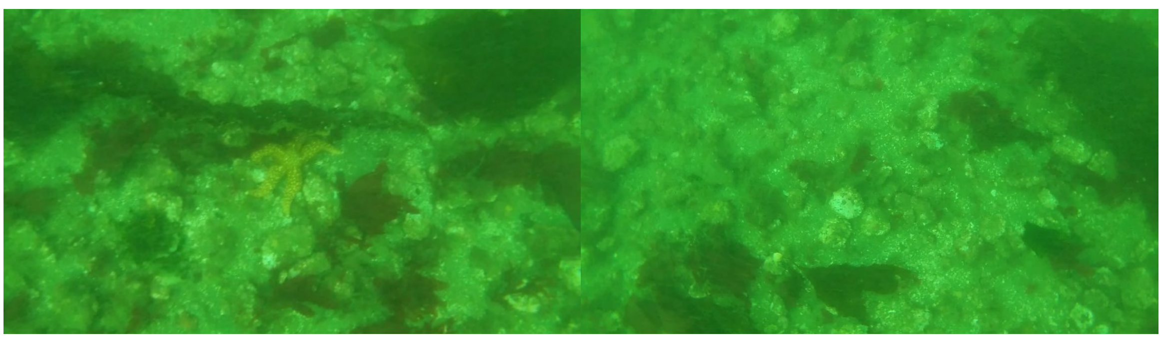
Photos 18 and 19. Soft seabed bed habitat type; Geoduck siphon (left); Dungeness crab with several seaweeds (right).

- **Rocky Reef Habitat**: this habitat type is described as a diverse assemblage of seaweeds and invertebrates attached to hard substrate. This may be where the artificial reef balls were installed in the past. In this habitat type, substrates were somewhat undiscernible due to the density of invertebrates and seaweeds, though boulders and cobbles are visible. Numerous seaweeds and kelps were observed in high densities in this band, including sugar kelp (*Laminaria spp*.), splendid iridescent seaweed (*M. splendens*), Turkish washcloth (*M. papillatus*), bull kelp (*Nereocystis luetkeana*), red laver (*Porphyra sp*.), and sea lace (*Microcladida sp*.). Invertebrates observed include acorn barnacles (*B. glandula*), Dungeness crabs (*C. magister*), red rock crab (*C. productus*), kelp crab (*Pugettia spp*.), dense assemblages of red sea cucumbers (*Cucumaria miniata*), Mottled seastar (*E. troschelii)*, and blood stars (*Henricia leviascula*).



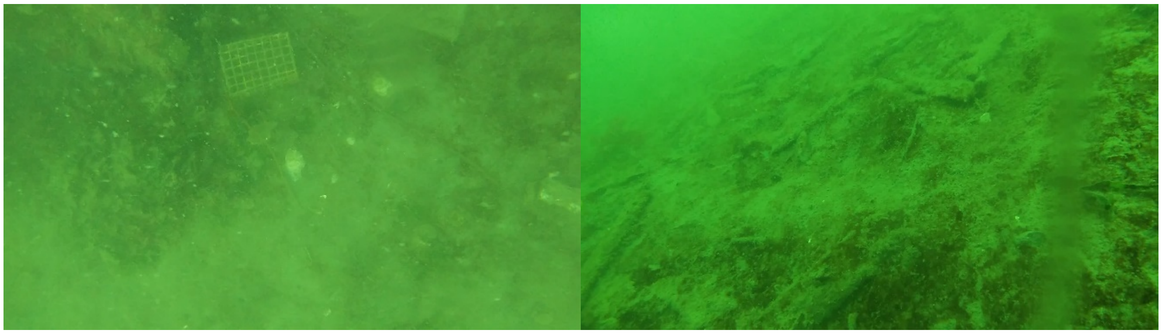
Photos 20 and 21. Rocky reef habitat type; dense seaweed with numerous red sea cucumbers feeding (left); red rock crab, red sea cucumber, mottled star with splendid iridescent seaweed (right).

- **Cobble / Shell Hash Habitat**: this habitat type had diverse seaweed and invertebrate assemblages due to the availability of hard substrate. Substrates consisted of cobbles upon sand /shell hash. Numerous seaweeds and kelps were observed in this band, including sugar kelp (*Laminaria spp*.), splendid iridescent seaweed (*M. splendens*), Turkish washcloth (*M. papillatus*), bull kelp (*N. luetkeana*), red laver (*Porphyra sp*.), sea lace (*Microcladida sp*.), rockweed (*F. gardneri*) and sea lettuce (*Ulva sp*.). Invertebrates observed include acorn barnacles (*B. glandula*), Dungeness crabs (*C. magister*), kelp crab (*Pugettia spp*.), Mottled seastar (*E. troschelii)*, and painted sea stars (*Orthasterias koehleri*), and California sea cucumbers (*Parastichopus californicus*).



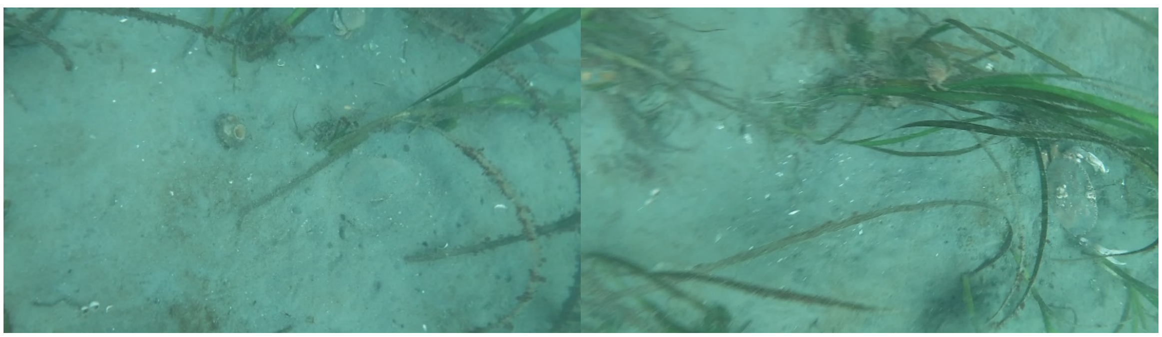
Photos 22 and 23. Cobble / shell hash habitat type; mottled seastar, sugar kelp, and splendid iridescent seaweed (left); sugar kelp and splendid iridescent seaweed (right).

- **Organic Material or Visible Waste on Soft Seabed Habitat**: Much of the project footprint, particularly those area nearest existing wharves showed some accumulation of anthropogenic debris such as abandoned traps, wood waste, old glass bottles, plastic bottles etc. Moreover, in these areas the seabed was largely dominated by fine sediments which showed an accumulation of organic material, or perhaps microorganism mats. These areas showed clear indications of anthropogenic effects, however marine life was still present and diverse in these areas. Numerous seaweeds and kelps were observed in this habitat type, including sugar kelp (*Laminaria spp*.), splendid iridescent seaweed (*M. splendens*), Turkish washcloth (*M. papillatus*), red spaghetti seaweed (*Gracilaria sp.*), sea moss (*Endocladida sp*.), rockweed (*F. gardneri*) and sea lettuce (*Ulva sp*.). Invertebrates observed include acorn barnacles (*B. glandula*), plumose anemones (*Metridium giganteum*), Dungeness crabs (*C. magister*), red rock crab (*C. productus*), and painted sea stars (*O. koehleri*). Shellfish siphon holes were also observed.



Photos 24 and 25. Organic material or visible waste on soft seabed habitat type; abandoned trap on woody debris (left); organic material and woody debris (right).

- **Low Density Eelgrass Habitat:** this habitat type was similar to the soft seabed bed habitat type but with some eelgrass (*Z. marina*) colonization present. In this habitat type, substrates consisted sand and silt. Where hard substrates were available to grow upon (e.g. rocks), the following seaweeds sugar kelp (*Laminaria spp*.), and sea lettuce (*Ulva sp.*) occurred in low densities. Invertebrates observed include Dungeness crabs (*C. magister*), kelp crab (*Pugettia spp*.), and geoducks (*P. generosa*).



Photos 26 and 27. Low Density Eelgrass Habitat type; eelgrass and geoduck siphon (left); eelgrass with kelp crab and Dungeness crab (right).

- **Dense Seaweed Habitat**: this habitat type is described as a diverse and very dense assemblage of seaweeds. In this habitat type, substrates were somewhat undiscernible due to the density of seaweeds. Numerous seaweeds and kelps were observed in high densities in this band, including sugar kelp (*Laminaria spp*.), splendid iridescent seaweed (*M. splendens*), Turkish washcloth (*M. papillatus*), bull kelp (*Nereocystis luetkeana*), red laver (*Porphyra sp*.), sea moss (*Endocladida sp.*), sea brush (*Odonthalia sp*.), red spaghetti seaweed (*Gracilaria sp.*), and sea lace (*Microcladida sp*.). Invertebrates observed include acorn barnacles (*B. glandula*), plumose anemones (*M. giganteum*), Dungeness crabs (*C. magister*), red rock crab (*C. productus*), kelp crab (*Pugettia spp*.), ochre stars (*P. ochreceus*), and painted sea stars (*O. koehleri*).

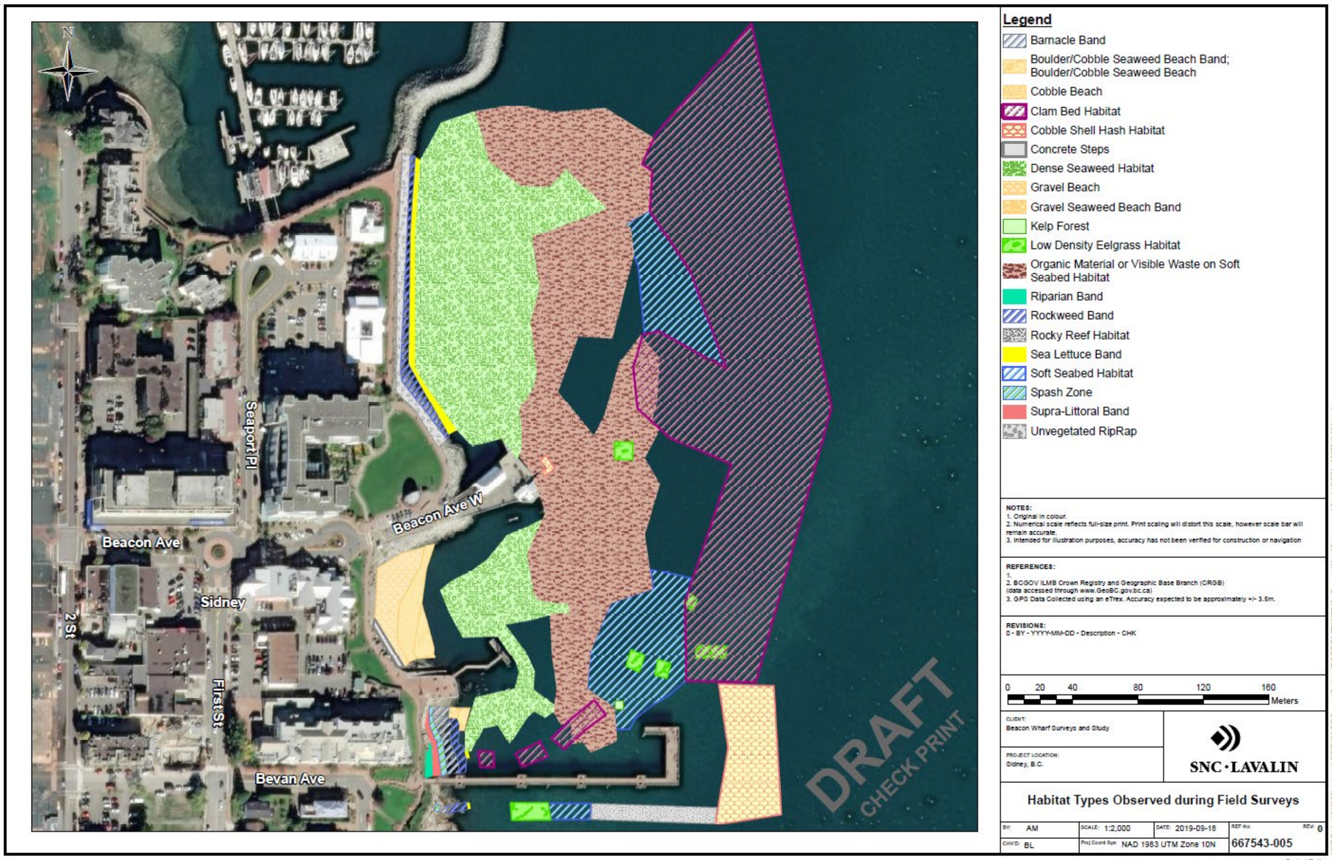
Photos 28 and 29. Dense seaweed habitat type; red rock crab amongst dense sugar kelp and sea lettuce (left); plumose anemone amongst dense splendid iridescent seaweed (right).

- **Kelp Forest Habitat**: Kelp forest habitat was observed from the sea surface.

Photo 30. Kelp forest habitat viewed from boat.

2.3. Habitat Map

A map showing the distribution of the habitats described above spatially is provided as Figure 5 with a larger version included as Appendix A. Note that habitat types outside of observation points have been interpolated based on nearby observations and professional judgement and may not reflect exactly what is on the seabed. Habitat types for larger areas where direct observations were not made and surrounding habitat types were variable, were not assigned; corresponding areas on the habitat map remain blank.



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 5: Habitat Map

3. Discussion

This study aimed to characterize marine habitat in the Beacon Wharf area and the marine footprint of Sidney's Downtown Waterfront Vision via desktop studies and field surveys.

The desktop review completed as part of this study indicated that numerous species at risk, biological resources, and fisheries resources either occur or potentially occur in the project area.

The field surveys completed as part of this study indicate that the project area contains numerous diverse habitat types in both the intertidal and subtidal zone. Some evidence of anthropogenic influence was observed.

3.1. Permitting Path Forward

To implement any or all of the Town of Sidney's Downtown Waterfront Vision, the environmental permits/authorizations listed in Table E may be necessary.

Table E: Environmental Permits/Authorizations; Sidney Downtown Waterfront Vision.

Permit	Agency*	Statute	Est. Timeline (months)	Description	Likelihood of being required
License of Occupation / Crown Land Lease	FLNRORD	*Land Act*	6-8	Occupation of provincial crownland in the project footprint, or altering/extending an existing crown land lease	Moderate to high (depending on existing leases)
DFO Request for Review	DFO	*Fisheries Act*	1-3	Determines the Potential for HADD of the project	Certain
DFO Authorization and Fish Habitat Compensation Agreement	DFO	*Fisheries Act*	6-12	Permits HADD associated with the project. Requires design and installation of habitat offsets for HADD and posting a letter of credit to DFO.	High
Permit approving incidental effects from the project on aquatic species at risk	DFO	*Species at Risk Act*	6-12	Permits any project component that may affect Species at Risk	Low
Notice to Minister	TC	*Navigation Protection Act* and forthcoming *Canadian Navigable Waters Act*	2-4	Permits works and obstructions that may interfere with navigation in navigable waters	High

***FLRORD: BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development**
DFO: Department of Fisheries and Oceans Canada (Federal)
TC: Transport Canada (Federal)
HADD: harmful alteration, disruption or destruction of fish habitat

Of the permits listed in Table E, the DFO authorization is likely to be the most onerous and costly as numerous potential project components may result in ‘*harmful alteration, disruption or destruction of fish habitat* (HADD)” as defined by the *Fisheries Act*.

The *Fisheries Act* requires all potential impacts to fish or fish habitat to be avoided, mitigated, and/or offset. In areas where impacts cannot be avoided or mitigated, all habitat that is affected must be fully characterized so that the extent of impact to each habitat type, in square metres, can be determined. The habitat characterization required to support a DFO authorization will likely exceed the level of this study and may require divers, particularly in areas where we were unable to access due to safety concerns such as beneath existing wharves (fishing lines, crab traps, etc. impeded access). The requirement and scope of any additional habitat studies would be determined by DFO after reviewing the proposed project, environmental management and mitigation plans, and this study as part of the DFO Request for Review.

If DFO determines that the project was likely to result in HADD, a DFO authorization would be required prior to any construction. A DFO authorization requires submission of an application form, habitat assessment, environmental management plan, habitat offsetting plan, monitoring plan and letter of credit.

Other permits listed in Table E are less onerous to obtain. It is likely that all information required to apply and receive the listed other permits would be available as part of project design and the DFO permitting process, as the information requirements are similar.

4. Closure and QEP Signatures

This report was prepared by the following Qualified Environmental Professional (QEP):

Brian Lynch, M.Sc., R.P.Bio.

Senior Marine Biologist
SNC-Lavalin

Reviewed by:

David McWalter, MBA, PMP

Project Manager, Ports & Marine
SNC-Lavalin

5. References

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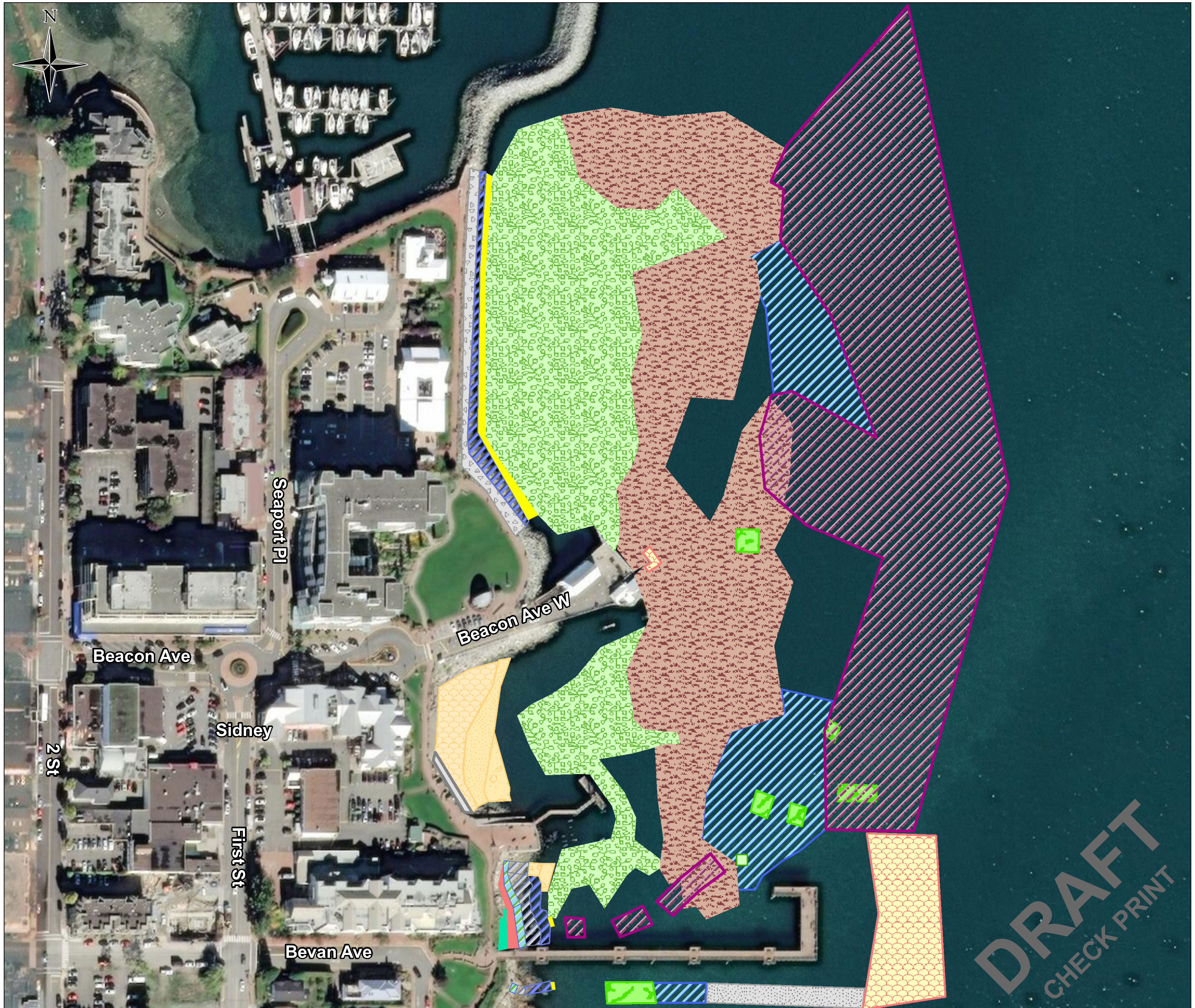
APPENDIX A HABITAT MAP



Legend

- Barnacle Band
- Boulder/Cobble Seaweed Beach Band; Boulder/Cobble Seaweed Beach
- Cobble Beach
- Clam Bed Habitat
- Cobble Shell Hash Habitat
- Concrete Steps
- Dense Seaweed Habitat
- Gravel Beach
- Gravel Seaweed Beach Band
- Kelp Forest
- Low Density Eelgrass Habitat
- Organic Material or Visible Waste on Soft Seabed Habitat
- Riparian Band
- Rockweed Band
- Rocky Reef Habitat
- Sea Lettuce Band
- Soft Seabed Habitat
- Spash Zone
- Supra-Littoral Band
- Unvegetated RipRap

NOTES:
1. Original in colour.
2. Numerical scale reflects full-size print. Print scaling will distort this scale, however scale bar will remain accurate.
3. Intended for illustration purposes, accuracy has not been verified for construction or navigation

REFERENCES:
1.
2. BCGOV ILMB Crown Registry and Geographic Base Branch (CRGB) (data accessed through www.GeoBC.gov.bc.ca)
3. GPS Data Collected using an eTrex. Accuracy expected to be approximately +/- 3.5m.

REVISIONS:
0 - BY - YYYY-MM-DD - Description - CHK

0 20 40 80 120 160 Meters

CLIENT: Beacon Wharf Surveys and Study

PROJECT LOCATION: Sidney, B.C.

SNC·LAVALIN

Habitat Types Observed during Field Surveys

BY: AM	SCALE: 1:2,000	DATE: 2019-09-18	REF No:	REV: 0
CHK'D: BL	Proj Coord Sys: NAD 1983 UTM Zone 10N		667543-005	

MXD Path: \\Sli2606\projects\LOB\EIAM-BC\Current Projects\TO BE FILED\667543 - Beacon Wharf Surveys and Study\GIS\Mxd\667543-005.mxd

Project Path:

SNC·LAVALIN

APPENDIX E – WHARF SKETCHES

PLAN

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SUBTITLE	OPTION 1 – PLAN
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CREATED BY:	AD
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SCALE:	NTS

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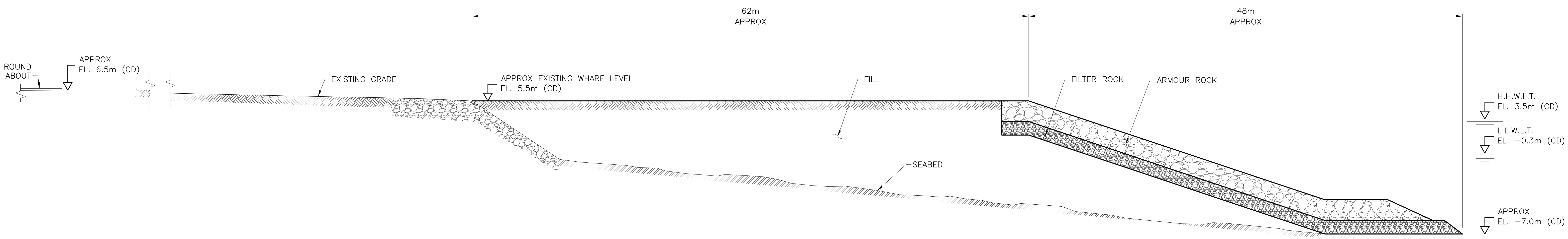

A SECTION
1000−4PEK−0001 1:200

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CREATED BY:	AD
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PLAN

1:150

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SUBTITLE	OPTION 2 – PLAN
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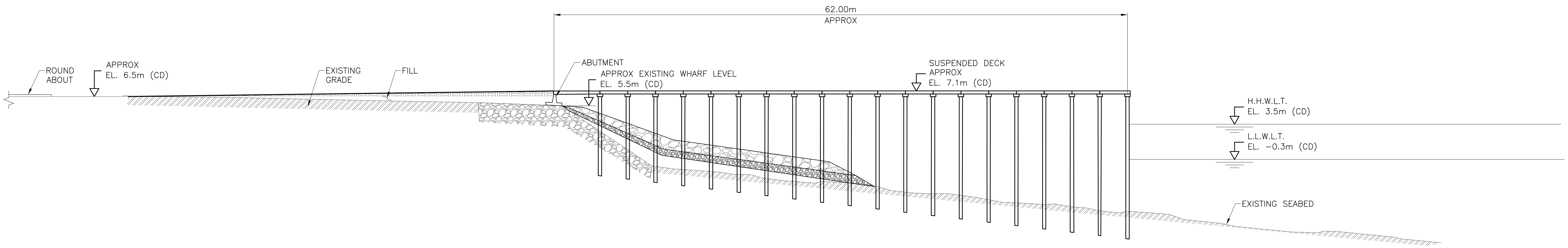
CREATED BY:	AD
DOCUMENT No:	667543-2000-4PEK-0001
SCALE:	NTS



A SECTION

2000–4PEK–0001 1:200

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

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CREATED BY:	AD
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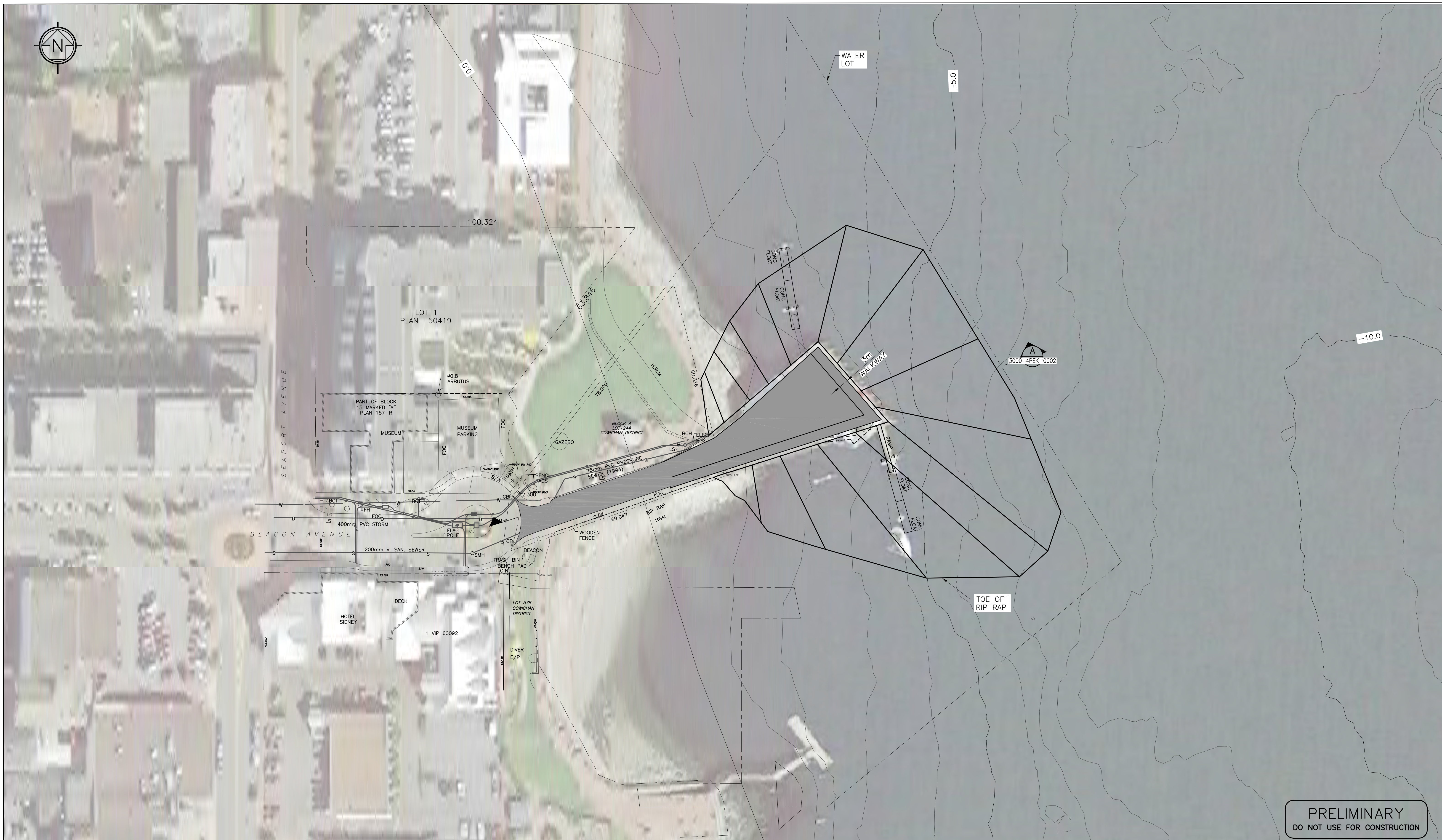

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

PLAN

1:500

CLIENT	TOWN OF SIDNEY
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SUBTITLE	OPTION 3 – PLAN
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-3000-4PEK-0001_REV 1
SCALE:	NTS

LAST SAVE: 2019/12/16 – 10:10am
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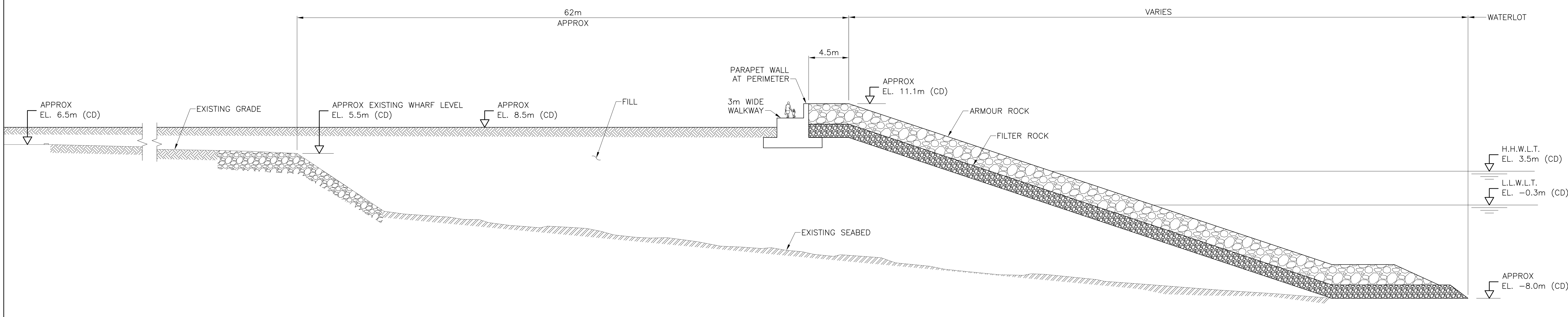

A SECTION
3000-4PEK-0001 1:200

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 3 – SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-3000-4PEK-0001_REV 1
SCALE:	NTS

PLAN

1:200

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 4 – PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-4000-4PEK-0001
SCALE:	NTS

LAST SAVE: 2019/11/13 – 9:33am
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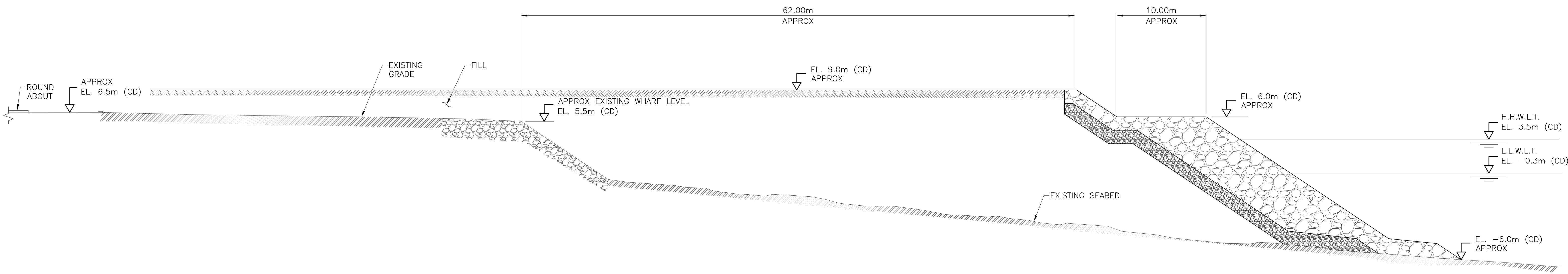

A SECTION
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PRELIMINARY
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TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 4 − SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543−4000−4PEK−0002_REV 1
SCALE:	NTS

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LAST SAVE: 2019/11/13 - 9:34am
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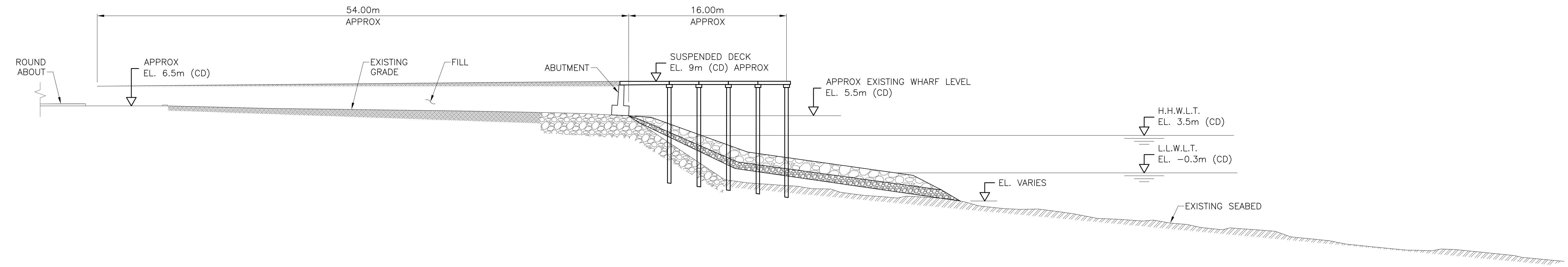
PLAN

1:500

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 5A - PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-5000-4PEK-0001
SCALE:	NTS



A SECTION
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PRELIMINARY
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TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 5A – SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543–5000–4PEK–0002_REV 1
SCALE:	NTS

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PLAN
1:500

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 5B – PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-5000-4PEK-0003
SCALE:	NTS

LAST SAVE: 2019/11/13 – 9:36am
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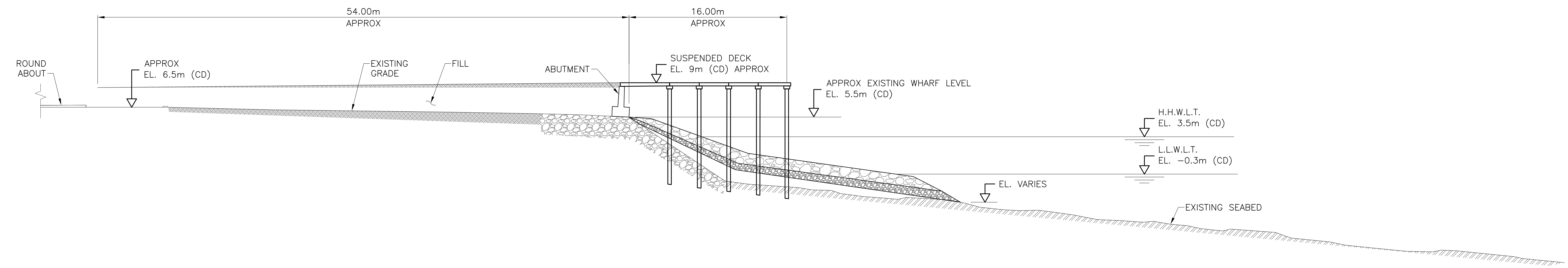

A SECTION
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PRELIMINARY
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SUBTITLE	OPTION 5B – SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
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SCALE:	NTS

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PLAN

1:500

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 6 – PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543–6000–4PEK–0001
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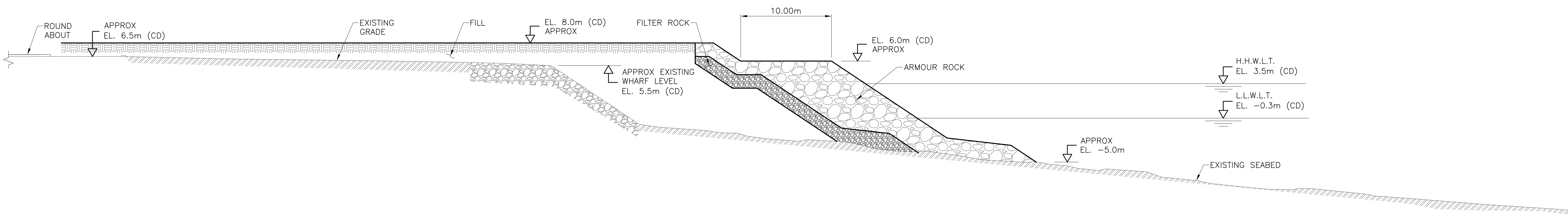

A SECTION
6000–4PEK–0001 1:200

PRELIMINARY
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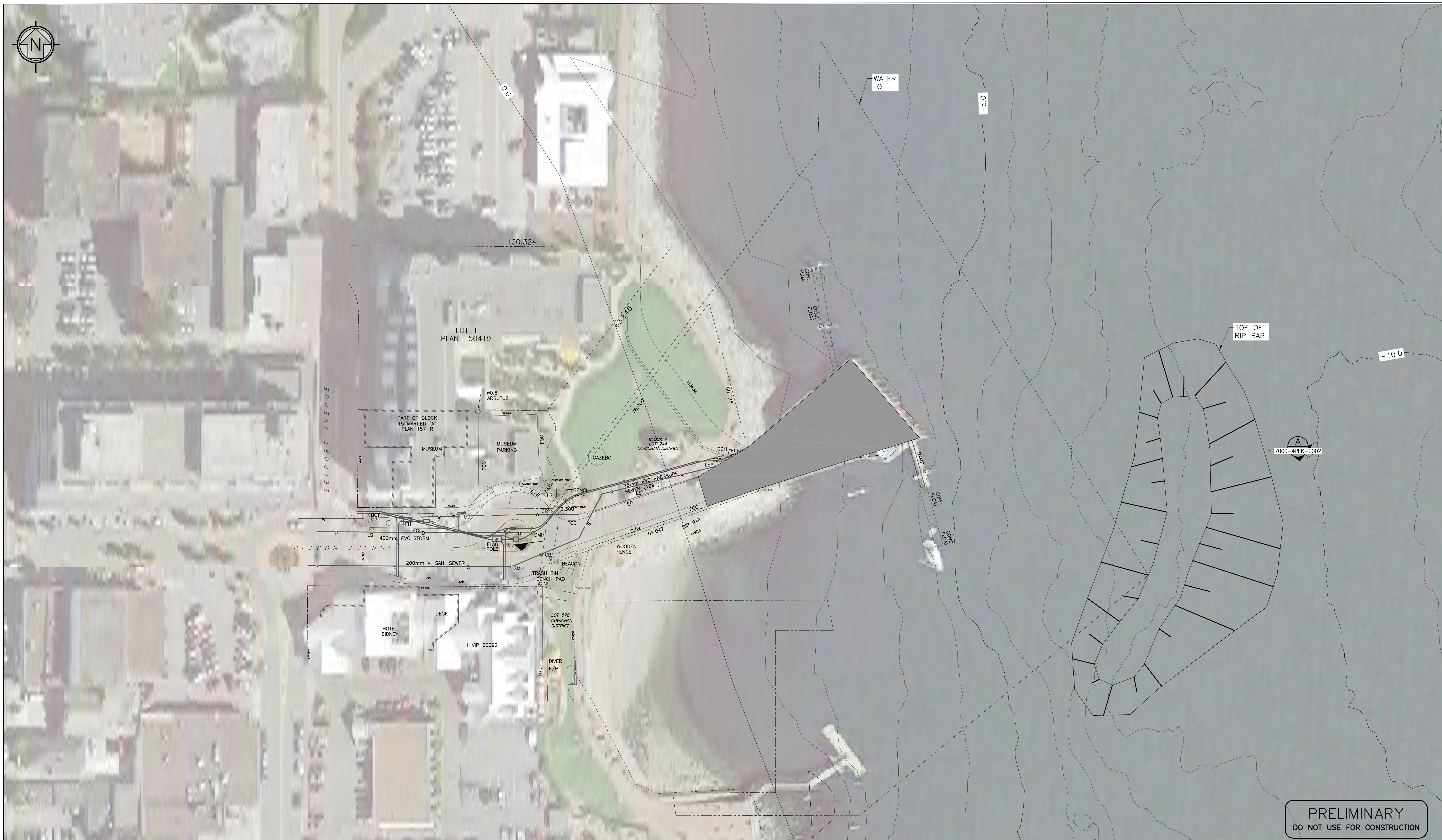

PLAN

1:500

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 7 – PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-7000-4PEK-0001
SCALE:	NTS

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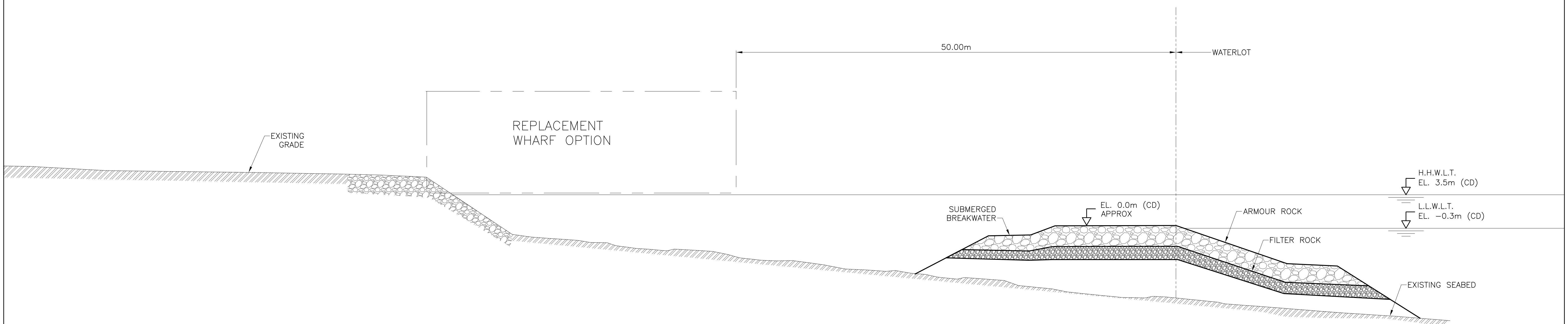

A SECTION
7000-4PEK-0001 1:200

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 7 – SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
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SCALE:	NTS

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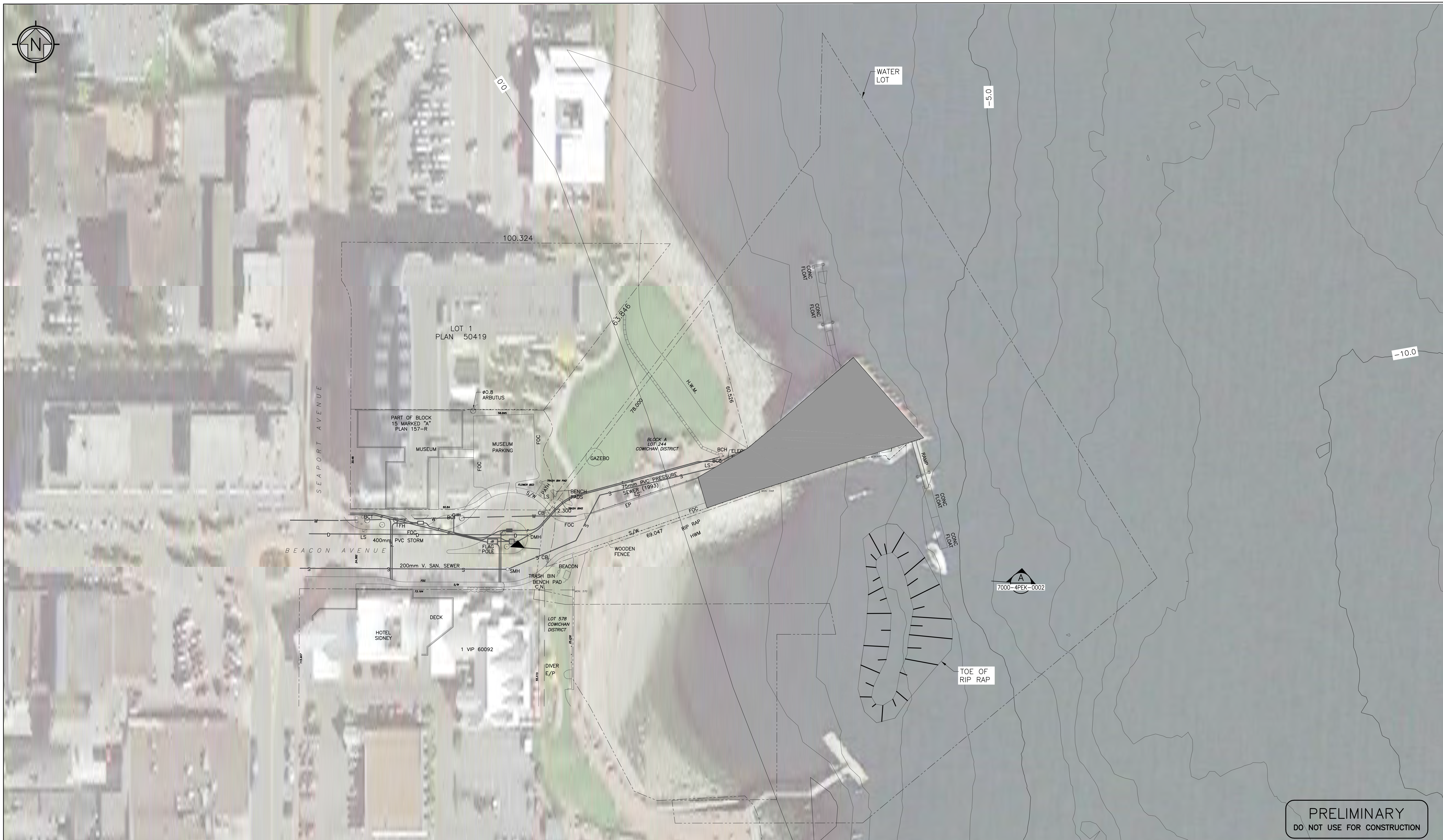

PLAN

1:500

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 8 – PLAN
DATE CREATED:	OCTOBER 16, 2019
CREATED BY:	AD
DOCUMENT No:	667543-8000-4PEK-0001
SCALE:	NTS

LAST SAVE: 2019/11/15 - 4:21pm
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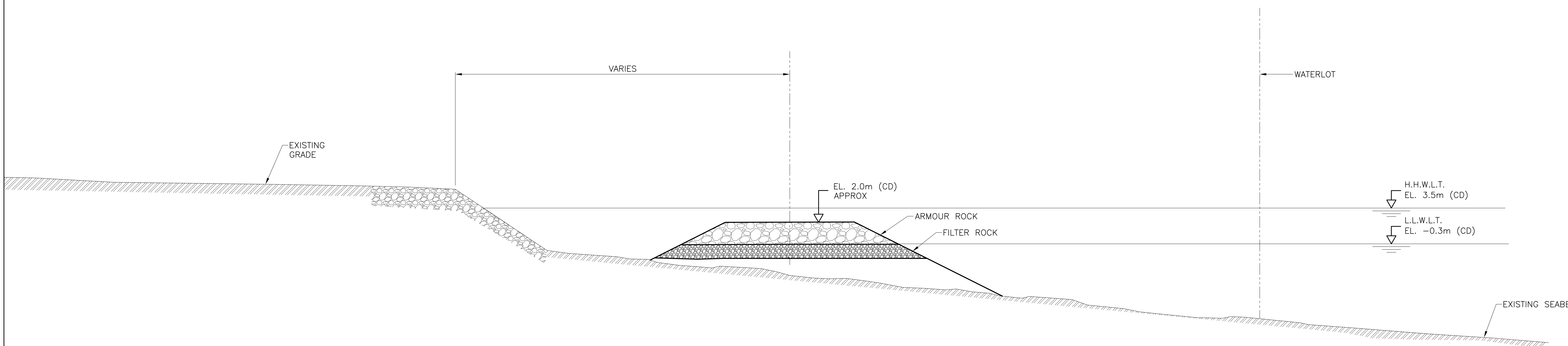

A SECTION
7000–4PEK–0001 1:200

PRELIMINARY
DO NOT USE FOR CONSTRUCTION

CLIENT	TOWN OF SIDNEY
TITLE:	BEACON WHARF REPLACEMENT OPTIONS
SUBTITLE	OPTION 8 – SECTION
DATE CREATED:	DECEMBER 16, 2019
CREATED BY:	AD
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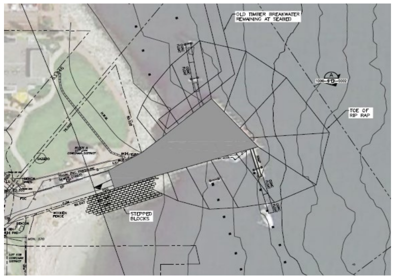
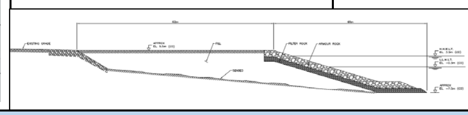
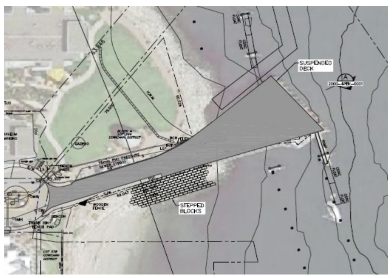
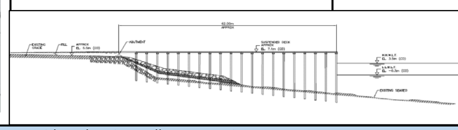
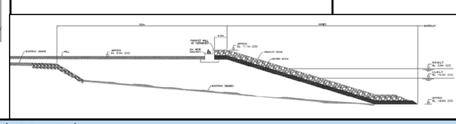
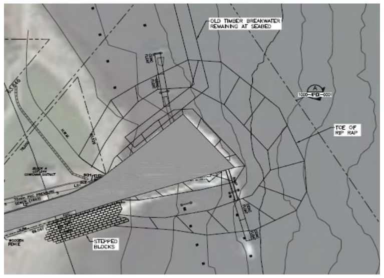
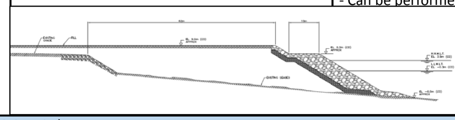
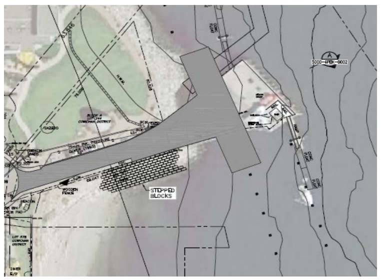
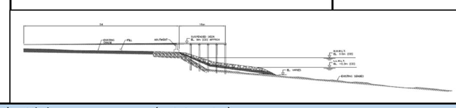
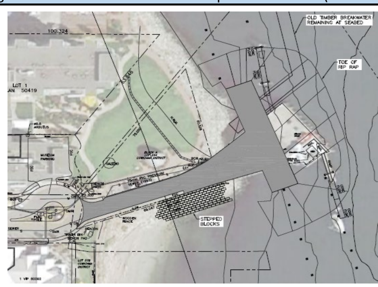
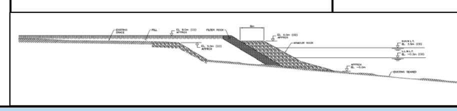
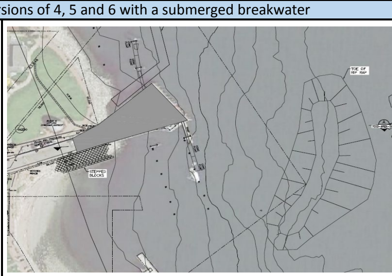
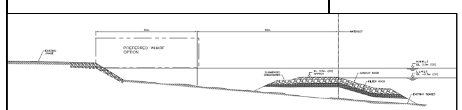
APPENDIX F – WHARF OPTION ASSESSMENT

Project: 667543 - Beacon Wharf
2019-12-02, RevPC
AD, PD, JR, CW

Beacon Wharf Replacement - Options Screening - Technical and Cost Considerations

Ref	Option	Description	Advantages	Disadvantages	Notes	Comparative Cost
1. Rubble mound wharf at existing elevation (+5.5m CD)						
1		Replace wharf with rubble mound breakwater at existing elevation of +5.5 m CD. Rock armour layer at 3:1 slope. 	- Same footprint as existing wharf - Ties in easily with surrounding areas as it does not require raising of approach	- Does not meet elevation recommendations - Most at risk of flooding and overtopping - Excessive overtopping risk is expected to mean that it would not be feasible to construct a normal building out on the wharf	Not considered feasible/advisable for 50 year consideration period.	$ 13,710,000
2. Suspended deck at current Sidney Interim FCL (+7.1m CD)						
2		Replace wharf with suspended deck at Sidney Interim Flood Construction Level +7.1 m CD. Fill existing approach from roundabout to top of wharf to line up with new elevation. 	- Same habitat footprint as existing wharf - Waves can pass underneath the structure	- Meets current TOS Interim FCL, but unlikely to meet updated FCL as per Provincial Guidelines (2018), and is therefore still at risk of flooding and overtopping. - Fill required to raise approach to match top of wharf elevation.	Currently available information suggests that this is unlikely to provide to necessary standard of protection for a normal inhabited building for the 50 year consideration period. Recommend considering raising the deck elevation or incorporating future mitigation measures to reduce risk exposure.	$ 8,540,000
3. Reclamation out to water lot with elevated crest (+11.1m CD), parapet with pedestrian walkway at perimeter						
3		Replace wharf with rubble mound breakwater at raised elevation of + 11.1 m CD, install parapet wall and walkway at perimeter of wharf. Fill approach and wharf to raise from roundabout to top of wharf elevation. Top of wharf elevation + 8.5m CD lower than armour rock crest +11.1 m CD. 	- Raised crest of rubble mound breakwater to eliminate risk of flooding and overtopping - Parapet wall and walkway to provide viewing area for public - Use of parapet wall to reduce required raising of the wharf from the approach - Option can be performed in phases, armour crest can be raised at a later time using the parapet wall. - Provides a degree of protection to adjacent upland areas	- Approach requires significant amount of fill - Large breakwater footprint - Large armour stone is a supply/cost risk - 6m above existing, very high level of reclamation may impact lines of sight.	Not recommended if performed all at once.	$ 20,760,000
4. Reclamation with elevated crest (+9.0 m CD) and berm revetment (+6.0 m CD)						

4		Replace wharf with rubble mound at + 9.0 m CD and berm revetment at + 6.0 m CD. Fill approach from roundabout to match elevation of top of wharf. 	- Raised crest to eliminate risk of flooding and overtopping - Use of berm to create steeper slope protection reduces footprint. - Berm breakwater can use smaller rock, wider gradation, and can be end-dumped rather than having rocks individually placed (i.e. cheaper rock). - Can be performed in phases.	- Fill required to raise approach 4m to match top of wharf elevation - Will affect sighlines from land (and buildings?).	Expected tobe preferable to traditional revetment for approximately equivalent or cheaper cost	$ 14,170,000
5. Marginal wharf - suspended deck oriented parallel to the shore (+9.0 m CD)						
5		Replace wharf with marginal wharf composed of suspended deck at +9.0 m CD. Fill existing approach from roundabout to top of wharf to line up with new elevation. 	- Smallest footprint required - Keeping the wharf closer to shore means allows for wave energy disssipation seaward of the wharf. - Deck elevation does not need to be raised as high as required at deeper depths - Likely to meet future FCL	- Fill required to raise approach to match top of wharf elevation - 4m above existing	Recommended, least amount of footprint used.	$ 8,680,000
6. Marginal wharf - reclamation oriented parallel to shore (+8.0 m CD) with berm revetment (+ 6.0 m CD)						
6		Replace wharf with marginal wharf composed of reclamation at +8.0 m CD and berm revetment at + 6.0m CD. Fill existing approach from roundabout to top of wharf to line up with new elevation. 	- Smaller footprint to normal breakwater - Keeping the wharf closer to shore means allows for wave energy disssipation seaward of the wharf. - Deck elevation does not need to be raised as high as required at deeper depths - Option can be performed in phases, berm crest can be raised at a later time.	- Larger footprint than Option 5	Recommended if berm can reduce footprint and provision is made for phased construction.	$ 14,130,000
7. Versions of 4, 5 and 6 with a submerged breakwater						
7		Replace wharf with preferred wharf option and use submerged breakwater with crest at low elevation to dissipate wave energy. 	- Allows slightly lower wharf elevation. - Can potentially act as artifical reef for ecological benefits - Protects a larger area of upland - Less visual impact	- Large footprint - Will likely exceed the waterlot perimeter. - Quite expensive relative to berm breakwater (which also minimises overtopping) - No significant cost saving for suspended deck options which are less cost-sensitive to height.	- Considered unlikley to form part of preferred option as it only provides significant cost reduction for the reclamation options by lowering crest level, but this can be achieved more economically by the berm breakwater. - only Considered beneficial if the environmental benefits are Considered significant.	$ 9,770,000

Notes:

1) Screening considered technical, constructaibility and cost aspects of the site only. All options will have ramifactions for the broader area, and a range of other aspects which will need to be considered by others such as planning, transport, social considerations, etc.

2) Cost estimates are Class D based on concept-level engineering and are for assessing realtive costs only. Further engineering would be required to establish a cost estimate suitable for budgeting.

3) Costs are in CAD $ for 2019 with no allowance for inflation. All costs include 25% contingency and 10% for engieering and other owner costs.

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