**Government of Newfoundland and Labrador**
**Department of Natural Resources**
**Geological Survey**

**MEMO**

The Geological Survey received a request from Dr. Ray Gosine on October 19th to provide advice in assessing coastal change in the Long Point, Shoal Point, and Fox River areas of Port au Port Bay. The Geological Survey is monitoring rates of coastal change at over 110 sites across the Province, including sites in the area identified by Dr. Gosine. The coastal monitoring program is a long-term, province-wide program, and findings will aid in determining which areas are most vulnerable to erosion, flooding, and slope movement. This information can then be utilized by town planners and other stakeholders to prioritize mitigation efforts and guide planning decisions. Any recommendations are based on field observations and from geographic knowledge and experience.

Attached is a description of coastal change observed in the area of interest and recommendations for planning.

If you have any further questions or concerns, please contact me.

Sincerely,

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**Surficial Geology**

The Port au Port area was affected by the last (Wisconsinan) glacial period. Subsequent deglaciation started about 13,500 BP, at which time sea level on the Port au Port Peninsula was up to 65 m higher than the present day. The sediments deposited below marine limit (the highest elevation that the ocean reached) during this period of raised postglacial sea level consisted of sand, gravel, silt and clay, and are termed *glaciomarine* sediments. At about 9500 BP, sea level fell to 25 m below present-day sea level. During this period, there were two large ponds in what is now East Bay and West Bay. Wetlands formed between these two ponds, in the area of Shoal Point, and the remains of the wetlands remain today in the form of peat deposits (Batterson and Sheppard, 2000).

**Coastal Monitoring**

There are coastal monitoring sites in the following locations (UTM coordinates are Zone 21, NAD 83):

- The beach northeast of Winterhouse (Easting 358883, Northing 5396035)
- The cliff parallel to the main road in Boswarlos (Easting 365655, Northing 5381465)
- The eastern side of Shoal Point south of the cabin area (Easting 364483, Northing 5388765)
- The beach south of Point au Mal (Easting 376731, Northing 5389432)
- The cliff parallel to the main road in Point au Mal (Easting 375768, Northing 5393060)

Studies use topographic-survey equipment, specifically a Real Time Kinematics (RTK) instrument, which collects precise (centimetre-scale) location data. The RTK equipment comprises a stationary base receiver (referred to as a 'base station'), one or more roving receivers, and a radio link. The base station continually collects satellite signals of its static location, and determines positional errors caused by factors such as satellite orbit errors and tropospheric delays. These error values are transmitted to the roving receivers, allowing for the coordinates of the roving receivers to be corrected in real time, resulting in precise relative and absolute location data (Pardo-Pascual and Garcia-Asenjo, 2005).

Coastal features, including the clifftop and toe, and beach features, such as berms, were surveyed. Clifftops are identified by a distinctive edge, or by a break in slope on vegetated slopes not having a distinctive edge. Shore-normal beach transects were surveyed at beach sites, extending landward of any coastal processes to the water.

**Observations**

*Winterhouse*

The beach northeast of Winterhouse is composed of well-rounded cobbles and pebbles, with only a few boulders in the lower foreshore. The beach width ranges between 30 and 40 m and the beach face is steep with several beach berms. Landward of the beach there is a vegetated bank of unconsolidated material that has a low elevation (2-4 m). Shore-normal beach transects and the seaward edge of the coastal bank were surveyed in 2013 and 2014. Between the two years, the beach profiles showed minimal change and the position of the coastal bank has remained stable. Additional surveying is planned to assess the stability of the site over a five to ten year period.

The site is considered to be relatively stable for the following reasons:

- Compared to more sandy beaches elsewhere, the pebble and cobble beach at Winterhouse will be less vulnerable to coastal change from the impact of wind or waves.

- Waves generally do not reach the base of the slope at the back of the beach, limiting their erosion of the base of the slope.
- The vegetation on the bank helps to stabilize the slope.
- The boulders in the lower foreshore dissipate incoming wave energy.

*Shoal Point*

The unconsolidated cliff south of the cabin area on Shoal Point was monitored in 2014. The cliff is between 2 and 4 m high, and fronted by a beach 35 m wide, which is composed of sand, with pebbles in the lower foreshore. The cliff is eroding currently, as evident from the presence of slumps and gullying on the cliff face and observations suggest that erosion rates are higher than the provincial average. Historic rates of coastal erosion rates of unconsolidated cliffs in Newfoundland are up 1 m per year, with an estimated average of 15 cm per year.

Several factors make Shoal Point prone to erosion:

- The cliff at Shoal Point consists of glaciomarine sediments that are overlain by terrestrial peat, which is susceptible to erosion from water, and may slump when saturated.
- The lack of large rocks on the beach and in the cliff means that there is little opportunity for natural armouring of the cliff. Large rocks either on the beach face or at the base of the slope can dissipate incoming wave energy, or decrease the vulnerability to wave erosion.
- The site has a large fetch (>350 km) to the northeast, potentially allowing for large, high-energy waves to form. This is of particular concern when storms or storm surges occur during high tide, as the tidal range can be significantly increased by storm surges.
- Most of the slope lacks vegetation.
- The presence of seaweed along the base of the cliff indicates that during high-water events, waves can reach it, and these waves can remove sediment.

*Boswarlos*

Evidence of erosion along the coastal cliff in Boswarlos includes recent slumps, rills (shallow channels) in the cliff face, overhanging turf mats along the clifftop, and deposits of colluvium (material transported by gravity), overlying the beach sediment.

The following factors are responsible for the increased susceptibility of the area to coastal change:

- The cliff is composed of sand, clay, silt with some gravel, and this type of sediment is particularly susceptible to erosion from wind and water. The silt and clay are slumping to the base of the cliff and rills, created by the passage of surface water, are forming in the permeable sediments on the face of the cliff. Wind is removing sand from the cliff face and forming overhanging turf mats.
- The toe of the cliff has limited shoreline protection. There are only a few boulders at the base of the cliff and in the foreshore, and these boulders will dissipate incoming wave energy.
- The lack of vegetation on portions of the face of the cliff makes those portions more susceptible to erosion.
- The presence of seaweed along the base of the cliff indicates that waves reach this area, and can remove sediment from the toe of the slope.
- The coast is exposed to large waves from the northeast due to the large fetch (>300 km) in that direction.

*Beach, Point au Mal*
Currently, the beach at Point au Mal appears stable. Beach transects were surveyed in 2013 and 2014 and the profiles of these transects show minimal change.

The following characteristics of the beach are responsible for the current low vulnerability of the beach to erosion, except during high water events:

- The slope of the beach is shallow compared to other beaches surveyed. The potential for erosion from a storm is less on beaches with gentle slope, compared to beaches with a steeper gradient.
- The backshore is well vegetated with grass, which is stabilizing the sediment and decreasing the erosion potential of wind.
- The beach face is composed of cobbles and pebbles with only minor amounts of sand. The cobbles and pebbles are more erosion-resistant than the more vulnerable sand.
- The fetch is limited by Shoal Point, resulting in the area being protected from the impact of storms from the west.
- The spit is subject to inundation as a result of its low elevation (below 4 m).

*Cliff, Point au Mal*
The cliff at Point au Mal is eroding. This is evident from gullying, rills, overhanging turf mats along the top of the cliff, and the presence of recent slumps and colluvium deposits overlying the beach sediment at the base of the cliff. The average change for the measured interval between 2013 and 2014 was a recession of 62 cm/a, ranging from -22 cm/a (indicating advance) to 220 cm/a. These rates of erosion are only for an interval of one year, and may be higher or lower than the longer-term average, due to natural fluctuations in erosion rates. High recession rates along the clifftop are attributed to gullying, while advance is attributed to slumping of material over the cliff edge.

The area is highly susceptible to coastal change due to the following factors:

- The cliff is composed of clay, silt, sand, and gravel with some boulders. The sand layers are easily eroded by water and wind; the silt and clay are more resistant to erosion but will slump if undercut or saturated.
- The top layer of sediment contains cobbles and boulders. As the cliff erodes landward, these large clasts will roll down to the cliff base, and may provide protection from wave action to the toe of the cliff.
- Much of the slope lacks vegetation.
- The width of the beach is moderate compared to other beaches surveyed. The beach width was 15 m close to high tide (low tide at 5:40, high tide at 11:21, and site measured at 11:00). The presence of seaweed along the mid-beach face, and not the base of the cliff, indicates that waves do not regularly reach the toe of the slope.
- The coast is exposed to large waves and storms from the north and northwest due to the large fetch (>200 km) in those directions.

**Future conditions**

An important factor when assessing coastal change in the long term is the rate of relative sea level rise (the rate of sea level change relative to the land surface). During the last glacial period, the removal of the ice sheets caused the crust of the earth to rebound. This process is still occurring, resulting in the land rising in portions of the Province, and falling in others (which is the case for most of the Island). For

the Port au Port area, Batterson and Liverman (2010) project that by 2099, relative sea level will have risen between 90 and 100 cm compared to 1990 values. More recent projections (James *et al*., 2014) indicate that median relative sea level for Corner Brook (the closest community for which projections were calculated) will increase somewhat less: 73 cm in 2081-2100 relative to 1986-2005. Higher sea levels will increase the height of both extreme water levels and the high tide, resulting in heightened potential for coastal flooding further inland, and for increased erosion of the bases of cliffs.

Potential consequences of climate change that may increase erosion rates include the following (Finnis, 2013):

- Increased mean daily precipitation
- An intensification of precipitation events
- An increase in precipitation falling over consecutive days

These projected changes will increase the vulnerability to erosion of unconsolidated bluffs, due to an increase in surface run-off and groundwater flow. Projected warming air temperatures (Finnis, 2013) will likely result in warmer ocean temperature and a decrease in sea ice. The latter will result in an increase in the fetch, creating the potential for larger storm surges and waves (Barnhart, 2014). Furthermore, a decrease in the duration of sea ice will increase the period in which the shoreline is exposed to erosional processes associated with wind and waves.

**Implications for development**

Planning should take into account rates of cliff recession in the setting of coastal setback limits, defined as the distance from the shoreline within which development is either prohibited or restricted. Setback limits should aim for a 100-year planning time frame, and also ensure that episodic events are accounted for. The suggested setback limit is therefore two times the average yearly recession rate, times 100.

For Point au Mal, the average rate of recession between 2013 and 2014 was 62 cm per year; based on this figure, the recommended setback limit is 124 m. However, caution must be exercised when using this rate of recession as it is based only on one year of data, and a minimum of five to ten years of data are normally required for reliable estimates of coastal change. Recession rates are extremely dependent on local conditions, and a single storm can cause significant change. However, the recession rate measured is high, compared to other cliff environments in Newfoundland, and the cliff at Point au Mal has a high sensitivity to erosion. For Boswarlos and Shoal Point, additional data are required to quantity the rate of change, but site characteristics indicate the cliffs may be receding at rates similar to Point au Mal.

All terrain below the 4 m contour should be included in setback limits, as such low-lying terrain is subject to flooding during storm surges that occur during high tide, in particular in areas of rising sea levels.

Within setback areas, changes to the landscape, such as earth moving and vegetation removal, should be avoided. Modification of the ground surface, such as replacing natural vegetation with impervious surfaces like pavement, causes change to the flow and amount of groundwater, and the surface run-off, and removal of surface material can decrease the stability of a slope. Setback limits need to be reviewed at regular intervals in the light of continued data collection, to ensure that the appropriate distance is maintained, in particular in areas of accelerated recession rates.

**Summary**

There is evidence of coastal erosion at cliff sites examined at Shoal Point, Boswarlos and Point au Mal. Recession rates measured at Point au Mal are high (62 cm/a) and site observations from the other sites suggest that recession rates are elevated compared to the provincial average. The cliffs are made of unconsolidated, fine-grained material, have limited shoreline protection, and are only partly vegetated. The spit at Point au Mal is less than 4 m above sea level and is will become increasingly susceptible to coastal inundation due to rising sea levels. Setback limits, at a minimum of two times the yearly recession rate, times 100, are suggested for all coastal areas. These limits must be reviewed as additional data become available, and as the shoreline retreats.

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