SAVARY ISLAND DUNE AND SHORELINE STUDY

Report

To

The Powell River Regional District

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SUMMARY

Thurber Engineering Ltd. (TEL) and Strix Environmental Consulting have conducted a geotechnical and environmental assessment of Savary Island, BC. The study was carried out for the Powell River Regional District with the following objectives:

- To establish hazard setback lines for the entire perimeter of the Island to ensure building locations are safe from erosion hazards for 50 and 200 year horizons.
- To confirm the location, extent and sensitivity of the dune area on the Island.
- To refine draft development guidelines for a Savary Island Official Community Plan.

We anticipate that this report will be used by Savary Island property owners and Regional District officials to guide development that limits exposure to geological hazards and risks and which promotes environmental stewardship.

Savary Island is influenced by erosive storm waves driven by prevailing southeasterly winds. The winds have formed now relict longitudinal sand dunes on the central Island. Storm wave attack over the past 11,000 years since deglaciation has reduced the Island from its former extent as far southeast as Mystery Reef. Storm waves and other natural processes continue to reduce the Island's south shore.

Shoreline and bluff erosion rates have been estimated in previous studies by TEL and others and it is evident that, in general, the south shore erodes at a significantly higher rate than the north shore. A more definitive study of bluff crest retreat was made for this study using superimposition and comparison of ground detail from geometrically rectified 1967 and 1999 aerial photos of the Island. Within an accuracy of plus or minus 1 m, measurements at 51 locations around the shoreline indicated a maximum erosion of 13 m along the south shore and 8 m along the north shore over the 32 year period between airphotos. These values correspond to average rates of erosion of 0.41 m/year and 0.25 m/year

on the south and north shores, respectively. These values are similar to those that have been revealed by the previous studies.

Primarily based on the erosion rates obtained from the airphoto study, projected for 50 and 200 years, building setbacks from the current bluff crest have been established from geotechnical considerations of a safe long-term slope. Recommendations for building setbacks from the current natural boundary in shoreline areas where no bluffs exist or the shoreline is bedrock are also provided. These setbacks will guide residential development around the Island shoreline.

Supplemental geotechnical advice to land owners is also provided in the report together with recommended guidelines for professional reporting in hazard and risk assessment work.

Our review of existing draft development guidelines suggests that their non-regulatory nature will not adequately protect public health and safety along high bluff areas or provide assurance over the quality and quantity of shallow aquifers utilized for domestic water supplies.

The Island's relict and active sand dunes provide unique ecological habitats which are described with special reference to plant species and plant communities. Some modifications of existing, environmentally defined, Development Guideline areas are recommended, as are several new ones.

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1. INTRODUCTION

This report is an assessment of bluff erosion rates and limits and related geotechnical development issues on Savary Island. The location and environmental sensitivity of Island sand dune areas are also evaluated. This report provides recommendations based, in part, on our professional mandate under Bylaw 14(a)(1) of the Engineers and Geoscientists Act of BC[1].

The study has been carried out in accordance with the Request for Proposal (RFP) issued by the Powell River Regional District (the Regional District) on February 21, 2002. Geotechnical elements of this study were evaluated by Thurber Engineering Ltd. (TEL). Environmental issues were evaluated by Strix Environmental Consulting (Strix). Strix's report is included in Appendix A in its entirety. Highlights are presented in Section 8.

Our work involved office studies of aerial photos, maps and reports provided by the Regional District and information contained in the TEL library. Background reports, maps and aerial photos used in the study are listed in *References*. Previous reports by Tupper (1996) and Bornhold et al (1996) were especially useful for the geotechnical assessment. We do not include all the factual or interpretive information contained in these reports, nor do we refer to their many original sources of information. TEL and Strix conducted field work in early May and mid-June 2002.

McElhanney Consulting Services Ltd. completed an analysis of 1967 and 1999 airphotos to establish bluff crest retreat over the 32 year period between the airphotos.

[1] "Professional Engineers and Geoscientists shall hold paramount the safety, health and welfare of the public, the protection of the environment, and promote health and safety in the workplace."

We understand this report will be used by Regional District staff and Savary Island landowners for guidance in planning and permitting for safe and environmentally appropriate residential development.

Use of this report is subject to the enclosed Statement of General Conditions.

2. GEOLOGY AND GEOLOGIC PROCESSES

2.1 Climate and Weather

Savary Island is surrounded by the Strait of Georgia and is located in a distinctly dry and mild, rain-shadow climate zone identified as the Coast Douglas-Fir Biogeoclimatic Zone by the BC Ministry of Forests (1988). The Island receives between 950 and 1,300 mm of precipitation a year (Tupper, 1996). The comparatively dry climate and prevalent, often well-drained but erodible soils on the Island condition its distinctive ecologic settings and surface processes such as wind erosion and deposition. Prevailing storm waves, driven by southeast winds, have important erosion and sediment transport effects along the Island's south shore.

2.2 Geology

2.2.1 Bedrock

The only known bedrock on Savary Island is granitic rock around Mace Point at the east end of the Island, as shown on Dwg. 14-197-0-1. The bedrock resists ocean wave erosion.

2.2.2 Pleistocene-Age Deposits

Most of the Island is formed by a Pleistocene (Ice Age) deposit known as Quadra Sand (Clague, 1977). It is a thick sequence of nearly horizontal layered, fine to coarse sand with lesser clay, silt and gravel. This material was deposited by meltwater streams in front of glaciers which advanced southward through the Strait of Georgia over 20,000 years ago. The sandy deposits were eventually overridden by advancing ice which deposited cobble and boulder-rich glacial till and other glacial sediments (collectively identified as 'drift') on top of the Quadra Sand (Photo 1).

The Quadra Sand contains discontinuous beds of silt and clay. Some sand units have a significant silt content. Groundwater breaks out in springs and seeps along these relatively impermeable beds on the Island's steep bluffs. Buried, relatively impermeable silt and clay rich beds also control several island aquifers which are tapped for domestic water supplies (Tupper, 1996).

2.2.3 Holocene-Age Deposits

The period since the great deglaciation about 11,000 years ago is known as the Holocene (Recent) Period. Holocene deposits and features include sand dunes, active along the ocean shore and comparatively inactive across the central Island, beaches (including forested beach deposits at Indian Point) and the extensive sandy shoals that surround the Island.

Much of the Island's surface materials (including variably thick sheets of wind-blown sand) are relatively permeable and there are no identifiable creek systems. Groundwater discharges on bluffs, coupled with ocean wave erosion, promote a variety of slope activities including gullying and landslides.

The Island has been considerably affected over the Holocene Period by southeast storm winds which reduced the Quadra Sand and its drift cover to boulder-mantled sand shoals which extend southeastward to Mystery Reef and southward to Stradiotti Reef (Bornhold et al, 1996). Relict, longitudinal sand dune orientations on the central Island reflect a long history of prevailing southeast winds.

2.3 Shoreline Erosion

All of the Island is surrounded by Holocene sand beaches. Accreted (i.e. built-up) beach deposits attain considerable width at Indian Point. In our judgment, the 200 to 300 m wide tract of low ground between Mace Point and the government wharf and the shoreline beneath bluffs as far west as First Point are Holocene beach deposits.

Beach sand may continue to accrete in these and other Island areas but deposition is punctuated by episodic, localized and sometimes intense erosion.

2.4 Bluff Erosion

Much of the Island is ringed by 20 to 50 m high, steep shoreline bluffs. The highest bluffs are located along the south shore where the slope is exposed to storm wave attack. Wave erosion at the base of slopes triggers slumps and slides up higher (Photo 2). Groundwater discharges also promote slide activity (Photos 3 and 4). Sandy debris from the slopes and wind-blown sand from offshore accumulate at the foot of the south bluffs. The accumulated material may temporarily protect the bluffs from wave erosion but eventually it is mobilized by storm wave attack and is cycled into an offshore sediment drift system which moves from east to west along the south shore.

Bluff erosion on the south shore is relatively high compared to that on the largely forested north bluffs. Further discussion of bluff erosion is presented in Section 4.

2.5 Offshore Sediment Transport

Sediment in the Island's offshore transport system originates in the south shore beaches, bluffs and shoals. It is transported westward by storm waves and tidal currents. Bornhold et al (1996) state:

> *"Net sediment transport on the south side of Savary Island is east to west in winter, with an estimated total possible sediment*

transport of 330,000 cubic metres per year. From observations made during field work and from prevailing summer wind directions, west to east longshore sediment transport at a much reduced rate is predicted through the summer months. Sediment sinks in the local sediment transport system are the deep area northwest of Indian Point and the broad sand shoal in Manson Passage".

"Sediment from the south shore of Savary Island is driven westward into Manson Passage . Some ...is accreted to Indian Point. The spit at Indian Point appears to grow episodically; i.e. it extends offshore for several years and catastrophically disappears during violent storms, into the deep basin to the north of Savary Island. Sidescan sonar and high-resolution seismic reflection surveys revealed the presence of numerous prominent downslope-oriented channels along the north coast of the island. These are conduits through which sediment, originally moved by longshore drift along the south coast, is periodically carried into the deep basin north of the island. This process of slow growth and rapid erosion at Indian Point is anticipated to continue for a very long time without any net overall accretion in the area except perhaps at the west side of the point in the very shallow Manson Passage."

2.6 Wind-Blown Deposits

Sand dunes on the Island are unique physical features which host ecologically significant plant communities. Much sand has accumulated in dunes in various states of activity. Strix (Appendix A) describes dune formation processes. Tupper (1996, Map 1b) maps active dune areas along the Island shores.

The prominent longitudinal dunes on the central Island appear to be relatively inactive (relict) features. They must have been formed by prevailing southeast winds. We suspect they formed when the island extended southeastward to Mystery Reef. The sand probably originated from west-facing beaches that are now eroded away. Tupper (1996) notes that the relict dunes are likely to have formed during periods of wildfire.

The RFP for the study requires the relict dunes to be mapped, with particular reference to their western extent. The extent of the dunes is shown on the Appendix 1 map of the Strix report (Appendix A).

We have observed remarkable amounts of sand entrained by strong southeast wind at the crest of a 50 m high bluff above South Beach. Prominent, forested, transverse dunes are situated along the bluff rim. In some locations, sand is well exposed in excavations made to improve ocean views from the bluff crest.

Sand sheets extend north of the bluffs beneath forest soil. Wind blown sand is loose and highly erodible. We observed what appear to be naturally eroded holes and tunnels (soil pipes and caves) in dune sand along the South Beach bluff crest.

2.7 Groundwater Systems

The Island's groundwater systems are evaluated by Tupper (1996). His work uses available data to assess the availability of groundwater for domestic supplies, rates of groundwater consumption and the quality of selected well and spring water samples. Although Tupper's work is preliminary, it is systematic and valuable.

The Island's hydrogeology is complex and not yet fully understood. Groundwater systems on the Island are a valuable and locally vulnerable resource. Some are geotechnically significant (e.g., Indian Spring). Evidence of current development activity on the Island indicates that the number of wells counted by Tupper in 1996 (and cited by us below) must have increased.

Tupper identifies a single Main Aquifer on the Island. It appears to comprise the lower portion of the Quadra Sand and it extends beneath the entire island. He subdivides it into 6 groundwater domains as shown on his Map 1b. The domains are further subdivided along the Island's topographic divide that trends east to west. This aquifer provides excellent well capacities with theoretical values of greater than the 7.6 and 9.5 l cited by Tupper (p.20). The latter value is estimated from a well drilled to below sea level; perhaps below the Main Aquifer.

Tupper also identifies, on his Map 1b, 3 perched or shallow aquifers, including the Keefer Bay Aquifer, the 3-component West Aquifers and the Indian Point Aquifer. Tupper's mapping of the shallow aquifers is reproduced on Dwg. 14-197-0-1. These aquifers feed 4 springs: Indian Spring, Neilsen Spring, Julian Road South Spring and Sutherland Road North Spring. All but the Sutherland Road North Spring are used for domestic water. The Julian Road and Neilsen Springs have very low flows (Tupper, 1996, p. 18) and Indian Spring is the only public and reliable source of drinking water.

The Keefer Bay aquifer is defined by a cluster of shallow wells and well points. It occurs at a depth of 3 to 4.5 m below ground. Rates of consumption suggest it has a relatively high yield.

The West Perched Aquifers are based on the Island's relatively impermeable drift. Tupper estimates the extent of its 3 separate portions from the distribution of shallow dug wells and area springs. The east portion is related to Indian Springs but there are only 2 shallow wells in its 9 ha area. Groundwater clearly flows north from this area to Indian Springs (Tupper, 1996, p. 21). The central portion of the West Perched Aquifer has an area of about 30 ha and is located on the highest part of the Island. Its average depth is only 1.5 m and its waters rise to the ground surface after periods of rain. This portion of the aquifer supplies about 15 known shallow wells, some of which dry up seasonally.

The west portion of the system occupies about 36 ha in a broad, flat bowl that slopes southward to the sea. It supplies 12 wells from an average depth of 4.3 m. This portion has been affected by area development and it appears that it is recharged by surface water flows (Tupper, 1996, p. 21-22).

The Indian Point shallow aquifer is about 20 ha in extent and has at least 72 wells, almost all of which are shallow, extending to depths of 2 to 4.6 m (Tupper, 1996, p. 22). In spite of high demand, the wells have sustained yields. Tupper suggests there is considerable groundwater flow from the uplands to the east which supports his contention that the Main Aquifer is under hydrostatic pressure from the Burnett Road area westward.

In our judgment, hydrogeological investigations, including pre-development water level monitoring and water quality testing, are warranted if increased development is anticipated in shallow aquifer areas.

3. EROSION PROCESSES

Shoreline and bluff erosion is a widely recognized geological hazard. The BC Ministry of Environment and Parks (1987) presented a discussion paper on coastal environment construction. A paper on erosion at Indian Point on Savary Island was published by the BC Ministry of Environment, Lands and Parks (1993). Most shoreline erosion literature indicates that a building setback from eroding bluffs is the only cost-effective means of limiting risk to residential buildings.

Shoreline erosion, as defined by storm wave removal of sand, occurs at several locations on Savary Island. These include accreted beaches near Indian Point and the north side of Malaspina Promenade, just west of Mace Point, dune sand along South Beach and debris below steep bluff faces along the south shore.

From a development perspective, shoreline accretion or long term balance between erosion and accretion is ideal. Unfortunately, as pointed out by Bornhold et al (1996) for Indian Point, long periods of shoreline accretion and equilibrium are punctuated by significant erosion events.

Bluff erosion is a continuous, but episodic activity which involves regression of the bluff crest resulting from shoreline erosion at the toe or landslide activity, uncontrolled surface drainage, seepage erosion, falling trees and incautious human activity on the slope. Larger areas of bluff erosion are shown on Dwg. 14-197-0-1.

The rate of bluff erosion is reduced by established brush and tree cover on the slope and accumulations of gully and landslide debris and stranded logs and till-derived boulders which protect the steep slopes from direct storm wave attack. A heavy cover of broom was planted in 1912-1914 to limit erosion on the high bluff above South Beach (Strix, Section 2.2.1). Wildfires on the bluffs are likely to increase the rate of slope erosion.

4. BLUFF EROSION RATES

4.1 Sources of Information

In this Section, we present all of the data concerning the rate of erosion of the bluffs that has been collected by various investigations to allow the hazard limits discussed in Section 5 to be established. The sources of data are described below.

Previous estimates of bluff crest retreat were made by Klohn-Crippen Consultants Ltd. (Klohn-Crippen) in 1993 for a landowner, Bornhold et al (1996) and Golder Associates Ltd. (GAL) in 1999. GAL's report was provided for our information by the Regional District. We evaluated bluff erosion for a site at the east end of Malaspina Promenade and the same site as Klohn-Crippen (1993) on the south shore, about 1 km from Mace Point, for the landowner in 2001.

To provide further data regarding bluff erosion for this study, McElhanney Consulting Services Ltd. (McElhanney) was retained to evaluate bluff retreat using airphotos of the Island taken in 1967 and 1999.

4.2 Analysis Procedures

To establish a long term bluff erosion rate, Klohn-Crippen (1993) inferred that the existence of shallow water which extends for about 1.5 km offshore of the current shoreline at the study site (on the south shore about 1 km west of Mace Point) marks the position of an ancient sea cliff which has been subject to wave attack and erosion over the last 8000 years.

Information in Bornhold et al (1996) concerning bluff erosion rates is based on a comparative study of 1965 and 1982 aerial photos. They note (p. 7):

> "*the lack of reliably recognized datums over much of the island meant that the measurements, in general, had to be made on the total width from the north coast to the south coast along transects approximately normal to the axis of the island.*"

In effect, Bornholm et al measured the rate of narrowing of the Island by erosion or widening by accretion. Two of the authors, Drs. Bornhold and Conway, confirmed (*pers. com.*, August 2002) that numbers shown in the Geological Survey of Canada report are estimates of Island narrowing based on aerial photo measurements between north and south high tide lines, not bluff crests.

GAL (1999) estimated the rate of bluff erosion in the Second Point and Beacon Point areas using aerial photo interpretation. They reference the estimated rates of erosion to the natural boundary and survey cross sections.

TEL's evaluation of bluff erosion for sites along Malaspina Promenade and southwest of Mace Point utilized legal survey plans from 1910 and recent survey by the landowner.

McElhanney's work involved superimposition and comparison of ground detail from the 2 series of airphotos using photogrammetric techniques. The comparisons required the aerial photo images to be geometrically rectified using existing map control data. Measurements were made or attempted at 51 locations selected by TEL. No measurements were possible in areas obscured by trees, particularly along the north coast. Furthermore, McElhanney judges the distance measurements to be accurate to plus or minus 1 m.

4.3 Analysis Results

The bluff erosion rates (defined by the average over the period of record) obtained from the various studies described in Section 4.1 are presented on Dwg. 14-197-0-2 for each location studied. Except for Klohn-Crippen (1993), all of the studies reported herein consider a period of record of, at most, the last 90 years. In contrast, Klohn-Crippen's calculated rate of erosion is based on an 8000 year period. Considering the episodic nature of bluff retreat, Klohn-Crippen's rate, if based on a correct assumption, provides the most reliable estimation of all reported values. Additional comments relevant to each analysis are presented below.

Estimated rates of erosion estimated by Bornhold et al (1996) have an uncertain error. Except for bluff crest retreat measured at 3 locations over about 1 year, the numbers are estimates of total erosion (or accretion) between the north and south shores over 17 years. The authors do not differentiate rates of erosion on the north and south coasts and note:

> "*It can be assumed that, in general, erosion is considerably greater along the south coast than along the north whereas accretion can occur on either.*"

Bornhold et al (1996) show shoreline erosion rates are especially high on the west sides of Garnet, Whalebone and Beacon Points where refracting waves have strong effects.

At TEL's study area on Malaspina Promenade, the road right of way has been almost fully breached by waves developed by strong northwest winds and/or by refracted waves around Mace Point developed by southeast winds. Wave erosion may also be influenced by tidal effects.

The 1980 aerial photos show what appear to be waves billowing northwest from the narrow passage between Mace Point and Hurtado Point on Malaspina Peninsula.

4.4 Estimated Rates of Erosion Around Island

4.4.1 Mace Point to Garnet Point

This portion of the Island's shoreline is the most exposed to storm waves driven by prevailing southeasterly winds and it is reasonable to expect the rate of bluff crest retreat to be comparatively high. However, McElhanney's analysis of 7 locations along this section of shoreline indicates no apparent change in the bluff crest from 1967 to 1999. For a location about 1 km from Mace Point, shown on Dwg. 14-197-0-2, based on consideration of legal lot lines established during the 1910 subdivision in relation to the current top of bank, we concluded that the bluff crest retreated 12.5 m between 1910 and 2001 for an average erosion rate of 0.14 m/year. We consider our evaluation to be correct implying that the erosion took place between 1910 and 1967, confirming the episodic nature of bluff retreat around the Island's shoreline. In comparison, Klohn-Crippen (1993) estimated a long term erosion rate of 0.2 m/year.

4.4.2 Garnet Point to Whalebone Point

Bornhold et al (1996) measured a bluff crest erosion rate of 0.38 m/year on the west side of Garnet Point of over a 1year period in 1994-1995 ascribed to refracted wave effects. This very high rate of erosion is confirmed by McElhanney's estimated erosion rate of 0.34 m/year for the same location. However, McElhanney recorded no significant erosion over 32 years between the west side of Garnet Point and Whalebone Point.

4.4.3 Whalebone Point to Beacon Point

Between Whalebone Point and Beacon Point, McElhanney's analysis indicates no significant erosion. In comparison, Bornholm et al measured an erosion rate of 0.08 m/year on the west side of Whalebone Point and Golder (1999) estimated a rate of 0.07 m/year at 3 locations within 0.6 km of Beacon Point. It is evident that the erosion rate in this section of the shoreline is low.

4.4.4 Beacon Point to Indian Point

Around the west side of Beacon Point, there is some inconsistency in erosion rates determined by Bornholm et al, Golder and McElhanney. We tend to accept McElhanney's analysis which suggests the erosion rate is between 0.1 and 0.2 m/year within 0.5 km of Beacon Point.

Further west, for nearly 2 km, McElhanney indicates an erosion rate of between 0.13 and 0.40 m/year. This section of shoreline is the most extensive in exhibiting consistent and relatively high erosion rates.

Most of the remaining west facing shoreline up to Indian Point is shown by McElhanney to have negligible erosion, with the exception of the bay 0.5 km south of Indian Point where a 12 m bluff retreat was recorded, giving an average rate of 0.38 m/year.

4.4.5 North Shore

Of 18 locations studied by McElhanney along the north shore of the Island, only three showed measurable bluff retreat. The maximum retreat, equivalent to 0.25 m/year occurred on the east side of Second Point. These results are supported by Golder's 1999 analysis of the shoreline from 0.5 km west of Second Point to 0.3 km east of the Point.

At the east end of Malaspina Promenade, good agreement is shown between the average erosion rate of 0.19 m/year calculated by Thurber for the period 1910 to 1989 and the average rate of 0.14 m/year calculated by McElhanney for 32 years between 1967 and 1999.

5. PRELIMINARY BLUFF CREST HAZARD SETBACKS

5.1 Klohn-Crippen's Recommendations

Klohn-Crippen (1993) recommended that permanent buildings on the top of the bluff be set back 30 m behind the intersection of a line drawn at 35° from the toe of the slope with the ground on top of the bluff. The 30 m distance was based on a 200 year erosion allowance of 0.15 m/year, somewhat less than the long term 0.2 m/year calculated by geologic reasoning. At the location studied by Klohn-Crippen, the setback from the crest of the bluff determined in accordance with this criteria was about 40 m.

5.2 Golder Associates' Recommendations

Golder Associates (1999) made the following recommendations for building setbacks from the crest of the bluff in the west portion of DL1375 , east and west of Second Point on the north shore and Beacon Point on the South Shore for a 50 year horizon:

- From the natural boundary at the toe of the bluff extend a horizontal distance equal to the estimated erosion over the 50 year assessment period.

- Extend the line at 40° to intersect the ground surface at the top of the bluff.

- Add a horizontal setback of 10 m for slopes up to 20 m high and 15 m for slopes more than 20 m high.

5.3 BC Ministry of Water, Land and Air Protection (formerly Environment, Lands and Parks) Subdivision Requirements

The Ministry's August 3, 2000 memorandum concerning a proposed subdivision on Savary Island refers to the *Floodplain Development Control Program Procedure Manual* of the *Interim Coastal Procedures* published in November 1988. This Manual states that no building shall be closer than 15 m, to or less than 1.5 m above, the natural boundary along a coastal shoreline [2]. The setback from the natural boundary can be reduced to 7.5 m where the shoreline is bedrock. In bluff areas on the Island, the natural boundary will generally be defined by the high water mark along the toe of the bluff. The Manual further states that where the building site

[2] The BC Land Act (Section 1) defines the naturel boundary as "the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in respect to vegetation as well as in respect to the nature of the soil itself."

is at the top of a steep coastal bluff the subject to erosion, the setback, as measured from the toe of the bluff shall be a horizontal distance equal to 3 times the height of the bluff. This requirement is illustrated on Figure 1a. The Ministry's memorandum points out that this criterion makes no allowance for future erosion at the toe of the bluff caused by wave action. The memorandum concluded that the Manual's requirements were not sufficiently conservative and recommended that the building setback line should be based on revised criteria similar to those recommended by Golder Associates (1999), except for an increased assessment period of 100 years for the bluff erosion allowance. These criteria are illustrated on Figure 1b and defined as follows:

- From the natural boundary at the toe of the bluff, extend a horizontal distance equal to the estimated erosion over 100 years, subject to a minimum allowance of 15 m (equivalent to an erosion rate of 0.15 m/year).

- Extend the line by the typical natural slope angle (40°) to intersect the ground surface at the top of the bluff.

- Add a further horizontal setback of 10 m for slopes up to 20 m high and 15 m for slopes more than 20 m high to define the geotechnical hazard setback.

- Check that the total horizontal setback is more than 50 m from the natural boundary.

As indicated in the Ministry's memorandum, application of these guidelines results in a 100 year building setback varying from about 50 m to about 120 m from the bluff crest for the site studied by Golder Associates

5.4 Recommended Setback Criteria

We recommend that bluff crest setback be determined in accordance with the revised criteria provided by the MWLAP and presented in Section 5.3, except that, in accordance with the terms of reference established by the Regional District, the erosion period is to be 50 years and 200 years and a 40° line should be used to define the stable slope angle. However, we consider that the Ministry's 15 m minimum erosion allowance for a 100 year period for shoreline areas where the observed rate is low or zero, but could increase over the long term, should also apply to the 200 year period. This is equivalent to an average erosion rate of 0.075 m/year, similar to the minimum rate reported by Golder Associates (1999) but conservative in comparison to the zero rate reported by McElhanney (2002) for many locations around the Island's shoreline for the 32 year period. For the 50 year horizon, we recommend a minimum erosion allowance of 5 m, equivalent to an average erosion rate of 0.1 m/year. These criteria are illustrated on Figure 2. Setbacks determined in accordance with these criteria, subject to a minimum horizontal setback of 50 m from the natural boundary, are shown on Dwg. 14-197-0-3 and discussed in Section 5.5. A minimum setback of 7.5 m should apply where the natural boundary is formed by bedrock bluffs for 50 and 200 year horizons.

It should be recognized that the setbacks recommended herein are for guidance only and can be revised, more likely reduced than increased, by a site specific geotechnical study carried out by a suitably experienced geotechnical engineer. It should also be recognized that this study and its recommendations make no allowance for the rise in sea level which is projected to occur due to global warming. One estimate, by the US Environmental Protection Agency, is that the most likely rise in sea level is 0.15 m by year 2050 and 0.34 m by year 2100. Such an increase in sea level may cause the rate of bluff crest regression to increase significantly from the rates identified to date. Shoreline erosion will also increase.

Building setbacks elsewhere on the Island where no bluff exists, such as Indian Point, require a setback of not less than 15 m from the natural boundary in accordance with MWLAP's guidelines. However, even though we are not aware of any instances of building damage due to proximity to the natural boundary along the shoreline to account for the episodic, localized and sometimes intense erosion referred to in Section 3, we recommend a minimum setback of 20 m from the current natural boundary for 50 and 200 year horizons.

5.5 Bluff Setbacks

Building setbacks from the current bluff crest for 50 and 200 year horizons determined by application of the recommendations in Section 5.4 are shown on Dwg. 14-197-0-3. It should be recognized that the setbacks are preliminary and for guidance only. They assume that the current slope angle of the bluff is 40° and that the contours on the base plan accurately represent the bluff height. They should be defined in the field by survey of the bluff height and crest and consideration of the erosion which might have taken place since this report was prepared.

Additional comments are presented below.

- Setbacks established in the Golder Associates (1999) study of DL1375 on the north and south shorelines for the 50 year horizon have not been changed in these locations. The 200 year setback allows for 150 years of additional erosion.

- A 7.5 m setback from the natural boundary is shown for the bedrock-controlled shoreline around Mace Point. This will protect buildings from flooding due to wave run-up.

6. SUPPLEMENTARY GEOTECHNICAL RECOMMENDATIONS

6.1 Introduction

Although our report focuses on geotechnical hazard issues related to bluff erosion on the Island, we consider that other geotechnical issues require discussion. These issues include general advice to landowners to limit the need for geotechnical services and adversities which may arise if the concepts cannot be implemented.

6.2 Least Costly Hazard and Risk Prevention Concepts

The following hazard and risk prevention concepts are the easiest and least costly to apply by landowners who plan development activity:

- Do not locate residential buildings on or near the crest or base of steep slopes.

- Do not direct surface water or a significant quantity of groundwater onto any portion of a steep slope.

- Do not dump fill (including soil, rock, lawn clippings, brush cuttings or trash) on or below the crest of a steep slope.

- Do not excavate soil on any portion of a steep slope.

6.3 Septic Fields

In general, almost any septic system will pollute groundwater directly beneath it but as effluent travels through soil, purification takes place and effluent may be rapidly returned to drinking water quality. If aerobic conditions are maintained in well drained soils, harmful bacteria and viruses can be absorbed over remarkably short flow distances above the groundwater level.

The density of septic fields and their relationship to shallow aquifers present significant potential problems on Savary Island. Notably, the residential lot densities shown on the two Garden and Taylor Survey Maps of 1910 are impossible to achieve given modern septic field siting standards. If septic field densities are to increase in shallow aquifer areas, hydrogeological investigations are warranted. Tupper's 1996 findings and his delineation of aquifer areas are critically important in considering septic field design and placement. The BC Health Officer in Powell River provides guidelines and instructions for septic field design including their proximity to steep slopes.

6.4 Road Ditch and Culvert Systems

The Island's ditch and culvert systems allow passage of storm water but, to the best of our knowledge, all most such facilities allow excess water to infiltrate into the ground. Tupper (1996, p. 21-22) describes a situation in which newly constructed road ditches appear to have diverted surface water which supplied a shallow well in the west portion of the West Perched Aquifer.

Hydrogeological investigations may be warranted if ditch and culvert systems are planned in other shallow aquifer areas. We recommend that storm water directed to bluffs or other steep slopes should be conveyed downslope in well secured and periodically inspected pipe systems. Outlets for such systems at the base of steep slopes or along shoreline slopes are likely to require considerable erosion protection.

The outer edge of the road directly above Indian Spring is being eroded by surface runoff that originates on Vancouver Boulevard and Cunningham Road. Road repair will require interception and redirection of road drainage.

6.5 Roof and Footing Drain Systems

Roof and footing drain outlets or other concentrated water flows should not be directed to bluff slopes or crests. We do not recommend that such drainage be conveyed downslope in pipes because individual homeowners cannot take responsibility for periodic inspection and repair of pipe systems.

If residential buildings are located well away from bluff crests and if roof water is not collected for gardening or other needs, we recommend that roof and footing drains be directed to surface outlets with appropriate erosion protection or into engineer-designed rock pits.

6.6 Uncontrolled Soil Excavation and Fill Placement

Incautious soil excavation on or at the foot of steep slopes and uncontrolled fill dumping on or below slope crests may each generate significant over-steepening effects. Some steep slope excavation and filling can proceed with geotechnical design and supervision.

6.7 Bluff Tree and Brush Clearing

Trees may be cleared from a development site for many reasons. Geotechnical specialists are often asked to comment on hazard consequences after trees are removed from steep slopes or slope crests. Tree roots draw water from the soil and also tend to anchor soil masses on or near steep slopes. On the other hand, large trees add considerable mass to potentially unstable ground. Wind may generate adverse dynamic effects in large trees on unstable ground. Trees will not remove excess volumes of water; rates of soil water removal decline during dormant periods. Tree removal on steep slopes may cause considerable ground disturbance.

Ecological issues are pertinent to considerations of tree removal, as discussed by Strix. Geotechnical issues defy ready analyses and professional judgment must prevail. We recommend that no large trees be removed from the bluffs or bluff crests. Heavy brush should be promoted and maintained for the same reason. Danger trees require advice from a professional arborist.

6.8 Guidelines for Professional Reporting

Our experience in geotechnical hazard and risk assessment work indicates that Regional Districts and municipalities are best served by BC geotechnical professionals (including professional engineers and geoscientists) if guidelines for professional reporting are made available to permit applicants.

Guidelines should differentiate professionally recognized roles for engineers and geoscientists. Hazard and risk assessment investigations should only be conducted by professionals with required training or experience. Designated or nominated professionals should confirm that they have requisite credentials.

Reports should be supported with factual data (including exploratory test pits or drill holes as necessary), slope monitoring results, engineering analyses, professional judgments, determination of hazard and risk, technical recommendations and certification required by the BC Local Government Act. All such reports must be signed and sealed in accordance with requirements of the Engineers and Geoscientists Act of BC. Sketch maps and diagrams, if not survey maps, are almost always required. In general, we recommend that reports should be substantive enough to be constructively reviewed (if requested by the Regional District) by an independent professional without a requirement to engage in fieldwork.

7. PROPOSED REVISIONS TO HAZARD LAND DEVELOPMENT GUIDELINES

7.1 General

The current Savary Island OCP is a draft document. It defines 5 development guideline (DG) areas. The guidelines are non regulatory and are intended to protect the Island's natural environment and residential development from hazardous conditions such as bluff erosion activity. These guidelines are included in Appendix A. There is no provision for issuance or refusal of building permits by the Regional District. Septic field approvals are regulated by the BC Health Act and shoreline development is regulated by the BC Land Act.

Presumably, Island landowners are expected to voluntarily follow the guidelines. However, unenforceable geotechnical recommendations involving consideration of hazard and risk provide no assurance over public health and safety.

7.2 DG-1 Shoreline Areas

DG-1 areas form an almost continuous band along and above the Island shoreline. Mapped DG-1 areas include accreted beach areas (i.e. the margins of Indian Point and the south shore of Keefer Bay) and almost all Island bluffs and zones along bluff crests.

For geotechnical clarification, we suggest that DG-1 areas be revised to only include low-relief shorelines where residential development is subject to minimum setback requirements from the natural boundary. We suggest a new classification (DG-1B) for bluff slopes and along bluff crests where our recommended slope hazard limits apply. The following discussion assumes that DG-1 areas only include portions of subdivided land along Indian Point and the south shore of Keefer Bay between Mace Point and Phyllis Road near First Point.

Item a

As we observe in Footnote 6 and considering Provincial guidelines for 200 year flood proofing and 475 year landslide occurrence with 10% probability, 50 years is a short period of time to consider building vulnerability to erosion hazards. The point may be moot because the minimum building setback is defined by the BC Land Act. Geotechnical specialists may recommend greater but not lesser setbacks.

Item d

This item suggests limiting garden watering and other surface water discharges within 30 m of the top of the shoreline, presumably meaning the natural boundary. We have no objection to the general intent of this item but, given probable rates of soil evapotranspiration, the permeable nature of accreted beach deposits and the presence of shallow aquifers beneath Indian Point and south Keefer Bay, garden watering is highly unlikely to generate significant or observable shoreline erosion effects.

Item h

This item seeks to avoid shoreline erosion by limiting foot access to public trails. This is a worthy goal, but potential erosion effects in low-relief beach front areas may best be limited by construction of removable or permanent wooden walkways.

Item i

This notes that works to protect against natural shoreline erosion shoreline are not recommended. Somewhat inconsistently, it then notes that such works should not alter or disturb shoreline habitat. We agree that *ad hoc* or piecemeal shoreline protection measures may do more harm than good. However, BC Ministry of Water Land and Air Protection approval officials must approve or reject such measures.

As best we can tell, beach groins built between Garnet and Whalebone Points may have some positive effect in retaining beech sand. The groins and a cover of broom may help to limit erosion along the adjacent bluffs (Dwg. 14-197-0-1). We do not detect adverse shoreline changes to the west, the direction in which offshore sediment migrates. We suggest that professionally designed shoreline protection measures warrant consideration on Malaspina Promenade near Mace Point.

7.3 DG-1B Bluff Residential Areas

We recommend that a new designation (DG-1B) be established to include bluff slopes and the recommended 15 to 30 m to 40 m preliminary bluff hazard limits presented in Section 5. The following discussion conforms to the items given in the current DG-1 guidelines. The discussion applies to all subdivided land along the Island's north and south bluffs except areas where previous, more detailed geotechnical evaluations have defined building setbacks (see Section 5.4).

Item a

As we observe in Footnote 6 and considering Provincial guidelines for 200 year flood proofing and 475 year landslide occurrence, 50 years is a short period of time to consider the eventuality of erosion hazards. However, Island land owners and their elected representatives may choose a 50 year or longer period. In our judgment, recommended preliminary bluff hazard limits be can be interpreted to approximate erosion limits some 200 years hence.

Item d

This item suggests limiting garden watering and other surface water discharges within 30 m of the bluff crests. In our judgment it is prudent not to place a garden within 15 m or so of a bluff crest but with this advice, limited hose watering or sprinkling is unlikely to have significant or observable bluff erosion effects. We suggest that below-ground irrigations systems be equipped with shut off valves that will be triggered by sudden losses in system pressure. In our judgment, Section 6.5 recommendations for roof and footing drains are most important in bluff crest areas.

Item e

This item is intended to preserve vegetation to preserve habitat and prevent erosion. In our judgment, a recommended 5 m wide leave strip from the top of bluff slope is too narrow. Instead, the leave strip should be defined by the possible presence of a transverse sand dune as along the crest above south beach. In some places this dune is very wide and it is covered with trees and brush. We recommend that because of geotechnical concerns over soil erosion and slope instability, no vegetation should be removed from any flank or crest of a transverse dune along a bluff crest. This means that no transverse dune should be excavated away to build a home or improve an ocean view. (Also see Section 6.6).

Item h

This item suggests seeks to avoid bluff erosion by limiting foot access to public trails. Potential erosion effects in on steep bluff slopes may best be limited by construction of removable or permanent wooden walkways in selected locations.

Item i

This item is intended to prevent slope protection measures from causing environmental or property damage. The narrow width of most bluff crest lots means slope repairs on individual lots will rarely avoid affecting adjacent land. Furthermore, major slope repairs on individual residential lots are unlikely to be practicable or economically feasible.

Considering this, new houses located near bluff crests without the benefit of professional geotechnical advice should be constructed in a manner that allows them to be moved, as readily as possible, to a new location further away from the crest.

7.4 DG-2 Ecologically Sensitive Areas

Six ecologically sensitive areas are defined on the Island, all partially active shoreline dune areas. We do not endorse residential development of these areas and although blowing sand can be a considerable nuisance and freshly deposited sand may require continuous clean up, they are not geotechnically hazardous in the normal context of geotechnical hazard and risk assessment.

Five areas are adjacent to steep bluffs along the south shore; one area is located on the accreted beach just east of Indian Point. Aerial photos from 1999 indicate none have residential development. The western 3 areas are located beyond the limits of subdivided land in the Sunset Trail shoreline corridor and near Indian Point. We assume no residential development is allowed at these locations.

The eastern 3 areas are located along the south margin of the Inland Dunes (DG-3 Area), a significant portion of which is now jointly owned by a private citizen and the Islands Trust. Geotechnical engineering guidance for residential development was provided by GAL (1999) in the DG-2 area on the east side of Beacon Point. One of the two ecologically sensitive areas east of here is partially located in a bluff area where we recommend a 30 m wide bluff hazard area along the crest (Dwg, 14-197-0-3). If development is allowed in the area above Duck Bay, our judgment is that building setbacks from the natural boundary should be defined by the BC Land Act .

7.5 DG-3 Inland Dune Area

This area includes the relict dunes on the central Island. Part of the dune area west of Leighton Road is densely subdivided. Except in the area previously investigated by GAL in 1999 (Dwg. 14-197-0-3) our 15 and 30 m preliminary bluff slope hazard limits apply along the north and south shores. We do not necessarily endorse residential development on Inland dunes but, like comparable features in DG-2 areas, they are not distinctly hazardous.

7.6 DG-4 Indian Springs Watershed

The Indian Springs Watershed is in a densely subdivided portion of the Island. The watershed area is mapped by Tupper (1996) and is also shown on Dwg. 14-197-0-1. Indian Springs is a licenced water supply for several residents and a public water supply for many others. The area and its guidelines are defined to protect the springs from excess drawdown of its aquifer and from septic pollution. Considering the importance of other shallow aquifers described in Section 2.7, it is not clear why they are designated with similar development guideline areas.

We attempted to map the Indian Springs aquifer limits by looking for changes in vegetation. We were not successful. Tupper's 1996 work remains the best attempt to date.

Severe erosion is occurring on an apparently unregistered road right of way above the springs. Some erosion appears to be caused by groundwater discharge on the north bluff. We visited the site one day after heavy rain in early June 2002. Riprap placed we are told, by

Ministry of Transportation personnel in an apparent attempt to limit erosion activity (and which we observed in place in early May) was eroded away during the heavy rain. Area residents pointed out that surface water originating on a newly constructed section of Vancouver Boulevard. and on Cunningham Road flowed to the erosion site and caused erosion of the riprap which is now deposited on the beach below. We confirmed these observations. On July 22, we observed that some surface water may have also originated in the forest just south of the erosion site and that groundwater also appears to affect the erosion site. Also on July 12, we were informed that area residents, not the Ministry of Transportation, had constructed the new section of Vancouver Blvd. The Indian Springs Road erosion site requires investigation, design and construction to reopen the road. In the meantime, groundwater and surface water erosion activity will continue.

Our comments on the draft development guidelines for the Indian Springs watershed are as follows:

Item a

Section 5.3 recommends that a 30 m wide preliminary bluff hazard limit be defined along the bluff crest above Indian Springs. Evidence of seepage related slope instability and severe surface water erosion justify this recommendation.

It is not unreasonable to limit disturbance of vegetation within 10 m of the springs although adjacent vegetation is already disturbed by natural processes. Vegetation along the top of the bluff was removed to build the local roadway. It is not unreasonable to limit use of chemicals (presumably fertilizers, cleaning solvents and similar products) within 30 m of the springs but chemical spills could adversely affect the water from greater distances.

In our judgment, prohibition of septic systems within 100 m of the springs and on more than 40% of residential lots within the aquifer does not ensure that the Indian Springs will remain uncontaminated. The only way to investigate the possibility of spring water contamination, ground water utilization and septic field densities is to conduct a detailed hydrogeological evaluation of the aquifer system. This admonition covers most elements of Items b through g of the draft guidelines.

Surface drainage has not been controlled at Indian Springs and the shallow aquifer is susceptible to several development adversities. In our judgment is that it is unlikely that voluntary compliance with well intended but generalized guidelines will adequately protect Indian Springs.

7.7 DG-5 Retention of Vegetation and Development of Large Parcels

This guideline has no bearing on geotechnical hazards. Bluff crest portions of large parcels are affected by our recommended hazard area limits.

8. ENVIRONMENTAL ISSUES

8.1 General

Highlights from Strix's report are presented in this Section. It does not form a complete summary of the report and reference should be made to Appendix B for a complete assessment of the environmental issues.

8.2 Dune Areas

Strix describes various dune settings, dune formation processes, plant successions and the environmental values in the Island's unique dune areas. Relict dune environments do not pose particularly difficult geotechnical problems but development activity will destroy the features themselves and their sensitive ecology.

8.3 Development Guideline Areas

Strix discusses several Development Guideline Areas including DG-1 (Shoreline Areas), DG-2 (Ecologically Sensitive Areas) and DG-3 (the Inland Dune Area). These areas were defined prior to our work. Strix (p.1) recommends subclassification of several DG-2 areas and suggests (p. 14) that further work may be required to identify defining ecologic features in the Indian Spring area (DG-4). It is also recommended that Mace Point be defined as an Ecologically Sensitive Area (p. 14).

9. SUMMARY OF CONCLUSIONS

Savary Island will continue to be reduced in width from south to north by natural erosion forces. Soil erosion, including landslide activity is a constraint to residential development along south island bluffs. Bluff wildfires are an ominous potential hazard which could greatly increase the rate of local slope erosion. If global warming causes a significant rise in sea level, erosion rates will almost certainly increase from those of the past.

Much of the island was densely subdivided early in 1910 but there are indications that dense residential development may eventually generate adversities including septic contamination of shallow aquifers which are commonly utilized for domestic water supplies. Dense residential development is also likely to affect portions of the Island's unusual sand dunes and their plant communities.

Non-regulatory (i.e. un-enforceable) geotechnical recommendations involving consideration of hazard and risk provide no assurance over public health and safety. Our geotechnical evaluation of Indian Springs Watershed guidelines suggests that recent *ad hoc* development activity and non-regulatory guidelines with no scientific grounding are unlikely to protect the Indian Springs aquifer system.

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MAPS

BC Ministry Environment, 1982. 92F.096.2.3, 2.4 and 92F.097 1.3, 3.1. 1:5,000 scale with 2 m contours and physical features shown.

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Garden and Taylor Land Surveyors, 1910. Savary Island Park showing subdivision of Parts of DL 1372 and 1373, (East Island) New Westminster District. 1 inch = 200 ft. Dated June 10, 1910.

Garden and Taylor Land Surveyors, 1910. Savary Island Summer Resort showing subdivision of Lots 1376 and 1377. (West Island) New Westminster District. I inch = 200 ft. Dated June 10, 1910.

G. F. Drabble 1891 Survey of Savary Island. Plotted by Anonymous from original survey notes, 1968. 1 inch = 400 ft. Survey data plotted by Underhill and Underhill Surveyors, Vancouver. November 25, 1968.

NTS 92F/15 (Powell River) 1:50,000 scale

AERIAL PHOTOS

Year	Flight Lines	Photo Numbers
1965	BC4319	157-161, 168, 169
		168-169
1982	BC82004	128,132,138
	BC82011	178 .
1994	30BCC941439	001-009
1999	167330 R352	L29 1-7

Savary Island Dune And Shoreline Study
Ecological Component

Report to

Powell River Regional District

Strix Environmental Consulting
Fort Langley, BC

Phil Henderson, R.P. Bio
Project Biologist

in association with

Thurber Engineering Ltd.
Vancouver, BC

January 10, 2003

Table of Contents

1.0 Introduction

The ecological component of this study by Thurber Engineering Ltd. endeavours to determine potential effects of the estimated shoreline retreat by describing existing conditions in key areas. The two major assumptions that can be used when estimating these potential ecological effects are

1. that the entire estimated shoreline retreat area will be eliminated. This is the worst case, and most unlikely scenario;
2. that within the estimated shoreline retreat area there will be differential processes and effects that will result in the persistence and prolongation of certain features, the modification, movement, or decimation of others, and the creation of new ones.

The most likely scenario will involve elements of number 2, but it is useful to consider number 1 as it forces one to focus on the relative values (such as diversity, rarity, fragility, insularity, and non-recreatability[1]) inherent in the areas considered.

One should also consider potential overall effects, or the effects within a larger scale. For example, how will the projected loss of land affect the distribution and abundance of plants and animals over the entire Island? What levels of human activity and development can certain organisms or communities withstand and how will these be influenced by potential shoreline retreat? Some elements of ecology to consider include the introduction and spread of non-native plants and animals (introduced rabbits, for example, can have devastating effects on dune plant communities), habitat fragmentation, insularity, uniqueness, and non-recreatability.

The Development Guideline Areas Map provided for this project was used to describe the study area. This map delineates the major Development Guideline Areas: DG-1, Shoreline Areas; DG-2 Ecologically Sensitive Areas; DG-3 Inland Dune Area; and DG-4 Indian Springs. It also shows contour lines and property boundaries. In this report, the DG-2 areas are distinguished from one another by the addition of a letter: “a” through “g”.

A number of general areas were selected for description based on those outlined in Powell River Regional District’s (PRRD’s) Terms of Reference for this study and Thurber Engineering’s (TEL’s) proposal. They include the *South Slope* (various types of slopes or bluffs), the *Dunes*, the *Bluff Crest*, and *Indian Springs*. *Indian Point* and the *Mace Point Rock Outcrop* were added because of issues of ecological significance. The focus was on the south shore because of the greater rates of erosion and its concentration of ecologically significant features. Most of the descriptions for these areas are based on vegetation. The animals of Savary Island are discussed briefly at the end of the report

This is the final version of the report. The draft version was circulated and available on the Powell River Regional District’s web site (http://www.powellriverrd.bc.ca/) and that of the Savary Island Land Trust (http://www.silt.ca). Few comments were forthcoming.

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1 non-recreatability – inability to re-create the richness and complexity of the original ecosystem (Morris and Therivel 1995)

Comments from Liz Webster of the Savary Island Land Trust were gratefully appreciated and incorporated into this final report. Golder Associates Ltd. (and Shearwater Mapping Ltd.) conducted its own ecological survey of the area for Roger Sahlin, co-owner of D.L. 1375, as well as a formal critical review of the Thurber and Strix draft reports. Its comments were considered for this final report.

1.1 Physical and Ecological Setting

Savary Island is located 30 km northwest of Powell River in the Straight of Georgia. It is a long, narrow island 7.5 km long by 0.37 to 1 km wide, comprising 450 hectares (1,100 acres). Generally, the island's elevation profile is saddle-shaped, with the central dunefield comprising the lowest area, and higher land rising to the east and west. The highest point is approximately 55 m. The island has no permanent watercourses, and no natural inland waterbodies.

The BC Government uses the Biogeoclimatic Ecosystem Classification (BEC) system to classify ecosystems across the province. This system of classification uses vegetation, soil, climate and other features to group areas with similar characteristics. Savary Island lies within, and at the northern limit of, the Coastal Douglas-fir Biogeoclimatic Zone (CDFmm) (Roemer 2000; CDC 2002). This zone is characterized by warm, dry summers and mild, wet winters (Green and Klinka 1994). The CDF formerly consisted of two subzones, one of which has now been grouped into the Coastal Western Hemlock biogeoclimatic zone (CWHxm) which occupies adjacent sites and is distinguished from the CDFmm by its occurrence at higher elevations (>150 m when next to CDFmm), a greater abundance of western hemlock (considered rare in CDFmm)[2], very few bigleaf maple (common in CDF), and fewer arbutus on drier sites (Meidinger and Pojar 1991; Green and Klinka 1994). Two site associations typical of the CDFmm that are well represented on Savary Island, particularly within the central dune area, are *Douglas-fir – Salal* and *Douglas-fir – Shore pine – Arbutus.*

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2 The information presented in Section 3.4 suggests that western hemlock is not rare on Savary Island. Some plant communities within the CDFmm have a high occurrence of western hemlock. Western hemlock occurs in at least 60% of the sites for the *Thuja plicata - Pseudotsuga menziesii - Kindbergia oregana (Eurhynchium oregana)* plant community of the CDFmm (Carmen Cadrin, pers. comm.).

2.0 South Shoreline

The portion of the south shoreline examined for the ecological component of this study includes the area between the rock outcrop at Mace Point at the east end of the island, and the small foredune[3] immediately west of Sunset Trail near the west end of the island. The total shoreline distance between these points is approximately 8.6 km. The area considered is not restricted to the shoreline, but includes the backshore[4], the foredunes, and the slopes or banks rising to the inland forests. It is these banks and foredunes that are emphasized because of their fragility and the unique assemblages of plants that they support.

Much of this area was traversed on foot, but the examination of some areas involved visual inspection from the beach and the bluffs, often with the aid of binoculars. Recent and historical aerial photographs were also examined.

Steep slopes comprise approximately 5.5 km, or 64 per cent, of the South Shoreline. They are present to the east and west of the low elevation dunefield located between Whalebone and Beacon Points. The eastern portion of continuous high, steep banks extends 280 m west from the rock outcrop at Mace Point (the east end of the island) to Whalebone Point. The western section of high, steep banks, or bluffs, extends approximately 270 m westward from Beacon Point. These bluffs generally range in slope from 30 to 50 degrees, but in some areas are nearly vertical. Maximum bluff height is approximately 50 m. The majority of these bluffs are covered with a mix of shrubs and herbaceous plants, but in a few areas are forested or barren. The barren areas tend to occur on the steepest slopes.

2.1 Forested Bluffs

Forested bluffs are relatively uncommon along the south shore; the majority of bluffs support shrubs and herbaceous plants while the steepest slopes remain barren. On the forested bluffs, Douglas-fir (*Pseudotsuga menziesii*) is the most common tree, but others such as shore pine (*Pinus contorta* var. *contorta*), arbutus and even bigleaf maple (*Acer macrophyllum*) are present on some slopes. A forested portion of the bluff at the west end of South Beach (between Mace Point and Garnet Point) is dominated by Douglas-fir, but also includes a few arbutus (*Arbutus menziesii*), small western redcedar (*Thuja plicata*) near the bottom, and salal (*Gaultheria shallon*), dull Oregon-grape (*Mahonia nervosa*), Scots broom (*Cytisus scoparius*), and Pacific crab apple (*Malus fusca*). Near the east side of Garnet Point, a column of arbutus extends up the bluff, and bigleaf maple grows nearby.

2.1.1 Gentle to Moderate Forested Slopes

A few small sections of gentle to moderate forested slopes are present on the south side of Lot 1375 between the open areas of sand dune. A 40 m stretch of forest comprised of dense

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[3] foredune – the frontal dune developing immediately behind (landward to) the backshore. This area is DG-2-F.

[4] backshore – area adjacent to the foreshore (area between high and low tide marks, i.e., the area normally influenced by tides and waves) beyond the reach of normal tide and wave action (may be affected by storms and exceptionally high water). Primary source of dry sand for dune formation.

3-5 m shore pines and Douglas-firs is present within a low portion of DG-2-B. Growing amongst these small trees are various grasses, Scots broom, trailing blackberry (*Rubus ursinus*), evergreen huckleberry (*Vaccinium ovatum*), and yarrow (*Achillea millefolium*). A forest of shore pines and Douglas-firs stretches approximately 100 m between the small dune meadow at the west end of DG-2-B and the dune meadow of DG-2-C. Salal is abundant in the understory, especially near the shoreline.

Farther west, a forested slope of shore pine is present between the dune meadows of DG-2-C and DG-2-D. A dense thicket of salal forms a 5 m wide strip that separates this forest from the rocks and logs of the beach ridge[5] below. A freshwater seep drains from this forest, giving rise to a dense patch (7 m^2) of Lyngby's sedge (*Carex lyngbyei*) amongst the rocks where the sea meets the land.

Moderate forested slopes are present along Sunset Trail at the west end of the *South Shoreline*, an area in which many residential lots are developed.

2.2 Non-forested Slopes

Non-forested slopes are the most common slopes along the south shoreline. They are covered with various mixtures of shrubs and herbs, or are barren as a consequence of steepness.

2.2.1 Steep Non-forested Slopes (Bluffs)

Steep non-forested slopes are characteristic of the *South Shoreline*. They are predominantly a mixture of shrubs and herbaceous plants whose abundance and species composition varies with the amount of disturbance, water, and nutrients. In many areas Scots broom forms the dominant cover on the slopes, fulfilling its intended role as soil binder and bank stabilizer. It was first introduced to Savary Island in 1912 (Sherman 1931) or approximately 1914 (Kennedy 1992). Scots broom destroys native plant communities by displacing native species, a fact noted by Sherman (1931) in his account of the ecology of Savary Island published in 1931: "If it could be confined to the steep sand-slopes of the south shore, this shrub might in time vindicate its existence and the wisdom of those who introduced it; but, unfortunately, it has invaded the interior of the island where it is becoming a menace to our native flora."

Broom persists on the dry, open slopes where it has aided bank stabilization, but has resulted in low structural and floristic diversity, especially of native species (Figure 1). On the slopes above South Beach, numerous plants — mostly weed species — grow amongst and beneath the dense cover of Scots broom: field chickweed (*Cerastium arvense*), entire-leaved gumweed (*Grindelia integrifolia*), hairy cat's-ear (*Hypochoeris radicata*), yarrow (*Achillea millefolium*), cleavers (*Galium aperine*), miner's-lettuce (*Claytonia perfoliata*), sheep sorrel (*Rumex acetosella*), chickweed (*Stellaria media*), dovefoot geranium (*Geranium molle*), bull thistle (*Cirsium vulgare*), purple dead-nettle (*Lamium purpureum*), sweet vernalgrass (*Anthoxanthum odoratum*), orchardgrass (*Dactylis glomerata*), other grasses, and trailing blackberry (*Rubus ursinus*).

5 beach ridge – a mound of material deposited by wave and wind action behind the beach or in the backshore.

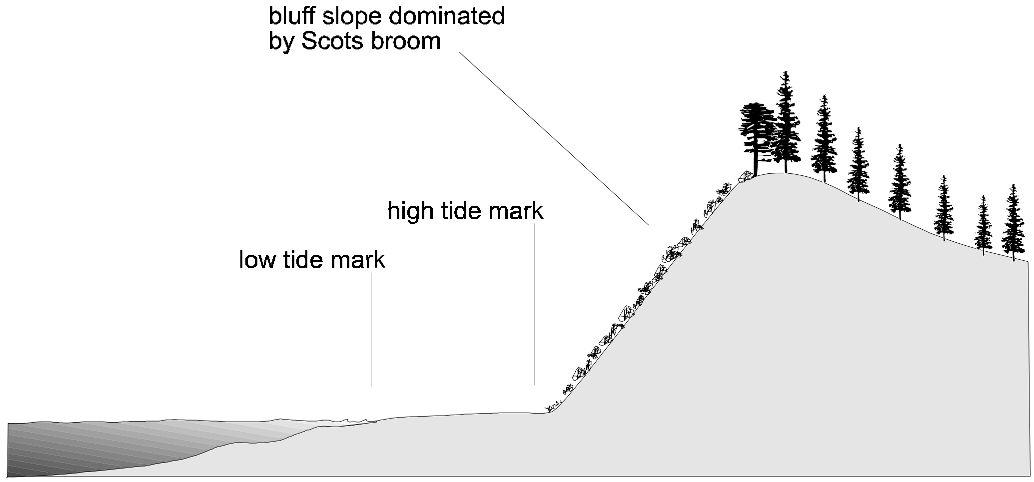

Figure 1. Cross sectional view east to west of South Beach, showing the easternmost portion dominated (and stabilized) by Scots broom.

Salal and other native shrubs thrive on wetter slopes, which broom — despite its prevalence on dry slopes — also invades. Other shrubs present on these slopes, but which are generally less abundant than salal, include Pacific crab apple (*Malus fusca*), trailing blackberry, tall and dull Oregon-grape (*Mahonia aquifolium* and *Mahonia nervosa*). Small specimens of Douglas-fir, arbutus, and shore pine are in some areas present amongst the shrubs. At the top of the bluff, approximately 170 m west of Beacon Point, scouring rush (*Equisetum hyamale*) grows in dense patches beneath the thick cover of salal. Scouring rush indicates an abundance of subsurface water.

Loose soils and steep slopes appear to conspire against the establishment of all but a few shrubs and trees along banks on which herbaceous species predominate. In these "sloping fields" the thin layer of plants are often sloughed off, exposing barren patches of the underlying sandy soil. As a result of sloughing and erosion, the topography of these slopes can be quite varied: a series of ridges, depressions, cliffs, gullies and mounds. These landforms and the underlying moisture and nutrients influence the type of plants that occur, and their configuration.

Generally, these "open" slopes support a variety of grasses, a few weedy species such as sheep sorrel, and an abundance of native plants such as northern wormwood (*Artemisia campestris* ssp. *pacifica*), entire-leaved gumweed (*Grindelia integrifolia*), meadow death-camas (*Zygadenus venenosus*), barestem desert-parsley (*Lomatium nudicaule*), common vetch (*Vicia sativa*), two-coloured lupine (*Lupinus bicolor*), field chickweed (*Cerastium arvense*), western buttercup (*Ranunculus occidentalis*), bracken fern (*Pteridium aquilinum*), scouring rush, and common horsetail (*Equisetum arvense*). Many of these same species are present in the gently sloping dune meadows.

The steep slopes along the shoreline, extending approximately 1000 m west of Beacon Point, have very sparse vegetation cover.

2.5 Gentle to Moderate Non-forested Slopes

The gentle to moderate non-forested slopes tend to occur in transitional shoreline areas where high steep banks yield to low banks of gentle slope. They occur within the Environmentally Sensitive Areas (DG-2) where the outer sand dunes (foredunes) interface with older dunes, or mounds of differentially derived materials whose soils are more consolidated. A good example is DG-2-G (See map, Appendix 1) which consists of unconsolidated sand material and sparse vegetation cover in the western foredune portion, and extensive vegetation cover in the eastern portion comprised of a 30° slope (Figure 2). In May, this eastern slope was completely covered with grasses and various native herbaceous species such as meadow death-camas, chocolate lily (*Fritillaria affinis*), field chickweed, western buttercup, two-colored lupine, bracken fern, common vetch, giant vetch (*Vicia gigantea*), seashore bluegrass (*Poa micrantha*), and two shrubs: trailing blackberry and tall Oregon-grape. The west portion of DG-2-G has an excellent example of a foredune running parallel to the bank and located just above the shoreline (See Section 3.0 Dunes).

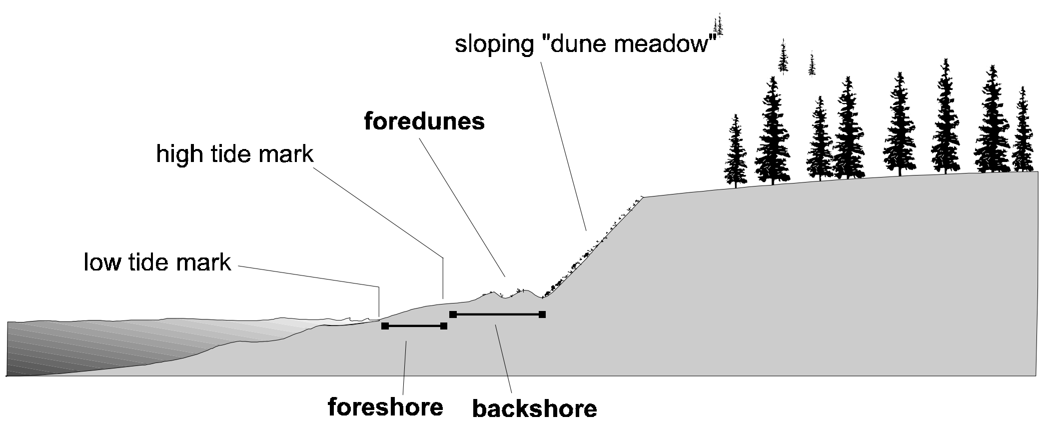

Figure 2. Cross sectional view east to west of the "dune meadows" on the steep slope overlooking the foredune just east of the east terminus of Sunset Trail (DG-2-G). This slope supports a great diversity of herbaceous plants (plus tall Oregon-grape) typical of foredune and coastline dune meadows.

3.0 Dunes

A number of previous reports have focussed on the ecology and geomorphology of the dunes in Lot 1375 (Sherman 1931; Dunster 2000; Roemer 2000; Bawtinheimer and Roemer 2000; Sadler 2000; CDC 2002). The Savary Island dune complex is considered the greatest remaining example of dunes within the Coastal Douglas-Fir biogeoclimatic zone (CDF) (Roemer 2000) and one of the best examples of coastal sand dunes in Canada (Dunster 2000). Other dunes occur within the Coastal Western Hemlock biogeoclimatic zone but these support different vegetation assemblages and associations owing to differences in climate (Roemer 2000).

Dunster (2000) outlines the geologic history of the dunes. Basically, two glaciation events — the retreat of Semiahmoo Glaciation 60,000 to 25,000 years ago and the advance and retreat of Fraser Glaciation 25,000 to 11,000 years ago — resulted in the deposition of silt, sand and gravel. Sand was also deposited from streams and rivers draining onto floodplains that were present in the area (Bornhold et al. 1996). Sand available for dune formation is transported landward by water current and wave action in the nearshore bottom zone (low water mark to 9 m below water surface) which is always submerged, and the foreshore or littoral zone (low water mark to high water mark) which is alternately submerged and exposed; and by wind action in the foreshore zone and the backshore zone (zone above the high water mark) (Krumbein and Slack 1956, *cited* in Ranwell 1972 and Packham and Willis 1997; Brown and McLachlan 1990). The dune zone or dunefield is entirely terrestrial and influenced by wind.

The movement of sand particles is influenced by moisture, wind velocity and the size of the particles. Sand moves across the surface in three main ways which are dependent on the size of the particle: suspension, saltation, and surface creep. The smallest particles, forming dust, are suspended in the air; larger particles leap and bounce across the surface (saltation); and the largest particles roll across the surface when they are struck by the saltating particles (surface creep). The saltating particles are thrust upward and move in a small arc before striking the surface and pushing larger particles forward (Dunster 2000, Brown and McLachlan 1990).

The sand particles continue moving until impeded by physical obstructions such as vegetation. The vegetation traps the sand and small mounds or ridges form. Wind passing over these mounds of sand loses velocity, causing deposition of the sand on the leeward side of the ridge (Wiedemann 1999). The sand accumulates until the ridge slope reaches an angle of approximately 33 degrees at which point the sand slips away. It is by this means that the dune advances. This process occurs on a small scale, such as in the formation of 1 to 2 m high foredunes (DG-2-G), and on a large scale where huge ridges advance on more substantial vegetation such as trees (inland dunes). Dunster (2000) noted the presence of buried trees near Beacon Point!

Wind descending the leeward side of the ridge increases in velocity and removes sand until wet, heavy material is exposed that cannot be moved. The resultant depressions between dune ridges are called dune slacks. Because of greater levels of moisture, dune slacks usually support different types and assemblages of plants than dune ridges.

A characteristic of coastal dunefields is a general gradient of influence from predominantly physical forces near the beach to predominantly biological forces inland. A floral (plant) and faunal (animal) gradient of increasing diversity is evident from the shoreline foredunes (pioneer or early successional dunes) to the interior longitudinal dunes (forested dunes). Vegetation cover and canopy height also increase along the gradient from shoreline to interior dunes. Biological interactions increase from shoreline to the interior dunes (Brown and McLachlan 1990).

The degree of endemism (when organisms are restricted to a certain region) in plants and the incidence of unique plant species are high in dunes, while plant diversity (number of species) is generally low. The degree of endemism in animals and the incidence of unique animal species is generally low in dunes (Brown and McLachlan 1990).

3.1 Foredunes and Coastline Dunes

The foredunes are the frontal or most seaward dunes (Figure 2). They develop in the backshore or upper shore area beyond the reach of ordinary wave and tide action. The foredunes consist mainly of open sand with intermittent patches of vegetation. For the most part, the material is unconsolidated and readily moved by wind, so plants found there are usually well adopted to periodic burial. Foredunes represent an early successional stage in the development of a transverse dunefield.

In some areas foredunes seem to be lacking or are indistinct from the first ridge of the inland dunefield in the centre portion of the island (Lot 1375). This seems to be the case in the mid-portion of DG 2-B at Duck Bay. The main dune face with its areas of loose sand and dune meadows, is the south side of large dune ridge extending inland to the northwest. These large frontal dunes which are distinct from the small foredunes will henceforth be referred to as coastline dunes.

Plants that are able to endure partial burial are considered dune building species. They provide the barrier against which wind-blown sand can accumulate. To survive in this dry, nutrient poor environment, pioneer sand dune plants have specialized root systems. Some have roots that spread considerable distances horizontally; others have taproots that reach great depths (Salisbury 1952; Wiedemann et al. 1999). Some plants such as large-headed sedge (*Carex macrocephala*) and seashore bluegrass have extensive underground stems (rhizomes) which allow them to spread across the open sand. Seashore bindweed (*Convolvulus soldanella*) spreads by means of prostrate stems (stolons) that extend across the surface of the sand.

The *Gentle to Moderate Non-forested Slopes* and the *Open Foredunes and Coastline Dunes* together comprise the Ecologically Sensitive Areas (DG-2). The five distinct DG-2 areas discussed in this report occur along approximately 1800 m, or 20 per cent, of the *South Shoreline*. The unconsolidated sand dunes vary on Savary Island from gentle sloping mounds (DG-2-F, west Sunset) to steep banks (portions of DG-2-G and DG-2-B).

The Red-listed contorted-pod evening-primrose (*Camissonia contorta*) was found in DG-2-B (see section 3.5). Other plants found in the DG-2 areas include dwarf owl-clover[6] (*Triphysaria pusilla*) and springbeauty (*Claytonia* sp.).

The backshore and foredune areas are the most sensitive to human disturbance (Brown and McLachlan 1990). Sensitivity decreases as one moves inland from these areas to older, forested dunes. The uniqueness of the plants and plant associations found on the foredunes and coastline dunes (Table 1, 2), and the sensitivity of these areas to disturbance[7], are the prime reasons for their ecological significance.

Table 1. Rare Plant Associations of Ecologically Sensitive Areas, DG-2's. (CDC 2002)

Artemisia campestris - Grindelia integrifolia (*Festuca rubra*)
pacific sagebrush - entire-leaved gumweed - (red fescue)
S1 - Red list;

Carex macrocephala herbaceous vegetation
large-headed sedge
S2 - Red list;

Festuca rubra - Ambrosia chamissonis herbaceous vegetation
red fescue - silver burweed
S2 - Red list;

Leymus mollis ssp *mollis* - *Lathyrus japonicus* herbaceous vegetation
leymus - beach pea
S3 - Blue list[8]

[6] dwarf owl-clover (*Triphysaria pusilla*) specimen identified by Ken Marr, Curator of Botany, RBCM. Specimens deposited with the RBCM herbarium.

[7] Within the context of the natural processes affecting these areas, the plants and the ecosystems in which they occur are tolerant of, and adapted to, disturbance. They are sensitive to environmental processes (such as wind, and sand deposition) in that they respond to them and persist. They are more susceptible (sensitive) to disturbance caused by humans (such as trampling, compaction and scarification). This was evident by a bicycle trail that detoured across firm ground consolidated by plants in the foredune where the forest opens into the northwestern backshore dune (DG-2-F). The main trail was no longer suitable for riding as the plants that bind the sand had been destroyed.

[8] Blue list – Includes indigenous species or subspecies considered to be Vulnerable in British Columbia. Vulnerable taxa are of special concern because of characteristics that make them particularly sensitive to human activities or natural events. Blue-listed taxa are at risk, but are not Extirpated, Endangered or Threatened. (CDC 2002)

Table 2. Some uncommon plants of the Ecologically Sensitive Areas, DG-2's (CDC 2002)

scientific name	common name	status	
Allium acuminatum	taper-tip onion	G5 - S3	
Brodiaea coronaria	harvest brodiaea	G4 - S3	
Camissonia contorta	contorted-pod evening-primrose	G5 - S1	Red List
Carex inops	long-stoloned sedge	G5 - S3	
Carex macrocephala	large-headed sedge	G5 - S3	
Claytonia exigua ssp *exigua*[9]	pale springbeauty	G?t? - S3	
Convolvulus soldanella	seashore bindweed	G5 - S3	
Grindelia hirsutula var *hirsutula* (historic record for which the location is not specified and the population has not been relocated)	hairy gumweed	G5t? - S1	Red List
Lupinus bicolor ssp *bicolor*	two-coloured lupine	G5t5 - S3	
Lupinus littoralis	seashore lupine	G5 - S3	
Montia fontana	water chickweed	G5 - S3	
Homalothecium arenarium (moss present on foredunes and in dune-meadow transitional areas)		*G4 - S2S3*	*Blue List*

3.2 Dune Meadows

As discussed in Section 2.4, *Steep Non-forested Slopes*, dune meadows (areas with an assemblage of plants very close to low-slope dune meadows) occur on steep slopes (Figure 2), but usually they occur on gentle slopes. They often occur on the periphery of areas of open, loose sand, such as in the west portion of DG-2-B. There, the meadows form around a "bowl" of open sand and support such species as meadow death -camas, sea blush, field chickweed, seashore bluegrass, long-stoloned sedge, cheatgrass (*Bromus tectorum*), bracken fern, and tall Oregon-grape. See Section 2.4, *Steep Non-forested Slopes* and Figure 3, for further details on plants typical of dune meadows.

Dune meadows represent a stage in the succession of the plant community. The general sequence in the development of plant communities from open sand to dune meadows is presented in Figure 3. Dune meadows should eventually succeed to a shrub-dominated community, and finally to a forest. However, dune meadows — as with other successional stages represented on Savary Island — may persist for longer than expected, or indefinitely, because of the environmental pressures to which they are subjected: exposure to sun, wind, sand deposition, wave action, erosion, and salt water spray.

[9] *Claytonia exigua* ssp. *exigua*. Also known as *Claytonia spathulata* (Douglas et al. 1990; Hitchcock et al. 1964).

foredune slope

loose, moving sand
low per cent plant cover
undulating surface
clumps or sporadic single occurrences of specialized herbaceous plants
northern wormwood, entire-leaved gumweed, blue-eyed Mary, dwarf owl-clover (*Triphysaria pusilla*), bracken fern, beach morning-glory, large-headed sedge (*Carex macrocephala*), pale springbeauty (*Claytonia exigua* ssp *exigua*), seashore lupine (*Lupinus littoralis*), hairgrass (*Aira praecox* or *A. caryophylliea)*.

(Dunegrass (*Leymus mollis*), especially, and American searocket (*Cakile edentula*) may occur here but are more abundant in the lower areas along the shoreline, between the foreshore and the backshore.)

foredune/dune meadow transition

encrusted/coalesced sand
variable percentage plant cover (70-90 per cent with high percentage of mosses)
flat surface
sporadic plants
two-colored lupine, sea blush, tall Oregon-grape, thimble clover (*Trifolium microdon*), large-headed sedge, sea blush (*Plectritis congesta*), cheatgrass, hairgrass, red fescue, sheep sorrel.
mosses
Racomitrium canescens (s.l.), *Bryum capillare*, *Bryum* sp., *Tortula ruralis*, *Homalothecium arenarium*, *Ceratodon purpureus*.

dune meadow

bound soil/sand
generally even (non-undulating) but sloped surface
~ 100 per cent plant cover
meadow death-camas, sea blush, shore blue-eyed grass (*Sisyrinchium littorale*), field chickweed, western buttercup, yarrow, chocolate lily, lomatium, woolly eriophyllum (*Eriophyllum lanatum* var. *lanatum*), two-colored lupine, cheatgrass, red fescue, few-flowered witchgrass (*Panicum oligosanthes* var. *scribnerianum*), grasses, bracken fern, tall Oregon-grape
mosses
Dicranum scoparium

Figure 3. Succession from foredune and unconsolidated sand dune area, to dune meadows.

3.3 Inland Dune Area (DG-3)

The ancient sand dunes are most fully developed in the centre portion of the island (Figure 4). They comprise one third of the area of Savary Island, or 150 ha (CDC 2002). The series of parallel ridges and slacks (depressions between ridges) are aligned along a southeast-northwest axis, following the alignment of the prevailing southeast winds. These dunes lie mainly within Lot 1375 but extend to and terminate in Lot 1376 to the northwest. The dune ridges reach a maximum elevation of 31 m above sea level. The greatest difference in elevation between dune ridges and adjacent slacks is approximately 20 m.

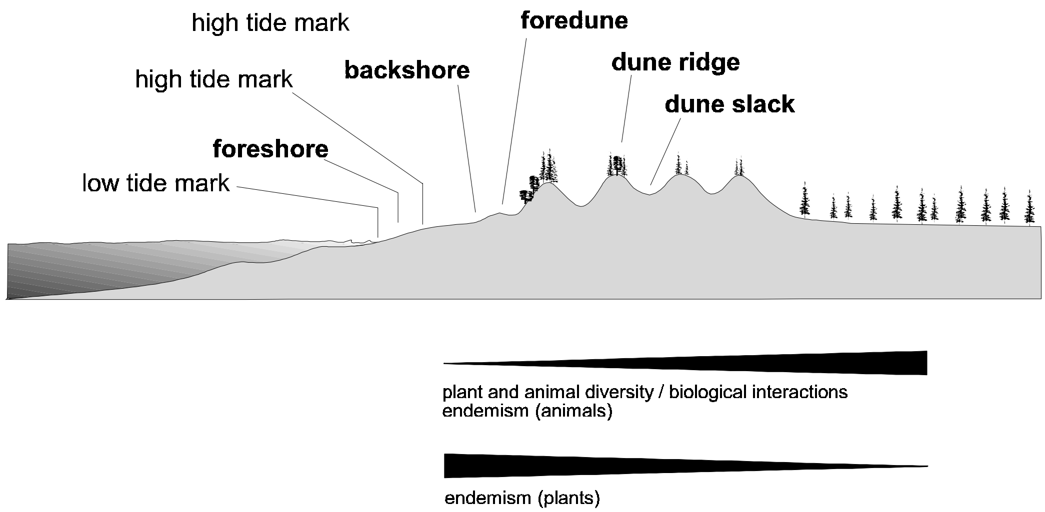

Figure 4. Cross sectional view from east to west of the inland dunes extending northeast from foredunes and dune meadows east of Beacon Point (DG-2-C,D). To illustrate the general configuration, the dunes in this diagram are represented as being parallel to the shoreline when they are actually aligned obliquely to the shoreline: the shoreline is oriented east-west, while the dunes are oriented southeast-northwest. The elongated triangles show trends (increasing or decreasing) in diversity, endemism and biological interactions along a gradient from foredunes/dunes to inland forests (after Brown and McLachlan 1990).

The large central dune ridges and slacks are forested. The forests of the dune ridges differ from those in the slacks, and generally differ from forests present elsewhere on the island outside of the dune ridge complex. The dune ridge forests are less diverse than forests outside the dunes and support species that favour or tolerate drier, nutrient poor soil. Douglas-fir (some very large), western hemlock (smaller), shore pine, and arbutus are the typical species of the dune forest. Large and small arbutus are scattered throughout the dune ridges, with some particularly old, large specimens struggling beneath the canopy of the dominant Douglas-fir. Shore pine grows sporadically throughout the dune ridges, and occurs in association with Douglas-fir and salal, forming a plant association — shore pine, Douglas-fir and salal — considered very rare and designated as Red-listed[10] (Bawtinheimer and Roemer 2000; Dunster 2000; CDC 2002).

The common shrubs of the dune ridges are salal, red huckleberry (*Vaccinium parvifolium*), evergreen huckleberry, dull Oregon-grape and trailing blackberry. Ridges with smaller trees and more canopy gaps support a greater density of shrubs. Forests along the large ridges in the southwest portion of the dune complex are comprised of huge Douglas-firs and a relatively sparse shrub layer (~25% cover) of salal and red huckleberry. A very dense undergrowth of salal, with a minor component of evergreen huckleberry and red huckleberry, dominates the shrub layer of the Douglas-fir forests present on the dune ridge slopes and slacks in the south portion of Lot 1375.

[10] Red-listed – Includes indigenous species or subspecies that have, or are candidates for Extirpated, Endangered, or Threatened status in British Columbia. Extirpated taxa no longer exist in the wild in British Columbia, but do occur elsewhere. Endangered taxa are facing imminent extirpation or extinction. Threatened taxa are likely to become endangered if limiting factors are not reversed. (CDC 2002)

Herb layer plants are similarly varied and generally sparse on the dune ridges. Bracken fern appears to be the most abundant plant, a characteristic also noted by Roemer (Bawtinheimer and Roemer 2000). Northern twayblade (*Listera caurina*) and groundcone (*Boschniakia hookeri*), a plant parasitic on the roots of salal, were noted on one ridge. Roemer also recorded rattlesnake-plantain (*Goodyera oblongifolia*), Alaska oniongrass (*Melica subulata*), broad-leaved starflower (*Trientalis latifolia*), western fescue (*Festuca occidentalis*) and white-veined wintergreen (*Pyrola* c.f. *picta*).

On the main dunes within Lot 1375, the moss layer is poorly developed and tends to be associated with woody debris that has fallen from the trees. In open areas, mosses such as *Racomitrium canescens* (s.l.) can form extensive cover.

Smaller Douglas-fir and western hemlock are typical of the dune slacks. The shrub layer of the slacks is more dense and diverse than on the ridges, and is comprised mainly of salal with a small percentage of dull Oregon-grape, red huckleberry and trailing blackberry. Very small western hemlock were also present within the herb-layer in which herbaceous perennials were scarce. The slacks appear to have more coarse woody debris[11] than the ridges which have a greater cover of small debris[12] such as needles, cones and twigs. Moss is generally more abundant and diverse in the slacks, owing in part to the greater accumulation of organic material, increased shade, and moisture. Six species (*Dicranum fuscescens*, *Eurynchium praelonga*, *Hylocomnium splendens*, *Hypnum circinale*, *Rhizomnium glabrescens*, and *Rhytidiadelphus loreus*) representing 7 per cent cover were observed within one vegetation plot in a dune slack. By comparison, only two species (*Brachythecium asperrimum* (Wilf Schofield, pers. comm.), and *Eurynchium* sp.) with less than 5 per cent cover were found in two vegetation plots on dune ridges.

Soil nutrients and characteristics of dunes change in a typical manner along a gradient from the shoreline to the forested dunes (Brown and McLachlan 1990; Packham and Willis 1997). This is mainly a function of age, the oldest dunes being located inland. The following features decrease along a transect running inland from the shore: calcium carbonate, magnesium, potassium, pH, sand grain size, and sand transport potential. Nitrogen and organic matter tend to increase along transects running inland from the shore (Brown and McLachlan 1990; Packham and Willis 1997).

3.4 Ecological Differences in Dune Ridge, Peripheral Dune Ridge, and non-Dune Areas: Vegetation Plot Data

In addition to differences in vegetation between dune ridge and dune slacks, and between dunes and non-dune areas, vegetation also differs among dune ridges located within different areas of the forested dunefield. Vegetation plots were established to supplement information from walk-through surveys and these suggest differences in vegetation species composition between the main dune ridges (Lot 1375) and peripheral dune ridges (properties west of Lot 1375).

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[11] coarse woody debris (CWD) - sound and rotting logs and stumps that provide habitat for fungi, plants, animals, their predators, and nutrients for soil development. It includes snags, stumps and downed wood with a diameter greater than 1 cm (Note that there is no internationally accepted standard definition for CWD; some definitions do not allow for the inclusion of snags, and may have a smaller minimum diameter.)

[12] small organic material less than 1 cm in diameter can be referred to as *litter*.

3.4.1 Soil

Five soil pits were dug within each of a small number of 5 m radius vegetation plots established to supplement information from walk-through surveys. Three plots were established in non-dune areas, three were established within the main dune area (Lot 1375) (two dune ridge and one dune slack), and five were established west of Lot 1375. The objective was to reveal general trends that would help define the dunes and distinguish them — in addition to information on topography and vegetation — from adjacent areas that may not represent dunes. The soil pits were up to 20 cm deep and approximately 7 cm in diameter. The main feature recorded for each pit was the depth at which the sand layer occurred. General notes on soil characteristics (colour, texture, organics, etc.) were also recorded.

Sand was evident in all of the plots but the amount of sand within the pits, and its characteristics, differed between sites. Two plots were established in the non-dune area northeast of the airstrip as a baseline for comparison to those within the dune complex and on its periphery. In these non-dune plots a distinct sand layer was usually absent within the 20 cm, so the depth at which sand particles were discernible was recorded. This depth was approximately double (13 cm) that recorded for pits (5.8 cm) on the dune ridges, the dune slacks, and along the western portion of the dunes near the borders differentiated in the Development Guideline Areas map. With the exception of one plot located at the bluff crest (avg. sand depth: 2.2 cm) there was no obvious difference between the average depth of the distinct sand layer for the eight plots located within the Inland Dune Area (DG-3) demarcated on the map. (See Appendix 2 for statistical details.)

Soil colour and texture differed between plots on the dune ridges within the central dune complex and those located on the periphery, to the west. Sand comprising the sand layer of the central dune plots was white-grey and coarse. Sand within the peripheral plots was medium to fine grained with some degree of red coloration: reddish-brown, grey-reddish, or orange-grey. Sand from a central dune ridge extending into Lot 1376 (DR7) was light brown-grey and of medium to fine texture. Sand from the southernmost dune ridge extending west of Lot 1375 was of medium texture and brown-grey-red. Sand within the plots located in the non-dune area northeast of the air strip was reddish and of medium coarseness (texture) and occurred within a mixture of finer organic-based soil; not as a distinct layer. Sand from another non-dune plot located west of the dune complex, at the east border of the area designated Indian Springs (DG-4), was grey-black and of very fine texture; it stuck together when pressed between the fingers.

3.4.2 Vegetation

Douglas-fir is the most abundant tree in the dunefield. The largest specimens are present along the south portion of the dune fields in a Douglas-fir forest with an dense understory of salal. In this area, Douglas-fir — with the occasional arbutus — is the only tree species present on the dune ridges, the slacks, and the south slope of the last dune ridge, facing the ocean. On the dune ridges to the north, the trees are generally smaller and western hemlock and shore pine become more common. Shore pine is the least abundant of these three main conifers. It occurs sporadically along the dune ridges, and on some ridges forms small "forests." Arbutus is nowhere abundant, and shows a scattered distribution across the dune ridges of the central portion of the dunefield (the largest dunes within Lot 1375). Information from the small number of plots show that Douglas-fir is slightly more abundant than western hemlock in the central portion of the dunefield. However, data from plots in this central area and the peripheral area to the west (Lot 1376), reveal a similar abundance (based on per cent cover) of Douglas-fir (23 %) and western hemlock (28 %). Western hemlock becomes more abundant on the peripheral, western dunes, and seemingly on dunes that have been disturbed more recently. It is common in some areas of the dunefield and areas outside the dunefield. Western redcedar is restricted to the peripheral dune ridges and becomes more abundant in areas outside the dunefield. Bigleaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), and grand fir (*Abies grandis*) are common in interior portions of the island outside the dunefield.

Salal is the most common shrub within and outside the dunes, followed by evergreen huckleberry, red huckleberry and dull Oregon-grape. Common herb-layer plants within the dunes include bracken fern, sword fern and broad-leaved starflower (*Trientalis latifolia*). Sword fern and bracken fern are also common in forests outside the dunefield.

Although information from these plots is limited because of the small number of plots examined and the depth of the soil pits, it does suggest that the Development Guideline Areas Map accurately defines the extent of the dune complex, DG-3. The presence of different soil and plant characteristics on the periphery of the dune complex does not mean that these areas are not dunes; one expects a certain degree of common features within an area transitional between two distinct ecological areas. One assumes that the duration and magnitude of processes acting on (influencing) the central dune area are different than those acting on the peripheral portions. This may explain the absence of arbutus and presence of western redcedar on the peripheral dune ridges near the west boundary of DG-3, west of Lot 1375.

3.5 Red- and Blue-listed Elements

A rare plant was discovered on the coastline dune of DG-2-B. During field work May 7, 2002, specimens of contorted-pod evening primrose (*Camissonia contorta*) were photographed and collected (two specimens deposited with the RBCM herbarium) on the dune along the south edge of District Lot 1375 (DG-2-B). Jennifer Penny, Botanist with the CDC, identified the specimens (Jennifer Penny, pers. comm.). Contorted-pod evening primrose is a Red-listed species found in only four sites in BC: one recently, two in the 1970's, and one historically (Jennifer Penny, pers. comm). This Savary Island record appears to be the most northern documented occurrence in B.C.

The Blue-listed moss *Homalothecium arenarium* was recorded in the sand of open dune habitats, and was abundant in D.L. 1375 (Sadler 2000). It was also noted during field work for this report in DG-2-B (D.L. 1375) and in DG-2-F.

The following rare plant association occurs within the forested dunes of District Lot 1375 (CDC 2002):

Pinus contorta var. contorta - Pseudotsuga menziesii/Gaultheria shallon
shore pine - Douglas-fir/salal
S2 - Red list.

The complete BC Conservation Data Centre information is provided in Appendix 4.

4.0 Bluff Crests

Vegetation along the bluff crests is variable but typically composed of the common species found on the island. Thus, Douglas-fir dominates these areas. Arbutus is perhaps more abundant along the bluff crest than in any other area of the island outside of the dunefield. Arbutus and western yew (*Taxus brevifolia*) grow along the edge of the bluffs, and a few very large specimens of each are found there. The famous "giant arbutus" of Savary Island, a record specimen for BC (CDC 2002), is present on Garnet Point at the west end of South Beach. This specimen has a circumference at breast height of 5.58 m (diameter of approximately 1.7 m) and is ranked the sixth largest arbutus in BC with 312 AFAR points, based on circumference, height, and average crown spread. A large western yew near the top of the bank was estimated to have a diameter at breast height of 0.5 m. Large Douglas-firs along the bluffs provide excellent perches for bald eagles, and a number of nests are present in these trees near the cliff edge.

A small section of forest on the bluff above South Beach, just east of the giant arbutus, included Douglas-fir, western redcedar, patches of red alder (*Alnus rubric*), bigleaf maple (*Acer macrophyllum*), a few grand fir (*Abies grandis*), and an understory of salal, red huckleberry, oceanspray (*Holodiscus discolor*), trailing blackberry, vanilla-leaf (*Achlys triphylla*), broad-leaved starflower, and wall lettuce (*Lactuca muralis*). Most of the bigleaf maple observed on Savary Island have a columnar growth of tall, unbranched trunks rising high before branching out into the canopy, the result of competition for light with other trees in this dense forest.

Houses built along the edge of the high bank, and associated openings, create gaps in an otherwise continuous forest. New clearings are evident along this edge. Openings, whether anthropogenic or natural, alter the landscape. These openings may facilitate the establishment of non-native species, especially when occurring next to a house, road, or trail, or they may simply provide opportunities for native species that favour these conditions. A semi-open area on the bluff at the west end of the sand dunes, that was at least partly created by the establishment of a nearby house and garden plot, supports an abundance of bitter cherry amongst a dense undergrowth of salal (80 per cent cover) and a few arbutus.

The high bluff represents edge habitat along the top of the bank. This edge habitat is typically different in terms of plant species composition and growth. Wind, sunlight and precipitation have a greater influence on plants along the edge than those in the interior of the forest. Light and moisture levels are different between the two areas. As the high bluff area retreats, this forest edge will be lost, but a new edge will be established within an area of the current interior forest. The current interior forest will therefore be subjected to new elements and environmental pressures. Features such as forest insularity will be lost and reduced, but new opportunities for plants and animals will be also created.

In addition to providing valuable resources for animals, the vegetation along the bluff crest is crucial for maintaining the physical integrity of this landform. The vegetation provides the only means of soil stabilization and may prevent or delay the earth from sliding or slumping (Myers 1993). The largest trees and shrubs provide a network of roots that penetrate the soil much deeper than do the roots of small shrubs and herbaceous vegetation.

The preservation of bluff crest vegetation will help reduce erosion and the potential for slope failure, though ultimately, since the bluffs are being undercut by wave action, their failure is inevitable. Vegetation along the bluff slope will have similar benefits but the same ultimate fate. Bluff crest vegetation also provides a screening affect, reducing the penetration of wind-born sand to the interior portion of the island.

4.1 Plant Restoration and Maintenance: Bluff Crest and Slope

Restoring vegetation on the bluff crest is much easier than restoring vegetation on a bluff slope. A slope greater than 1.5:1, or 33 per cent, is too steep for successful restoration. Slopes less than this can be planted with herbaceous species, shrubs and small trees. Large trees are not recommended for planting on the slope. If large trees are blown over, their rootwads create areas of loose, open soil that may greatly exacerbate erosion problems.

Slope stabilization with plants should incorporate plant species native to Savary Island. Although introduced species may perform well, they tend to displace native plants and reduce opportunities for native animals. (See discussion of Scots broom, Section 2.4, Steep Non-forested slopes.) Table 3 lists a few suitable native trees and shrubs for restoring vegetation on bluff slopes and crests. Nursery stock should be obtained from plants grown in the area. Early spring and late fall, while the plants are dormant, are the best times for planting.

Table 3. Some suggested plant species for bluff slope and bluff crest plantings.

common name	scientific name	crest	slope
Trees			
Douglas maple	*Acer glabrum* var. *douglasii*		•
bigleaf maple	*Acer macrophyllum*	•	
red alder	*Alnus rubra*	•	
Pacific crab apple	*Malus fusca*	•	•
shore pine	*Pinus contorta* var. *contorta*	•	
bitter cherry	*Prunus emarginata*	•	•
Douglas-fir	*Pseudotsuga menziesii*	•	
western yew	*Taxus brevifolia*	•	
Shrubs			
Saskatoon	*Amelanchier alnifolia*	•	•
kinnikinnik	*Arctostaphalos uva-ursi*		•
oceanspray	*Holodiscus discolor*	•	•
tall Oregon-grape	*Mahonia aquifolium*	•	•
mock-orange	*Philadelphus lewisii*	•	•
red-flowering currant	*Ribes sangineum*	•	•
Nootka rose	*Rosa nutkana*	•	•

common name	scientific name	crest	slope
thimbleberry	*Rubus parviflorus*	•	•
salmonberry	*Rubus spectabilis*	•	•
Sitka willow	*Salix sitchensis*	•	•
coastal red elderberry	*Sambucus racemosa* ssp. *pubens* var. *arborescens*	•	•
evergreen huckleberry	*Vaccinium ovatum*	•	•

Some degree of plant restoration in clearings will occur naturally. Decisions will have to be made regarding the suitability of certain plants that establish naturally. For example, Douglas-fir growing on slopes may not be suitable and will have to be monitored and possibly removed. Due to the size of Douglas-fir, it should be monitored on crest plantings, and preferably established inland from the crest edge. Exotics (non-native plants) such as Scots broom that begin to establish (seedlings, etc.) should be removed. Well-established exotic plants on the crest and the slope contribute to soil and slope stability and therefore should not be removed without careful consideration. The best option in such a case may be to inter-plant with native species.

Commercially available "wildflower" mixes should not be used because they contain a high percentage of weedy, non-native plants that establish well under a broad range of conditions. They are therefore a great potential threat to the native plants of Savary Island. Rose campion (*Lychnis coronaria*), an example of such a plant, was seen in a number of foredunes, and at the edge of the abandoned airstrip. It is an attractive ornamental that often escapes gardens or is planted to liven up "barren" areas such as the foredunes, which upon closer inspection are often not barren at all. Many of the plants that grow in these difficult conditions are simply small and sparsely distributed, and no less beautiful than their big, bold exotic surrogates.

Fertilizer in the form of spikes or pellets inserted into the soil beside the root mass may help the early establishment of planted trees and shrubs. Commercially available broadcast fertilizers (granular fertilizers) may help herbaceous plants but will likely provide the most benefit to non-native weed species, resulting in a proliferation of exotic plants at the expense of native species. It could completely change the natural plant species composition within sand and dune areas in which important native species with special adaptations to low nutrient and moisture requirements thrive. Any application of fertilizer must therefore be considered very carefully. The best course to follow is simply to plant and encourage native species that are suited to the conditions present.

Myers (1993)[13] offers wise advice regarding prevention: "No amount of slope disturbance followed by replanting should replace rational site planning when it comes to avoiding slope disturbances. Should you have the option, maintain all the native vegetation you can and potentially accept the natural retreat of the slope crest. Accordingly, you should plan the location of your residence carefully. Maintaining a greenbelt along slope crests is good

[13] See Section 10.0 Literature Cited for internet access to this publication and its companion publication (Menashe 1993).

practice. Do not assume cutting trees to "unweight" your slope is beneficial to slope stability – often it is not. Also, remember as a general rule, do not introduce water onto or into your slope."

5.0 Indian Springs

Indian Springs (DG-4) is located just west of the central dunefield in one of the most narrow sections of Savary Island (~ 450 m). Its boundaries, as indicated on the Development Guideline Areas Map, run between the north and south banks of the island, between Cunningham Road on the west, and Henderson Road on the east. This area comprises approximately 6.75 ha, but its actual size and its boundaries are difficult to confirm.

The land slopes sharply upwards to the west of Indian Springs. The general trend is a decrease in elevation from the south and the west towards the north and the east. The north and south edges of the island are steep bluffs with heights of approximately 40 m on the south, and 24 m on the north.

The actual spring outlet is located on the face of the north bluff. Water seeps into a small pool which drains through a plastic pipe. Two trails from the top of the bank lead to this water source where locals come to fill their buckets. One local resident wondered about the water quality and how it might be affected by the recent introduction of septic fields on nearby lots. A large portion of Savary Island Road, which runs along the top of this bluff, has collapsed.

Trees along the bluff on either side of the spring outflow are predominantly deciduous, suggesting recent and possibly intermittent disturbance. The understory and shrub vegetation is typical of abundant ground water. Red alder, some as large as 0.75 m dbh, is the most common tree along the bank in the Indian Springs area where the forest is rather uniform in species and structure. A large western redcedar and a large Douglas-fir are present there, and they become the dominant species on the bluff to the west and the east. This deciduous-dominated forest extends approximately 75 m on either side of the spring outflow pipe. Salmonberry dominates the understory from mid-level to the bottom of the bank, while salal is abundant in the top portion. Thimbleberry (*Rubus parviflorus*) and coastal red elderberry (*Sambucus racemosa* ssp. *pubens* var. *arborescens*) are also present in the lower portion.

The small understory plants observed in the area near the spring outflow are indicative of moist, water-receiving and water-draining sites: miner' -lettuce (*Claytonia perfoliata*), Siberian miner's lettuce (*Claytonia sibirica*), wall lettuce, mountain sweet-cicely (*Osmorhiza chilensis*), sweet-scented bedstraw (*Galium triflorum*), fringecup (*Tellima grandiflora*), common horsetail (*Equisetum arvense*), spiny wood fern (*Dryopteris expansa*), and sword fern (*Polystichum munitum*). Mosses found near the outflow are typical of the wet conditions: *Plagiothecium denticulatum*, *Rhizomnium glabrescens*, and *Eurynchium praelonga*.

Approximately 50 to 75 m east of the spring outflow is an area of dense shrubs and few trees. A few logs and recently felled western redcedars are scattered on the slope. It appears that this area has either naturally sloughed away or has been cleared of trees which exacerbated sloughing and caused blow-down. Salal and thimbleberry are abundant in the upper levels of the bank, while salmonberry and coastal red elderberry are common in the mid and low levels. Douglas maple (*Acer glabrum* var. *douglasii*) is also present in the lower area at the west edge of this clearing.

The upland portion of Indian Springs adjacent to and south of Savary Island Road is a dense forest consisting primarily of very tall Douglas-fir, with a few tall red alder and bigleaf maple. Small western hemlocks (~ 3 m) are very abundant in the understory. The shrub layer and understory consists mainly of salal, red huckleberry and sword fern. Western buttercup (*Ranunculus occidentalis*), wall lettuce, mountain sweet-cicely and pathfinder (*Adenocaulon bicolor*) are present at the forest edge. Other portions of the forest comprising DG-4 consist of large western redcedar, western hemlock, Douglas-fir and bigleaf maple. Common understory plants include salal, dull Oregon-grape, evergreen huckleberry, sword fern, bracken fern and vanilla leaf.

Based on this cursory examination of the area, it is difficult to determine specific ecological features that may define the Indian Springs upland (DG-4) and differentiate it from surrounding areas. Differences in plant species composition in the forest may provide clues, such as an increase in the number of western redcedar, but rigorous, systematic sampling is required to make reliable inferences. The lack of arbutus within DG-4, and the presence of western redcedar, western hemlock, red alder and bigleaf maple, may help to distinguish this area from others such as the dune ridges, but not from other areas of the island with similar species composition.

The abundance and concentration of plants associated with high levels of soil moisture found along the north bluff, was not observed elsewhere on the island. It is one of the few areas dominated by deciduous trees. (Red alder dominates some forests on the island, such as the area near Savary Shores, but understory vegetation is different and less diverse, consisting mainly of sword fern.)

6.0 Indian Point

The Development Guideline Areas Map shows an Ecologically Sensitive Area (DG-2-E) at the northeast tip of Indian Point. Field investigation revealed an area in the backshore with a dense growth of dunegrass (*Leymus mollis*) and open areas of large-headed sedge, entire-leaved gumweed, northern wormwood, and American searocket (*Cakile edentula*) near the backshore-foreshore interface. The area of greatest open sand (60-70%) and greatest abundance of large-headed sedge, entire-leaved gumweed, and northern wormwood, extends approximately 75 m northwest from the forest at the south end of the east side of Indian Point. Dunegrass and American searocket are most abundant along the ridge between the foreshore and backshore. Beyond this 75 m, stretching around to the north point, dunegrass and Scots broom become dominant, although intermittent small open areas with large-headed sedge persist.

The residents in homes fronting this area have created tidy, narrow trails to the beach which restricts traffic and prevents trampling of vegetation in the sensitive areas between them. The dune species persist in the areas between the paths, but many of the species noted in the foredunes along the south shoreline (such as D.L. 1375) were not noted at Indian Point.

An early successional dune area that is not marked on this map is located along the west side of Indian Point (Bawtinheimer and Roemer 2000; BC Government Air Photos). Roemer (Bawtinheimer and Roemer 2000) describes this site as gently sloping, 60-80 per cent open sand, with nearly flat dunes in the earliest stage of dune succession. From air photos, it appears to extend approximately 500 m from the northwest tip of Indian Point and reaches its greatest width of 50 m within the south half, but its exact characteristics were not confirmed in the field. Nonetheless, because of the fragility and rarity of these dune formations, its extent should be confirmed, and it should be considered for designation as an Ecologically Sensitive Area (DG-2).

7.0 Mace Point Rock Outcrop

The only area of outcropping bedrock on Savary Island is at Mace Point (formerly Green's Point) at the northeast tip of the island. It comprises less than 2 ha. (Eis and Craigdallie 1977). Rock outcrops support distinctive vegetation communities that are easily damaged by trampling. Some plants recorded here such as grassland saxifrage (*Saxifraga integrifolia*), small-flowered alumroot (*Heuchera micrantha*), and fern-leaved desert parsley (*Lomatium dissectum*) (Stanley 1980) may not be present elsewhere on the island. The only recorded garry oak (*Quercus garryana*) on the island is located on this rock outcrop. Savary Island is close to the northern limit of this species' range.

A forest dominated by large Douglas-fir extends to the outermost open areas of the rock outcrops. At this forest's edge, in the shallow soil of the slopes and between the rock outcrops, salal, oceanspray, and tall Oregon-grape are very abundant. Trailing blackberry, sword fern, and bracken fern also occur in this area, and in depressions between rock outcrops with Saskatoon (*Amelanchier alnifolia*) and common snowberry (*Symphoricarpos albus*). Sword fern, Indian-pipe (*Monotropa uniflora*), Pacific sanicle (*Sanicula crassicaulis*), and wall lettuce (*Lactuca muralis*) grow in the forest edge.

Scots broom and sweet vernalgrass grow together in great abundance on some of the outer rock outcrops. Other plants observed among the rock outcrops included red columbine (*Aquilegia formosa*), coastal strawberry (*Fragaria chiloensis*), nodding onion (*Allium cernuum*), and harvest brodiaea (*Brodiaea coronaria*). A variety of mosses grow on the bare rock of the rock outcrops and rock faces, while others thrive on small accumulations of organic matter on rock or in depressions within and between the rocks (Table 4). Wallace's selaginella (*Selaginella wallacei*) is present amongst the mosses.

Table 4. Mosses growing on the rock outcrops.

on bare rock
Bryum capillare, Dicranum scoparium, Eurhynchium sp., Hypnum cupressiforme*, Isothecium stoloniferum, Racomitrium aciculare, Ulota phyllantha**
on organic matter
Bryum capillare, Dicranum scoparium, Ditrichum heteromallum, Eurhynchium oregana, Isothecium stoloniferum, Leucolepis acanthoneuron, Plagiothecium denticulatum, Polytrichum commune, Polytrichum juniperinum, Eurynchium praelonga, Racomitrium canescens (s.l.), Racomitrium lanuginosum, Rhizomnium glabrescens, Rhytidiadelphus loreus, Rhytidiadelphus triquetris

* - confirmed by Dr. Wilf Schofield, Professor Emeritus, UBC Department of Botany

False lily-of-the-valley (*Maianthemum dilatatum*) is very abundant on the lower slopes of the northeast portion of the point. In the lowest areas along the shoreline in the northeast portion of Mace Point, yellow monkey-flower (*Mimulus guttatus*), coastal pearlwort (*Sagina maxima*), miner' -lettuce, and seashore bluegrass grow in the crevices of the rock face. Pacific hemlock-parsley (*Conioselinum pacificum*), entire-leaved gumweed, and the introduced perennial sow-thistle (*Sonchus arvensis*) and broad-leaved peavine (*Lathyrus* *latifolia*), are present at the base of the rock face. Sea plantain (*Plantago maritima* ssp. *juncoides*) grows on low ledges just above the shoreline.

Despite signs of disturbance, the rock outcrop supports a variety of native vascular plants and bryophytes that form plant communities restricted to coastal rock outcrops. Further study would help to reveal its ecological significance within Savary Island, the CDFmm, and the surrounding area. This area should be considered for designation as an Ecologically Sensitive Area because of its uniqueness and fragility.

8.0 Animals

No formal surveys were conducted for animals. All observations of animals were noted during field work by SEC. These included animals observed along the shore (birds, mammals, reptiles), offshore (birds, mammals), and along the coastline and interior of the island (birds, mammals and reptiles). The sandy substrate of the interior and foreshore dune areas provided excellent sunning sites for garter snakes (*Thamnophis sp.*). They were very abundant in May along the sandy trails in the dunes near the airstrip, on the bluff to South Beach, and along the lower edge of the foredunes (DG-2-F and DG-2-G). Garter snakes (probably western terrestrial garter snake (*Thamnophis elegans*)) also frequent the south shore where one was seen among the shoreline rocks and water, and an unfortunate individual (~0.6 m) was causing problems for great blue heron (*Ardea herodias*) attempting to swallow it head first. The heron eventually won the battle!

Numerous holes are present in the vertical and near-vertical, sandy bluff faces on the south and north shores. Belted kingfishers (*Ceryle alcyon*) and northern rough-winged swallows (*Stelgidopteryx serripennis*) use these burrows for nesting. Although no belted kingfishers were seen entering or exiting the burrows, the large diameter of the burrows, the way in which the earth was worn around the hole, and the presence of stains extending beneath the hole, indicate probable nesting. A cliff swallow was observed exiting a hole near Second Point. The hole was probably excavated by a kingfisher.

The numerous large Douglas-firs on Savary Island provide excellent nesting and perching trees for bald eagles. A number of nests were noted on the island, and these are indicated on local maps highlighting natural features. An impressive graphical map highlighting the natural features of Savary Island was produced by the Savary Island Land Trust and is present on their web site (www.silt.ca). It features some plants and animals not noted in this report.

The following lists provide selected information on the animals observed on Savary Island during field work for this study conducted by SEC May 6 - 9, 2002, and from supplemental information gathered during an informal visit (vacation) to Savary by SEC's principal, July 13 to 20, 2002. Additional information is available in other studies which are cited, and their lists of animals are not reproduced here. Other sources of information such as personal communications are noted.

8.1 Birds

No formal surveys of birds were conducted during field work for this report, but all birds observed were recorded. Birds listed in Appendix 3 were recorded during May and July of 2002 by SEC. Their occurrence on Savary Island during these periods is described as *very common*, *common*, or *uncommon*. These descriptors are not associated with specific ranges of abundance, but represent an estimate of commonness (likelihood of being observed) based on a limited number of observations from these two periods.

8.2 Mammals

The two mammals seen most frequently are black-tailed deer (*Odocoileus hemionus columbianus*) and Douglas' squirrel (*Tamiasciurus douglasii*). Harbour seals (*Phoca vitulina*) were common on haul-out rocks along the south shore. A river otter (*Lontra canadensis*) was also seen in the water off the south shore. A female and young bat (possibly little brown myotis (*Myotis lucifugus*)) were reported roosting in a cabin.

8.3 Reptiles

In May, garter snakes (*Thamnophis* sp.) were very abundant in open sandy areas of the dunes, the bluffs, and along the shoreline. Fewer were observed in July, and most of these were observed foraging amongst the rocks on the beach. Common garter snake (*Thamnophis sirtalis*) and northwestern garter snake (*Thamnophis ordinoides*) are the species most likely to occur on Savary Island, but western terrestrial garter snake (*Thamnophis elegans*) may also occur.

Liz Webster (pers. comm.) reported seeing a northern alligator (*Elgaria coerulea*) on the south meadow of DL 1375.

8.4 Amphibians

No amphibians were seen during field work for this report.

8.5 Invertebrates

Numerous seashore organisms were seen during field work: cnidarians (jellyfish); mollusks (Japanese mud snails (*Batillaria attramentaria*), bivalves (oysters, mussels, clams)); arthropods (crustaceans: crabs); and echinoderms (sand dollars, starfish).

Dunster (2000) lists four Red- and Blue-listed butterflies which may occur on Savary Island based on information regarding their distribution, habitat, and plant preferences. None of these has been recorded there. Other species of butterflies and invertebrates such as dragonflies and damselflies, might be discovered with further field work.

Sherman (1931) notes the presence of a fly (*Cuterebra froutauella*) which he believed to be parasitic on Douglas' squirrel. He believed that this fly and domestic cats introduced by summer residents, were decimating the population of Douglas' squirrels. The status of the fly is unknown, but the squirrels persist!

The B.C. Conservation Data Centre has no records of Red- or Blue-listed animals for Savary Island.

9.0 The Future

The distinct vegetation communities and viable populations of native plants and animals may persist as the shores of Savary Island are slowly eroded. Areas of open, unconsolidated sands in the backshore will be washed away, but new, similar, areas will be created by erosion and the sloughing of the uplands. The failure of the slopes that support herbaceous species, shrubs and trees will result in barren areas — slopes, mounds, and sand flats — that plants from adjacent and nearby sites will colonize.

The greatest threat to the ecology and biodiversity[14] of Savary Island in the short term (~100 years) is people. The persistence of communities of native organisms, and the natural restoration of disturbed sites resulting from shoreline failure, will be influenced greatly by the people on the island through physical processes such as trampling and vegetation clearing, and ecological processes such as the introduction of non-native organisms, particularly plants. This point is not intended to suggest that people be excluded from the ecosystems of Savary Island (although this may be appropriate for small areas of greatest sensitivity), and it is not intended to heap all the blame on people. Natural processes play a major role through small and catastrophic events that influence the ecology of Savary Island. The key point is that humans, *like other organisms*, influence their environment, and that humans, *unlike other organisms*, can exert a conscious influence on how they do so.

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[14] biodiversity – literally, the "diversity of life." The word has been used in many different ways. "The difficulties in defining biodiversity 'originate' from the general character of the term: it is a descriptive, but simultaneously an abstract and descriptively complex term." (Haila and Kouki 1994). The key to the term is "heterogeneity" a characteristic implicit in e cosystems (Haila and Kouki 1994). The three oft-cited components of biodiversity are genetic, species, and ecosystem. Scale is also an important component of biodiversity. From Soule and Terborgh (1999):

> *Biodiversity is the "variety and variability among living organisms and the ecological complexes in which they occur" (U.S. Office of Technology Assessment 1987). The term encompasses not only all species everywhere, but the variations in the compostion, structure, and functional process of the ecosystems in which they live. Noss (1990) described an integrated biological hierarchy for biodiversity that recognized four components: genetic; population-species; community-ecosystem; and landscape or regional.*

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11.0 Personal Communications

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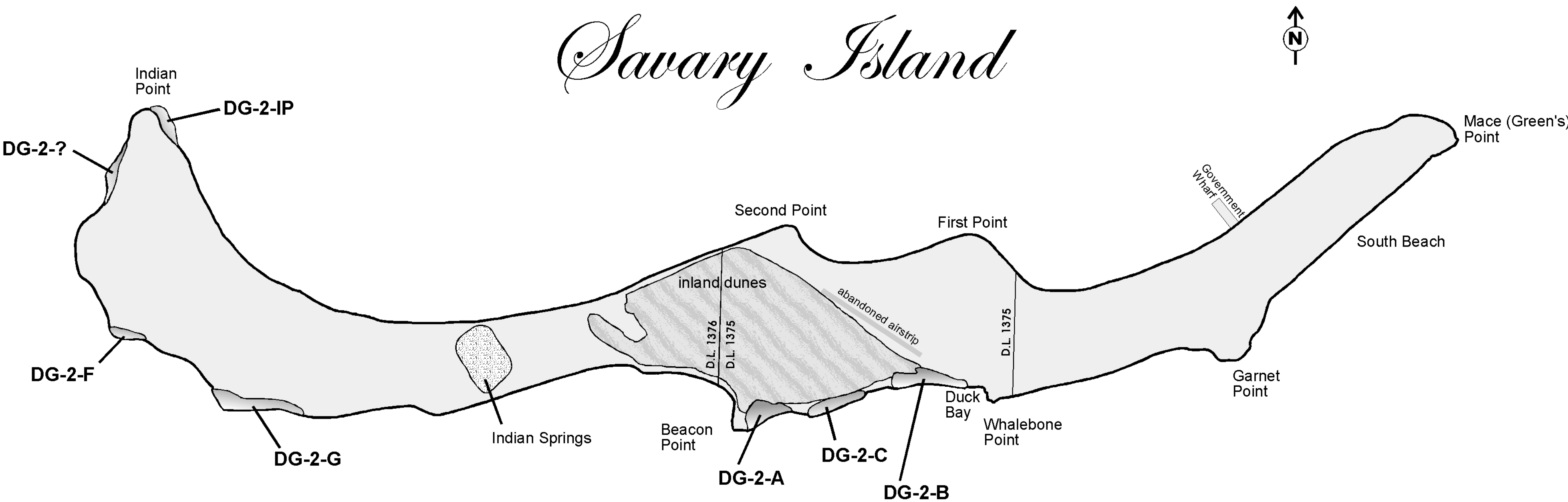
Liz Webster, Savary Island Land Trust.

Appendix 1 – Map



Appendix 2 – Elementary Statistical Details, Vegetation Plots

Inland Dune Area (DG-3)

Average depth for 8 plots
6.8, 7.0, 7.2, 2.2, 6.0, 4.6, 6.8 and 5.8 cm.

Total average depth for 8 plots (n = 40)
5.8 cm

Standard Deviation for 8 plots (n = 40)
4.4 cm

Range of depth for 8 plots
1 to 20

Non-Dune Area (2 plots northeast of dunefield, 1 plot west of dunefield)

Average depth for 2 NW plots
11.8, 14.2 cm

Total average depth for 2 NW plots (n = 10)
13 cm

Standard Deviation for 2 plots (n = 10)
6.1 cm

Range of depth for 2 plots
3 to 20

Average depth for 2 NW and 1 W plots:
11.8, 14.2, 6.8 cm

Total average depth for 2 NW and 1 W plots:
11.2 cm

Standard Deviation for 3 plots (n = 14):
6.0 cm

Range of depth for 8 plots:
3 to 20

Appendix 3 – Birds Observed on Savary Island, May 6-9 and July 13-20, 2002.

common name	scientific name	when observed	where observed	frequency of observation
American pipit	*Anthus rubescens*	*May*	*south shoreline*	uncommon (1 seen)
American robin	*Turdus migratorius*	*May, July*	*various*	very common (seen, heard)
bald eagle	*Haliaeetus leucocephalus*	May, July	adults and immatures seen frequently, mostly along shoreline, nests present	common (seen, heard)
barred owl	*Strix varia*	July	– two immature – hissing call from near Eric and Juanita's house (east central island)	uncommon (seen, heard)
belted kingfisher	*Ceryle alcyon*	July	various – mostly along shoreline – excavated nest holes in vertical face of bluff (not observed using holes)	common (seen heard)
Bewick's wren	*Thryomanes bewickii*	May, July	various – forest edge airstrip	uncommon (heard)
black-throated gray warbler	*Dendroica nigrescens*	May	various – forest	common (in May) (seen, heard)
Cassin's vireo	*Vireo cassinii*	July	various – forest – southeast of Indian Point	uncommon (heard)
chestnut-backed chickadee	*Poecile pubescens*	May, July	various – forest, forest edge	common (seen, heard)
common loon	*Gavial dimmer*	May	offshore	uncommon (seen)
common merganser	*Merges merganser*	May	offshore	uncommon (seen)
common raven	*Corvus corax*	May	forest	uncommon (seen, heard)
European starling	*Sturnus vulgaris*	May	forest	uncommon (1 seen)
glaucous-winged gull	*Lars glaucescens*	May, July	beach	common seen, heard
golden-crowned kinglet	*Regulus satrapa*	May	forest	uncommon (seen, heard)
great blue heron	*Ardea herodias*	July	south shore, feeding among rocks, seen individually	common (not abundant) (seen)
greater or lesser yellowlegs (probable)	*Tringa melanoleuca* or *Tringa flavipes*	May	south shore	uncommon (1 seen at great distance)
hairy woodpecker	*Picoides villosus*	May	forest	uncommon (1 heard)
harlequin duck	*Histrionicus histrionicus*	May	south shore - offshore	common (in May) (seen)
Hutton's vireo	*Vireo huttoni*	May	forest - Indian Springs area	uncommon (1 heard)
killdeer	*Charadrius vociferus*	July	south shore, Duck Bay	common (one area) (max of 6 seen together)
least sandpiper	*Calidris minutilla*	July	south shore, Duck Bay mud flats and among rocks	common (one area) (10 seen)
long-billed dowitcher	*Limnodromus scolopaceus*	July	south shore, Duck Bay (July 20) 2 feeding in the soft mud/sand and vegetation along the high tide line	uncommon (fall migrant) (seen, heard)
merlin	*Falco columbarius*	July	Indian Point (July 20) very noisy (disturbed), flying above large trees	uncommon (seen, heard)
northern flicker	*Colaptes auratus*	May, July	various – near airstrip	common (not abundant) (seen, heard)
common name	**scientific name**	**when**	**where observed**	**frequency of**

		observed		observation
northern rough-winged swallow	*Stelgidopteryx serripennis*	July	various – airstrip, north and south shore. 1 seen flying out of hole (~10 cm) in sand bank near Second Point	common (seen)
northwestern crow	*Corvus caurinus*	May, July	various	very common (seen, heard)
orange-crowned warbler	*Vermivora celata*	May	airstrip	uncommon (1 heard)
Pacific-slope flycatcher	*Empidonax difficilus*	May, July	forest, throughout the island	very common (heard, seen)
pigeon guillemot	*Cepphus columba*	July	offshore, N of Indian Point	uncommon (seen)
pileated woodpecker	*Dryocopus pileatus*	May, July	abundant sign (excavations) throughout island	common (not abundant) (heard in May) (sign)
pine siskin	*Carduelis pinus*	May, July	throughout island	common (seen, heard)
red crossbill	*Loxia curvirostra*	July	conifer forests throughout island	common (seen, heard)
red-breasted nuthatch	*Sitta canadensis*	May, July	throughout island	uncommon (heard)
ruby-crowned kinglet	*Regulus calendula*	May	forest, uncommon	uncommon (heard)
rufous hummingbird	*Selasphorus rufus*	May, July	various, airstrip, interior openings	uncommon (seen, heard)
savannah sparrow	*Passerculus sandwichensis*	May	south shore	uncommon (seen, heard)
song sparrow	*Melospiza melodia*	May, July	shrubs and small trees along shore and bluff crest 1 seen carrying food July 13th at bluff crest E of Duck Bay	common (seen, heard)
spotted towhee	*Pipilo maculatus*	May, July	throughout island 1 immature and adult seen on bluff crest E of Duck Bay, July 13	very common (seen, heard)
Townsend's warbler (?)	*Dendroica townsendii*	July	possibly – heard July 20th in forest of Indian Point	unconfirmed observation (heard ?)
turkey vulture	*Cathartes aura*	July	observed circling over north shore, July 18 and over Indian Point, July 19	uncommon (seen)
varied thrush	*Ixoreus naevius*	May	forest	common (not abundant) (heard)
warbling vireo	*Vireo gilvus*	July	forests, inland	uncommon (heard)
western sandpiper (?)	*Calidris mauri*	May	flock on shores of Indian point (probable)	unconfirmed (seen at distance)
willow flycatcher	*Empidonax trailii*	July	airstrip	uncommon (seen, heard)
winter wren	*Troglodytes troglodytes*	May, July	forest, various locations	common (heard)
yellow-rumped warbler	*Dendroica coronata* ("Audubon's")	May, July	forest, shoreline	uncommon (seen, heard)

Appendix 4 – BC Conservation Data Centre Report

Georgia Basin Ecosystem Initiative.
B.C. Conservation Data Centre Site Report
Savary Island Dunes

Source file (savary-sbr.doc) provided March 6, 2002 by BC Conservation Data Centre.

Photo 1 - Looking west along the south shore bluffs between Sutherland Road and Cunningham Road. Glacial drift with apparent boulder till-like soil forms a near-vertical face at the top of the bluff overlying beds of Quadra Sand.

DNR 105-8, 9
106-10, 11

Photo 2 - Looking north at the south shore bluffs between McLean Road and Sutherland Road. Slumps and planar soil landslides are promoted by groundwater discharge in the Quadra Sand. Lines of lush vegetation define seepage zones higher on the slope.

Photo 3 - Looking north at a gully on the south shore near the end of Sutherland Road. A recent slide has taken place, initiating on the east side of the gully head. Slide debris from past events has built up a debris cone at the base of the slope.

Photo 4 - Looking north at the erosion face in Quadra Sand on the west side of Garnet Point. Eroded sand accumulates at the base of the slope and is removed by wave action. Intense erosion here is ascribed to refracted storm waves from the southeast. The Geological Survey of Canada measured 0.38 m of bluff crest retreat in 1 year at this location.

NOTES

1. Bluff and shoreline erosion areas shown on drawing are approximate and mapped by field observations and aerial photo interpretation primarily by lack of vegetation. Only larger, active areas are shown.
2. For estimated or measured shoreline and bluff crest erosion rates, see Dwg. 14–197–0–2.

DESIGNED RFG	Powell River Regional District
DRAWN KM	ACTIVE BLUFF EROSION AREAS AND SHALLOW AQUIFER AREAS
DATE March 12, 2003	
APPROVED	
SCALE 1:10,000	Savary Island Dune and Shoreline Study

THURBER
DWG. NO. 14–197–0–1

March 12, 2003
VE01373.DWG

LEGEND

- ○ Bluff erosion
- □ Shoreline erosion
- 0.19 m/yr (typ.) Average rate of erosion over period of record

SOURCE OF INFORMATION

1. Klohn Crippen, 1993
2. Bornhold et al, 1996
3. Golder, 1999
4. Thurber, 2001
5. McElhanney, 2002

NOTES

1. Refer to Section 4 of report for explanation of analysis procedures to establish erosion rates. In particular, the McElhanney (2002) analysis using airphotos to establish the bluff or shoreline location over a 32 year period is estimated to be accurate to +/− 1 m.

DESIGNED RFG	Powell River Regional District	
DRAWN KM	ESTIMATED OR MEASURED EROSION RATES	THURBER
DATE March 12, 2003		
APPROVED		
SCALE 1:10,000	Savary Island Dune and Shoreline Study	DWG. NO. 14-197-0-2

March 12, 2003

VED01374.DWG

LEGEND

- - - - - Setback from bluff crest for 50 year horizon (in metres)

— — — Setback from bluff crest for 200 year horizon (in metres)

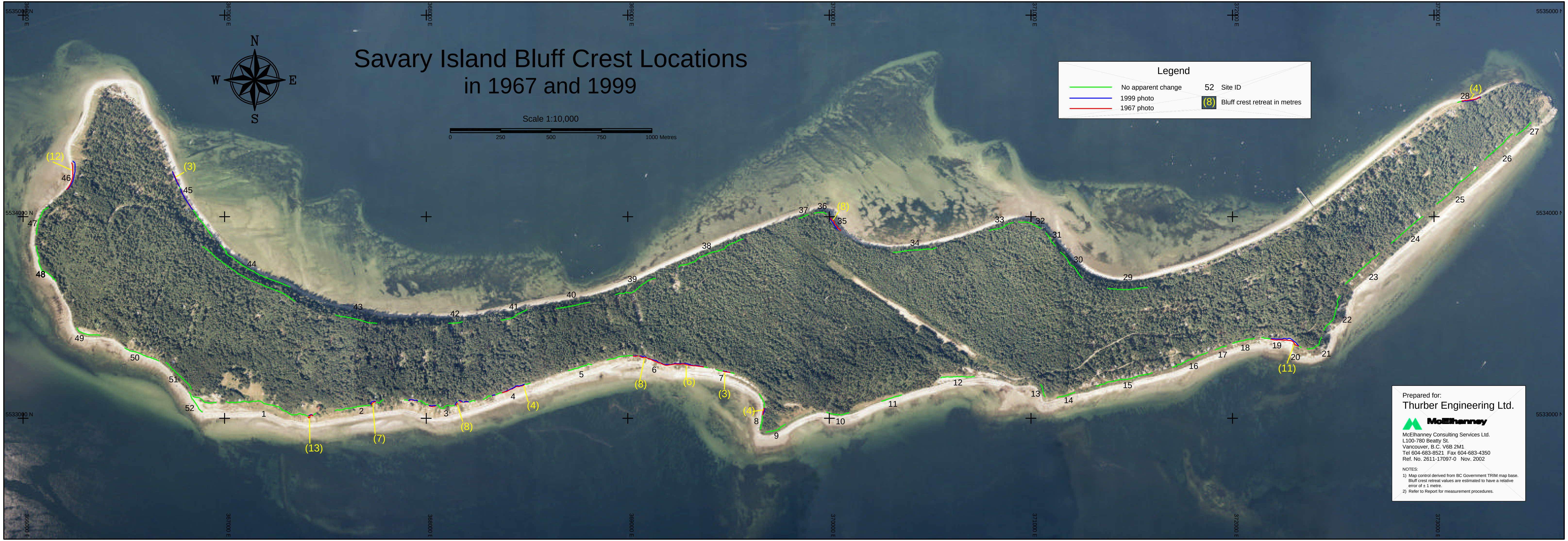
NOTES

1. Recommended setbacks are from current (2003) bluff crest or natural boundary.
2. Setbacks must be defined by survey using criteria presented in Section 5.4 of report.

DESIGNED DS	Powell River Regional District	THURBER
DRAWN KM	RECOMMENDED BUILDING SETBACKS	
DATE March 12, 2003		
APPROVED		
SCALE 1:10,000	Savary Island Dune and Shoreline Study	DWG. NO. 14-197-0-3

March 12, 2003

VED01375.DWG



Savary Island Bluff Crest Locations
in 1967 and 1999
N
S
E
W
Scale 1:10,000
0
250
500
750
1000 Metres
Legend
No apparent change
1999 photo
1967 photo
52 Site ID
(8) Bluff crest retreat in metres
Prepared for:
Thurber Engineering Ltd.
McElhanney
McElhanney Consulting Services Ltd.
L100-780 Beatty St.
Vancouver, B.C. V6B 2M1
Tel 604-683-8521 Fax 604-683-4350
Ref. No. 2611-17097-0 Nov. 2002
NOTES:
1) Map control derived from BC Government TRIM map base. Bluff crest retreat values are estimated to have a relative error of ± 1 metre.
2) Refer to Report for measurement procedures.
5535000 N
5534000 N
5533000 N
367000 E
368000 E
369000 E
370000 E
371000 E
372000 E
373000 E
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(7)
(13)
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(8)
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