Appendix 4

Detailed Terrain Analysis Report

Terrain Mapping

Introduction

Helliwell Park is located on the eastern peninsula of Hornby Island, British Columbia, within National Topographic System area 92F/10 at approximately $49^{o}31'$ latitude and $124^{o}35'$ longitude. The writer was asked to complete a preliminary terrain analysis as part of a terrestrial ecological mapping project of the park. This mapping of Helliwell Park, excluding Flora Islet, was completed during December 2000 and included three days field work.

Mapping control was provided by air photographs (5791 33-38 & 73-76) taken in July 1997, which are at a nominal scale of 1:5000. These photos are excellent quality, however, within the heavily treed portions of the park it was usually impossible to determine exact locations therefore pace and compass control was required. Procedures used and symbols employed during mapping are outlined on the government publications WEB site http://www.elp.gov.bc.ca/rib/wis/terrain/publications/hk/qua.htm. Geological discussions with Jim Aitken benefited the author.

Mapping symbols employed include texture prefix, surficial material, surface expression suffix and hyphenated soil drainage. Where identified, the major lithology of the bedrock was added in brackets at the end of the map symbol. Symbols used include:

Texture (lower case prefix)	
cobbles	k
pebbles	p
sand	s
silt	z
clay	c
humic	h
Surficial Material (upper case)	
colluvial	C
fluvial	F
rock	R
beach deposit	B
Surface Expression (lower case suffix)	
plain	p
rolling	m
gentle slope	j
hummocky	h

Surface Expression (lower case suffix) continued,	
moderately steep	k
steep	s
blanket	b
veneer	v
thin veneer	x
Soil Drainage (suffix after dash)	

rapidly drained	r
well drained	w
moderately well drained	m
imperfectly drained	i
poorly drained	p
Bedrock Lithology (in brackets)	
Gabriola Formation conglomerate	cg
Gabriola Formation sandstone	ss

Other than those symbols used for bedrock lithologies, and active beach deposits noted with a B, which were created by the author, an explanation of the above symbols can be found on the government WEB site. Examples of terrain symbols designated for Helliwell Park are: Rks (cg), bedrock composed of conglomerate with a moderately steep to steep surface; spkCpmb-m, colluvium composed of a blanket of sand, pebbles and cobbles with a plain to rolling surface and moderately well drained; sFjb-p, fluvium composed of a blanket of sand with a gentle slope and poorly drained. Symbols used which refer to the composition of surficial or bedrock material indicate only the major constituents present, minor components not considered to be essential to the designation of the unit may have been recorded but were not incorporated into the terrain symbol. Also, the structure of the terrain symbol only permits a certain number of symbols in each position, for instance, a maximum of three lower case letters can be used to designate texture.

Only the major elements of bedrock geology were mapped and outcrops are largely restricted to the park shoreline. Elsewhere, surficial deposits were examined by digging shallow pits; after noting features of the soil profile and materials encountered, the pits were backfilled. Thirty-two pits were dug; most were 30-60cm deep, a few as much as 90-100cm. Locations of test pits, and terrains having similar geological characteristics, are illustrated on Figure 1. Although the 2000 fall season was relatively dry compared to some years, there had been considerable precipitation prior to the field work being conducted. Accordingly, surficial deposits were wet and drainage characteristics somewhat difficult to estimate; the emphasis was placed on the development of the soil profile for determining soil drainage classes.

Geolgogy

Geology, glacial history, terrain and soils

All of Hornby Island, as well as adjacent Denman Island and portions of the northeast side of Vancouver Island, are underlain by sediments of the Nanaimo Group. This sequence of rocks is Late Cretaceous age, deposited between 87 and 66Ma. Nanaimo Group (Muller & Jeletzky, 1970; England & Hiscott, 1991) has been subdivided into numerous formations; the sediments underlying all of the eastern peninsula of Hornby Island, including Helliwell Park, have been assigned to the Gabriola Formation. Some authors (England, 1989) have used the name Hornby Formation, rather than Gabriola, to distinguish these sediments from similar units exposed on Gabriola Island. Gabriola is the youngest formation of the Nanaimo Group. The main rock types of the Gabriola Formation are deltaic deposits of sandstone, shale and conglomerate; conglomerate and sandstone outcrop along the shoreline and on the islands within Helliwell Park. Sedimentary beds of the Gabriola Formation in the park have been estimated by Muller and Jeletzky (1970) to be 180-240m thick; where bedding attitudes could be determined by the author, they strike northwest and dip 6-8o northeast. Composition of the sandstone beds is roughly 50% quartz, 30% feldspar, with the balance composed of dark minerals and rock fragments. Conglomerate is clast supported, that is, it is largely composed of pebble and cobble size clasts in contact with one another, with very little finer grained matrix between the clasts. The pebbles and cobbles are generally well rounded.

Glaciers filled the Strait of Georgia and covered Hornby Island to a depth greater than one kilometre as recently as 14,000 years ago (Clague, 1991; Halstead & Treichel, 1966). The weight of this ice sheet depressed the land below sea level. The ice gouged the land surface, removed rock and surface material, and brought in rock fragments from distant locations. As the glaciers retreated, fine and coarse grained material carried by the glaciers was deposited. Angular boulders 0.5-2 metres in diameter were dropped when the ice melted and are scattered over the surface of Helliwell Park. These erratics are composed of granitic or volcanic material and were derived from the Coast Mountains on the mainland or from Vancouver Island.

Along the shoreline of Helliwell Park, outcrops of Gabriola Formation sandstone and conglomerate form cliffs as much as 15m high. Small outcrops of conglomerate exist approximately 200m from the south shore on the access trail, and within the parking lot. The oldest Gabriola Formation unit in Helliwell is the sandstone exposed at the shore in the southwest corner of the park. This is overlain by a thick bed of conglomerate which forms most of the bedrock exposure along the shoreline. A slightly younger conglomerate bed is exposed as small outcrops in the parking lot and expressed on Figure 1 as the hRmx-w terrain unit in the northwest corner of the park. This conglomerate bed is possibly separated stratigraphically from the main conglomerate bed exposed along the south shore, by an unexposed, recessive sandstone bed. Overall, the conglomerate and sandstone beds underlying Helliwell Park form a gentle, northeast dipping homocline which is reflected in the topography and in turn is a major control on drainage.

Unconsolidated surficial deposits within the park comprise a thin layer of clay, silt (0.002-0.06mm), sand (0.06-2mm), pebble (2-64mm), cobble (64-256mm) and boulder (>256mm) size material. The thickness of this material in the park ranges from zero to greater than one metre; in the nomenclature for terrain mapping the thickness has been designated x (a thin veneer 2-20cm thick), v (a veneer 10-100cm thick), or b (a blanket >1m thick). A shovel was used to dig shallow pits into the surficial material, however, a thorough evaluation would require deeper penetration with a backhoe or drill. The dominant size fractions encountered during this brief survey were silt, sand, pebble and cobble. If any surficial deposit was encountered, a dark, chocolate-brown, organic-rich A horizon, 5-30cm thick, was invariably present. Surficial deposits greater than 20-30cm thick usually displayed an oxidized B horizon which ranged from a very subtle and weakly rusty, dark brown to a distinctly rusty, medium red-brown layer 20-40cm thick. A few pits encountered a deep layer of light to medium yellowish-buff-brown to grey-brown, often coarse grained material interpreted to be a C horizon.

In several locations sand comprised >80% of the profile and these terrains are designated F on the assumption that the material could be of fluvial derivation, or derived from sediments that have been reworked by streams. These sample sites are in the northern portion of the park and in each case are in low topographic areas, relatively close in elevation to present sea level, and usually coincident with present day, albeit subdued, drainages. Terrain units designated fluvial (F) are not extensive and two of the three have a linear pattern parallel to the drainage. Surficial material in the remainder of the sample locations, those areas not designated as fluvial or rock, has been termed colluvial on the basis that much of it, especially the coarser fraction, is locally derived and has simply migrated down-slope from its source. Pebbles and cobbles in this material are well rounded and compositionally similar to those in the underlying conglomerate; they were likely derived from the nearby bedrock. Cobbles and coarse pebbles are often more abundant at the bottom of dug pits, coincident with a C horizon if one was encountered, often common in the A horizon, but can occur at any depth. The derivation of sand-sized material in the colluvium is problematic. It likely represents glacial outwash, at least in part, but some could have been derived from the underlying Gabriola Formation, or from reworked sandy material deposited prior to the last glaciation. The most plausible explanation for the origin of surficial material (designated C) is that it is polygenetic, the pebbles and cobbles being locally derived and the colluvium with the sand, primarily a product of glacial outwash.

Terrain Units

A preliminary interpretation of terrain units, based on widely spaced sample sites, is illustrated on the Geology Map, Figure X. Boundaries between terrain units are approximate and may not be suitable for detailed planning purposes; depending on the application of the terrain data, more detailed sampling may be required. No two sample sites are identical and terrain units have been outlined on the basis of similarities of major parameters in adjacent sites.

A more or less continuous unit of bedrock (R) exists along the shoreline of the park; s, m and k suffixes simply indicate variations in surface slope. This unit has been subdivided into areas which are dominantly conglomerate (cg) or sandstone (ss). Discontinuous beds of sandstone, some as much as 2m thick, are often present in the exposures mapped as conglomerate. Topography in the bedrock terrain unit is often steep to cliff forming and as such is locally unstable; large blocks weighing many tonnes could break off at any time.

Immediately inland from the bedrock terrain unit is a continuous band across the southern part of the park, about 150-200m wide, which is designated hRmjx-w or hRhx-w. This unit could be termed subcrop as bedrock is very close to surface. Surficial material is generally less than 20cm thick and dominated by dark brown, organic-rich A horizon soil plus cobbles and pebbles. The cobbles and pebbles are derived from the Gabriola Formation and are believed to be close to their source. A few outcrops of sandstone were mapped at the west side of the park within this terrain but the dominant underlying rock type is probably conglomerate. A similar terrain unit (hRmx-w) in the northwest corner of the park is also underlain by conglomerate; this unit has surficial material up to 30cm thick and does display a weakly developed B horizon. These terrain units seem to be fairly well drained, however, the underlying bedrock has low porosity and permeability so that drainage would primarily be surface runoff.

North of the R terrains, the central portion of the park is covered with a veneer or blanket of colluvium composed of silt, sand, pebble and cobble size material. Slopes are gentle to rolling, and soil is imperfectly to well drained. Terrains in this region with symbols spkCmb-im, spkCjvb-mw, spkCpmb-mw and zspCjb-m are all similar with only slight variations in sediment grain size, surface slope or drainage characteristics. Surficial material in these terrain units usually displayed a distinctly rusty, medium red-brown, oxidized B horizon 20-40cm thick. A few pits encountered a deep layer of yellowish-buff-brown to light grey-brown, often coarse grained C horizon. In terrain zspCjb-m, silt is abundant but cobbles are absent; this represents an overall finer grain size than adjacent colluvium, which in turn suggests a locally lower energy regime of the medium that transported the sediment. As indicated previously, material designated colluvial is likely a mixture of both colluvium and glacial outwash.

One terrain unit in the western park is designated zpkCpv-m and one in the east is designated spCpmv-i. These represent a transition zone, with respect to thickness and grain size of the surficial material, between hRmjx-w to the south and spkCpmb-mw or spkCmb-im to the north. It is likely that more detailed sampling would demonstrate that this transition zone is continuous across the park. The eastern terrain unit is somewhat enclosed in a topographic basin and, also on the basis of a poorly developed B horizon, has been classified as imperfectly drained.

Three terrain units in the northwest part of the park are designated fluvial (sFjb-p, sFpb-m & sFmjb-m). Two of these areas have a linear outline coincident with the present drainage, hence are considered to be fluvial deposits superimposed on the colluvial blanket. It is possible that these deposits represent sedimentation during a period of relatively recent marine incursion as all of these deposits are in areas of low elevation and only slightly above present day sea level. The four pits dug in the two linear fluvial terrains partially filled with water which curtailed further digging. Surficial material in the fluvial terrains is dominantly composed of sand size fragments plus the occasional cobble. In the linear fluvial terrain unit along the west park boundary, the soil profile is poorly developed with the B horizon exhibiting only a faint rusty colouration and a slightly lighter shade of brown than the A horizon, indicative of relatively poor drainage. Drainage in the other fluvial areas, although the soil was wet, was designated ‘well drained’ on the basis of better developed B horizons.

The zskCpb-p terrain in the northern part of the park is a topographically low, wet and poorly drained area. Surficial material is approximately 85% silt plus sand and 15% pebbles plus cobbles. B horizon is poorly developed, typically medium greyish-brown and only weakly rusty.

Interpretation

The Gabriola Formation conglomerate and sandstone beds underlying Helliwell Park, other than being tilted slightly to the northeast, have not been greatly disturbed by tectonic activity since they were deposited about 70 million years ago. With the exception of local irregularities caused by glaciation, and more recent erosion and deposition of surficial deposits, the topography within the park follows the same gentle, northeast slope. Prior to, during and after the last glacial period, thin and irregular layers of unconsolidated clastic sediments were deposited on the bedrock surface. Within Helliwell Park, these sediments are dominantly composed of silt, sand and well-rounded pebbles and cobbles.

During the last 13,000 years, a soil profile has developed on the unconsolidated surficial material and is represented throughout the park by an organic-rich A horizon. Where the depth of surficial material is greater than 20-30cm, surface water has percolated through the sediments and moved material from the A horizon to the underlying B horizon. This process of eluviation has moved some organic material into the B horizon and also oxidized the B. The variable development of the B horizon observed is interpreted to reflect the degree of water movement; a visually subtle change from A to only a faint rusty colouration in B is considered to represent low fluid movement and poor drainage, whereas an abrupt change from dark brown A to a distinctly rusty, lighter coloured B is indicative of high fluid movement in a well-drained soil.

Generally, all surficial deposits within Helliwell, at least to a depth of about one metre, are relatively coarse grained with much less clay and silt size material than sand, pebbles and cobbles. Therefore, drainage is probably largely dependent on topography, and if drainage is poor it is probably more a function of a low hydraulic gradient rather than impermeable surficial deposits. Very little clay was encountered in sample pits, although there could be impermeable layers of clay or other material beneath wet areas which are difficult to sample. Precipitation that falls on the terrain units designated R will primarily be removed as surface runoff. This is because there is little or no surficial material in these areas, and the underlying rock, dominantly conglomerate, is not particularly porous or permeable.

The shoreline, and especially the bluffs along the south shore of Helliwell Park with its unique flora, comprise one of the primary park attractions for both island residents and tourists. Unfortunately, because of the somewhat rugged topography and the lack of surficial material, this area is also the most sensitive area of the park. Natural regeneration of areas damaged by high human traffic will be extremely slow. A partial solution to this problem may be in relocating portions of the trail, and enforcing ‘stay on the trail’ and ‘dogs on leashes’ policies. The present trail, which is almost totally within the open area along the shore, could be made more sinuous so that large segments are relocated within the treed area thereby eliminating the trail in some of the most sensitive open areas.

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References (Clague 1991) (England 1989 and 1991, (Halstead and Treiechel 1966) (Muller and Lelettzky 1970)