MANSON'S LANDING PARK COASTAL ENGINEERING OPTIONS FOR SHORELINE PROTECTION

MINISTRY CONTRACT: OP20NAN116

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FINAL REPORT

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1 INTRODUCTION

Manson's Landing Provincial Park is located on the southwest side of Cortes Island, BC (Figure 1). The spit and lagoon within the park are part of a Special Feature Zone, which serves to protect their significant cultural and natural features. Important historical and cultural features are located on the upland portion of the shoreline and the park serves as important habitat for several unique plants, birds forage fish and marine invertebrates. Nearby sections of shoreline to the south also provide important recreational opportunities. BC Parks is concerned about ongoing shoreline erosion along the Manson's Landing Park spit. Northwest Hydraulic Consultants Ltd. (NHC) was retained by BC Parks to investigate the causes of ongoing erosion and to develop viable engineering options to reduce erosion, while preserving the natural park setting as much as possible.

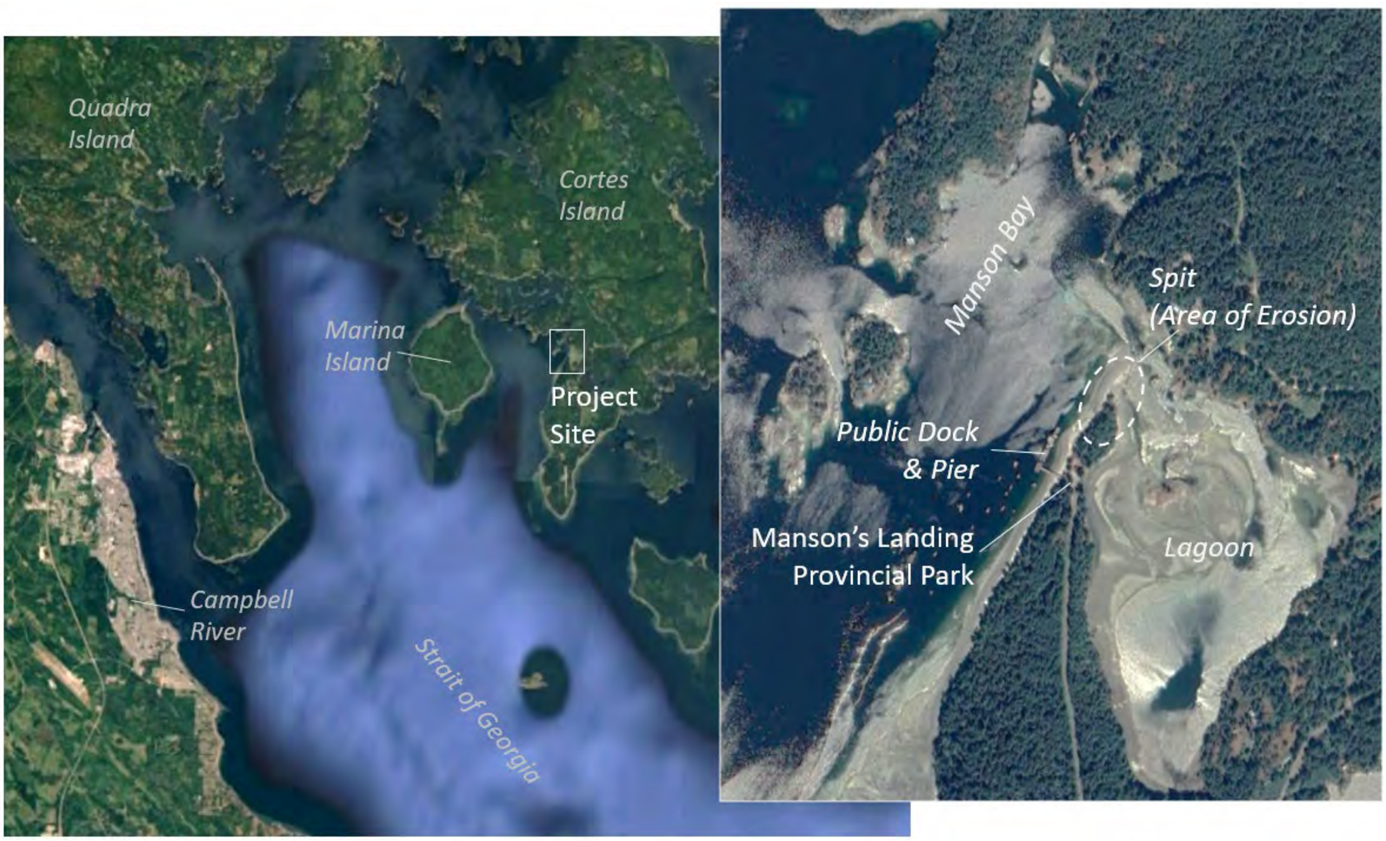

Figure 1 Site location (images: Google Earth, 2019)

Figure 2 shows the boundary for Manson's Landing Park. Of note is that the wharf and floats are owned by the Federal Government and operated by the Harbour Authority of Cortes Island. Specifically, the public fock is excluded from the park under a Transportation Transfer of Administration of 0.3876 hectares to Public Works and Government Services Canada (ref Plan DD39447). Also, Sutil Point road and Seaforth Road are owned by the BC Ministry of Transportation and Infrastructure (MOTI) , and there is a BC Hydro right-of-way within the Sutil Road right-of-way.

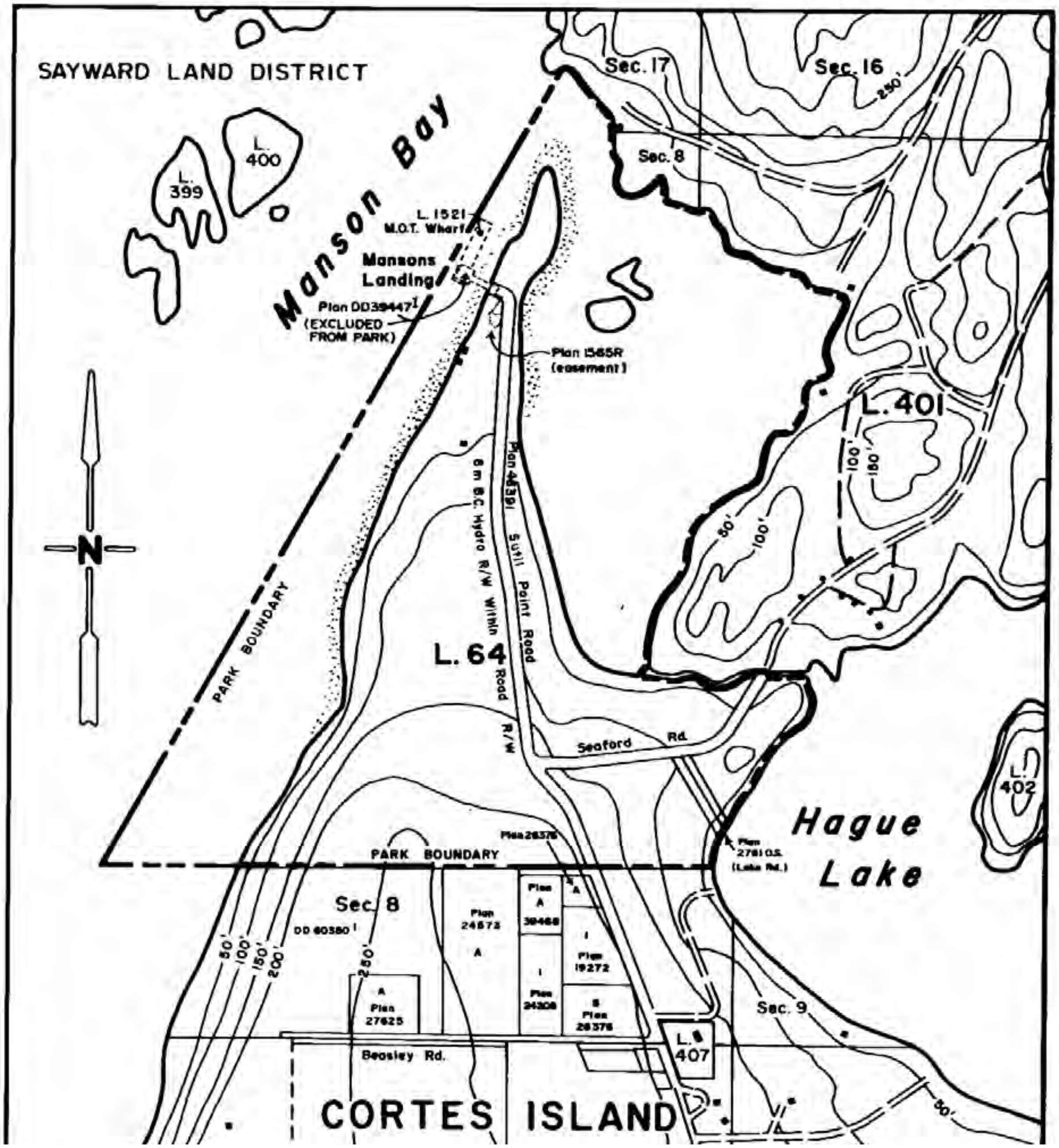

Figure 2 Park Boundary (ref: Dwg 0264, BC Minitry of Lands, Parks, and Housing. Revised 1991)

The following report outlines the findings from a site inspection, results of a coastal assessment, and provides conceptual options for shoreline protection.

1.1 Scope of Work

NHC's scope of work described within this report includes the following tasks:

Task 1. Undertake a site inspection and review existing data
Task 2. Develop a coastal design basis
Task 3. Prepare recommendations/concepts for shoreline protection

2 BACKGROUND & PREVIOUS STUDIES

2.1 Reference Documents

BC Parks provided several reference and background documents that were reviewed as part of this assessment, including the following:

- Holden, B. (1989). *Manson's Landing Provincial marine Park – Spit Erosion.* File: 905-3050-S. Dated 13 March 1989.
- Catherine Berries Associates and Hay & Company Consultants (1989). *Manson's Landing Provincial Park – Boat Launching Ramp Assessment.* File: 82150-40/Manson. Dated August 17, 1989.
- BC Parks (1990). Letter exchange between Fred C. Zwickel and BC Parks. Dated December 9, 1990.
- BC Parks (1990). *Re: Environmental Protection for Manson's Landing Provincial Park*. Letter exchange between BC Parks and Dr. Elliot. Dated December 21, 1990.
- BC Parks (1991). Letter exchange between BC Parks and Loretta Joseph. Dated February 14, 1991.
- BC Parks (1994). *Project Outline – Manson's Landing, Spit Monitoring Program.* File: 87600-20/Mansons. Dated March 1994.
- BC Parks (1999). *Re: Well Being of Manson's Landing Provincial Park.* Letter exchange between BC Parks and Friends of Cortes Island. File: 85000-40/Mansons Landing. Dated February 1999.
- BC Parks (2003). *Mansons Landing Provincial Park – Purpose Statement and Zoning Plan.* Dated February 2003.
- Ministry of Sustainable Resource Management, BC (2003). *Cortes Island Coastal Plan for Shellfish Aquaculture.* Dated July 2003.
- Zwickel, F., Zwickel, R., & Sullivan S., (2007). *Fauna and Flora Associated with Mansons' Lagoon, a portion of Manson's Landing Provincial Park.* Dated August 25, 2007.
- Mense, S. (2018). *Coastal Sand Ecosystems: Community outreach report with a focus on Manson's Landing Provincial Park.* Written by Sabina Leader Mense for Friends of Cortes Island Society in partnership with Erica McClaren and Derek Moore, BC Parks. Dated February 2018.

2.2 Site Overview

Based on information provided by BC Parks (Stephanie Govier, Conservation Coordinator, West Coast Region), it is understood that the community of Manson's Landing was originally settled circa 1920s. The original pier and small dock were constructed prior to 1947 (based on available airphotos). After acquiring the site in the 1960s, the Department of Fisheries and Oceans built a larger public float in the 1964-1965 fiscal year. Manson's Landing Provincial Park was later established in 1974 and has since had heavy recreational usage. In the years prior to 1988, BC Parks became aware of significant erosion along the spit. Since then, numerous studies and measures have been implemented to mitigate this erosion with limited success. These studies are described in Section 2.3.

As shown in Figure 1, Manson's Landing Provincial Park is comprised of a number of prominent physical features. While the majority of the park's land area is forested upland, the majority of public use and interest is focused on the shoreline and inter-tidal areas of the park. The west side of the park is a long beach feature and dominant sediment transport along the beach has moved material northwards to form a spit at the north end of the park, which partially closes off a tidal lagoon to the east. Tidal exchange between the lagoon and Manson Bay has maintained the opening; however, it appears that sediment likely moves back and forth through the opening in response to tides and waves. Outflow from the lagoon that discharges into the deeper water of Manson Bay has formed a broad bar feature that resembles an alluvial fan-delta, though this feature is not associated with a discharging river.

The Manson's Landing Provincial Park Purpose Statement and Zoning Plan (BC Parks, 2003) outlines that the primary role of the park is to "protect the natural values associated with the northern gulf islands" and that a secondary role is to provide "recreational opportunities". These values are reflected in the Zoning Map (reproduced in Figure 3), which delineates the park into zones as follows:

- **7% Intensive Recreation Zone:** Includes the roadways, parking area, and the public pier/docks.
- **60% Natural Environment Zone:** Aims to protect natural features while providing non-invasive recreational opportunities.
- **33% Special feature Zone:** Covers the lagoon and sand spit, with the aim of protecting natural and cultural (archaeological) values.

The north end of the spit – which is the primary focus of this study – is located within the Special Feature Zone.

2.2.1 Recreational Usage

Manson's Landing Provincial Park provides important recreational opportunities on Cortes Island. The pier and dock provide a marine-access point to the island and moorage for boats. Boats also anchor offshore within Manson Bay. Smaller non-motorized boats (dinghies, kayaks, etc.) are frequently pulled onshore and stowed along the crest of the beach on either side of the pier despite the storage of boats above the natural boundary as being contrary to the Park Act and Regulations. A beach access road is located on the eastern side of the spit, which is frequently used to access the beach and launch boats near the northwest end of the spit. The park is also used for low-impact activities such as swimming, picnicking, and nature walking.

2.2.2 Archaeological Context

Manson's Landing Provincial park is located within the traditional territory of the Klahoose First Nation and the Xwemalhkwu (Homalco) and it is noted that Tla'amin Nation have a traditional reserve in the area. The Special Feature Zone designation aims to protect the significant cultural and natural features within the park, including a midden located on the upland portion of the shoreline along the spit. The midden is threatened by erosion along the spit. The NHC team did not have the opportunity to engage with the regional First Nations as part of this scope of work and would be beneficial for the project to receive feedback on the conceptual erosion mitigation options that have been proposed.

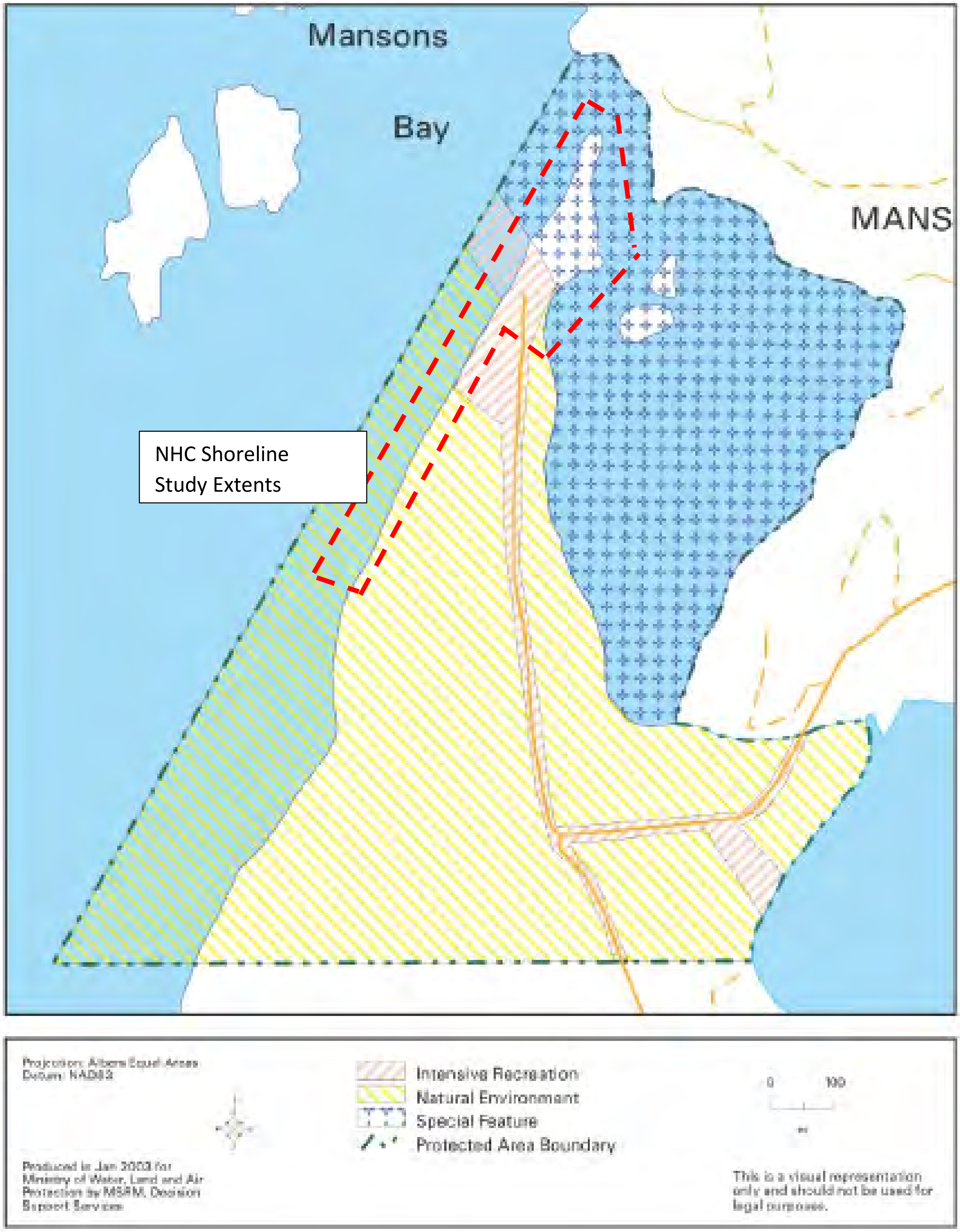

Figure 3 Zoning map of Manson's Landing Provincial Park (BC Parks, 2003)

2.2.3 Ecological Context

Manson's Landing Provincial Park is understood to have significant ecological values. The park is noted to host an important coastal sand ecosystem (Mense, 2018), which includes endangered communities of dune wildrye-beach pea. In 2016 and present day there has been significant work undertaken by BC Parks and the Friends of Cortes Island Society to remove invasive Scotch Broom that threatenes the natural ecosystem. Future work is expected to include additional invasive species removal and restoration of native plant species. The upland area near the spit (SW shoreline of the lagoon) are densely populated with coastal Douglas-fir and western redcedar, with lesser amounts of western hemlock, lodgepole pine, and pacific madrone also observed (Zwickel et al, 2007).

Zwickel et al (2007) described the lagoon mouth as a 'piston' which pumps nutrient rich water into the lagoon creating a biologically diverse environment. They monitored and summarized many of the fauna and flora that have historically been and are presently associated with the lagoon, including eelgrass (*Zostera marina*), which was once prevalent but steadily declined between 1992-1995. The loss of eelgrass was thought to be associated with commercial clam digging and exacerbated by increased populations of Canada Geese.

Despite this, the spit and lagoon provide important habitat for marine and coastal birds, including Bald Eagles, Blue Herons, various shorebirds, and other marine mammals. Salmon spawning records exist for Coho in the stream draining into Manson's Landing (Mense, 2018). Juvenile Chum, Pink, and Chinook Salmon are also noted to use nearshore habitats in rearing during the spring (Mense, 2018). No additional information was available on historical forage fish populations.

Several of the available background documents indicated that erosion of the peninsula may be leading to degradation of the park's ecological values.

2.3 Previous Studies

In February 1989, an inspection of the spit was undertaken by BC Parks and a report was subsequently published in March 1989. The report indicated that the principle direction of longshore transport is from the south towards the north-northeast. The large bulge (deposit) of sand on the shoreline in the lee of the public pier/docks was also noted at the time. The report indicates that the pier, docks, and moored boats may provide enough sheltering from wave action that sediment transport alongshore is disrupted resulting in deposition of sediments in this area. Although the report notes that this deposit may serve to interrupt the longshore transport of sediment and thus starve the shoreline to the north, it concludes that this is likely not a governing factor of the spit erosion. The report also notes the importance of large woody debris and dune grass in stabilizing fine sand on the spit, and that vehicle access both actively and passively erodes the shoreline through destruction of this vegetation. In August 1989, Catherine Berris Associates and Hay & Company undertook a feasibility study for a boat launch in the park. As part of this study, they undertook an analysis of shoreline processes, including a qualitative geomorphological analysis based on 30 years of airphotos. They interpreted the locations of the treeline, foreshore, and delta over this period (

Figure 4). The authors found that the spit had exhibited relatively little change over the study period except for the development of the sediment deposit (bulge) in the lee of the pier/dock structure. However, the spit foreshore can be seen to have grown narrower and more elongated in the NE direction over time. In addition, the delta fan appeared to expand. The report recommended that the boat launch not be constructed in the park to avoid increased erosion of the spit and to avoid additional impacts to the recreational and ecological values of the site.

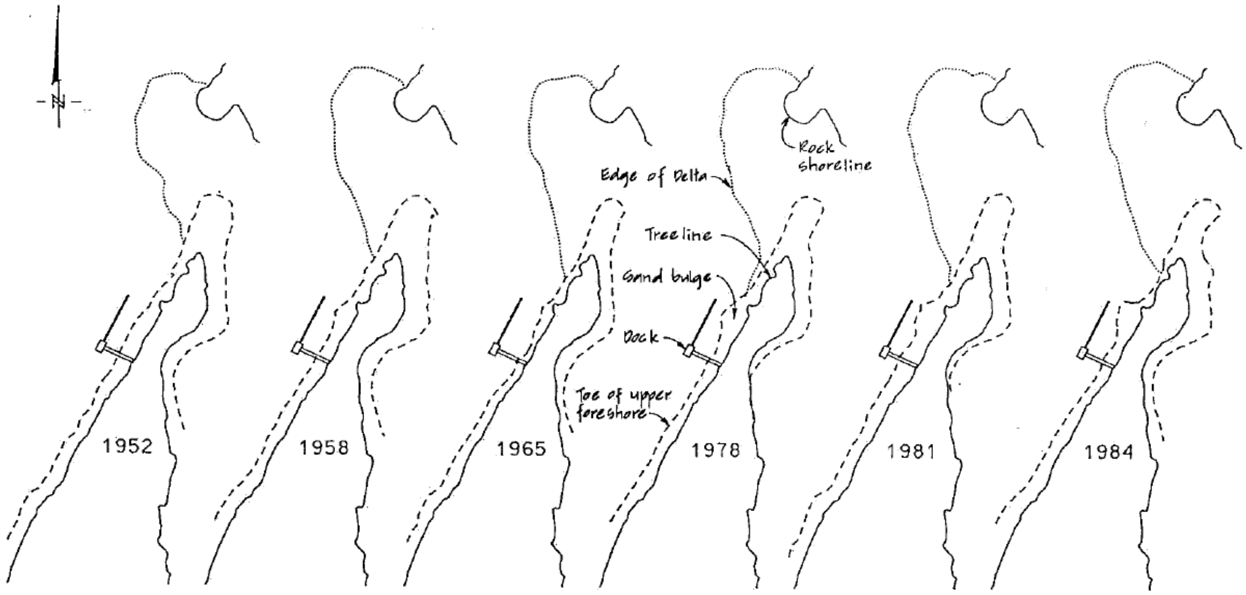

Figure 4 Geomorphic analysis/sketches from Catherine Berries Associates and Hay & Company Consultants, 1989

In the winter of 1989/1990, several measures were taken to reduce erosion including measures to limit vehicle access on the beach, installing anchored “log barriers” (otherwise known at Large Woody Debris, LWD), and planting Dunegrass. However, it was noted in several letters/correspondences that the log barriers were damaged shortly after placement and the survival rate of the Dunegrass was low. In one letter (BC Parks, 1991), it was also noted that shellfish harvesting within the lagoon was problematic and steps were being taken to resolve the issue.

In 1994, BC Parks prepared a document outlining a program to monitor erosion along the spit. It suggested establishing baseline transects, documenting the existing conditions, and undertaking regular monitoring for seasonal and annual changes. Unfortunately this program was not initiated.

Correspondence between BC Parks and Friends of Cortes Island in 1999 (BC Parks, 1999) again outlines concerns regarding erosion of the spit and mentions that additional measures were taken to control erosion and vehicle access. Measures included installation of logs on the lagoon side of the spit, concrete curbs in the parking lot for vehicles, and rocks along the beach prevent vehicle access onto the spit.

3 SITE INSPECTION

A site inspection was conducted on August 16, 2019 during the early afternoon to coincide with a low tide window. The site visit was attended by Jessica Wilson, P.Eng. (Coastal Engineer, NHC), Erica McClaren, R.P.Bio. (BC Parks), Derek Moore (BC Parks), Heather Steere (BC Parks), Helen Hall (Friends of Cortes Island) and Tim Lloyd (Quality Recreation Ltd.). General observations and measurements of beach slopes and water depth at the docks are provided in Section 3.1 and photographs are included in Section 3.2 (ordered in a clockwise direction starting from the SW side of the park).

3.1 General Observations

Key observations from the site visit are summarized below and shown on Figure 5:

- The SW end of the park is characterized by a relatively straight section of shoreline, with a coarse gravel/cobble lower slope with a narrow band of fine sand at the beach crest (Photo 1).
- A public pier and dock are located on the west side of the park (Photo 2). The pier is a wooden piled structure (Photo 3). The dock includes three floats and provides marine access to the shoreline and long-term moorage for numerous boats, many of which were rafted together at the time of inspection, creating the effect of a wider floating breakwater.
- The crest of the beach on either side of the dock is heavily used by the public to store small vessels, such as dinghies and kayaks (Photo 4). It is noted that this is contrary to the Park Act and Regulations.
- A large deposit (or bulge) of sediment is located on the leeside of the docks near the northern end (Photo 5). The deposit has a relatively steep gravel face with a mildly sloping fine sand crest. Dunegrass and other vegetation are growing at the crest of this deposit (Photo 6).
- There is some minor erosion to the northeast of the bulge (Photo 7).
- The major feature of the site is a long spit on the west side of a tidal lagoon. Large eroded banks were observed on both the west and east sides of the spit (Photos 8, 9, and 12). Erosion on the east side (inside the lagoon) has undermined the root system of a tree.
- The spit is comprised of gravel on the lower slope and fine sand on the upper portion of the spit (Photo 10). The west side of the spit has a mild slope, whereas the east side is substantially steeper.
- Some remnant vegetation and historic installations of Large Woody Debris (LWD) are present on the crest of the spit (Photo 11).
- A row of large boulders is located on the NE side of the spit to prevent vehicle traffic on the crest and west side of the spit (Photo 12). BC Parks staff noted that due to infilling of the lagoon, vehicles generally drive as far north along the spit as possible (up to the line of boulders).
- Just south of the erosion on the east side of the spit, there are remnants of stacked LWD installations, which may serve to prevent erosion in this area but might also starve areas downdrift of sediment (Photo 13).

- The mouth of the lagoon is located north of the spit and south of a bedrock shoreline. Depending on the stage of tide, the lagoon mouth is between 20 m and 100 m wide with a gravel delta visible at the outer mouth of the lagoon on the south side.
- Vehicle access to the beach is obtained through an access point to the NE of the parking lot which extends directly along the beach crest on the east side of the spit (Photo 14 and Photo 16). Notably there is no vegetation growth along this vehicle access path.
- A vehicle/trailer turn-around area also extends into the wooded upland area of the park (Photo 15).
- Depth measurements were taken off the inside edge of the public dock as shown in Figure 6. On the inside edge of the dock, the depth increases from south to north from approximately 5.0 m to 6.5 m below geodetic datum (CGVD2013), or 3.8 m to 5.5 m below Chart Datum.
- Beach slopes were estimated using a hand-held inclinometer at the locations shown in Figure 6. The site generally has mild slopes between seven degrees (8:1 H:V) and five degrees (10:1), with the exception of the gravel deposit in the lee of the pier/docks which has a slope of approximately nine degrees (6:1), and the inside edge of the gravel spit which has a slope of approximately twelve degrees (5:1).

Figure 5 Key observations and site features (image: Google Earth, 2019)

Figure 6 Slope and depth measurements (image: Google Earth, 2019). Water depth measurements were taken between 1:10 to 1:20 pm (PDT) on August 16, 2019, in which low tide was about 1.3 m above Chart Datum.

3.2 Site Photographs

Photo 1 - Beach southwest of docks, looking north

Photo 4 – Boat storage on shoreline near pier

Photo 2 – Pier leading to the public docks

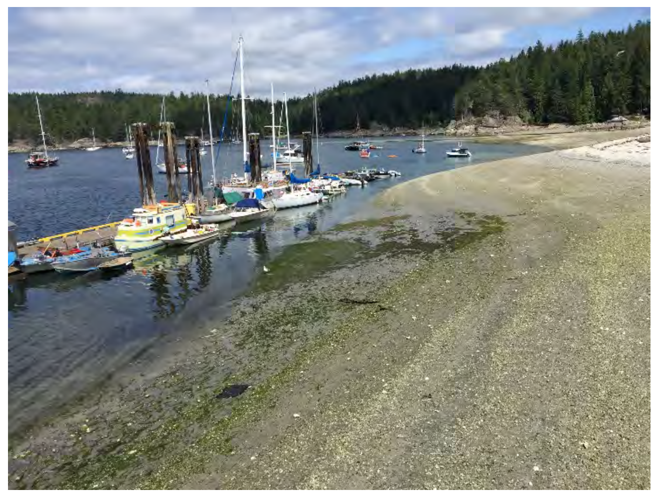

Photo 5 – Sediment deposit in the lee of the docks

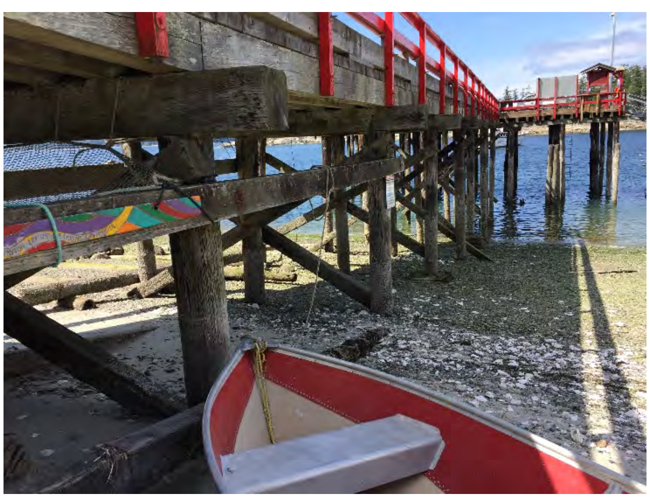

Photo 3 – Pile structure underneath pier

Photo 6 – Vegetation at crest of "bulge"

Photo 7 - Minor erosion north of the gravel deposits

Photo 8 - Severe erosion on west side of the spit, looking south

Photo 9 – Severe erosion and fencing on west side of the spit, looking north

Photo 10 – End of spit, looking south

Photo 11 – Remnants of shoreline protection using anchored logs on the end of the spit

Photo 12 – Severe erosion and fencing on east side of the spit, looking north

Photo 13 – Stacked log installation on east side of the spit, looking north

Photo 15 – Vehicle/trailer turn around area on east side of the spit

Photo 14 – Vehicle tracks and stacked log installation on east side of the spit, looking south

Photo 16 – Vehicle access road on southeast side of the spit

4 COASTAL DESIGN BASIS

As part of the coastal design basis, key parameters of design water levels (astronomical tides, storm surge allowances, and sea level rise) and the incident wave climate have been calculated and are described herein.

4.1 Vertical Datum

For the purpose of this project elevations, including water levels, are referenced to the Canadian Geodetic Vertical Datum 2013 (CGVD2013) unless stated otherwise. Note that the following formula can be used to convert elevations in CGVD28 to CGVD2013, assuming a *dH* of + 0.160 m for the project site[1].

$$Elev_{CGVD2013} = Elev_{CGVD28} + dH$$

4.2 Design Criteria

4.2.1 Design Working Life

The design working life of a structure is taken as "the specific period for which a structure is to be used for its intended purpose with planned maintenance" [British Standard 6349-1]. This report will consider mitigation options that have a design working life of between 15 and 25 years, depending on the option. The rationale for choosing this design working life is based on providing a design with a relatively low cost and also considering the limitations of site access.

4.2.2 Design Event

This project is designed for a 200-year return period event, which is approximately equal to a 1/200 year Annual Exceedance (AEP) probability event (i.e. 0.5 % probability) occurring in any given year. This is a low probability event but is recommended for this site due to the difficulty in conducting maintenance and repairs given the remote location.

It should also be noted that the combined probability of the design wind event coinciding with the design water level will be slightly lower at the beginning of the design life than at the end, because an allowance for sea level rise has been considered (see Section 4.3.5). This sea level rise allowance effectively allows for an additional Factor of Safety at the beginning of the project's design life.

[1] As per: http://webapp.geod.nrcan.gc.ca/geod/tools-outils/gpsh.php?wbdisable=true

4.3 Water Levels

4.3.1 Astronomical Tides

Tide elevations at the project site are based on the Point Atkinson Reference Port and transformed to Manson's Landing based on adjustments published by CHS (2019). Tidal ranges are provided in Table 1.

Table 1 Summary of tidal elevations at Gorge Harbour (CHS, 2019)

Tide Level	Tide Elevation (m, Chart Datum)	Tide Elevation (m, CGVD2013)
Higher High Water Large Tide (HHWLT)	5.7	2.26
Higher High Water Mean Tide (HHWMT)	5.0	1.56
Mean Water Level (MWL)	3.6	0.16
Lower Low Water Mean Tide (LLWMT)	1.5	-1.94
Lower Low Water Large Tide (LLWLT)	0.3	-3.14

4.3.2 Storm Surge

The Ministry of Environment (2011a) report estimates storm surges for various locations in BC based on water level measurements and tidal predictions at local tide stations. Storm surge estimates for the Strait of Georgia are replicated below in Table 2.

Table 2 Estimated residual water levels (storm surge) in the Strait of Georgia (MOE, 2011a)

Annual Exceedance Probability, AEP (1/years)	Return Period , T_R (years)	Storm Surge (m)
Annual	1.4 years	0.75
1/5 year	4.5 years	0.83
1/10 year	9.5 years	0.90
1/25 year	~25 years	1.00
1/50 year	~50 years	1.10
1/100 year	~100 years	1.20
1/200 year	~200 years	1.25

4.3.3 Probability of Storm Surge and Tides Occurring Simultaneously

Additive approaches to determine design water levels conservatively assume that high tide, storm surge, and the design waves occur concurrently. When using an additive approach, it is common practice to select a HHWMT when combining tides with a low probability storm surge, since there is a low likelihood of a worst-case storm surge coinciding with a HHWLT. Using this method, HHWMT is combined with a 1/200 year AEP storm surge, for a total water level of 2.81 m CGVD2013.

Alternatively, when using an additive approach, a storm surge and HHWLT combination can be selected to produce a combined 1/200 AEP probability. According to MOE (2011a), a typical 6-hour storm surge has a 1/20 probability of occurring during a HHWLT window. For a combined 1/200 AEP probability, a 1/10 year AEP storm surge (0.90 m) is used, for a total water level of 3.16 m CGVD2013.

As a third option, rather than an additive approach, the joint probability of storm surge and high tide occurring simultaneously can be assessed by studying historical total water level observations. This probabilistic approach generally results in better estimations of extreme water levels than the previously described additive approaches. Based on historical observations at the Point Atkinson station, NHC and Triton (2006) estimated the 1/200 AEP total water level[2]. After transforming these values from Point Atkinson to Gorge Harbour (CHS, 2019), a total water level of 3.12 m CGVD2013 is estimated for the project site using a joint probability approach.

For the purpose of this project, NHC recommends a design water level of 3.12 m CGVD2013 for the 1/200 AEP total water level (not including wind set-up or sea level rise).

4.3.4 Wind Setup

Wind setup is the effect of wind blowing over a water surface, exerting a horizontal stress on the water surface and piling water up in the downwind direction. In long, enclosed, shallow bodies of water (such as lakes), wind setup can raise the still water level significantly. Conversely, in small bays (such as the project site) and deep bodies of water, wind set-up is minimal and not a governing factor in design. As such, wind setup along the shoreline has not been included as part of this assessment. Section 4.4 discusses the wind analysis in detail upon which the incident wave climate is estimated from.

4.3.5 Sea Level Rise

Global Sea Level Rise

Global climate change is expected to result in increased sea levels resulting from melting of global ice and increased ocean volume due to rising water temperature. The BC Provincial Climate Change Adaption Guidelines (BC MOE, 2011c) recommends that Sea Level Rise (SLR) associated with global climate change will result in a base water level increase of 1 m above that seen in the year 2000 by the year 2100 (or 10 mm / year) (Figure 7). For the purpose of this assessment, this rate of global sea level rise has been considered. Note, that the rate of SLR is projected to increase as the climate warms; therefore, any increase over the past 19 years is expected to be minimal and was hence excluded.

The recommended SLR for planning and design in BC was based on a 2008 study by Fisheries and Oceans Canada (Thomson et al., 2008) and MOE (Bornhold, 2008). The authors of those works acknowledge the design SLR for BC is greater than the global mean SLR projected by the IPCC AR4 (2007) for the year 2100 (roughly 40 cm greater). More recent studies, such as IPCC AR5 (2014), suggests global mean SLR of up

[2] Based on the mean 1/200 AEP estimate for January and December, as opposed to the 95% Confidence Interval estimate, which is approximately 0.1 m higher.

to 1 m or more by the year 2100. Other studies have investigated the potential effect of a collapse of the Antarctic ice sheet and have shown that such an event would result in higher levels of SLR.

Recent changes in estimates of global mean SLR to the year 2100 or 2200 have not yet been addressed in the context of coastal BC, but based on recent conversations with FLNRORD, the province is amidst a study of SLR to update the 2011 design values. This study is has not been concluded as of the writing of this report. As such, NHC will recommend that 1 m of SLR for year 2100 is considered for design.

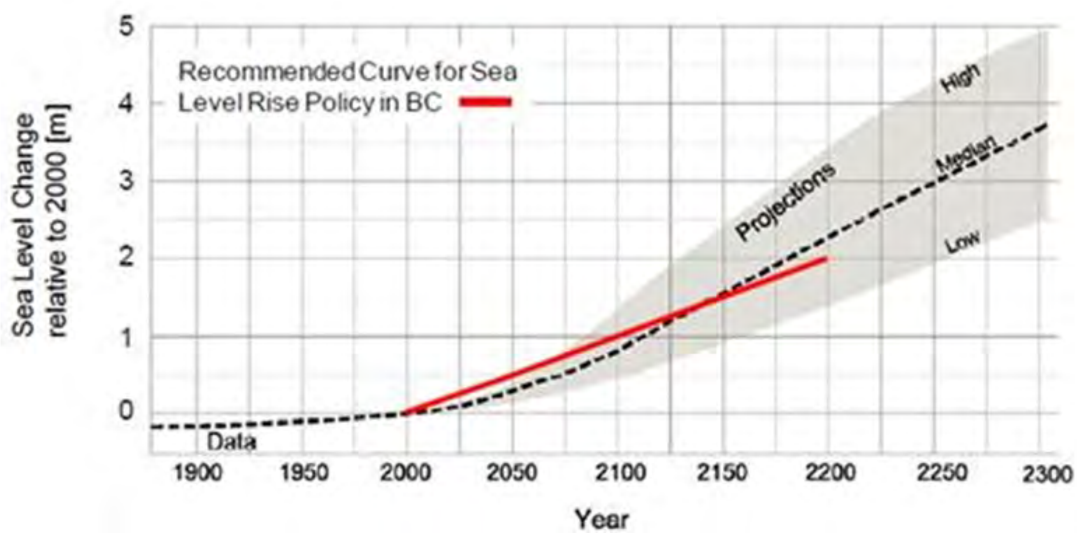

Figure 7 Recommended sea level rise recommended for planning and design in BC (BC Ministry of Environment, 2011c)

Local Relative Sea Level Rise

In addition to global SLR, isostatic rebound, tectonic uplift, and/or sediment consolidation may influence the local relative sea level rise. The MOE (2011c) published rates of uplift/subsidence for various stations across BC. The total vertical land movement for the closest relevant stations are as follows:

- Campbell River (19km away) +4.1 mm/year
- Little River (37km away): +3.0 mm/year

These observations suggest that the region may experience between 3.0 and 4.1 mm of uplift per year relative to ocean levels, thereby slightly offsetting the effects of global sea level increase. Because no observations exist for Cortes Island (nor on any of the nearby islands) and because measurements vary across the region, a conservative value for uplift of 3.0 mm/year has been assumed. (Note, a smaller value of uplift is more conservative than a larger value.)

The calculation of the local relative sea level rise is based upon the global sea level rise allowance of 10 mm/year minus the local uplift. **Assuming a 25-year design life and construction in 2020 (i.e. project service life to year 2045), NHC recommends that the project include an allowance of +7 mm/year of**

local relative sea level rise beyond year 2000 reference water levels (eg. 0.32 m of SLR for year 2045) that accounts for both sea level rise and local vertical land motion.

4.3.6 Design Water Levels

The water levels considered in this assessment include a range of water levels that the shoreline may be exposed to over the life of the project. The total design still water levels (DWLs) for present day and future sea level rise considerations are presented in Table 3.

Table 3 Design water levels

Scenario	Tide (m, CGVD2013)	Surge (m)	Local SLR (m)	DWL (m, CGVD2013)
LLWLT, Present Day	-3.14	0.00	0.00	**-3.14**
LLWMT, Present Day	-1.94	0.00	0.00	**-1.94**
MWL, Present Day	0.16	0.00	0.00	**0.16**
HHWMT, Present Day	1.56	0.00	0.00	**1.56**
HHWLT, Present Day	2.26	0.00	0.00	**2.26**
1/200 AEP Total Water Level, Present Day	3.12		0.00	**3.12**
1/200 AEP Total Water Level, Future (year 2045)	3.12		0.32	**3.44**

4.4 Winds

4.4.1 Local Wind Stations

Environment Canada (EC) and the Department of Fisheries and Oceans (DFO) operate several wind stations (anemometers) and wave buoys that help describe the regional wind climate in the Strait of Georgia. Data from two stations in particular – Cape Mudge and Sentry Shoal – are assumed to be representative of the winds that may generate waves at the project site (Table 4). However, wind data from Cape Mudge (17 km away from the project site) has an incomplete data record and can therefore not be used to generate wind statistics and predict wave heights. Instead, data from Sentry Shoal (located 18 km S of the project site) is used for this purpose, since it has a long, continuous, and up-to-date data record. Additionally the Sentry Shoal buoy also records wave data[3], which is useful when estimating wave events at the project site (see Section 4.5).

[3] NHC has performed a quality review of Sentry Shoal wave data, and excluded suspect wave from October 1998 until April 1999.

Table 4 Nearby relevant wind stations

Station Name	Operator & ID	Data Type	Record Length	Location (relative to project site)
Cape Mudge	EC 1021330	Wind Only	1994 – 2001 **(incomplete)**	17 km WSW
Sentry Shoal	DFO C46131	Wind and Wave	1992 – 2019 **(continuous)**	18 km S

4.4.2 Wind Assessment

Winds measured at Sentry Shoal were reviewed to better understand the wind climate in the northern portion of the Strait of Georgia and the exposure at the project site. A wind rose for this station is included in Figure 8.

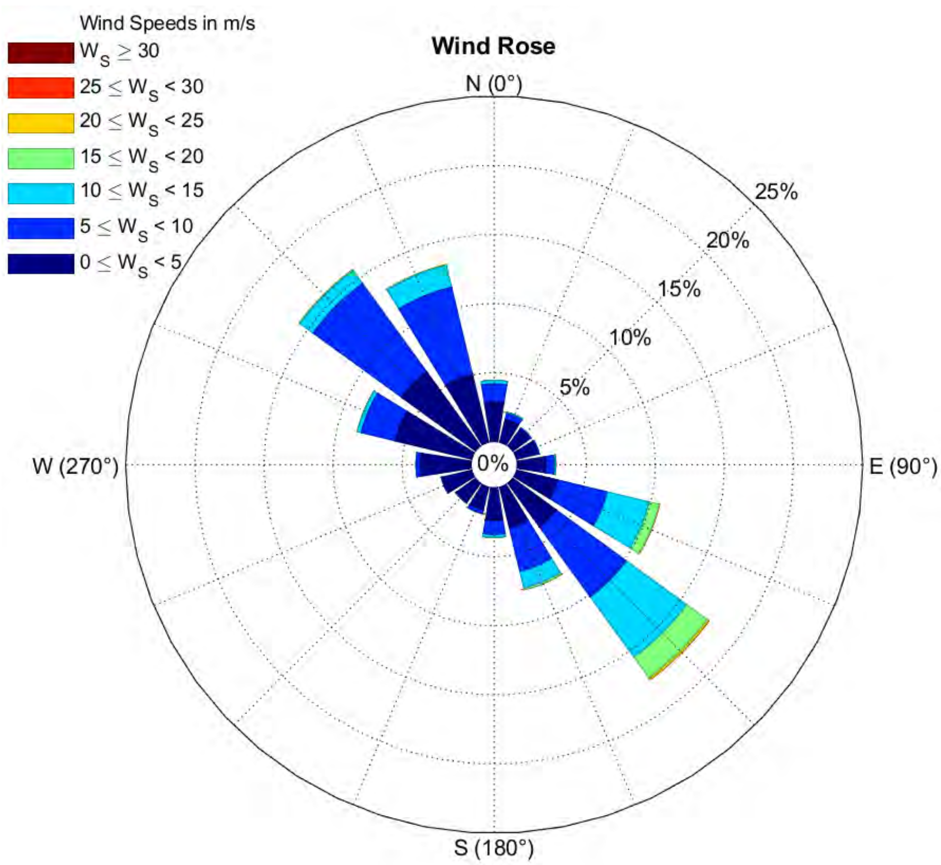

Figure 8 Sentry Shoal wind rose based on the period of record (1992-2019)

In general, the Strait of Georgia experiences winds oriented in a NW-SE direction in the central Strait of Georgia. At the north end of the strait (near Sentry Shoal and the project site), the strong SE winds are capable of generating large waves offshore of the project site but they are not directly incident because of the angle of the shoreline relative to the incoming waves. Southwesterly winds are generally weaker and infrequent. Strong northwesterly winds frequently occur, but have a short fetch for generating waves near the project site. Based on this understanding, it is reasonable to expect that the project site will be directly exposed to frequent locally-generated waves during both SW and NW winds events, and indirectly exposed to large swell waves during severe SE storm events. Wind speeds for a range of estimated return periods for these three exposures are provided in Table 5, based on the Sentry Shoal wind station.

Table 5 Estimated return periods for NW, SW, and SE exposures based on Sentry Shoal

Annual Exceedance Probability, AEP (1/years)	Wind Speed (m/s)		
	NW	SW	SE
Annual	16.4	12.3	22.3
10	21.5	16.0	26.6
20	23.0	16.8	27.8
50	25.0	17.9	29.5
100	26.6	18.6	30.8
200	28.1	19.4	32.1

4.4.3 Design Winds

Design wind speeds and direction for the project are included in Table 6. Note that climate change may cause some changes to the frequency, magnitude, duration, and/or direction of wind events; however, there is currently no information available for this region to justify adaptations to the design wind characteristics to account for climate change effects. As such, no modification to the design wind speed or direction has been made for this phase of the project.

Table 6 Design wind speeds

AEP (1/years)	NW		SW		SE	
	Wind Speed (m/s)	Wind Dir. (o^{TN})	Wind Speed (m/s)	Wind Dir. (o^{TN})	Wind Speed (m/s)	Wind Dir. (o^{TN})
50	25.0	305	17.9	210	29.5	160
200	28.1	305	19.4	210	32.1	160

4.5 Incident Wave Climate

The incident wave climate is the design wave conditions that occur near the project site in relatively deep water (e.g. waves are not affected by interactions with the seabed). For the purpose of this project, the incident wave climate is defined at two points:

(1) on the west side of the spit approximately 100 m offshore (Pt 1, Figure 9) and

(2) on the east side of the spit approximately 30 m offshore (Pt 2, Figure 9).

NW and SW design incident wave heights were directly estimated at Pt 1 based on the straight-line fetch over which winds generate waves. SE design waves at Pt 1 were first estimated in deep-water offshore of Cortes Island (Pt 3, Figure 9) and then transformed offshore of the park (Pt 1). SE design waves at Pt 2 were directly estimated based on the straight-line fetch. Resulting design incident wave heights are provided in Table 7. Note that SW and SE incident waves are highly oblique, and are therefore likely to drive significant longshore sediment transport. The significant wave height (H_s) is the average of the highest 1/3 of waves.

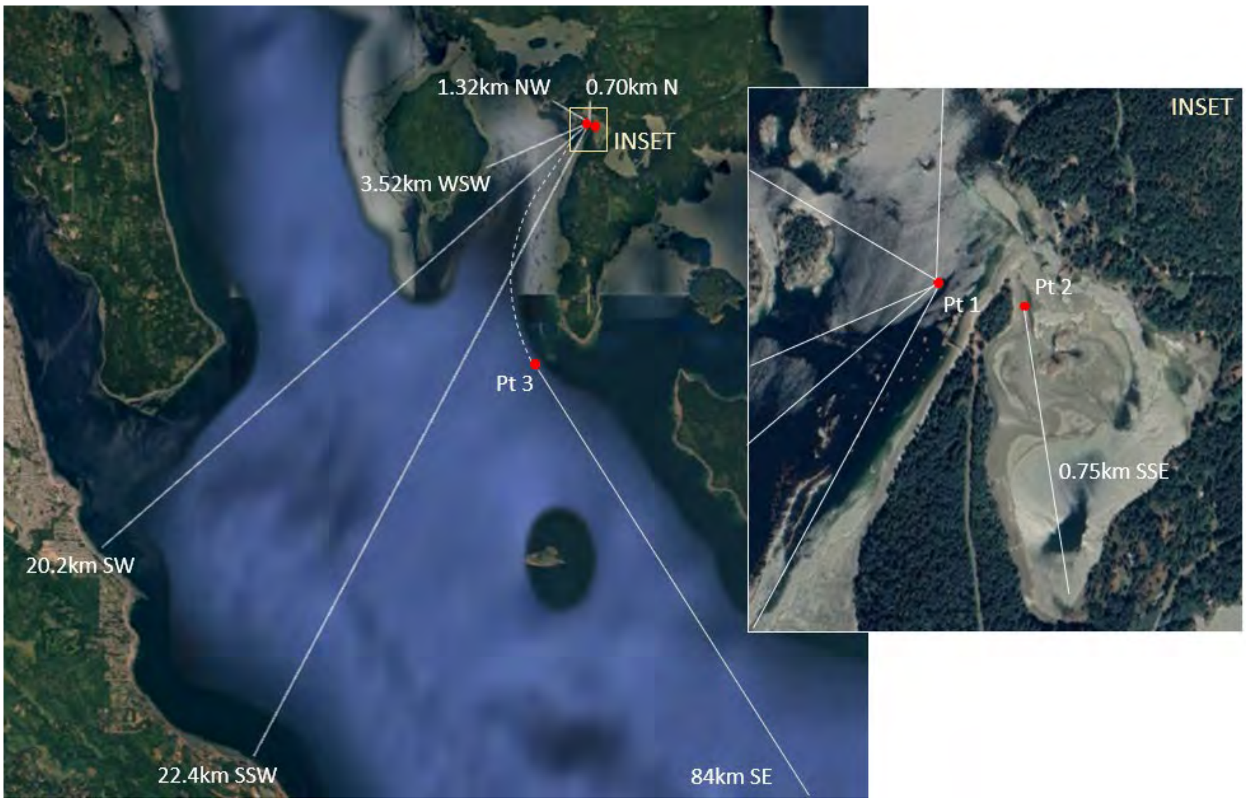

Figure 9 Fetch lengths and incident wave height estimate locations (ref: Google Earth, 2019)

Table 7 Design incident wave heights for the west side of the spit

Location	NW		SSW		SE (SSE pt 2)	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)	Hs (m)	Tp (s)
Pt 1	0.5	1.9	1.6	4.3	1.5	8.2
Pt 2	-	-	-	-	0.5	1.7

4.6 Run-Up

Wave run-up is the maximum vertical extent of wave uprush on a beach or structure above the still water level. For design purposes, wave run-up is generally calculated in terms of the two percent exceedance value of wave run-up ($R_{2\%}$), i.e., only two percent of the wave run-up values observed will reach or exceed $R_{2\%}$. The crest level of the shoreline treatment can then be estimated by adding the DWL, the $R_{2\%}$ value specific to each shoreline type and slope, and an appropriate freeboard, specific for the area and land use (note this is not equal to the Flood Construction level).

For the purpose of estimating wave runup on potential design options, runup levels ($R_{2\%}$) were estimated for a 2:1 (H:V) riprap slope and a 6:1 (H:V) gravel beach, during the design storm events. For a riprap slope, the maximum wave run-up is estimated to be 1.0 m on the western side of the spit and 0.5 m on the eastern side of the spit. For a gravel beach, the wave run-up is estimated to be 1.2 m for the western exposure and 0.3 m for the eastern exposure of the spit.

4.7 Coastal Geomorphology

The British Columbia shoreline is highly irregular and with dynamic coastlines thanks to the effects of Quaternary glaciation and the large changes in sea level that occurred following the retreat of glaciers from the region between 7,000 and 15,000 years ago. Following the retreat of the glaciers the shorelines have continued to evolve in response to the actions of tides, currents, waves, the configuration of the shoreline and the supply of sediments.

A special feature of Manson’s Landing is the large spit that forms the northern part of the park and partially closes the lagoon. A spit “is a beach with one end joined to the shore and the other end free where it terminates in a hook or recurve.” (ref: Thomson, 1981). There are many examples of such spits of varying scales in the coastal waters of the region with Rose Spit (northeast end of Graham Island, Haida Gwaii) and Dungeness Spit (WA) as two examples of very large spits. Rebecca Spit (Quadra Island) and Sidney Spit (Sidney Island) are also classic examples of spits known to recreational boaters. Coastal spit features tend to grow where there is a supply of sediments and a net long-shore transport of sediments that feeds the spit. Instabilities in spits, in which storm waves overtop or breach the spit and carry sands to the inner side of the spit are natural processes that help to widen the spit over time. If the supply of sediments to the beach spit is in balance with the loss of sediments then the spit will remain stable. However, if the supply of sediments to the spit is disrupted, then the spit will begin to shrink in size as sediment losses exceed accretion. Tidal exchange between the lagoon and the Strait of Georgia creates strong currents that evacuate the sediment delivered to the northern tip of the spit to maintain the opening.

The southern end of Manson’s Landing park has upland areas composed of interglacial deposits of Quadra sands that form steep bluffs and feed the shoreline to the north (downdrift) through a process of gradual shoreline erosion that have formed and maintain the spit. Based upon the site visit and interpretations of reports and air photos, we note the following:

- There are small upland stream channels that discharge into the SE corner of the lagoon. These streams likely have minimal sediment input compared to the overall lagoon sediment budget.
- The lagoon mouth funnels water and sediment into and out of the lagoon, resulting in a coastal delta feature on the offshore side of the lagoon mouth and infilling of the lagoon itself.
- A review of airphotos indicates that the sediment deposit ('bulge') that exists inshore of the pier and floats began to form after these were constructed. Given the location relative to the floats, the primary wave exposure, and the direction of longshore transport, it is expected that the 'bulge' formation is a direct result of wave sheltering from the floats and moored vessels.
- Preferential deposition of material in the lee of the floats has likely resulted in starvation of the beach downdrift of the floats (i.e. on the north side of the "bulge").
- Natural spit migration is likely exacerbated by sediment starvation, and potentially also by vehicle access on the east side of the spit, and pedestrian access on the upper beaches.

Figure 10 shows an aerial photo of the project site that is marked up to denote the conceptual model of the dominant sediment transport processes. Figure 11 shows a collection of aerial photos that have been collected for the project site. It is possible to observe the growth of the sediment "bulge" adjacent to the north end of the floats following their construction.

Figure 10 Conceptual model of sediment transport processes. Yellow arrows denote longshore transport, green arrows areas of deposition, and red arrows erosion (image: Google Earth)

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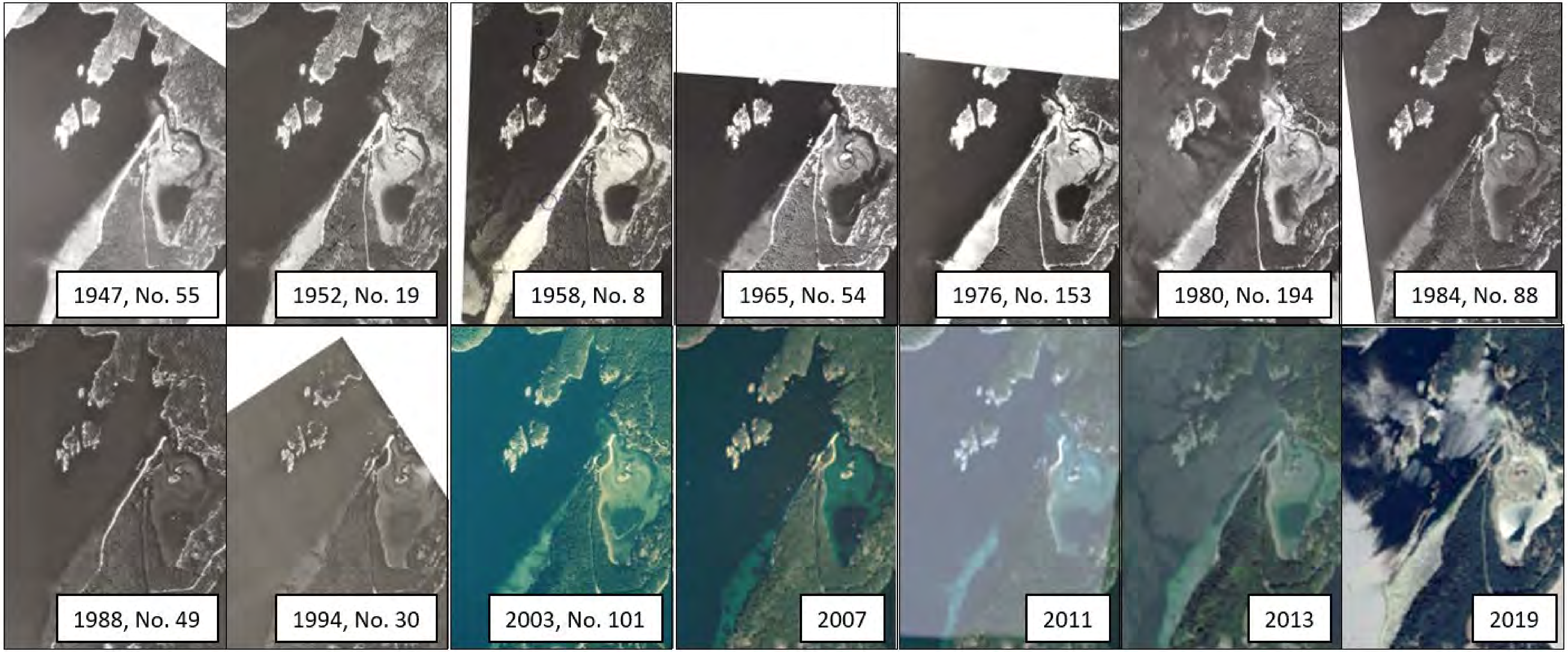

Figure 11 Aerial-photographs of Manson's Landing Provincial Park from 1947 to 2019

5 EROSION MITIGATION OPTIONS

5.1 Objectives

The objectives of erosion mitigation are as follows:

- Upgrade or improve the existing shoreline protection to protect the bluffs against erosion from the present and future wave climate,
- preserve the cultural values and features of the site,
- add to the recreational value and aesthetics of the beach (if possible),
- maintain or improve the existing foreshore and intertidal habitat, and
- provide a cost-effective and simple constructible design.

It is possible that any attempt to protect the spit from erosion (even using nature-based approaches) could result in undesirable impacts to the existing coastal processes and ecological values elsewhere along the shoreline. As such, these project objectives are not necessarily complementary. Since the primary function of the park is to protect natural features, BC Parks should consider options that promote natural shoreline behaviour (including erosion) and require minimal human intervention. As such, several potential approaches for the site are outlined herein, which include non-invasive (monitoring), passive (management), and active (protection) approaches.

The following mitigation options are presented in two themes:

1. An approach that is focused on returning the park to a more natural state
2. Interventions to halt erosion but that introduce artificial structures to the park.

The first approach includes a potential mix of non-invasive and/or passive projects, such as reducing the size of the moorage floats to restore the longshore transport, taking steps to prevent vehicle access to the spit, and taking steps to prevent recreational activity in the spit area where erosion is occurring. These options fall within a framework of restoring the spit as much as possible to a natural setting, and then allowing natural processes to occur. It is noted that while some actions (such as removal of floats) are expected to reduce erosion in some areas as long shore transport is restored, there will still be on-going erosion that will need to be monitored. As such, taking this approach does not preclude a higher level of intervention to protect specific shoreline areas in the future, and the two approaches are not mutually exclusive.

The second approach considers options that actively protect the shoreline from erosion. These include a large beach nourishment to replenish the eroded section of beach north of the “bulge”, a stacked wood log revetment, and a more traditional rock armour revetment. Each of these would represent a major intervention in the natural shoreline processes, but would serve to provide protection over the short to long term against erosion of the upper beach.

The following subsections describe in detail the mitigation options as noted above. Section 5.2 discusses recommended monitoring to better understand the existing situation. Section 5.3 contains options associated with the first approach of management changes and usage changes in the park, while section 5.4 contains options associated with the second theme of intervention and protection against erosion.

5.2 Monitoring

Although significant anecdotal evidence indicates that the spit is eroding and numerous studies have been completed for the project site, NHC is not aware of any systematic efforts to monitor elevation changes along the Park's shoreline and along the spit in particular. In order to avoid unexpected impacts from potential mitigation measures, it is recommended that a monitoring plan first be implemented.

In 1994, BC Parks published a "*Project Outline – Manson's Landing, Spit Monitoring Program*". This document recommends establishing baseline transects and recording the substrate type, elevation, and vegetation at 5 m intervals. The report recommends monitoring changes to the spit on a seasonal basis and inventorying vegetation on an annual basis.

An updated version of this monitoring plan could include the use of drone overflights of the shoreline on a seasonal or annual basis to capture high resolution imagery and elevation data of the entire project site. This data could be used to map sediment sizes and vegetation, estimate LWD volumes, extract elevation transects, and estimate erosion or deposition rates. It is recommended that monitoring should be completed for at least five years to better understand both short (seasonal) and long-term changes to the project site, before implementing additional management or protection measures. In addition, elevation data from these surveys could be used to inform the eventual design of shoreline protection options, allowing for more optimized designs and more accurate volume and cost-estimates.

A potential downside of additional monitoring is that the site may experience additional erosion and degradation to the upland archaeological site during the monitoring period.

Example of a Monitoring Program

The monitoring could be completed in a day, with a small boat bathymetry survey undertaken during a mid to high tide period and the drone survey and land survey being conducted during low tide. The bathymetric survey would be to primarily sample the sub-tidal area adjacent to the pier and floats, and northwards along the western side of the spit. The drone survey would allow for a topographic DEM to be constructed of the inter-tidal and upper beach areas. The land survey would be to provide ground control for the photogrammetry processing of the aerial photos, and to capture elevations in areas hidden from the drone by vegetation. It is worth noting that a drone flight is fairly easy to conduct, but that undertaking proper ground control and quality control in processing requires a geomatics specialist to ensure that the processing of the drone imagery results in accurate topographic information.

A monitoring program could be conducted by two persons. For example, NHC is able to mobilize a small aluminum boat, RTK GPS, and RTK drone for a site survey. An allowance of one day for preparation and mobilization, one day for the site visit for two persons, and three days for data processing and reporting should be given. Allowing for equipment and travel with mobilization from a Nanaimo office, the total costs for the survey and data reporting are estimated to be $12k (inclusive of a 10% contingency, and excluding taxes) per visit. At a minimum surveys are recommended once per year for four (4) years to establish baseline conditions.

5.3 Management & Changes to Site Usage

5.3.1 Remove Floats & Reduce Moorage near to the shoreline

Based on the geomorphological assessment of the site, it is likely the existing pier, docks, and moored vessels are promoting sediment deposition on the lee side and starving the shoreline downdrift of sediment. Removal of the pier and dock structures in their entirety would thus have the greatest effect of restoring the natural longshore transport processes at the site; however, it is understood that the public pier provides an important marine access point to both Manson's Landing Provincial Park and Cortes Island and thus its complete removal is undesirable.

A more acceptable option may be to remove the existing floats and replace them with one short float (as small as 7 m in length (similar to the small float at Teakerne Arm Marine Park) to be used only for temporary docking of small tenders to allow public access (Figure 12). This approach would result in less than one quarter of the existing dock length. Restricting moorage would effectively reduce the present "floating attenuator" effect caused by larger boats using the floats. A detailed assessment was not performed, but when multiple recreational vessels raft together on the dock they may extend past the waterlot for the floats. While these measures are expected to restore much of the natural sediment transport processes at the site, the positive benefits on the shorelines in the downdrift direction may not be apparent for several years. Removal of the floats would also improve the natural aesthetics/view from the shoreline. If additional moorage is required, additional mooring buoys within Manson Bay for visiting boaters.

This option requires the removal of the existing floats (which could be re-purposed or sold if in good condition) and results in no 'hard' structures on the shoreline. A condition assessment of the floats has not been done as part of this scope of work, so we are not able to comment on their potential value.

As the floats are not owned by BC Parks, there would need to be negotiations with the owners of the infrastructure along with the Harbour Authority of Cortes Island for their approval and participation in the project, and such discussions would need to occur to determine the initial feasibility of this project.

The largest cost for removal of the floats is associated with hiring a contractor to remove the timber piles that are no longer required. An Environmental Impact Assessment would also be required before work commenced, although this study suggests removal would reduce impacts at the site. We note that piles could be left in place for a period of time after removal of the floats to evaluate the effectiveness of the removal of the floats on the long-shore transport. If contaminated sediments are present adjacent to the piles, then removal of piles may involve cutting the piles just above the seabed to avoid disturbance of sediments.

A budget level cost estimate to remove the existing floats and piles as indicated in Figure 12 is $50k, which allows for $46k[4] for a marine contractor and $4k allowance for project administration internal to BC Parks for the project. This cost does not include any environmental permitting or monitoring that may be required as part of the work to remove the piles, nor costs for meetings and negotiations with other agencies.

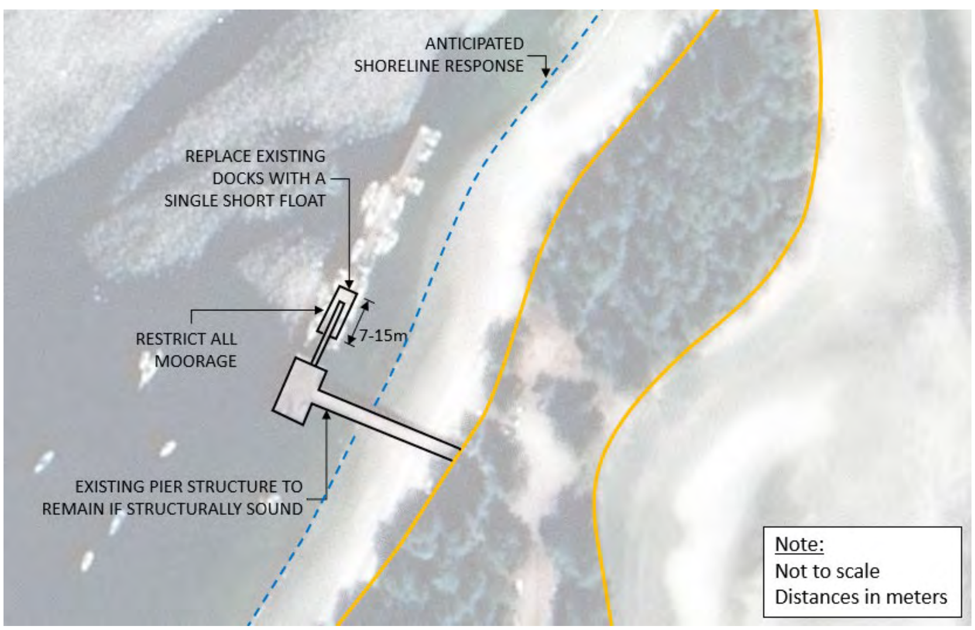

Figure 12 Conceptual sketch of dock removal

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[4] A budget level cost estimate was obtained from Pacific Industrial & Marine Ltd. (Cowichan Bay, BC). Their cost estimate includes mobilization and demobilization of a barge and crane, crew transport, accommodations and expenses. Scope of work includes removal of floats, removal of piles and disposal of timber piles. Estimate includes a 15% contingency. (2019 pricing)

5.3.2 Inhibit Vehicular Beach Access

Vehicle access is currently permitted on the east side of the peninsula to allow for users to launch boats near the NE end of the spit. Vehicle access may have the dual effect of actively mobilizing sediment and inhibiting vegetation growth, which may otherwise help to stabilize the shoreline. Vehicle access on the foreshore also increases the potential for petroleum products or other pollutants to be introduced into the ecologically sensitive lagoon. As such, it is recommended that BC Parks considers eliminating vehicle access to the foreshore. Removing vehicle access would also have the effect of reducing boat traffic within the lagoon, which may both reduce erosion and provide ecological benefits.

Costs to implement this change would include the installation of large rocks or jersey barriers to limit vehicle asses onto the upper beach “road” in the lagoon. A local contractor under direction of BC Parks staff could undertake such work. It is estimated the costs would be less than $5k.

5.3.3 Minimize Recreational Usage on Spit

Recreational usage of the park may serve to prevent establishment of native vegetation and exacerbate ongoing erosion processes. As such, minimizing pedestrian access to some areas of the spit and lagoon should be considered. Methods to accomplish this include improved signage, additional fencing, relocation of the parking lot[5] and walking trails further south, and disallow storage of small boats/kayaks on the beach crest. Despite the obvious negative impact to recreational usage of the site, this management technique would be low cost and help protect the ecological and cultural values of the park. Further, the park is relatively large and there would remain other areas for public access.

5.3.4 Continue Vegetation Restoration

BC Parks and the Friends of Cortes Island Society have previously undertaken initiatives to remove invasive species and promote establishment of native vegetation along the shoreline. Continuation of these efforts will help naturally stabilize the shoreline, but are likely to be the most effective if paired with measures to reduce pedestrian and vehicle traffic on the beach. A habitat inventory by a Registered Professional Biologist would also likely provide beneficial information on existing habitat, vegetation types that are likely to have the most benefits and highest survival rates, and potential effects of any shoreline protection measures on the site’s ecological values.

The costs for having a consultant undertake a habitat inventory is likely on the order of $10k for the north end of the park and spit area.

5.4 Protection

Conceptual options for protecting the spit from erosion are presented in this section. A number of options are presented for completeness, including a Green Shores type option and a conventional

[5] It is noted that the roadway is under BC MOTI jurisdiction, and any changes to the roadway and vehicle access in the park will require consultation with both the community and BC MOTI representatives.

('hard') option. The options have been developed in consideration of the archaeological [6] and environmental sensitivities of the site, as well as the assumption that the budget for construction will be limited. The options also consider sea level rise and wave run-up processes; however, site elevations must be surveyed/confirmed to ensure that the outlined options provide sufficient protection from wave run-up at the end of the design life.

Note that NHC recommends undertaking monitoring and the aforementioned management techniques prior to implementing any of these measures.

5.4.1 Beach Nourishment

Beach nourishment is a common approach to shoreline protection/restoration and generally complies with the principles of Green Shores. Beach nourishment would include placement of a large volume of sand and gravel/cobble (Figure 13) at strategic locations to provide an additional source of material for the longshore transport system. This size material is known to be very effective at absorbing and dissipating wave energy and would match the natural aesthetic of the site. Gravel/cobble beaches are generally constructed at a slope of 6:1 (H:V) or milder; however, because the existing beach slope is already relatively steep, a steeper beach fill would be required to tie into the existing slope (approx. 4:1), and the design would be such that the beach nourishment would be placed and then it would be expected that natural forces would reshape the beach over time.

Vegetation and some logs could be installed at the beach crest to help stabilize the upper beach, provide habitat, and reduce wave run-up. As with all 'soft' approaches, dynamic behaviour of the beach shape and character is expected on a seasonal and annual basis, resulting in potentially undesirable beach erosion if the winter storm season is stronger than expected. That said, the beach nourishment is intended to act as a "sacrificial beach" that could tolerate erosion while protecting the existing extents of the upland vegetation on the spit at Manson's Landing.

The primary advantage of the beach nourishment is that the protective materials are natural to the environment (coastal BC) and would be reshaped by natural processes. As such the natural setting of the park, the habitat values of the park, and the recreational opportunities within the park would not be adversely affected by a beach nourishment effort. The beach nourishment as described here would be designed to have a service life of 10 to 20 years.

[6] NHC was not able to meet with First Nations representatives during the site visit. It is assumed that consultation would be included in the next steps towards development of any shoreline protection measures.

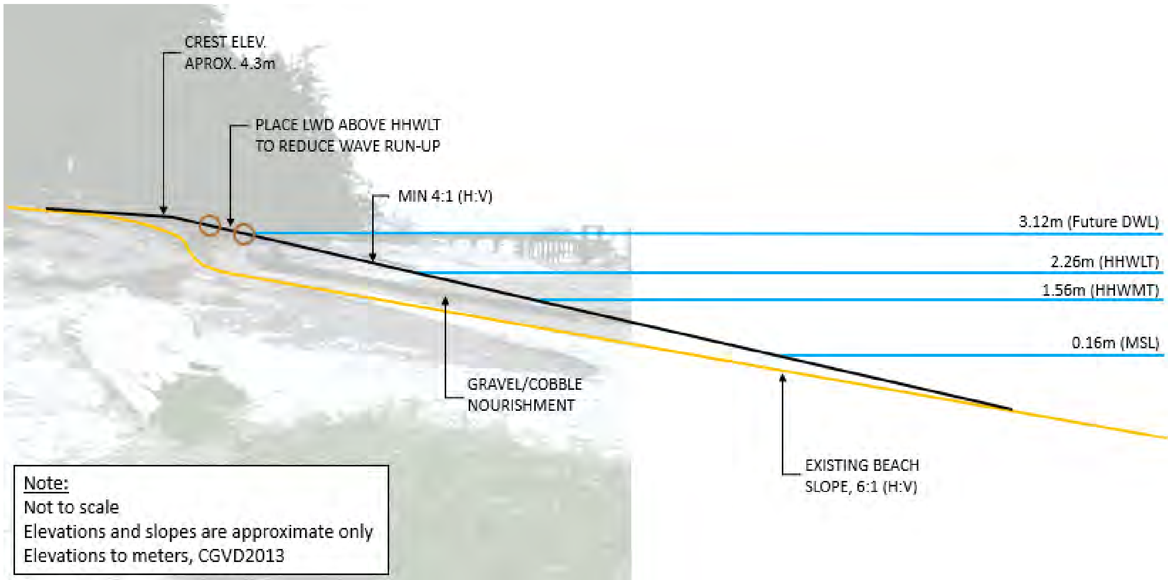

Figure 13 Conceptual sketch of mixed sand/gravel nourishment concept

The cost estimate for a 120 m length of beach nourishment, on the north side of the "bulge" where it could feed the spit and protect the upper beach area would be approximately $100,000. This includes capital costs for the materials and their placement, a 20 percent allowance of capital costs for engineering and permitting, and a 25 percent contingency on construction costs.

This cost estimate is based upon an assumed nourishment of 2,100 tonnes at a cost of $10 per tonne for washed sand and gravel from the Lehigh quarry at Sechelt, and a cost of $12 per tonne for transport by barge to the project site. Lehigh (as well as other contractors) have barges with conveyors that can deposit the material on the upper beach. A work crew with a medium size bulldozer is required to re-work the material as it is deposited on the upper beach from the conveyor on the barge.

5.4.2 Extension of existing stacked log protection

Historic installations of stacked logs are located on the north-eastern side of the peninsula. The existing installations stop just southeast of the sand spit (approximately at the locations of the boulder array preventing vehicle traffic), where significant upland erosion was observed during the site visit. As a 'hybrid' option, the existing stacked log structures could be extended to the north-west, wrapping around the spit where the most significant bank erosion is located (up to 100 m linear meters of shoreline). Because poor longevity of previous stacked log installations was noted in the background documents, additional measures would have to be taken to ensure stability, including placing a cobble toe to prevent scouring (Figure 14). This option can be implemented at a relatively low cost, but it must be acknowledged that the option should be considered as having a relatively short service life (possibly <10 years) before additional maintenance or upgrades would be required.

Although logs are a natural material, their continuous placement along the shoreline prevents natural shoreline erosion and therefore sediment supply to areas downdrift. In addition, even natural materials, if hard and stacked, will behave similarly to a rip-rap revetment when exposed to wave action (increase reflection at the shoreline); as such, it is debatable whether stacked/anchored logs qualifies as a ‘soft’ or ‘hybrid’ approach (eg. Green Shores type approach). Despite this, the approach may provide some ecological benefits, such as acting as a substrate for vegetation and helping to retain moisture during dry summer months.

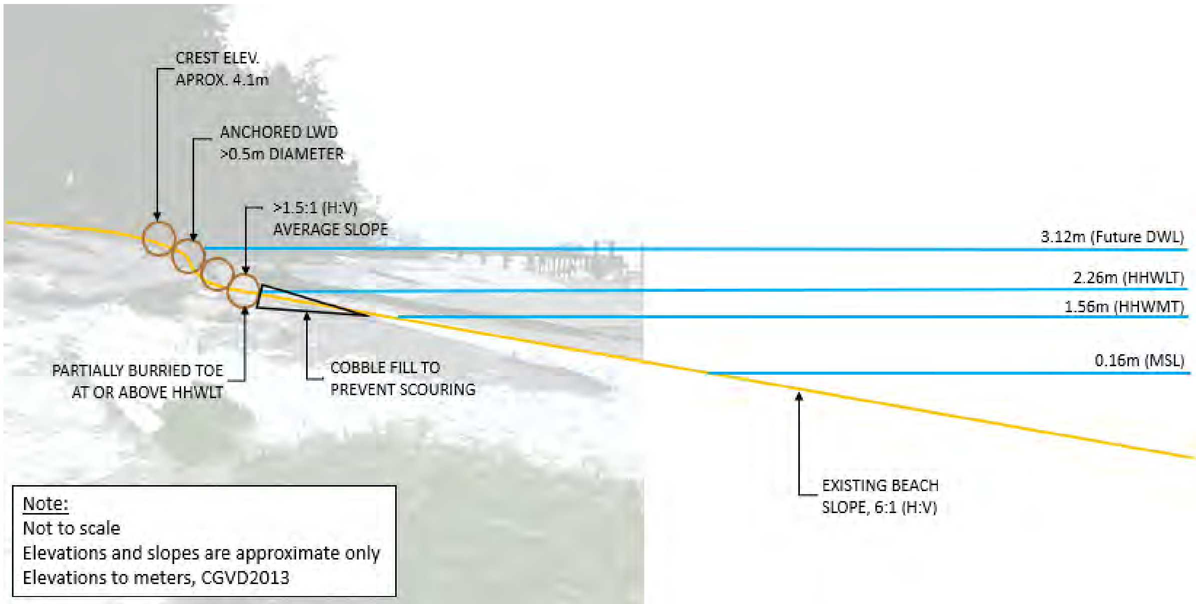

Figure 14 Conceptual sketch of concept to extend existing stacked log structures

The cost of construction for the design sketch is estimated at approximately $400 per linear meter of shoreline, assuming suitable wood logs are available in the area. A budget level estimate including some contingency to install 100 m of stacked logs and cobble fill (scour prevention) as per the above sketch is $40,000.

5.4.3 Rip-Rap Revetment

Rip-rap revetments are frequently installed to protect shorelines and are relatively efficient at absorbing incident wave energy. This option would include placement of a cobble filter/base layer overlain with two layers of rock armour at a 2:1 slope (Figure 15). The option should also include a buried toe to prevent undermining of the rock slope. A benefit of this option is that it involves significantly less material placement on the foreshore than the beach nourishment option; however, it may detract from the recreational or ecological values of the park.

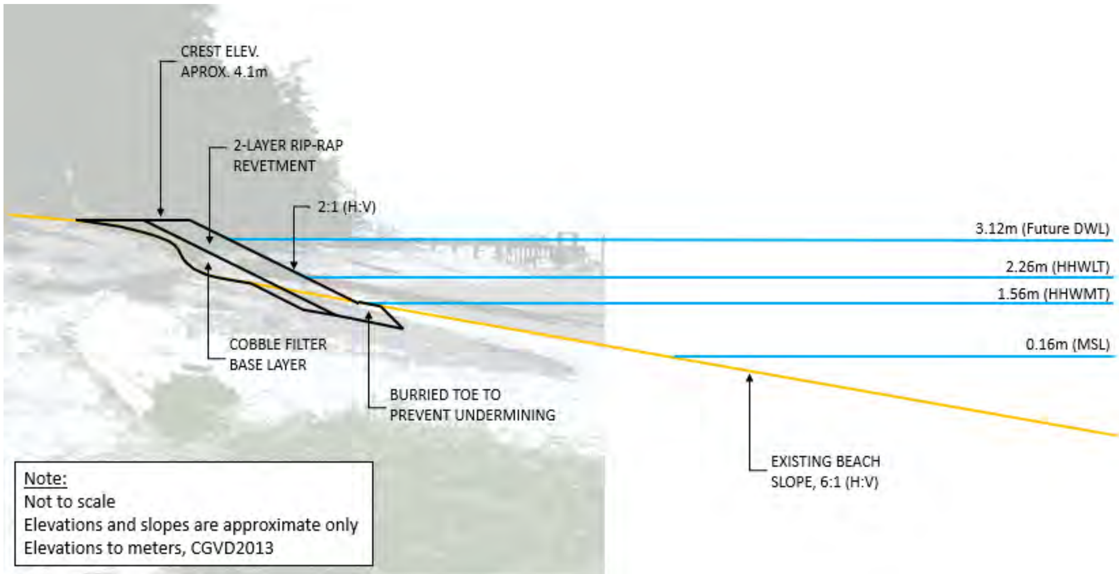

Figure 15 Conceptual sketch of rip-rap revetment option

The typical costs for installation of a rip-rap revetment as indicated in the sketch can be between $1,400 and $2,000 per linear metre of shoreline, depending on the availability of suitable rock in the vicinity. For installing protection of 100 m of revetment at the site, a budget estimate of $200,000 (allowing for contingency) is recommended.

The rip-rap armour is a more robust solution that would be better at withstanding direct wave attack without damage. That said, the rock armour would completely change the natural setting of the spit and would represent a significant alteration to the landscape. As such, we do not recommend such action unless there is an extreme need to ensure no further erosion or upland changes to the spit.

5.5 Additional Considerations

Additional design/construction considerations and risks are described below. These are general design considerations for shoreline protection works in BC.

5.5.1 First Nation Engagement

This project site is within the traditional territory of the local First Nation. Engagement with local First Nations should explore decisions as to whether to protect or accommodate sea level rise, and the trade-offs between the options presented in this report in terms of costs, function, and aesthetics.

5.5.2 Geotechnical Assessment

A geotechnical assessment is generally recommended for any options that require foundations. However, it is not anticipated that a geotechnical assessment would be required for any options described within this study, given the existing conditions observed on-site and the depths of the placements of rock materials.

5.5.3 'Soft' Shoreline Solutions

'Soft' shoreline techniques can have significant benefits to a project in terms of aesthetics, environmental effect, and ease of permitting; however, they may also require additional maintenance if a winter storm season is stronger than expected or if longshore sediment transport potential has been underestimated during design. As with any shoreline project, it is recommended that a budget allowance be set aside to conduct inspections and maintenance over the life of the project.

5.5.4 Timing of Work

Work in or near water (below the highwater line) should respect the timing windows set by Fisheries and Oceans Canada (DFO) to avoid harm to fish species. According to the DFO website, work in the foreshore at the project sites (Area 13 – Campbell River / Sayward) should generally only occur between July 1st – September 1st, and November 1st – February 15th. Any work above the highwater line is not limited to these windows.

In addition, proposed work should generally coincide with the tidal work windows so that no work is completed in-water. To utilize the winter fisheries window, this may require working during the night if the winter window is utilized to avoid construction during the summer season.

5.5.5 Fisheries and Oceans Canada (DFO) Project Review

Shoreline stabilization work such as rock protections, planting and bioengineering that increase the existing footprint below the high water mark will require a Qualified Environmental Professional (such as an R.P.Bio) to complete an assessment of the project and prepare a project review request. Under the new Fisheries Act (2019) there is no longer an option for self assessment of projects. DFO will determine if the project will result in a HADD (harmful alteration, disruption, and destruction) of fish habitat under Section 35.

5.5.6 Navigation Protection Act

The Navigation Protection Program (NPP) administers the Navigation Protection Act through the review and authorization of works in navigable waters. Works meeting the assessment criteria of the Minor Works Order are classified as "designated works" under the NPA and may proceed without a Notice to the Ministry as long as they comply with the legal requirements. These potential works include erosion-protection works, docks/boathouses, and boat ramps/slipways/launch ramps that encompass the repairs to the wooden pile crib structure, and reinforcement of the beach with coarse gravel. It is not expected that any of the outlined shoreline protection options would require Notice to the Ministry.

5.5.7 Municipal Approval

For most projects the land owner generally also needs to provide details (habitat report, design basis, specifications, etc.) of the project to municipal staff. Part of the municipal process will involve referrals to any pertinent committees (including Islands Trust), which may result in a staff report to Council, for Council approval. However, because this project is within the jurisdiction of BC Parks, it is not clear if this is required. It is recommended that the Chief Administrative Officer at the municipality be contacted to clarify the process.

6 NHC RECOMMENDATIONS

NHC recommends the following actions:

1. It is important to recognize that shoreline erosion is a natural process, and that changes over time to coastal spits are expected as these coastal features respond to physical processes and available sediment supplies. For this reason, we recommend a comprehensive review of the upland value of archaeological sites and habitat areas within the park, and meaningful discussions with stakeholders (local residents, recreational boaters, BC Parks staff) and engagement with local First Nations with respect to tolerance for erosion within the park.

2. Development of management practices for the park that restricts vehicle and pedestrian traffic from sensitive and eroding areas.

3. Development of management practices to encourage establishment and growth of native vegetation in areas of erosion.

4. Implement a multi-year survey monitoring program to track changes to the shallow sub-tidal zone, inter-tidal beaches, and backshore areas. There is very limited data available at this time from which to infer rates of sediment transport and erosion, and the survey program would provide solid data upon which to make planning decisions. This data would also serve as the baseline from which to evaluate the performance of any mitigation options implemented in the future.

   Ideally the survey program would incorporate both drone surveys and nearshore bathymetric surveys. However, if budgets do not allow for both, then drone surveys of the inter-tidal beaches and backshore areas at low tide should be given priority.

5. Develop a funding plan for the removal of the recreational vessel floats in a 1 to 4 year time-frame. There is strong evidence that the long-shore transport of sediments to the spit is being disrupted by the presence of the floats and the vessels that use the facility. Removal of the floats would act to help restore the natural shoreline processes, and is recommended as the first mitigation action to consider.

7 CLOSURE

Manson's Landing is a beautiful marine park that is popular with recreational boaters and residents and visitors of Cortes Island. This report presents a summary of available information on the site conditions, and presents recommendations for further action to fill data gaps and to begin mitigations of shoreline erosion. Our immediate recommendations include steps to reduce visitor impacts on sensitive areas and to begin a survey program to develop baseline information on the rates of shoreline erosion and changes in the volumes of beach sediment within the park. This baseline data will better inform decision-making on capital expenditures for future mitigation actions.

Beyond the immediate scope of this project, NHC recommends that BC Parks begin the work of developing and adopting long-term strategies for dealing with sea level rise (SLR). Present science suggests that 0.5 to 1.0 m of SLR is likely to occur between now and year 2100, but also that it is possible that higher levels of SLR could occur depending upon future actions (or inaction) of humans and natural positive feedback loops. Potential SLR levels of between 1.4 m and 1.6 m have been suggested for the BC coast by year 2100 under enhanced scenarios. We note this to put into context that half a metre of SLR can be accommodated, but that two metres of SLR will radically alter Manson's Landing. The existing spit will transform into an intertidal sand-bar with two metres of SLR, with the loss of the existing upland vegetation on the spit. Given this, a long-term plan for the park may involve retreat of human structures (docks, roads) and creating space for a natural response of the park to rising sea levels. Other long-term plans could involve more aggressive protection of park infrastructure, but interventions (and costs) would need to increase in time based upon expected increases in the annual rates of SLR.

It is expected that there will need to be consultations with stakeholders and engagement with First Nations regarding protection of archaeological sites and habitat areas under threat of SLR. Regardless, having a long-term plan for marine parks and SLR would give a framework within which to make short-term policy decisions regarding site improvements and allocation of funding that would benefit the overall decision making process.

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