Terrestrial Ecosystem Mapping of TIXEN/Cordova Spit

Final Report - August 2009

For the Tsawout First Nation, CRD Parks, Canadian Wildlife Service and Central Saanich Parks

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Abstract

The terrestrial ecosystem mapping (TEM) project at TIXEN was completed for 143 hectares on the eastern coast of the Saanich Peninsula on Vancouver Island, in the Coastal Douglas-fir Moist Maritime (CDFmm) biogeoclimatic subzone. The study area is home to rare and sensitive sand dune and estuarine ecosystems. The area falls under the jurisdiction of several groups. This TEM was completed to inform a multi-jurisdictional conservation plan. The TIXEN landscape has evolved over the past 10 000 years since the end of the last glaciations. Glacial deposition, sea level change, climate change, long shore drift, erosion and deposition of sediments by wind and water, and human activities have all contributed to the current ecological state of the area.

Twenty one map units are mapped including sixteen natural ecosystems and four anthropogenic units. Eight of the natural ecosystems are red-or blue-listed in BC. Although approximately eighty-six percent of the study area is natural ecosystems, various disturbances are common throughout the entire study area. The TEM identifies sixty-one polygons. Twenty-one were field inspected for an ecosystem survey intensity level (ESIL) of 3 and a terrain survey intensity level (TSIL) of C. The mapping project includes this report and a shapefile with spatial and tabular polygon attributes.

Anthropogenic influences that continue to threaten the natural ecosystems include introduced plant invasion, altered drainage, development, recreational activities and shore line stabilization. An overarching multi-jurisdictional management plan is required to manage the varied interests on the land. The Coast Information Team responsible for ecosystem based management (EBM) on the north and central coast of BC produced a framework that can provide a starting point for the creation (or enhancement) of a management plan in TIXEN.

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1.0 Introduction

The primary objective of this study is to map and describe the terrestrial ecosystems in the coastal lands of the Tsawout First Nation's Reserve (East Saanich #2), Capitol Regional District's (CRD) Island View Beach Regional Park and the Municipality of Central Saanich's Cordova Spit Park following the Resource Information Standards Committee (RISC) *Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia*. This Terrestrial Ecosystem Mapping (TEM) project is one of several projects to inform a multi jurisdictional management and restoration plan for the Tsawout First Nation, Central Saanich Parks and Capital Regional District Parks. The study area, known as TIXEN[1] contains remnants of rare coastal sand dunes and estuarine ecosystems. Both are habitats of great conservation interest. These are special ecosystems, maintained by specialized site conditions and adapted to survive in small scale, cyclical disturbance regimes. In addition to protecting the coastal environment by absorbing energy from wind, tide and wave action, these dunes and estuaries are a unique and fragile environment that offers habitat to a number of plants and animals that are at-risk in British Columbia.

TIXEN is important to the WSANEC First Nation, for traditional and cultural reasons. It offers educational opportunities for members of WSANEC communities, and is an important educational resource for the Saanich Tribal School. Island View Beach Regional Park is used by numerous visitors for a variety of activities – dog walking, picnicking, boat launching and sunbathing to name a few. The area provides natural beauty and recreational opportunities enjoyed by residents and visitors alike. (Terms of Reference 2007). The study area is surrounded by housing development and agricultural fields; it includes a small campground and an area of private land south of Island View Beach Park. These land-uses all impact the natural ecosystems found here and the variety of interests and stressors necessitate a coordinated management effort for the study area.

Ecosystem maps provide a biological and ecological framework with which to plan land management activities (RIC, 1998). The information is applicable to many purposes, including:

- protecting species and ecosystems at risk,
- protecting ecosystem services,
- restoring or retaining certain features of the ecosystem and species habitat,
- providing a basis to assess resources such as plants with cultural values, berry production, etc.,
- providing a historic record of the ecological conditions at the time of mapping,
- offering a benchmark by which to measure change over time, including changes due to restoration activities, and

[1]In this report, TIXEN refers to the whole study area; the reserve or First Nation lands, CRD Park or Island View Beach Park, and Central Saanich Park or Cordova Spit Park refer to sub-areas within TIXEN.

- providing a demonstration tool to convey ecosystem and landscape diversity.

Terrestrial Ecosystem Mapping incorporates both the living (plants, animals, fungi, micro-organisms, etc) and non-living (surficial materials, soil, water, climate, etc) components of ecosystems. The map stratifies the landscape into map units[2] (polygons), according to a combination of ecological features, primarily climate, physiography, surficial material, bedrock geology, soil, and vegetation. Bioterrain mapping, the primary building block for TEM, delineates polygons to classify the landscape in terms of surficial material, landform, process and drainage. Ecosystem attributes are then applied to those polygons to classify ecological community, structural stage, and site disturbance.

The study area supports several rare plant species (Fairbarns 2007) therefore red and blue listed species are indicated in the ecological community descriptions. Correlations of plants used traditionally by the Tsawout[3] with the ecosystems and physical conditions that support those plants are also included.

This report describes the study area in general terms including the evolution of the landforms and dominant ecosystems. The mapping methods are described. The Results and Discussion section identifies the ecosystems mapped in the study area and discusses some of the factors that influence their development and threaten their ecological function. The expanded legend provides detailed ecosystem descriptions for all ecosystem units. Management considerations are introduced along with some thoughts for management planning. Mapping limitations and areas for further study are included as well.

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[2] **Map units** delineate portions of the landscape as polygons and may contain up to three ecosystem units and/or terrain units. **Ecosystem units** represent ecological communities or developed areas (anthropogenic units) in a polygon or portion of a polygon. Ecosystem units are identified on the map and in the database by a 2 or 4 character **mapcode**. **Terrain units** represent the character of the terrain (texture, surficial material, etc.) in a polygon or portion of a polygon. Terrain units are identified with a series of letters in the database. See the *Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia* for more details.

[3] Traditional use plants are based primarily on a plant list from Nancy Turner of UVIC and supplemented by Pojar and McKinnon (1994).

2.0 Study Area

2.1 Location

The study area covers approximately 143 hectares on the eastern coast of the Saanich Peninsula on Vancouver Island, approximately 6 km south of Sidney, BC. The spit is bordered on the west by Saanichton Bay and on the east by Cordova Chanel. The inland area is surrounded by residential housing and agricultural fields. The study area is known by various names - Cordova Shore, Cordova Spit, Island View Beach, and as TIXEN by the WSANEC peoples of the Saanich Peninsula.

The study area falls under the jurisdiction of several groups, the T'sawout First Nations – East Saanich Reserve #2 (approx. 87 ha), Capital Regional District Parks - Island View Beach Park (approx. 49 ha) and the Municipality of Central Saanich - Cordova Spit Park (approx 7 ha.). Only the spit, dunes and estuary were mapped; the upland portions of the Reserve are not included in this inventory. A small campground that bisects the CRD Park is included. An area of privately owned agricultural land to the south is also included in order to follow a terrain feature boundary and to edge match with an adjacent TEM mapping project.

2.2 Landscape Evolution

The geology of the area is a result of the tectonic processes that formed the coast of North America. The meta-sedimentary and meta-volcanic bedrock that underlies this area formed in the Paleozoic era (540-250 million years before present [YBP]) as a result of plate tectonics and metamorphosis. Subduction of the oceanic Pacific Plate under the continental North America Plate resulted in the accretion (addition) of oceanic islands to the continental edge. Heat, pressure and fluids in the subduction zone altered these rocks chemically and physically. Finally, uplift and erosion resulted in the exposure of the bedrock present in the area today. Only one rock outcrop is mapped in the study area (polygon 38). The type and form of bedrock influences soil and water chemistry, drainage and sediment delivery into the area.

The study area has a complex history of glacial advances between 13000 and 65000 years before present. During the Pleistocene (1.8 million to 10 000 YBP), British Columbia was subject to multiple glaciations. The majority of the materials present in the Victoria and Sooke area are the result of the most recent (Fraser) glaciation. Each glacial advance tends to remove and rework the sediments of the preceding one. At the height of Fraser glaciation, ice up to 1500m thick covered the greater Victoria area.

Sediments at Cowichan Head, which are exposed south of the study area, preserve evidence of the multiple glaciations and glacial advances. These sediments record the glacial and interglacial periods of Southern Vancouver Island and contain clues to past environments including sedimentation, climate, sea level and ecology. The Quadra Sands and Cowichan formations, for example, preserve evidence of plant and animal communities in the form of Mammoth bones and remnants of the tundra vegetation

communities that dominating the landscape 21000 years ago. The slope to the east of the study area is cut into glacial sediments (polygon 45).

This low-lying study area has been subject to sea level change with the shoreline fluctuating from 4m below the current level to 75m above. At the end of Fraser Glaciation the land was depressed due to the weight of the glacial ice. As the ice melted, sea level began to rise and the sea inundated the land as evidenced in the marine sediments of the Victoria Clay. The shore line was approximately 75m above present sea level 13000 years ago. As the land rebounded (isostatic rebound) out from under the weight of the ice, relative sea level began to drop till 11700 years ago when the shore was similar to today's. Between 5000 and 9250 years ago the shore line was 4 m below its current level (Blyth and Rutter 1993).

Fluctuating relative sea level has made for a dynamic coast and has influenced erosion and deposition of landforms, ecology, species and cultures. The name Sooke means rising land.

Post glacially, the actions of waves, wind, gravity and running water continued to shape the landscape. The majority of the study area is comprised of post glacial sediments resulting from erosion, transportation and deposition of materials by waves, wind, and streams. Current landforms are dynamic as these processes adjust and respond to seasonal, annual and longer term patterns and trends in weather, tides and sediment supply.

Sediments eroded from Cowichan Head are transported along Island View Beach by longshore drift, the result of prevailing winds, waves and tidal currents. The sediments are transported northward and are eventually deposited onto the spit. In the foreshore prevailing and storm winds erode the exposed and un-vegetated beach and deposit sand to form dune landforms.

In the course of a year, seasonal variations in wave action alternately build and erode the beach front. The inter-tidal zone is relatively steep in the winter as a result of winter storms. In the summer the beach is wider and more gently sloping (Maine Geological Survey 2005)

The high water table present in the low lying wetland areas are influenced by freshwater and saltwater. Tidal and storm events periodically flood the estuary and wetlands behind the dune front. The built up dune areas promote north-south flow patterns in the wetland areas. The ecology of these wetlands reflects variations in moisture and saltwater content and ecosystem development is controlled by very subtle changes in elevation, material texture, and organic content.

The layering of sediments over time in the dunes and wetlands trap and preserve evidence of past culture, climate, sea level, earthquake activity, sedimentation and ecology. These may have great value in understanding long and short term geomorphology, ecology, climate and cultural history and change.

2.3 Biogeoclimatic Zones

TIXEN is located within the Coastal Douglas-fir Moist Maritime (CDFmm) Biogeoclimatic subzone. In Canada the CDFmm occurs only on south eastern Vancouver Island and the Gulf Islands, on small portions of the Sunshine Coast and the Fraser River Delta ranging between sea level and 150 m. elevation. This subzone is small, representing less that one percent of BC's landbase (Meidinger and Pojar 1991).

The CDFmm lies in the rain shadow of the Vancouver Island and Olympic mountains. It has warm, dry summers and mild, wet winters. The CDFmm is primarily a forested subzone dominated by second growth forests that were logged at the turn of the century (ibid). Sand beaches and dunes are not common in the CDFmm. Although sandy beaches and dunes occur here and there, such as at Sidney Island, Esquimalt lagoon, Witty's lagoon and Savary Island, the rocky coast line, and wind, wave and tide conditions do not typically result in dune formation. Estuaries occur sporadically. Along with a few large estuaries such as the Cowichan, Chemainus and Comox estuaries there are numerous small estuaries on Vancouver Island similar in size to that found at TIXEN.

The vegetation of the CDFmm includes many rare species (ibid). Proportionally the ecosystems found within the TIXEN study area support a large number of at-risk plant species. A rare plant survey of the study area in 2007 identified eight at-risk plant species (Fairbarns, 2007). Eight at risk ecological communities are identified in the TEM.

The dune ecosystems support an unusual at-risk animal and at-risk plant relationship – the yellow sand verbena moth is entirely reliant on the yellow sand verbena plant. The estuary provides refuge for migrating shorebirds. The Great blue heron feeds in the area and seabirds use the off shore area for feeding and moving through.

A large part of the CDF is used for residential and industrial purposes, concentrated in the urban centers. Residential developments are a major land use and pose a threat to natural areas. A sensitive ecosystem inventory (SEI) of south-eastern Vancouver Island and the Gulf Islands (McPhee et al. 2000) identified land development as a major reason for ecosystem loss. Urban expansion continues throughout the region.

Agricultural production in the CDFmm includes field vegetables, small fruits, nursery stock, livestock, and dairy products. (Meidinger and Pojar 1991). The Saanich Peninsula is one of the primary centres for agricultural production on Vancouver Island (Vancouver Island Agri-Food 2000)

The CDF includes many small parks that are popular hiking, camping, and boating destinations. (Meidinger and Pojar 1991). Because the study area includes two of these parks, management considerations will need to address ways to balance recreational demands with protecting the natural features of the parks.

2.4 Climate

Warm, dry summers and mild, wet winters are typical for the study area. Mean annual temperatures in the CDFmm, range from 9.2 to 10.5^{o}C, with minimum temperatures

ranging from -21.1 to -11.7^{o}C. The monthly average minimum temperatures rarely fall below 0°C. Mean annual precipitation varies from 647 to 1263 mm. Most precipitation falls between November and March with very little (5% or so) falling as snow between November to April. In most winters the snow melts within a week of falling; this snow is usually wet and heavy (Meidinger and Pojar 1991).

Droughts and frequent ocean breezes are common in the study area during the summer months. According to weather stations in Central Saanich average rainfall in July and August ranges between 20.8 and 27.1 mm. Daytimes are typically warm, 21 to 22° C. with cool night time temperatures around 10 or 11°C. (Environment Canada 2008)

2.5 Ecology

A variety of ecosystem types are found within the study area. The two dominant natural ecosystem types – the dunes and the estuary (salt marsh and meadows) - are discussed in general terms in this chapter. All ecosystems mapped in the study, including the less dominant ones, such as the woodland and pocket wetlands, and the anthropogenic (developed) areas are discussed in the Results (Chapter 4) and described in detail in the expanded legend (Chapter 7.0)

Sand Dune Ecosystems

Sand dunes are dynamic landforms created by wind and formed mainly of sand sized particles. Three factors control dune form and function. These are sediment supply; wind strength and direction; and vegetation cover.

Similar to a river's floodplain, dune ecosystems have adapted to cycles of disturbance. Small disturbance from wind and wave action maintain sparsely vegetated dunes. Succession from unstable to stable dunes can occur as vegetation develops and sediments accumulate. With time and in the absence of major disturbance events some dunes may eventually progress to shrubby and forested dunes, such as those seen at the top of Savary Island and at Naikoon Park on Haida Gwaii. At some point in this process the specialized dune plants and animals (eg. Yellow sand verbena and the yellow sand verbena moth) disappear and non-dune species move in. However, given dunes are composed of unconsolidated sand, they are naturally fragile and mobile. They very often move through periods of stability to periods of instability caused by extreme weather or other disturbance that disrupts the plant community and stabilization progress, and the process begins again.

Sand dunes are a harsh and unstable environment where plants must adapt to survive. At the fore (beach), no vegetation grows within reach of the salty waves, and only at the back of the dune, beyond reach of the sea spray, can trees establish. In between is a range of micro habitats with different demands – wind, shifting sands, salt spray, desiccation and high temperatures along with minor changes in slope, aspect and wind exposure all affect what can grow. In addition, sand has poor moisture holding capability, low nutrient capacity and soil temperatures can reach 60° C even on a cloudy day. (Flynn et al

2006a). Dune soils tend to be young (poor soil development) due to the constant erosion and deposition of sand.

Dune plants have evolved various ways to survive. Some use periods of dormancy and grow only during the fall and winter, others develop deep roots able to reach cooler and moister sand below the surface. Because the soil of sand dunes tends to lack nutrients, some plants develop a symbiotic relationship with soil bacteria to survive. Some will flower early and spend the hot summers in seed form, yet others emphasize seed production instead of vegetative structure hence they may go unnoticed to the casual dune observer. (Flynn et al 2006a)

As plants colonize the dunes, they act to stabilize the dune by moderating blowing sediment. The early colonizing vegetation at TIXEN, such as large headed sedge, black knotweed and yellow sand-verbena are able to tolerate extreme conditions of erosion and deposition. They begin the stabilization process by sending out roots and providing a surface for sand to accumulate upon. As the sand stabilizes other species get a foothold, enabling a progression of species to establish and ecological communities to develop.

Dunes typically have fewer species than other ecosystems. Paradoxically, a very high proportion of rare and at-risk plant species are found in dune ecosystems and TIXEN is no exception.

Estuaries (salt marshes and meadows)

Estuaries are low elevation, low relief areas that form where fresh water streams flow into the ocean. They develop from the accumulation of fine sands and silt deposited by tidal and stream water, inter-layered with organic material from decaying wetland vegetation. The roots, stems and leaves of the early colonizing vegetation dissipate the energy of waves and allow more sediment to accumulate. Over time, dead plant material and sediment build up, and the estuary grows. It then becomes cut with channels and tidal creeks, from the flow of both fresh water and the tide. As the structure of the estuary changes, different plants and animals colonize the sediment, depending on their tolerance to salt and flooding, and their ability to compete with other species. (CRD 2007)

Salinity varies by the proximity to fresh water and the frequency and duration of tidal flooding. Hence the upper tidal zones (meadows), furthest from the ocean are the least salty, experiencing less frequent and brief tidal flooding. Vegetation here is relatively diverse. Only vegetation well adapted to high salinity and flood conditions can survive in the lower tidal zone (marshes) which are flooded twice daily, often for several hours. (Mackenzie and Moran 2004) At TIXEN these marsh areas are usually dominated by one or two species such as sea-shore saltgrass or American glasswort.

Estuarine soils tend to be young (have poor soil development) due to the continual processes of erosion and sedimentation; they often have buried horizons resulting from annual flooding events.

2.6 Ecosystem Services

Natural ecosystems provide ecosystem services. Ecosystem services are fundamental life-support processes upon which all organisms depend; examples include oxygen production, water purification, pollination, soil formation and nutrient recycling.

Sand dunes and beaches are important for providing stability to the shoreline and mitigating erosion of personal property from the onslaught of ocean winds and waves. Vegetated dunes are able to stabilize sediments and soil building processes can develop. The quiet coastal bay environment, sheltered by the spit at TIXEN, provides habitat for a variety of organisms, and of course recreation, is a primary social value provided by these dune ecosystems.

Sand dunes are special places for humans. TIXEN provides cultural values and recreation opportunities for the many people that visit and live in this area. Given the dynamic nature of dune ecosystems and the special environment that these plant communities struggle within it is especially important that humans are aware of how their activities affect this place.

Estuaries provide important feeding and breeding grounds for many bird species and resting sites or winter habitat for many migrating birds. They act as nurseries for fish such as Pacific salmon and Cutthroat trout. About 80% of coastal wildlife species use estuaries at one time or another. Mudflats, those unvegetated areas at the edge of the estuary that are exposed at low tide, support a variety of benthic invertebrates and microalgae, microscopic plants (phytoplankton) and animals (zooplankton), worms, and molluscs (Fisheries and Oceans Canada 2007)

These intertidal environments are among the most productive ecosystems on earth due to constant fertilization from river sediments. Tides carry in nutrients, plankton, and oxygen and carrying away wastes. (Flynn et al 2006b). This hydrological sequence (the movement of water through the ecosystem) is essential to the function and survival of these ecosystems.

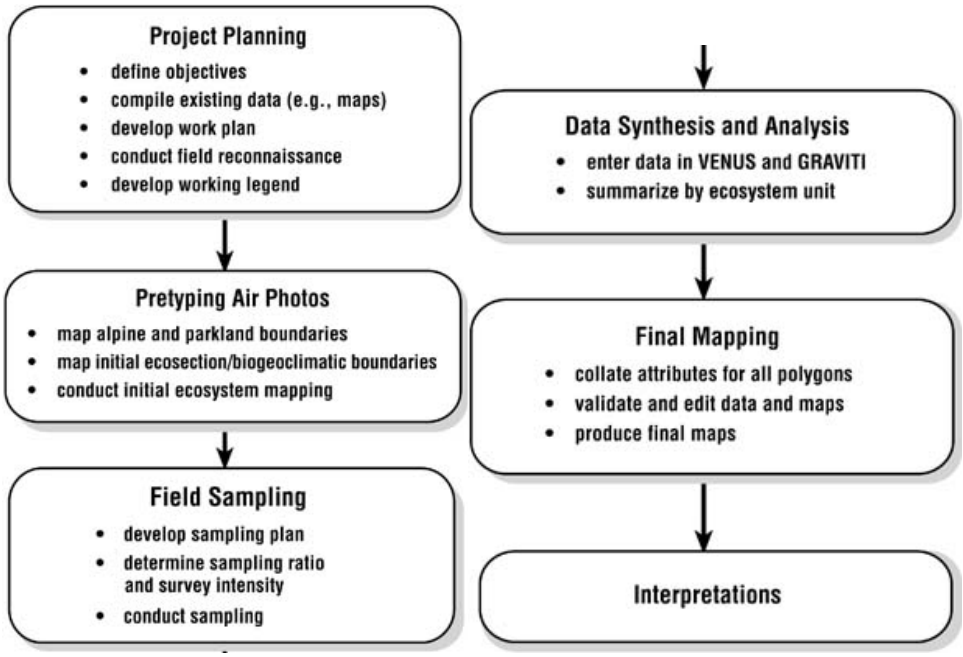
Estuaries provide critical ecosystem services. They filter and store pollutants that flow through streams and groundwater from urban sources. Vegetation helps to anchor sediment and soil along the shoreline. This impedes stream flow, rainwater and waves from scouring away the land. This natural barrier also helps to dissipate the energy of large waves that can damage human life and property. The plant material from estuaries is broken down by microorganisms, and exported offshore by tidal currents. This material is subsequently ingested by free-floating plankton, upon which many fish and marine mammals prey (CRD 2007).

3.0 Methodology

The intent of the project is to map the terrestrial ecosystems in the study area following the *Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia* (1998). These methods were followed in most instances except for the technique to capture polygon linework into the Geographic Information System (GIS). Also, standard soil pits were not excavated at field sites to avoid site disturbance. Scientific and common plant names follow the RISC standard, British Columbia plant species codes and selected attributes (Meidinger et al 2004).

Figure 1, adapted from the *Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia* (1998), shows the general steps involved in producing Terrestrial Ecosystem Map.

Figure 1: Steps to producing a Terrestrial Ecosystem Map



Background information on the project and the study area were gathered and reviewed. This included information on land uses, bedrock geology, surficial materials, soils, ecology, disturbance history, dunes and estuaries. Air photos and images available in the study area where considered to choose the best images for the purpose of the study.

Initially bioterrain polygons were delineated on stereo images at 1:15 000 scale, flown in 2005, using standard air photo interpretation methods outlined in *Guidelines and Standards to Terrain Mapping in British Columbia* (RIC 1996). Terrain classification and drainage classes were assigned to each polygon following *Terrain Classification System for British Columbia* (Howes and Kenk 1998) and *Field Manual for Describing Terrestrial Ecosystems* (BC MoF MoEL 1998) (see Appendix B Terrain Legend for more information). The study area was extended beyond the southern CRD Park border in

order to follow a natural bioterrain feature and to edgematch with the CDFmm TEM project underway at the time of mapping. Air photos were also used to direct the field sampling plan and to navigate when on site. Sample sites were pinpricked on the photos while in the field.

Field work methods followed *Describing Terrestrial Ecosystems in the Field* (1998). Fieldwork was completed on August 14 and 15, 2008, with a reconnaissance visit May 17, 2008. Twenty-one of 61 polygons (34%) were field inspected (several larger polygons were evaluated at more than one location to determine variability across the polygon). A total of 39 locations were sampled. Full plots (FS882s), Ground Inspections (GIFs) and Visual inspections, each with different levels of detail were used to evaluate polygons. Ground inspections are less detailed than full plots and visuals are less detailed than ground inspections. Conservation evaluation forms were completed for each full plot and ground inspection. Conservation forms include information on disturbance, adjacent land-use, threats and other factors used to evaluate the conservation value of a site. Examples of field forms are included as Appendix C. Field inspection met Terrain Survey Intensity Level (TSIL) C and Ecosystem Survey Intensity Level (ESIL) 3.

Field sampling was used to characterize and describe the ecosystem units and terrain units in the study area. During sampling information was collected on terrain features such as surficial material, terrain texture and surface expression; site characteristics like soil drainage, soil texture and site disturbance; and plant community information including dominant vegetation, percent cover, structural stage and the presence of introduced species. Due to the cultural and natural sensitivity of the area only very shallow surface digging with a hand trowel and surface observations were used to gain insight into soil properties for this project, limited information on soil moisture (SMR) and soil nutrient (SNR) regimes was collected. Observations of materials at depth were limited to existing excavations and stream cuts.

The plot data was entered into a software package called VENUS. The field data was extrapolated across the study area to evaluate the polygons not visited on the ground.

Up to three ecosystems units were mapped for each polygon; bioterrain attributes were captured along with disturbance information. The project uses a standard TEM database and includes all relevant core polygon attributes as well as additional disturbance fields (see Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia Ecosystem Technical Standards and Database Manual April 2000 available at http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/temcapture/index.htm.)

Purview[4], and ortho-photo stereo models were used to capture polygon boundaries and to aid in ecosystem identification. This technique allowed mappers to zoom in and see much greater detail than was possible using traditional stereo pair interpretation methods.

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[4] Purview is an I.S.M. International Systemap Corp. product that adapts the ArcGIS Desktop into a stereo-viewing environment enabling 3D visualization and data capture. PurVIEW interacts directly with the geodatabase, digital elevation models, and georeferenced imagery data.

The ortho-photo models were based on 2005 images. Field observations revealed that subtle changes in the topography, surficial material, and drainage greatly influence ecosystem diversity in the study area. This modified process was chosen to improve the detail and accuracy of the mapping and increase the utility of the map product for land-use planning.

Once the attributes and linework was captured into the GIS a draft map was produced for review purposes. Edits were then made as appropriate.

Plot data analysis and other resources were used to develop an expanded legend. The legend describes in detail each ecosystem and anthropogenic unit mapped in the study area. Because of limits to digging full soil pits SMR, SNR and full material and soils descriptions have not been included in the expanded legend for the majority of map units. However, some of the textual descriptions may include detail on soil moisture and nutrient regimes where this information is taken from field guides and other reports on dune and estuarine ecological communities. The vegetation list for each unit indicates species as native, introduced, red- and blue-listed (see At-Risk Status below for more information on listing of species and ecosystems), and culturally significant or not. Culturally significant (traditional use) plants were derived from lists by Nancy Turner, an ethnobotanist at the University of Victoria, based on field visits with members of the First Nation in 2007.

Personnel included Carmen Cadrin and Marta Donovan (BC Conservation Data Centre) who were influential in initiating the mapping project through consultation with Canadian Wildlife Service and the Tsawout First Nation. Field inventory was completed by Carmen Cadrin, Erin Prescott, Deepa Spaeth Filatow and Jo-Anne Stacey. Bioterrain mapping was done by D. Filatow; ecosystem mapping by J. Stacey. Data entry was shared by the mappers. J.Stacey captured the linework into the GIS; D.Filatow reviewed the spatial product. Corey Erwin (Ecosystems Information, MoE) provided helpful mapping review and comments.

3.1 Mapping Limitations

The information and analysis contained in this report are based on observation from the air photographs, of current land-surface conditions and of current understanding of geomorphic and ecological processes. Selected field samples describe the ecological conditions at the sample points.

Quality and accuracy of mapping is influenced by

- Air photo scale and quality
- Transfer of line work
- Skill and experience of the mappers
- Field survey intensity levels (TSIL and ESIL)
- Complexity of the terrain and ecosystem units
- Quality control procedures
- Budget

Ecosystem descriptions may be constrained by limited field sampling (insufficient plot data to adequately classify the typical plant assemblage and site conditions). The extensive nature of disturbance and introduced species throughout the study area may misconstrue ecosystem classification and interpretation. Some ecosystem units were not sampled, for example the Ws51 and FC units. Soil pits were not excavated therefore SMR, SNR, soil classification and material classification are not well defined for ecosystems. Not all polygons were visited thus the mapped unit or proportions in the polygon may need adjustment with additional field survey.

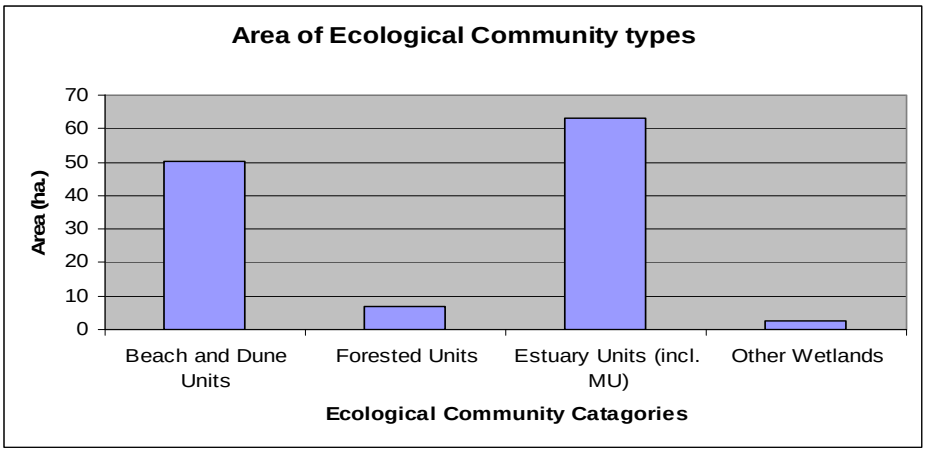
Conditions in the study area, such as structural stages, drainage patterns, disturbance, etc may have changed since the date of the images and the time of mapping due to the natural dynamic processes of the ecosystems or due to land management activities.

4.0 Results and Discussion

4.1 Summary of ecosystem units

Twenty one map units[5] were mapped in the study area. Each unit is described in detail in the expanded legend (Chapter 7.0) Seven dune units (including the beach, BE), five estuarine units (including the mudflats, MU), three other wetland types (open water units and a forested swamp), and two forested units were mapped. Figure 2 shows the area covered by these four different groupings of natural ecological communities. The remaining four map units were anthropogenic units – road surfaces (RZ), rural (RU), urban developments (UR) and cultivated fields (CF).

Figure 2: Area mapped of different ecological community types.



[5] **Map units** delineate portions of the landscape as polygons and may contain up to three ecosystem units and/or terrain units. **Ecosystem units** represent ecological communities or developed areas (anthropogenic units) in a polygon or portion of a polygon. Ecosystem units are identified on the map and in the database by a 2 or 4 character **mapcode**. **Terrain units** represent the character of the terrain (texture, surficial material, etc.) in a polygon or portion of a polygon. Terrain units are identified with a series of letters in the database. See the *Standard for Terrestrial Ecosystem Mapping (TEM) in British Columbia* for more details.

Approximately 86% (122.80 ha.) of the study area was mapped as natural ecological communities and just less than 14% (19.69 ha.) as anthropogenic units. Of the 86% natural very little area can be considered undisturbed. See Section 5.2 Ecosystem Threats for more details.

At-Risk Status

The BC Conservation Data Centre is responsible for evaluating the conservation status of ecological communities and plant and animal species (elements) in the province of BC. The CDC uses a standard methodology to determine conservation ranks for elements. More information on these methods is available on the CDC website[6]. Ecological communities and plant and animal species are "listed" in BC based on their conservation ranks. Red-listed elements are considered extirpated, endangered, or threatened; blue-listed elements are considered to be of special concern; yellow listed elements are considered secure. For some ecological communities there is little information or insufficient resources to complete an evaluation, these units are not yet ranked and listed.

Ecosystem units mapped in the TEM follow the Ministry of Environment's Provincial Site Series & Map Code List. Forested units correspond directly to the Ministry of Forests and Range (MoFR) Biogeoclimatic (BEC) site series classification. Recently, a wetland classification was adopted by MoFR and these are the estuary units mapped in this study. Other non-forested units may not correspond to the BEC classification.

The ecological communities listed by the CDC are derived primarily from the MoFR Vegetation Classification (plant associations), which identifies plant communities based on a diagnostic combination of plant species as they reflect soil moisture and soil nutrient conditions. More than one BEC site series may be capable of supporting the same diagnostic combination of plant species. As a result the CDC ecological community names often do not correspond exactly to the mapped ecosystem units in this study.

Table 1 shows all ecosystem units mapped in the study, indicates the mapcode, the amount of area mapped and the provincial status for the natural ecosystems. Where the ecosystem unit name does not correspond to the CDC ecological community name the unit has a footnote indicating the CDC name.

Many of the ecosystem units mapped at TIXEN are ecological communities at-risk. At risk status may be a result of ecosystems being disturbed by human or other means or they may be naturally rare due to site requirements that are uncommon in the provincial landscape. Both situations are present in this study area.

Several units – mostly dune - have not been classified by either MoFR or the CDC. Although these units do not yet have a provincial status rank they are expected to be either red- or blue-listed given how uncommon dune ecosystems are in the province.

[6] http://www.env.gov.bc.ca/cdc/

Map Code	Ecosystem Unit Name	Provincial Status	Area Mapped (ha.)
AG	Silver burweed - Entire-leaved gumweed	Not assessed	1.31
BE	Beach	NA	9.00
CF	Cultivated Field	NA	14.01
CM	Big head sedge	Red-listed	5.06
DO[7]	Douglas-fir - Oniongrass	Red-listed	0.22
DW	Dune wildrye - Bea pea	Red-listed	3.75
Ed01	Tufted hairgrass - Meadow barley	Blue-listed	13.19
Ed03	Arctic Rush - Alaska Planatain	Red-listed	18.33
Em02	American glasswort - Sea-milkwort	Red-listed	0.56
Em03	Seashore saltgrass	Red-listed	19.43
FC	Fescue - Common camas	Under assessment	0.22
KV	Black knotweed - Yellow sand-verbena	Under assessment	6.24
MU	Mudflat	NA	11.74
OW	Shallow open water	NA	0.89
RA	Nootka rose - Pacific crab apple shrub unit	Under assessment	24.68
RF[8]	Western redcedar - Grand fir - foamflower	Red-listed	6.45
RW	Rural	NA	2.33
RZ	Road surface	NA	2.67
SW	American Bulrush wetland	Not assessed	0.14
UR	Urban	NA	1.18
Ws51	Sitka willow - Pacific willow - Skunk cabbage	Red-listed	1.60

Table 1: Map codes, Ecosystem units, Provincial status and area mapped

The Dune Ecosystems

Subtle changes in topography, soil drainage and disturbance regime influence the variety of unique ecosystems found within the dunes of the study area. The silver burweed – entire-leaved gumweed community is found at the back of the beach behind the driftwood. Also in this position, in some areas along the spit, the Nootka rose – Pacific crabapple shrub unit has established. The large-headed sedge community and the black knotweed – yellow sand verbena community are typically found in the dune slacks, slightly protected from the wind, yet in an area where sand disturbance is common. Behind these low herbaceous units is found the dune wildrye – beach pea unit, here the dune has become more stable and a dense, almost mono-culture of cover of dune grass is established. The crabapple rose unit is found in the dune areas as well as where the dunes

[7] CDC ecological community is Douglas-fir / Alaska oniongrass (*Pseudotsuga menziesii / Melica subulata)*
[8] CDC ecological community is grand fir / three leaved foamflower (*Abies grandis / Tiarella trifoliate)*

transition into the wetlands. “Islands” of the crabapple rose unit are common throughout the estuarine meadows.

Dunes are underlain by well sorted (very poorly graded) sands and course silts that have been transported by wind. Constant reworking of dune sediments inhibits soil forming processes and horizonation resulting in very poorly developed soils (regosolic soils). In areas where cycles of stabilization and destabilization occur, cummulic regosols develop (very poorly developed soils with buried horizons). Where the dunes are more stable brunisols (young weekly developed soils) begin to form. The addition of organic materials from established vegetation is the primary horizon forming mechanism in these soils and allows the succession of other plant species by providing nutrients and water holding capacity to these otherwise nutrient poor and very dry soils. For further information on these soil types see the Canadian System of Soil Classification 3rd Ed (**http://sis.agr.gc.ca/cansis/references/1998sc_a.html**) and the Soil Landscapes of British Columbia (**http://www.env.gov.bc.ca/soils/landscape/2.4order.html**).

The Estuarine Ecosystems

Estuarine ecosystems at TIXEN include a range of upper meadows, salt marshes and mudflats. Within the sheltered Saanichton Bay, an area of mudflat exists. This non-vegetated ecosystem is exposed during low tide and provides opportunities for birds and wildlife to feed on mudflat organisms. Also in this sheltered area behind the spit, in the lowest vegetated tidal zone where extreme saline conditions exist, is the saltgrass community. Above the saltgrass is found the American glasswort – sea milkwort community. These sites experience somewhat less tidal inundation than the saltgrass sites. Slightly higher again, in the next intertidal zone are the salt meadow communities. Here the Arctic rush – Alaska plantain and tufted hairgrass – meadow barley ecological communities develop depending on surficial material and drainage characteristics.

Estuaries are underlain by organic, marine and fluvial (river) sediments. These are well sorted fine sand, silt and mud (mix of silt and clays) deposited by water interlayered or capped with organic materials derived from wetland and marine organisms. Glysolic soils form where conditions are wet and soils lack oxygen while organic soils and peaty glysols form where conditions are wet and organic wetland vegetation accumulate to form thick carbon rich peat. Regosols exist where fresh sediments accumulate in stream courses and tidal drainages. For further information on these soil types see the Canadian System of Soil Classification 3rd Ed (**http://sis.agr.gc.ca/cansis/references/1998sc_a.html**) and the Soil Landscapes of British Columbia (**http://www.env.gov.bc.ca/soils/landscape/2.4order.html**).

Altered hydrology, due to drainage channels which change the frequency and duration of tidal flooding, has had a pronounced influence on ecosystem development and the assemblage of plant species in the interior salt flats. Typically ecosystems in a tidal flood area will develop in bands or lines based on their ability to tolerate saline and wet conditions. Other estuaries often include an open saltwater lagoon with freshwater influences at the base of the upland slopes. At TIXEN rather than the expected linear ecosystem pattern the altered drainage has resulted in an irregular mosaic of ecosystems

with non-native and upland species being established in what would typically have been estuarine ecosystems. Drainage ditches through and around the flats has modified the soils and vegetation composition in the area.

Other Ecosystem Types

In addition to dunes and estuaries several other ecosystem types are found at TIXEN. Two small pocket wetlands are mapped. These are areas of shallow open water (OW) with either a perimeter of, or emergent sedges (SW). These ecosystems are typically underlain by peaty glysols and organic soils. At the base of the slope surrounding the estuary on the north and west (polygon number 45), is a forested unit mapped as western redcedar - grand fir – foamflower ecological community (RF). This unit is underlain by stony-sandy-muddy glacial deposit (marine or till) that is imperfectly drained. A portion of a small bedrock outcropping (polygon 38) is forested and is mapped as the Douglas-fir - oniongrass (DO) unit. The non forested portion is mapped as the *Fescue* – common camas (FC) unit. These units are underlain by bedrock and small shallow pockets of rubbly-sandy colluvium and/or glacial till. Soils are shallow and enriched with organic materials (Ah horizon). One forested swamp, Sitka willow - pacific willow - skunk cabbage (Ws51) is mapped in polygon 4 just south of the Island View park boundary. Swamps typically have glysolic or peaty phases of glysolic soils. However this polygon was not field-checked and does not resemble other areas in the project. A field visit would be warranted to confirm the ecosystem call in this polygon.

4.2 Traditional-use plants and ecosystems

Traditional use plants are primarily based on plant lists from Nancy Turner of the University of Victoria (compiled as Appendix E) and supplemented by the Coastal Plants of BC (Pojar and Mackinnon 1994). Traditional use plants are denoted in the expanded legend vegetation lists using **bold text**. People interested in finding or managing for specific plants may review the expanded legend for ecosystems expected to support a particular species, and then refer to the map for potential occurrences of those ecosystem units.

5.0 Ecosystem Threats

5.1 Climate Change

Sea level rise due to global warming may threaten the ecosystems of TIXEN. Researchers predict sea level will rise in the Victoria area. Due to the nature of the landscape in the study area the salt marsh may not be able to adapt by migrating inland. Landward migration is constrained by topology, agricultural, residential and urban development. Increased storms resulting from climate change underlie a need to maintain natural ecosystems and the buffering services they provide. Changes in storm frequency and severity will influence erosion/deposition frequency and magnitude in dune and estuary ecosystems. It is important to integrate climate change into management considerations at TIXEN (Walker and Syneysmith 2008).

5.2 Anthropogenic Influences

For much of our history, the human species has attempted to live within or to modify our environment to improve our chances of survival and quality of life. As populations have increased, so too has our impact on natural ecosystems. Since the 19th century, with European immigration to the area, intensive conversion of ecosystems to agricultural crops, rural and urban settlements, and transportation networks is now pervasive within the Coastal Douglas-fir moist maritime (CDFmm) subzone. Almost 50% of the CDFmm has been permanently converted to these uses. TIXEN has fared somewhat better with 14% converted to human use.

Introduced plant species:

Introduced and invasive plants are a major concern for the ecology of natural ecosystems. Because they are not native to the region, these plants often have no natural predators or other controls. Invasive species can crowd out native species or alter the natural environment to favour conditions for the non-native plants. Additionally, non-native species often provide different habitat values. Some invasive species become so well-established that their eradication is not feasible without substantial cost and effort (CRD 2009)

Invasive plants are spread in a number of ways; humans can spread them by taking seeds from one place to another on clothing, tires, equipment, etc.; birds often spread seeds after eating the fruit; other wildlife and domestic animals including dogs and livestock can also disperse seeds or plant parts.

The following is a discussion of the various introduced and invasive plant species encountered at TIXEN and some species specific recommendations for control.

European beachgrass

In many places in the Pacific Northwest, European beachgrass (*Ammophila arenaria*) has crowded out native dune grass. European Beachgrass is more successful at stabilizing dunes than native dune grass (*Leymus mollis*). Consequently it forms a dense monoculture starving secondary dunes of sand, and changing habitat for other plant and insect species (CRD 2009).

At present *Ammophila* has limited distribution in the study area. Because it was only observed at one location in the CRD Park (north end of polygon 32) prevention now should be a high priority while simple mechanical means may still be successful in controlling European Beachgrass. The entire study area should be carefully and repeatedly inventoried for further spread of this weed, with removal and follow-up monitoring recommended to ensure its control.

Scotch broom

Another invasive species of concern is scotch broom (C*ytisus scoparius*), a major invader throughout the Capitol Regional District. Scotch broom is a hardy legume (member of the pea family) adapted to tolerate very poor soil. It is well adapted for the droughty conditions of dune ecosystems. It has a deep taproot, reduced leaf area, photosynthetically active stems, and a thick wax coating to prevent water loss. It prefers open sites, thriving in dry to very dry soils. Legumes are nitrogen fixers, which alters soil characteristics and can affect the ability of native plants to compete. Broom also tends to acidify surrounding soil, preventing other species from establishing.

Scotch broom is particularly difficult to control due to long lived seed banks, profuse seed production, drought tolerance, long life span, and lack of natural enemies. Mechanical controls such as uprooting often triggers the germination of old seeds in the ground. Therefore, control efforts must be sustained until the seed banks are depleted. Proper disposal of all plant pieces is critical to avoid re-infestation and spread to other areas. The Invasive Plants of Southwestern B.C. website (2003) suggests composting is not appropriate for disposal as this may result in further distribution.

Scotch broom is very well established in all dune areas in the study area. However, there is a very distinct line of invasion which parallels the CRD park and reserve boundary; extreme infestation is apparent on the park side of this line. Notable is the die back of broom in an area inundated with seawater during the winter storms of 2007/08 where the berm was breached.

Gorse

Gorse (*Ulex europaeus)* is also common in the Victoria area. Similar to broom it is a legume that produces abundant seed, which remain viable for a long time. Gorse can colonize disturbed areas, poor sites or those without vegetation. Gorse can displace native vegetation and reduce diversity once established. Furthermore, dense gorse creates a fire hazard; it has flammable foliage and litter tends to accumulate at the base.

According to Oregon State University Extension Services, South western Oregon dunes are so infiltrated with dense impenetrable cover of gorse they are deemed useless for recreation. They indicate prevention is the best management practice, noting that it is best to pull Gorse when first noted and to continue to monitor the site to ensure removal. (Parker and Burrill 2001)

One plant was noted (east side of polygon 56/plot V13) within the dune area. As with the introduced dune grass the opportunity for successful control is best while concentration is still low. We recommend removal of this plant as soon as possible. Due to the nature of this species (long seed bank life) and the predominance of invasion within the rest of the CRD, it is particularly important to continue to monitor the site, as well as the rest of TIXEN for other introductions.

Yellow toadflax

Yellow toadflax (*Linaria vulgaris*) is on the provincial list of noxious weeds. The province describes it as a creeping rooted perennial to 0.6 metres tall; the stalkless leaves are narrow and pointed at both ends; bright yellow "snapdragon-like" flowers with an orange spot on the lower lip are 2 to 3.5 cm long (similar to but smaller than Dalmatian toadflax (*Linaria dalmatica*)**.**

Toadflax seed is spread by the wind, and by birds and animals. A mature plant annually produces up to five hundred thousand seeds, viable for ten years. New plants also form from horizontal roots, which can be as long as 3.7 m. Hand pulling can be effective, especially in coarse-textured soils where roots can be pulled easily. Repeat pulling may be required until the seed bank and root fragments have been depleted (Ministry of Agriculture, Food and Fisheries, 2002).

Toadflax was noted along the border between polygon 49 and polygon 46. Although numerous plants were present, growing down the slope and under shelter of the shrubs, it was still a fairly small population that persistent management (annual removal) may be able to suppress. A follow up visit in July 2009, noted the toadflax had spread to the neighbouring flat area in polygon 46.

Grasses

Non-native grasses are common throughout the study area. Most have likely been introduced to the area as part of grass or hay mixes for grazing cattle and horses.

Many introduced grasses have the potential to completely alter the natural ecosystem. Decaying grass adds nitrogen to the soil, favouring the growth of non-native plants that are adapted to high nitrogen levels. Litter accumulation from the grass can also create conditions for high-intensity fires.

The introduced grass species at TIXEN are already well established and have become so naturalized they form a dominant component of the vegetation in some ecosystems. Management of introduced grasses can be challenging. Grass identification is difficult and expert consultation may be required to determine the appropriate course of action.

Management activities may be best implemented to prevent further spread and to rehabilitate areas deemed to have high conservation value first. Reestablishing natural drainage in the salt marshes might help control those species intolerant to tidal flooding and salinity.

Some of the grasses observed at TIXEN are listed and briefly described below.

Aira caryophyllea - silver hairgrass and *Aira praecox* - early hairgrass are European grasses introduced to North America. They establish on very dry to moderately dry soils, and, A. praecox, on nitrogen-poor soils, as well as vernally moist to dry, gravelly or rocky, open sites. Both are common on Southern Vancouver Island (E-flora 2008).

Arrhenatherum elatius - tall oatgrass is a tall, loosely tufted perennial introduced into meadows or pastures through seeding.

Dactylis glomerata - orchard-grass reproduces from seed and re-sprouts from underground stems. An extensive root system makes it drought-tolerant. It adapts to shade and some soil acidity. Orchard grass uses high levels of nitrogen, and is often found in association with Scotch broom (Cytisus scoparius), which adds nitrogen to the soil. (GOERT 2002).

Holcus lanatus - Common velvet-grass is native to Europe. It is a hairy, perennial grass that grows 50-100 cm tall with soft velvety leaves that are the most consistent feature for identification. The panicle (seed head) is often purplish and spike-like in the spring, becoming more open later in the season. It aggressively invades disturbed sites with wet, mildly acidic soils and prefers sunny or semi-shaded areas. It is very difficult to remove once established. (GOERT 2003)

Bromus tectorum - Cheatgrass is an annual grass that forms tufts up to 2 ft. (0.6 m) tall. The leaves and sheaths are covered in short, soft hairs. The flowers occur as drooping, open, terminal clusters that can have a greenish, red, or purple hue. Flowering occurs in the early summer. Cheatgrass can completely replace native vegetation and change fire regimes due to the accumulation of dry litter (INVASIVE.ORG 2009)

Blackberries

Himalayan (*Rubus discolour*) and evergreen or cutleaf (*Rubus laciniatus)* blackberry species are introduced from Eurasia. Both tend to form impenetrable thickets of spreading vines with very prickly stems. Himalayan blackberry is generally more widespread but both are extremely competitive on disturbed sites.

Himalayan blackberries prefer rich, well-drained soils, but they are highly adaptive and can grow well on a variety of barren, infertile soil types, a wide range of soil pH and textures, and are tolerant of periodic flooding by brackish or fresh water. Reproducing by seed, by rooting at stem tips, by sprouting from root buds and by stem fragments, thickets can produce 7,000-13,000 seeds per square meter. Seeds can remain viable in the soil for several years.

Blackberries reduce biodiversity by competing with native vegetation through shading and build-up of leaf litter and dead stems. Thickets can prevent larger mammal movement.

These weeds are very difficult to remove. A variety of methods have been tried with varying success – fire, physical controls such as hand pulling, cutting, and shading, and chemical means. The bottom line when managing blackberry is to ensure long-term control, otherwise the reproductive invasiveness of blackberry will likely allow it to prevail.

Rubus laciniatus and *Rubus discolor* are common throughout the study area in most ecosystem types except dune units that are extremely dynamic with constant soil disturbance (such as the CM, large headed sedge and KV, black knotweed –yellow sand-verbena units) and those estuarine areas where salt water flooding is sustained and frequent. Areas of the upper meadows where drainage channels are common are well inundated with blackberries.

Periwinkle

Periwinkle (*Vinca minor*) is a perennial evergreen that is winter hardy. Periwinkle is low growing but runners trail long distances and root at the nodes. The thick glossy leaves form a solid ground cover with blue flowers in spring. It has been known to compete with native plants for moisture, light, nutrients and recruitment niches. Because it mainly spreads vegetatively - stem and root fragments can re-sprout - all plant material needs to be removed from the site and disposed of in a manner that will not further spread the plant (CRC 2008).

Periwinkle was observed in an opening adjacent to the main trail in the CRD Park (polygon 28, plot V30) and should be removed.

Rugosa Rose

Rosa rugosa is native to eastern Asia where it is found in sandy soils in coastal and dune environments. These roses are widely used horticulturally in North America. (Flora of China). According to the US Department of Agriculture this species can become naturalized and has the potential to become invasive (USDA 2009).

One Rugosa rose was observed among the beach wood along the eastern shore of the spit. This plant should be hand pulled and the site monitored for further spread.

Altered drainage and ditches

The greatest cause of estuary loss in the past has been the draining and infilling of these ecosystems. Seventy percent of the Fraser River estuary wetlands have been diked, drained, and filled to reclaim land for development. Similarly, about half of the Nanaimo and Cowichan estuary wetlands have been lost (Flynn et al 2006b).

Studies on the eastern US coast (Portnoy 2003, Portnoy 1999, NPS 1999 – Chpt 10) show that blocking tidal flow to salt-water marshes increases fresh water influences, reduces salinity and gives way to the establishment of salt intolerant species and upland shrubs and trees. Biochemical changes occur when tidal flushing is reduced, water levels decrease and surface peat is seasonally drained and aerated which increases decomposition rates and can cause subsidence of the wetland. This lowering of the wetland may affect its ability to protect inland properties from storm surges. Soil and water acidification can occur in wetlands that are diked. Plants become stressed. Habitat values also change as the structure and composition of the wetland changes. Fish kills may occur due to oxygen depletion and mosquito populations usually persist. In wetlands that are also drained, these changes are aggravated.

Draining the estuary for mosquito control and to prevent flooding of private property was implemented at the study area by means of a grid of drainage ditches (Richard Waterfield, email com). A series of east to west running ancillary ditches feed into two north - south running main ditches. According to CRD Parks operations, the system of drainage ditches was developed before the Park was created. The Parks Management plan of 1989, states no new ditches were to be built east of the N-S ditch. Irregular maintenance of the main drainage ditch and back flow preventer now falls to Central Saanich; the remaining ditches have not been excavated in numerous years (Richard Waterfield, email com).

Regardless of the time since these ditches were excavated and the limited degree of maintenance to keep them clear of debris, they continue to impact the natural hydrology – flooding and draining – of the estuarine ecosystems. As water travels the route of least resistance, the ditches tend to flood more quickly than the surrounding soils. Likewise water drains quickly into the ditches rather then slowly filtering through the soil as the tide subsides. This results in vegetation development that is not well adapted to tidal inundation, hence changes to the natural plant community occur and non-native plant species establish. The US studies (Portnoy 2003, Portnoy 1999, NPS 1999 – Chpt 10) suggest biochemical influences may be changing the composition of the soils and waters of the wetland and wildlife habitat is being affected. These latter changes are not as easily observed as the vegetative changes so further study by wetland hydrologists may be warranted to determine the degree of change that has occurred and to consult on remediation possibilities.

Shoreline stabilization and sediment supply changes

Building shoreline stabilization structures is a common practice in an attempt to save private and public property from the erosion and deposition of materials on sand dunes. Sand dunes can be destroyed when structures are built too close to the shoreline.

Berms, retaining walls and off shore breakwaters all influence the natural ecosystem processes; breakwaters slow the wave velocity causing sediments to settle off shore starving the dune of sediment; berms and walls restrict deposition and erosion to the water side of the structure. Erosion continues seaside and will eventually undermine the

structures requiring reinforcement to better stabilize the beach and dune. Interrupting the natural processes in this way may over time destroy the dunes.

Building stabilizing structures where dune sediment originates can starve the beach and dune downstream. Cowichan Head to the south of the study area is a primary sediment source for TIXEN. Waves erode the till bluffs and longshore current carries the sediments north to the beach and dune ecosystems. If this sediment supply were cut off by retaining walls or other devices the balance of sedimentation and erosion would be unstable and the dunes could in time disappear.

A berm, running parallel to the beach, has been in place at Island View Beach Park since before 1989 (CRD Park Plan). It has been repaired at the south end several times by CRD Parks for flood control purposes. The berm is well compacted gravel over various fill materials including logs and riprap (Richard Waterfield, email com.). It serves as a walking trail and affords park users an elevated view of the beach and inland area. The berm is hemmed in with introduced plant species which are favoured over native plants by these altered conditions.

Drift logs can also interrupt the flow of sand that maintains sand dune ecosystems (Flynn *et al.* 2006a). Logs break the flow of sand across the dune (Leech 2008). As logs land on the beach or further inland during storms they obstruct the wind causing eddies where sediments settle, and they provide surfaces upon which sediment can accumulate. Although this is a natural process the abundance of drift wood on local beaches is not and the adundant driftwood probably comes from logs escaping log booms.

Beach logs form a considerable ridge at the back shore all along the eastern beach at TIXEN. It appears that storm events, probably in the winter of 2007/08, breached the logs (polygon 61 just north of polygon 21) resulting in saltwater inundation into the dune. Many Scotch broom plants are dead here.

Development and Land uses

Neighbouring land uses as well as on site development can influence ecosystems in the study area. With urban development, the rate of storm water run-off increases as impervious surfaces such as rooftops, roads and driveways are built; pesticide or herbicide use in neighbouring farms can travel to the estuary in ground water and via ditches; horticultural escapes of non-native plants accelerate as urban development encroaches; increased edge effects occur as areas are fragmented by agriculture, roads and residential developments.

Roads and other infrastructure, campgrounds, and agricultural activities are present at TIXEN. Wherever unnatural stabilizing structures occur, changes to the dynamics of the natural system also occur. The developments discussed below impact the dunes by increasing stabilization and altering soil properties and drainage patterns. Over time, these developments change the hydrology and hence the components of the estuary ecosystems as well. Many areas have been infilled and drained for various purposes as discussed in the section above. Presumably additional structures such as culverts and

perimeter drain systems that have been incorporated into the developments further accelerating the changes to the ecosystem. Introduced species tend to increase as roadways and trails are created. Run off from roads and parking lots and spillage from boats are potential sources of oil and gas pollution. Infrastructure that supports recreational activities – trails, toilets, picnic platforms, etc. - can also negatively affect natural ecosystems by altering the hydrology or change dune stability. Construction of these features can be extremely destructive. Recreational activities in the study area are discussed in the section 5.2.5.

Two paved roads provide access to the study area - one at Island View Beach, the other through the reserve. In the park, Island View Road leads to a parking area and concrete boat ramp. Homathko Road parallels the beach providing access to gravel parking areas and a private campground (polygon 15). Compacted gravel trails lace throughout the park. A broad flat area (polygon 8) is routinely mowed and maintained as a picnic area, and several pit toilets are provided in the park.

The reserve end of the study area is accessible via Sa,su Road (Beach Road) which crosses the edge of the estuary and extends into the dune. Fill and culverts for this road restrict tidal inlet to the wetland. The paved section ends after crossing the wetland, and the road then forks into several highly compacted roadways extending into the main dune area. One of the largest of these leads to the water plant (polygon 47) and carries on south about 1/3 of the length of polygon 46. Another runs more or less along the height of the dune, north along the spit, to a gathering area in polygon 57. It appears that fill has been deposited in this area between the time of the air photos and the field survey, expanding the level area for parking and other activities. In addition there are several semi compacted "roads" throughout the reserve which will over time become more permanent as regular use continues.

A mobile home park exists adjacent to polygon 48. Heavy equipment was on site at the time of the field inventory infilling and expanding the development site[9]. A private campground occupies about half of polygon 15, bisecting the park land. Although it was not assessed during the field inventory, air photo review suggests this area is well compacted gravel with semi permanent highly compacted trailer platforms; most ocean side sites have fences perpendicular and parallel to the shoreline which can impede sediment movement. Many small structures (outbuildings) are apparent as well, further stabilizing the shoreline.

Recreation

Destabilization of dunes is also a serious threat. Destabilization occurs when vegetation and the network of underground roots and rhizomes is damaged. Many dune plants are unable to recover once their roots are compacted. Native dune grass (Elymus mollis) for example dies when its roots are crushed (CRD 2009). Recreational activities compact the sand and crush vegetation –vehicles such as cars, trucks, motorbikes, and bicycles

[9] A July 2009 site visit found the trailer park has been extended further into the wetland. Development includes buildings, paved roads and trailer pads.

damage vegetative structure above and below the surface. Dogs, horses, and even repeated human foot traffic can cause harm by limiting plant growth and regeneration. Although one stroll through the dune may not cause much damage, when multiplied by numerous visitors every year, the damage can be significant, and recovery can take a long time. (Flynn et al 2006a).

There is widespread sign of recreational use at TIXEN. Island View Beach Park is well used by dog walkers, birders, picnickers, boaters, sunbathers and walkers. Other than bicycles, we did not see evidence of vehicle use outside of the access road and parking areas in the CRD Park. There is a network of walking trails through the upper meadow areas (e.g. polygons 24, 25, 29). Extensive vehicle tracks are visible throughout the dune on the reserve land. Semi permanent roadways have developed from repeated vehicle traffic, but vehicle use is not restricted to these areas. The north end of the dune is covered with random tracks and trenches from off-road vehicles; deep holes and damaged vegetation is common. Mud bogging type activity is evident through low lying areas of the spit (e.g. polygon 53). Without sufficient time for recovery from these activities the dune may well destabilize and essentially blow away.

The CRD Parks management report (1989) shows there was extensive equestrian use throughout the meadows and extending into the dune area in the past. Horses are no longer permitted in the park. There is an extensive network of trails used by walkers and their dogs through the salt meadows. There was little evidence of recreational use in the wetter marshes.

6.0 Management Considerations

6.1 Introduction

Management of natural ecosystems is always challenging. Questions abound. What are the management goals? Are we trying to restore the ecosystem to its natural function? What defines the natural function? Do we really know how that system would look without human influence? To complicate matters resource managers often face the need to balance the restoration of natural ecosystems and ecological processes with the social values of the human stakeholders that use the ecosystem.

Ecosystem mapping is one of many tools that contribute to ecosystem management and conservation. Development of an overarching management plan can constructively address ecosystem conservation and competing land uses within the unique environment (natural, social and economic) of TIXEN. This section points to a land management and decision making frame-work that could be a starting point and provide specific strategies to inform the development of the TIXEN plan. Many existing resources including this terrestrial ecosystem inventory will inform the plan. This section also provides summary information from the TEM that should be considered in conservation planning, action and monitoring.

6.2 Management Framework/Plan

Given the diversity of stakeholders and land use pressures in this study area there is need for a coordinated and detailed management plan that clearly defines the goals and preferred outcomes of management activities. It is necessary to evaluate the common and conflicting interests and decide how best to implement management activities. Although management goals may differ in some instances, cooperative planning can present opportunities to coordinate and consolidate resources and to build on each other's strengths. Establishing overarching principals or values agreed upon by the stakeholders can help in this effort. Before specific actions are implemented a clear plan that defines the restoration or management goals, the objectives or actions that will be implemented to achieve those goals, and methods to monitor and evaluate the success of those actions is needed. When goals and objectives are defined they should be as specific as possible and care should be taken to ensure they are measurable and truly evaluate the success of the action. The management plan should provide opportunities to adapt and adjust activities quickly if monitoring suggests that restoration and management activities are not working to achieve the goals.

The Coast Information Team responsible for ecosystem based management (EBM) on the north and central coast of BC produced a framework that can provide a starting point for the creation (or enhancement) of a management plan in TIXEN. Ecosystem based management was defined by this group as:

> "…an adaptive approach to managing human activities that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. The intent is to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological processes can be sustained, and human well being supported and improved." (ILMB 2004)

Many of the principles and goals identified by the Coast Information Team would be applicable in TIXEN and a good starting point for the plan. The advantage of an ecosystem based management approach is that it can provide for the habitat requirements of multiple at-risk species while preserving ecological communities and considering socio-economic values.

Through this approach stakeholders work together to define:

1. **Guiding principles** (e.g., Maintain ecological integrity; Promote human well-being; Sustain cultures, communities and economies within the context of healthy ecosystems; and Ensure planning and management is collaborative),

2. **Goals** (e.g., Maintain the ecological integrity of terrestrial, marine and freshwater ecosystems; Achieve high levels of human well-being) and

3. **Objectives** (e.g., Maintain ecosystem functions and processes (e.g., stream flow, water quality, soils productivity, natural disturbance rates and patterns) across scales and through the long term; Maintain the natural diversity of species, genes, and habitat elements across scales and over time; Protect and where

> necessary restore under-represented, endangered or degraded ecosystems; Recognize and accommodate aboriginal Rights and Title, and interests).

These in turn guide the design of requirements, targets and indicators. In addition, the framework provides guidance for conservation planning at multiple scales, working collaboratively, dealing with uncertainty, evaluating risk, and more.

> ” The purpose is to provide clear guidance as to where people want to go, how they plan to get there, how they can tell if they’re on the right road, and how to tell when they arrive.” (ibid)

The Ecosystem-Based Management Planning Handbook produced by the Coastal Information team can be found at**:** http://ilmbwww.gov.bc.ca/citbc/c-ebm-hdbk-fin-22mar04.pdf

6.3 TEM Considerations for Conservation Management

This Terrestrial Ecosystem map and report provide useful information and include recommendations for further study that can inform conservation planning, actions and monitoring. It is difficult to provide specific recommendations when the principals, goals and objectives of the TIXEN interest groups have not yet been defined.

The TEM identifies these primary issues threatening natural ecosystems at TIXEN:

Introduces species

The Invasive Plant Council of BC (2008) defines the term invasive plant “as any invasive alien plant species that has the potential to pose undesirable or detrimental impacts on humans, animals or ecosystems. Invasive plants establish quickly and easily and can cause widespread negative, economic, social and environmental impacts.”

They also point out that “second to habitat loss, invasive species have been identified as the most significant threat to biodiversity. Invasive plants are more than simply "plants out of place"; they are far-reaching in their impacts, permanently altering landscapes and ecosystem functions and costing economies millions of dollars each year.”

As native plant communities are replaced by invasive plant infestations, biodiversity declines and habitats change. These impacts are often irreversible and restoration can be extremely difficult, if not impossible; therefore, preventing their establishment and spread is critical (Invasive Plant Council of BC 2008).

Controlling introduced species should be approached within the framework of an overall restoration plan. Although introduced species are prevalent throughout the whole study area, Island View Beach Park is remarkable for the extreme numbers found there. As distance from the park boundary increases, the density of invasive species tends to decrease. Management would wisely consider options to halt further spread of these species into areas outside of the park. Consider site characteristics and available

resources to decide where to take management action, what action to take, and when. Care should be taken to ensure that introduced species are correctly identified to avoid removing native species that are similar to the weeds. Experts in controlling invasive plants should be consulted to help design and implement a long term plan. Public and staff education can be valuable in reducing or preventing the spread of invasive plants.

Although invasive species management can be complicated and difficult, some situations at TIXEN seem straightforward right now. For example, the small infestations of Rugosa rose, yellow toadflax[10] and gorse within the reserve and periwinkle in the Park, should be pulled immediately with follow up monitoring implemented. Only one instance of European beach grass was observed by the field crew which suggests this species is not wide spread at present. Control and monitoring should be implemented quickly. On the other hand, substantial invasions of broom, blackberries and grasses are widespread and will require a coordinated and long term plan to address them. Priority areas (those without invasive species now) and the feasibility of success should be examined as part of the planning.

Some references for managing introduced invasive species are listed in Appendix F.

Altered disturbance regime

Recurrent disturbance is a natural phenomenon in the dominant ecosystems at TIXEN. Aeolian processes of shifting sands, erosion and sedimentation in the dunes, and the tidal flooding and deposition in the estuaries are the governing factors that control these sites. Accidental and intentional actions that hinder these natural processes will over time result in the dysfunction and eventual loss of these areas. Changes are already apparent.

If the management team chooses return to natural function as the goal, they will need to know the natural state of the ecosystems. Similar intact ecosystems in other areas may to be used for comparison, old air photos, elder knowledge and past research studies may offer insights into earlier conditions at TIXEN – ever remembering the dynamic nature of these ecosystems, they exist in constant flux, growing and eroding…

Again, a coordinated effort will be needed to address the issues around altered disturbance regime. Public perception of safety and obligation to protect private property may challenge the implementation of a plan to re-establish natural disturbance patterns.

Stabilization: Roads, berms and other structures are increasing the stability of the dunes. Parking lots, trails and picnic areas are part of the Park infrastructure; the berm is in place to provide protection to inland areas from storm events (Waterfield 2009); fences and outbuildings are common in the private campground; beach wood is abundant along the eastern shore; and roadways are a dominant source of stabilization in the reserve. If decommissioning of stabilizing structures meets management goals, consider if they should be actively removed or allowed to deteriorate over time. Time, resources and

[10] Note: During the field survey the yellow toad flax infestation was only noted on the east facing slope bordering polygon 49 and 46. A visit to the study area on July 27, 2009 found this species has spread down the slope and is commonly found throughout polygon 46 as well.

public input should be evaluated. Restricted access to the site may subsequently be needed to prevent users from re-establishing the roads and structures. Public education is vital. Removing or preventing construction of new structures on private property will require collaboration with land owners to justify the need to reduce or eliminate these things.

Hydrological changes: Flood control, via a series of drainage channels, has been in place at TIXEN for many years. These structures are common in the CRD Park, Reserve lands and public property. Other drainage infrastructures associated with developments (buildings and roads) in and adjacent to the study area may also be influencing the flood and ebb of tidal inundation and the rate and duration of fresh water input to the wetlands.

These hydrological changes have resulted in vegetative shifts in the ecological communities and it is possible that biochemical and structural modifications may be occurring as well. Further study by appropriate specialists is needed to determine the extent of these latter ecosystem changes. Return to the natural flood regime would likely reverse the shift from freshwater and upland species back to estuarine marsh species. Although studies in the US suggest return of tidal inundation aids the restoration of estuaries they also suggest proceeding with caution (Portnoy 1999, Portnoy 2003). Temporary detrimental effects may be observed as restoration occurs and a cautious approach affords management time to monitor ecological and hydrological changes and may help ease public uncertainty.

Restoring the natural tidal influence may best be approached in a conservative and gradual manner. Whether this means a deactivation of some of the drainage ditches over time or merely a lack of maintenance of the system to allow their eventual destruction should be determined in consultation with hydrologists and those experienced in wetland restoration. Evaluating risks to private property (such as tidal contamination of any existing wells) must be part of the equation. Hydrological studies of the wetlands to understand the implications of actions are recommended.

Development

Fragmentation and conversion of land to development purposes not only reduces the area of natural ecosystems but also affects the remaining landscape. Fragmentation creates edges – places where a sudden rather than gradual transition occurs from one ecosystem to another (or to a developed site). Along these edges risk of introduced species invasion increases, changes in habitat values for both plants and animals occur, and the integrity of ecosystems is compromised. Building structures in the dunes and wetlands will affect the natural erosion and deposition regimes that govern the natural ecosystems. Infilling of wetlands for development and agriculture is the primary cause of estuary loss.

Development has already affected the function of these natural ecosystems. If additional land development is planned it should be very carefully considered and weighed against the goals and objectives of the management plan for the area. Further fragmentation from more roads, buildings, trails or other features will affect the health of the dunes and wetlands at TIXEN. Ecological restoration along with wildlife habitat values supported

by these ecological communities will be compromised if additional development occurs. Stakeholders may wish to keep abreast of land planning initiatives, such as Official Community Plans (OCP) or Stormwater management plans to ensure off-site development will not negatively impact TIXEN.

Recreational activities

Island View Beach Park was incorporated in 1966 as part of the CRD Parks system. The park mandate has evolved over time, moving towards protecting the natural environment from somewhat destructive activities such as extensive equestrian functions in the past. However visitor use has no doubt increased as the region's population has increased placing more stress on the systems. Park infrastructure, trails, fencing and parking areas provides for appropriate activities in the park. Although there are numerous walking trails through the upper meadows, there was little evidence of misuse, such as off trail or all terrain vehicles. However historic use has resulted in extensive infestations of non-native plant species which has greatly altered the natural ecosystems, and infrastructure has affected the normal disturbance patterns, as discussed above.

The Tsawout have used the area for many years for harvesting of resources, ceremonies and other uses (Terms of Reference 2007). Unfortunately some recent recreational activities are not conducive to ecosystem protection or conservation. In particular, the use of all terrain vehicles on the dunes is extremely destructive.

Restrictions (gates and fences) may be needed to prevent vehicle access to dune areas; public education through signage or site wardens may help users understand the sensitive nature of the ecosystems and understand the implications of even a small amount of inappropriate use. Some dune park systems use boardwalk trails to provide passive access to the area. However there are implications of building permanent structures, the act of construction is not without impact and the addition of permanent structures that further stabilize the dune should be weighed against the benefit of semi-controlled access.

Wildlife habitat values in the ecosystem are affected by visitor use so restrictions to keep dogs under control are suggested. Visitors should avoid breeding or nesting areas during critical times of the year. Dune plants should not be trampled or collected.

6.4 Concluding Thoughts

There is little question that past land-use at TIXEN has altered the natural ecosystems. Disturbance in the form of introduced species has altered the natural plant communities and changed wildlife habitat values. Altered hydrology has aggravated these phenomena and may have caused biochemical changes in the wetlands. Development, housing, trailer parks and campgrounds, roads and trails within and adjacent to the study area have caused changes to the stability of the dunes and the hydrology of the wetlands. Users of this report may refer to the results section for details on anthropogenic influences in the study area.

Land use planners should amass all available data for the study area and determine where knowledge gaps exist. By understanding the biotic community that would naturally exist, achievable and appropriate management action can be implemented. Planners need to understand the natural disturbance regimes. Similar, undisturbed (or less disturbed) ecosystems in other areas may provide a benchmark for management. Studying evidence of past ecosystems and disturbance regimes preserved in wetland, dune and adjacent glacial sediments provides information about past rates of change and ecosystem condition. Addressing ongoing degrading agents may be a first priority. (WLAP no date). Understanding the timeframe for positive changes to occur is needed – some initial actions may appear to cause increased disturbance (i.e. re-establishing tidal flooding). Restoration projects in other areas may indicate a reasonable interval within which to analyze the effectiveness of the plan.

Recognize that the public may not be receptive to changes and may perceive management activities to be damaging ecosystems (for example, allowing natural disturbance to occur, berms may be breached or fields flooded). Public outreach and education is a critical component of the management plan. Involving the public in restoration activities may promote a sense of ownership and encourage stewardship.

7.0 Expanded Legend

The expanded legend provides a detailed description of each ecosystem unit mapped in the TEM. Natural ecosystem units, anthropogenic units and un-vegetated units are described. The typical condition for each unit is mostly based on plot data and terrain attributes for the polygon where the unit is mapped but vegetation lists and site conditions may be augmented, as indicated, from descriptions of the unit in field guides or from other ecosystem mapping projects.

- Traditional use plants, based on Nancy Turner's lists and supplemented by Plants of Coastal British Columbia including Washington, Oregon and Alaska (Pojar and Mackinnon 1994) are indicated in **Bold** text.

- Introduced species are included in a separate box in each ecosystem description although in some cases introduced plant species may represent a significant component of the dominant or associate vegetation. Red and blue listed plants are indicated by coloured text and underlining.

- The provincial conservations status of ecosystem units is correlated to ecological communities tracked and listed by the BC Conservation Data Centre. The conservation status is indicated as red- listed, blue-listed, under assessment or not assessed. Red and blue listed ecosystem names are colour coded.

- Appendix D lists all the plants noted in the study and indicates the provincial status (listing).

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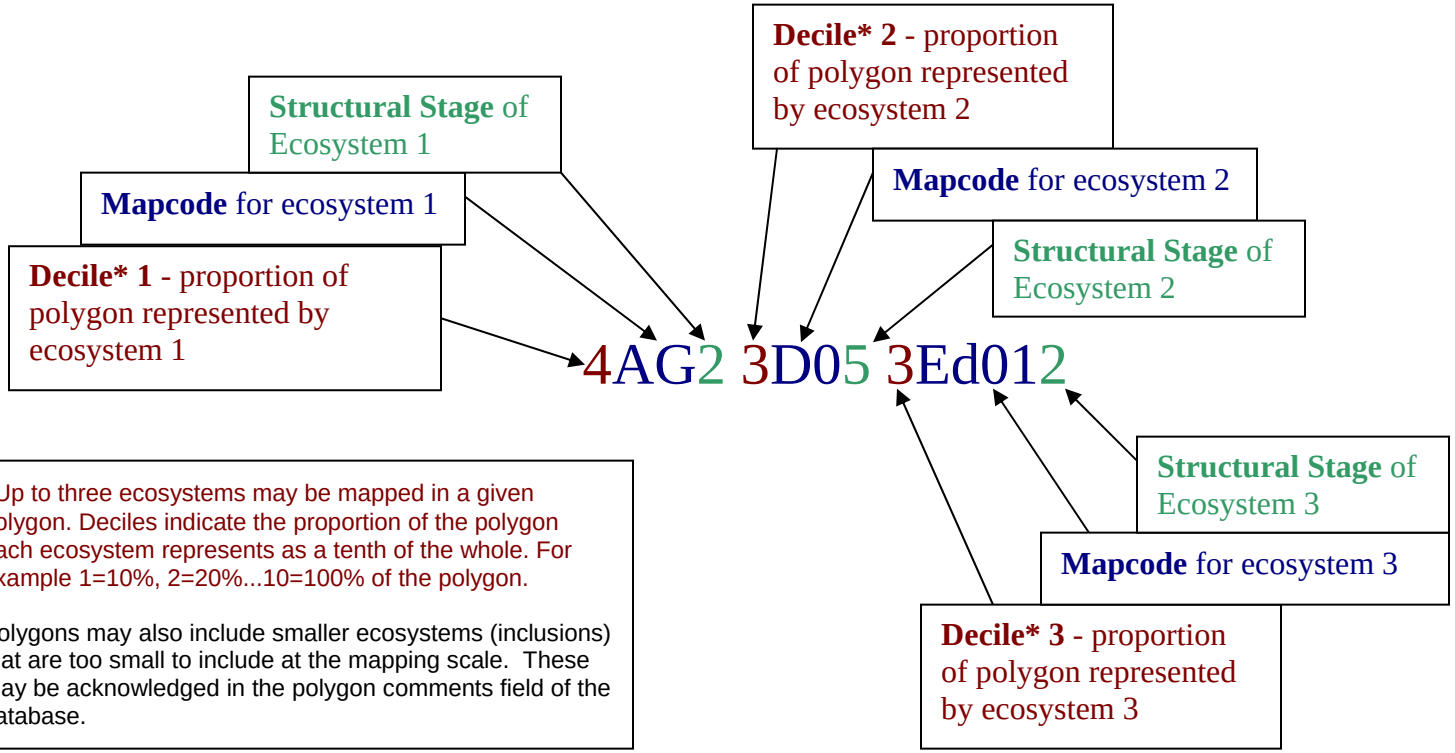
9.0 Appendices

Appendix A: Ecosystem Legend

Figure 1: Ecosystem Label Key



*Up to three ecosystems may be mapped in a given polygon. Deciles indicate the proportion of the polygon each ecosystem represents as a tenth of the whole. For example 1=10%, 2=20%...10=100% of the polygon.

Polygons may also include smaller ecosystems (inclusions) that are too small to include at the mapping scale. These may be acknowledged in the polygon comments field of the database.

This diagram illustrates the components of the ecosystem label in the Terrestrial Ecosystem Map (TEM). Mapcodes and Structural stages are explained in the attached tables. Disturbance codes are also included in the TEM database and are explained in table 3. The Digital Data Capture Standard for Terrestrial Ecosystem Mapping provides more details on the database fields http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/temcapture/index.htm

Table 1: Map Codes and Ecosystem Descriptions

Map Code	Name	Common Name	Plot Numbers	Ecosystem Description
AG	*Ambrosia chammissinis - Grindelia integrifolia*	silver burweed - entire-leaved gumweed	V4	Herbaceous ecosystem found along the dune ridge behind the driftwood at the back of the beach. Vegetation is dominated by silver burweed and entire-leaved gumweed.
BE		beach		Gently sloping sandy and gravely intertidal sites, reworked by wave action. Driftwood is common with little to no vegetation cover.
CF		cultivated field		A flat or gently rolling non-forested area subjected to agricultural practices including ploughing, non-native crop production or livestock grazing. Most cultivated fields in the study area are drained estuarine meadows and marshes with high cover of introduced grass species.
CM	*Carex macrocephala herbaceous vegetation*	large-headed sedge herbaceous vegetation	V12, V19, 02-3197	Herbaceous ecosystem found on rapidly drained sites. Soil moisture availability is low and soil nutrient regime is poor. This ecosystem develops in areas where shifting sand is common. Vegetation is dominated by large-headed sedge, red fescue and entire-leaved gumweed. Common associates are beach bindweed, yellow sand-verbena, black knotweed and thrift. Introduced grasses are common. Moss may develop on more stable sites.
DO	*Pseudotsuga menziesii - Melica subulata*	Douglas-fir - oniongrass	G3	Forested woodland type ecosystem found at the crest of slopes on shallow to bedrock, rapidly drained sites. These sites have very little soil moisture available but are rich in soil nutrients.

DW	*Leymus mollis - Lathyrus japonicus*	dune wildrye - beach pea	V13, 02-3139	Herbaceous ecosystem found on moderately well drained, sandy textured soils. Moderate soil moisture and soil nutrients are available. Vegetation is dominated by dune wildrye (dunegrass) and red fescue. Associate species include entire-leaved gumweed and yarrow. Weeds such as thistles, blackberries and sorrel are common.
Ed01	*Deschampsia cespitosa ssp. Beringensis - Hordeum brachyantherum*	tufted hairgrass - meadow barley	V16?	Upper tidal estuary ecosystems that are flooded briefly with brackish water each day. They have low species diversity dominated by seashore saltgrass and common velvet-grass.
Ed03	*Juncus arcticus - Plantago macrocarpa*	Arctic rush - Alaska plantain	V23-disturbed, V26, G4?	Estuarine ecosystem with a thin organic layer over sandy marine sediments. Peaty phase of glysolic soils. Soil drainage is imperfect to very poor. These sites are rich and wet. They occur in the high intertidal zone with vegetation in this study area is dominated by silverweed, spike bentgrass, seashore saltgrass and Arctic rush.
Em02	*Salicornia virginica - Glaux maritima*	American glasswort - sea-milkwort	V2, V14	Estuary ecosystem occurring in the lowest intertidal zone with daily, prolonged tidal flooding. Vegetation diversity is low and dominated by American glasswort and seashore saltgrass. Significant cover of tufted hairgrass and fleshy *jaumea* may also occur.
Em03	*Distichilis spicata herbaceous vegetation*	seashore saltgrass herbaceous vegetation	G1, G2, V6, V7, V15, V18	Estuary ecosystem occurring in the lowest vegetated tidal zone on imperfect to poorly drained, fine sand to silt textured marine sediments. These sites are flooded daily for prolonged periods. Organic materials may accumulate on slightly higher sites. Vegetation is typically dominated by seashore saltgrass but high cover of coast silverweed and common orache occurs on some sites in the study area.
FC	*Fescue - Cammassia quamash*	Fescue - common camas		An herbaceous ecosystem typically found on gentle slopes and ridge crests of bedrock hills, on shallow medium textured soils. Characteristically occurring in small pockets of well drained soils on bedrock benches. A lush herbaceous cover of wildflowers is common in the spring. Extreme drought in the summer.

KV	*Polygonum paronychia - Abronia latifolia*	black knotweed - yellow sand-verbena	V8, V9, V10, V11, V20	Herbaceous ecosystem found on sites where there is active erosion and deposition by wind and waves. Large areas of bare sand are common. Dominant vegetation includes black knotweed, yellow sand-verbena and entire-leaved gumweed. Other species include beach bindweed, dune wildrye, and silver burweed.
MU		mudflat		Flat non-vegetated plain-like areas with fine sediments. Exposed at low tide.
OW		shallow open water		A wetland with shallow open water (<2m) and lacking significant emergent vegetation.
RA	*Rosa nutkana - Malus fusca* shrub unit	Nootka rose - Pacific crab apple shrub unit	V21, V27	Shrubby ecosystem on well to moderately drained sites on eolian or marine sands, adjacent to estuarine ecosystems. Vegetation is dominated by a dense cover of Nootka rose and Pacific crabapple.
RF	*Thuja plicata - Abies grandis - Tiarella trifoliata*	Western redcedar - grand fir - foamflower	V1	Imperfectly to poorly drained, forested ecosystems found at the toe of slopes, with loamy soil texture. Theses sites are rich in soil nutrients and are relatively wet. The RF is mapped at young forest and shrubby structural stages within the study area.
RW		rural		An area where residential development is interspersed with natural ecosystems or cultivated crops.
RZ		road surface		An area cleared and compacted for the purpose of vehicular traffic passage.
SW	*Scirpus Americanus* wetland	American bulrush wetland	V3	Wetland on poor to very poorly drained organic soils in depressional sites. Vegetation is almost exclusively American Bulrush surrounded by ring of velvet grass and coast silverweed.
UR		urban		An area where human development make an almost continuous cover of the landscape.
Ws51	Salix sitchensis - Salix lucida - Lysichiton americanus	Sitka willow - Pacific willow - skunk cabbage		Closed canopy of shrubs and low trees dominated by Sitka willow and Pacific willow with some alder and a lush understory with skunk cabbage and lady fern.

Table 2: Structural Stages: Structural stage describe the current appearance, structural features and age of the ecosystem unit

Structural Stage Code	Description
1	**Sparse/bryoid**: Initial stages of primary and secondary succession; bryophytes and lichens often dominant; time since disturbance <20 years for normal forest succession, may be prolonged (50-100+ years) where there is little or no soil development (bedrock, boulder fields); total shrub and herb cover <20%; total tree cover <10%.
2	**Herb**: Early successional stage or herb communities maintained by environmental conditions or disturbance (e.g., snow fields, avalanche tracks, wetlands, flooding, grasslands, intensive grazing, intense fire damage); dominated by herbs (forbs, graminoids, ferns); some invading or residual shrubs and trees may be present; tree cover < 10%, shrubs ≤ 20% or < 33% of total cover, herb-layer cover > 20%, or ≥ 33% of total cover; time since disturbance < 20 years for normal forest succession; many non-forested communities are perpetually maintained in this stage.
3	**Shrub/Herb**: Early successional stage or shrub communities maintained by environmental conditions or disturbance; dominated by shrubby vegetation; seedlings and advance regeneration may be abundant; tree cover < 10%, shrub cover > 20% or ≥ 33% of total cover.
	3a **Low shrub** - dominated by shrubby vegetation < 2 m tall; seedlings and advance regeneration may be abundant; time since disturbance < 20 years for normal forest succession; may be perpetuated indefinitely by environmental conditions or disturbance; or **3b** **Tall shrub** - dominated by shrubby vegetation that is 2-10 m tall; seedlings and advance regeneration may be abundant; time since disturbance < 40 years for normal forest succession; may be perpetuated indefinitely.
4	**Pole/Sapling**: Trees > 10 m tall, typically densely stocked, have overtopped shrub and herb layers; younger stands are vigorous (usually > 10-15 years old); older stagnated stands (up to 100 years old) are also included; self-thinning and vertical structure not yet evident in the canopy; time since disturbance < 40 years for normal forest succession; up to 100+ years for dense (5000 - 15000+ stems per ha) stagnant stands.
5	**Young Forest**: Self-thinning has become evident and the forest canopy has begun to differentiate into distinct layers (dominant, main canopy, and overtopped); vigorous growth and a more open stand than in the PS stage; begins as early as age 30 and extends to 50-80 years; time since disturbance generally 40-80 years, depending on tree species and ecological conditions.
6	**Mature Forest**: Trees established after the last disturbance have matured; a second cycle of shade-tolerant trees may have become established; understories become well developed as the canopy opens up; time since disturbance generally 80-250 years.
7	**Old Forest**: Old, structurally complex stands comprised mainly of shade-tolerant and regenerating tree species, although older seral and long-lived trees from a disturbance such as fire may still dominate the upper canopy; snags and coarse woody debris in all stages of decomposition and patchy understories typical; understories may include tree species uncommon in the canopy, because of inherent limitations of these species under the given conditions; time since disturbance generally 250 years.

(Table derived from structural stages in *Field Manual for Describing Terrestrial Ecosystems*, Province of BC, 1998)

Table 3: Disturbance Codes: Disturbance codes describe on-site influences that affect or alter the vegetation and soil characteristics expected for the site in the absence of human influences.

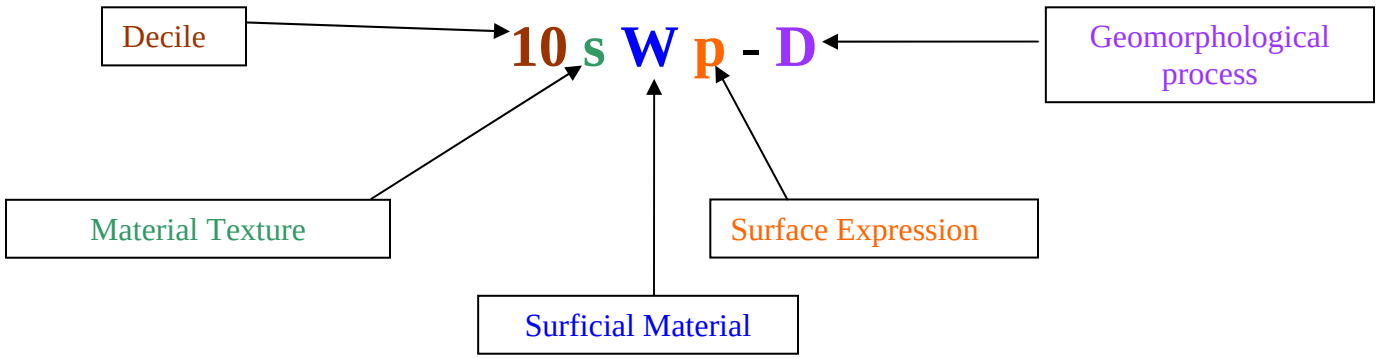
B. Biotic effects	
v.	aggressive vegetation
L. Forest harvesting	
c.	clearcut system
S. Soil disturbance	
c.	compaction
W. Water-related effects	
d.	water table control (diking, damming)
X. Miscellaneous -this is a user defined disturbance type, used to describe conditions in this study area.	
vm.	Vehicular disturbance – motorized
vn.	Vehicular disturbance – non-motorized

(Table derived from Disturbance Codes in *Field Manual for Describing Terrestrial Ecosystems*, Province of BC, 1998)

Appendix B: Terrain Map Legend

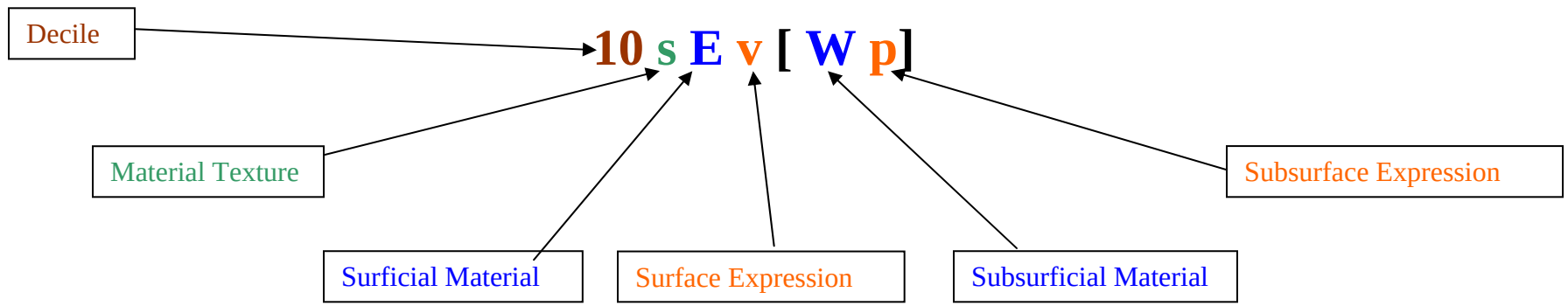
Figure 2: Terrain Label Keys

Figure 2A: SIMPLE TERRAIN SYMBOL



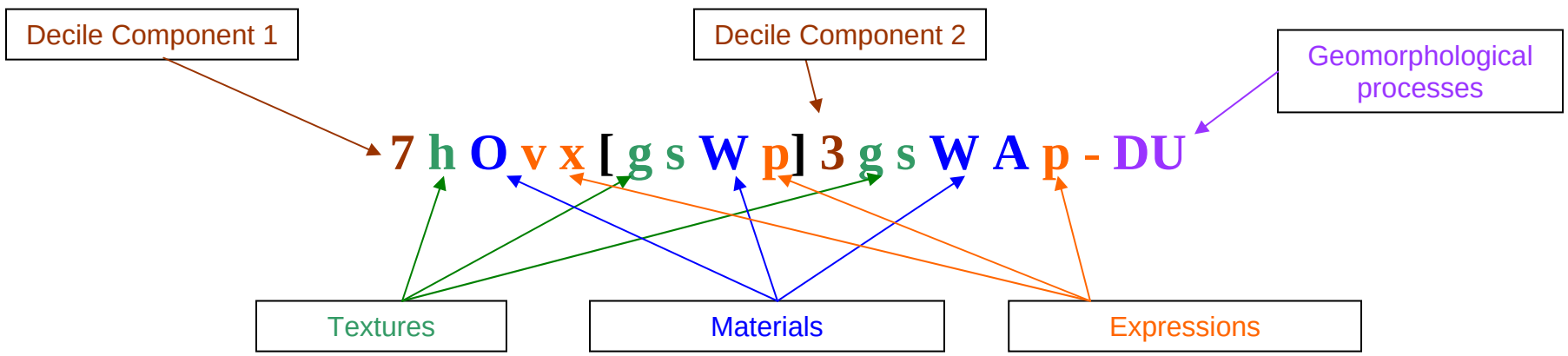
100 % sandy marine plane with deflation by wind.

Figure 2B: STRATIGRAPHIC TERRAIN SYMBOL
Stratigraphic symbols are used when one kind of material overlays another. Square brackets are used to indicate the underlying material.



100 % sandy eolian veneer **over** marine plane.

Figure 2C: COMPOSITE TERRAIN SYMBOL
Composite terrain symbols are used where more then one terrain type exists in a polygon. These are made up of 2 to 3 simple or stratigraphic terrain components.



70 % humic organic veneer and thin veneer over gravelly sandy marine plane, 30 % gravelly sandy active marine plane with deflation and inundation (flooding).

DECILE

Deciles are used in complex symbols to indicate the proportion out of ten that each component occupies in the polygon. Complex polygons can include up to 3 terrain components each proceeded by a decile.

e.g., 6hOb [sWAp]4sWp - U , 60 % humic organic blanket over sandy active marine plane and 40 % sandy marine plane.

Table 4: Texture Codes: Texture is represented by one to three lowercase letter codes that describe the size, roundedness and sorting of the particles in mineral sediments or the fiber content of organic materials.

Mineral		
c	clay	< 2μm
z	silt	62.5 - 2μm
s	sand	2 mm - 62.5μm
p	pebbles	Rounded; 2 - 64 mm
k	cobbles	Rounded; 64 - 256 mm
b	boulders	Rounded; > 256 mm
a	blocks	angular boulders
f	fines	any or all of clay, silt and fine sand
d	mixed fragments	mixed angular and rounded fragments
g	gravel	Rounded particles > 2mm
r	rubble	angular particles, 2 - 256 mm
x	angular fragments	mix of both rubble and blocks
m	mud	mix of both clay and silt
y	shells	shell or shell fragments
Organic		
e	fibric	Least decomposed
u	mesic	Moderately decomposed
h	humic	Well decomposed

Table 5: Surficial Materials Found in the Study Area: Surficial materials are the loose materials that overly bedrock. They are represented by an uppercase code of one or two letters.

A	Anthropogenic materials	Artificial materials, and materials modified by human actions such that their original physical appearance and properties have been drastically altered.
E	Eolian sediments	Sand and silt transported and deposited by wind; includes loess.
F	Fluvial materials	Sands and gravels transported and deposited by streams and rivers; floodplains, terraces and alluvial fans.
FA	"Active" fluvial materials	Active deposition zone on modern floodplains and fans; active channel zone.
M	Till	Material deposited by glaciers without modification by flowing water. Typically consists of a mixture of pebbles, cobbles and boulders in a matrix of sand, silt and clay.
O	Organic materials	Material resulting from the accumulation of decaying vegetative matter; includes peat and organic soils.
W	Marine sediments	Sediments that were deposited by settling and gravity flows in brackish or marine waters, and beach sands and gravels.
WA	“Active” marine sediments	The inter-tidal zone where sediments are actively being deposited by settling and gravity flows in brackish or marine waters, and beach sands and gravels.

Figure 6: Surface Expression (Landform): Surface expression is the three dimensions shape of the surficial material represented by one to three lowercase letter codes.

a	moderate slope(s)	predominantly planar slopes; 15-26° (27-49%).
b	blanket	material >1-2m thick with topography derived from underlying bedrock (which may not be mapped) or surficial material.
c	cone	a fan-shaped surface that is a sector of a cone; slopes 15° (27%) and steeper.
d	depression	enclosed depressions.
f	fan	a fan-shaped surface that is a sector of a cone; slopes 3-15° (5-27%).
h	hummocky	steep-sided hillocks and hollows; many slopes >15° (27%).
j	gentle slope(s)	predominantly planar slopes; 3-15° (5-27%).
k	moderately steep slope	predominantly planar slopes; 26-35° (49-70%).
m	rolling topography	linear rises and depressions; <15° (27%).
p	plain	0-3° (0-5%).
r	ridges	linear rises and depressions with many slopes >15° (27%)r.
s	steep slope(s)	slopes steeper than 35° (70%).
t	terrace(s)	stepped topography and benchlands.
u	undulating topography	hillocks and hollows; slopes predominantly <15° (27%).
v	veneer	material <1-2m thick with topography derived from underlying bedrock (may not be mapped) or surficial material; may include outcrops of underlying material.
w	mantle of variable thickness	material of variable thickness infilling depressions in an irregular substrate (rock or surficial material).
x	thin veneer	a thin veneer, where material is predominantly 10-25 centimetres thick.

Figure 7: Geomorphological Processes Active in the Study Area: Geomorphological processes are the natural mechanisms of weathering, erosion and deposition that result in the modification of surficial materials and landforms. Up to 3 uppercase codes can be used to describe the processes in the polygon.

D	Deflation	Removal of sand and silt particles by wind action.
U	Inundated	Areas submerged in standing water from a seasonally high watertable.
W	Washing	Winnowing of fines by flowing water; development of lag deposits.

Figure 8: Drainage Codes: Drainage is how rapidly water is removed from the soil in relation to additions. It is related to ground water level and soil permeability. Soil drainage symbols apply to the polygon as a whole and contain one or two drainage codes.

x	very rapidly drained	Water is removed from the soil very rapidly in relation to supply.
r	rapidly drained	water is removed from the soil rapidly in relation to supply
w	well drained	water is removed from the soil readily but not rapidly
m	moderately well drained	water is removed from the soil somewhat slowly in relation to supply
i	imperfectly drained	water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season
p	poorly drained	water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen
v	very poorly drained	water is removed from the soil so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen

Note: Where two drainage classes are shown: if the symbols are separated by a dash, e.g., w-i then all intermediate classes are present; if the symbols are separated by a comma, e.g., w,i then no intermediate classes are present. Examples:.

v	**w-i**	**w,i**
very poorly drained	well to imperfectly drained	well and imperfectly drained

For more information please refer to the following documents and resources:

Terrain Overview website
http://www.env.gov.bc.ca/terrain/terrain_files/overview.html

Terrain Classification System for British Columbia, 1997
http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/terclass/terclass_system_1997.pdf

Standards for Digital Terrain Data Capture in British Columbia – Errata 2006 1.1
http://ilmbwww.gov.bc.ca/risc/pubs/earthsci/terrain/Standard%20for%20Digita_Terrain_%20Data_%20Capture-Errata2006-1_1%20FINAL.pdf

Coastal Sand Dune Ecosystems in British Columbia, 2006
http://www.env.gov.bc.ca/wld/documents/sand_dunes_brchr06.pdf

The Terrestrial Ecosystem Mapping Website
http://www.env.gov.bc.ca/ecology/tem/index.html

Field Manual for Describing Terrestrial Ecosystems, 1998
http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm

Standard for Terrestrial Ecosystem Mapping (TEM) - Digital Data Capture in British Columbia, 2000
http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/temcapture/index.htm

Standard for Terrestrial Ecosystem Mapping (TEM) - Digital Data Capture in British Columbia, 2003
http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/temcapture/index.htm

Appendix C: Plot Forms

Full plots (FS882 parts 1 – 3)

ECOSYSTEM FIELD FORM

BRITISH COLUMBIA
MINISTRY OF FORESTS
BC ENVIRONMENT

DATE Y M D	PLOT NO.		
PROJECT ID.	FIELD NO.	SURVEYOR(S)	

SITE DESCRIPTION

LOCATION

GENERAL LOCATION				
FOREST REGION	MAPSHEET	UTM ZONE	LAT./ NORTH.	LONG./ EAST.
AIRPHOTO NO.	X CO-ORD.	Y CO-ORD.	MAP UNIT	

SITE INFORMATION

PLOT REPRESENTING						
BGC UNIT	SITE SERIES	TRANS./ DISTRIB.	ECOSECTION			
MOISTURE REGIME	NUTRIENT REGIME	SUCCESS. STATUS	STRUCT. STAGE	REALM/ CLASS	SITE DISTURB.	PHOTO ROLL
ELEV. m.	SLOPE %	ASPECT °	MESO SLOPE POS.	SURFACE TOPOG.	EXPOS. TYPE	FRAME NOS.

SITE DIAGRAM

NOTES

SUBSTRATE (%)

ORG. MATTER		ROCKS	
DEC. WOOD		MINERAL SOIL	
BEDROCK		WATER	

FS882 (1) HRE 98/5

SOIL DESCRIPTION

GEOLOGY BEDROCK	C. F. LITH.	SURVEYOR(S)	PLOT NO.
TERRAIN TEXTURE 1 / 2	SURFICIAL MATERIAL 1 / 2	SURFACE EXPR. 1 / 2	GEOMORPH. PROCESS 1 / 2
SOIL CLASS.	HUMUS FORM	HYDROGEO.	
ROOTING DEPTH cm	ROOT RESTRICT. LAYER TYPE	WATER SOURCE	DRAINAGE
R. Z. PART. SIZE	DEPTH cm	SEEPAGE cm	FLOOD RG.

PROFILE DIAGRAM

ORGANIC HORIZONS/LAYERS

HOR/ LAYER	DEPTH	FABRIC STRUCTURE	FABRIC vPOST	MYCEL. AB.	FECAL AB.	ROOTS AB.	ROOTS SIZE	pH	COMMENTS (consistency, character, fauna, etc):

MINERAL HORIZONS/LAYERS

HOR/ LAYER	DEPTH	COLOUR	ASP.	TEXT.	% COARSE FRAGMENTS G	C	S	TOTAL	SHAPE	ROOTS AB.	SIZE	STRUCTURE CLASS	KIND	pH	COMMENTS (mottles, clay films, effervesc., etc):

NOTES:

FS882 (2) HRE 98/5

VEGETATION

SPP. LIST	COMP. ☐ PART. ☐	% COVER BY LAYER	TREE (A)	SHRUB (B)	HERB (C)	MOSS / LICHEN (D)	SURVEYOR(S)	PLOT NO.	PAGE	OF

TREES	A1	A2	A3	A	B1	B2	B

SHRUBS	B1	B2	B

HERB LAYER (C)	%

MOSS / LICHEN / SEEDLING (D)	%

ADDITIONAL SPECIES	LAYER	%

NOTES: _____

FS882 (3) HRE 98/5

Ground Inspection Form (GIF)

BRITISH COLUMBIA

GROUND INSPECTION FORM

G ☐ vs V ☐	PHOTO	X:	Y:	DATE
PROJECT ID.		SURV.		
MAP SHEET		PLOT #	POLY. #	
UTM ZONE	LAT. / NORTH	LONG. / EAST		
ASPECT °		ELEVATION m		
SLOPE %	SMR	SNR		

MESO SLOPE POSTION	☐ Crest ☐ Upper slope	☐ Mid slope ☐ Lower slope ☐ Toe	☐ Depression ☐ Level
DRAINAGE - MINERAL SOILS	☐ Very rapidly ☐ Rapidly	☐ Well ☐ Mod. well ☐ Imperfectly	☐ Poorly ☐ Very poorly
MOISTURE SUBCLASSES - ORGANIC SOILS	☐ Aqueous ☐ Peraquic	☐ Aquic ☐ Subaquic	☐ Perhumid ☐ Humid
MINERAL SOIL TEXTURE	☐ Sandy (LS,S) ☐ Loamy (SL,L,SCL,FSL)	☐ Silty (SiL,Si) ☐ Clayey (SiCL,CL,SC,SiC,C)	

ORGANIC SOIL TEXTURE ☐ Fibric ☐ Mesic ☐ Humic	SURF. ORGANIC HORIZON THICKNESS ☐ 0–40 cm ☐ > 40 cm
HUMUS FORM ☐ Mor ☐ Moder ☐ Mull	ROOT RESTRICTING LAYER Depth _____ cm Type _____

COARSE FRAGMENT CONTENT
☐ < 20% ☐ 20–35% ☐ 35–70% ☐ > 70%

TERRAIN COMPONENT: TC1 ☐ TC2 ☐ TC3 ☐

TERRAIN TEXTURE	SURFICIAL MATERIAL	SURFACE EXPRESSION	GEOMORPH PROCESS
1	1	1	1
2	2	2	2

ECOSYSTEM COMPONENT: EC1 ☐ EC2 ☐ EC3 ☐

BGC UNIT	ECOSECTION
SITE SERIES	SITE MODIFIERS
STRUCTURAL STAGE	CROWN CLOSURE %

ECOSYSTEM POLYGON SUMMARY					TERRAIN POLYGON SUMMARY		
	%	SS	SM	ST		%	Classification
EC1					TC1		
EC2					TC2		
EC3					TC3		

Conservation Evaluation Form

CONSERVATION EVALUATION FORM			
PROJECT IDENTIFICATION		**DATE:**	
PROJECT ID:		**PLOT #:**	
POLY #:	**SEI CLASS:SUBCLASS:**		
ECOLOGICAL COMMUNITY			
CONSERVATION INFORMATION			
OWNER/JURISDICTION:			
DISTURBANCE:		**KNOWN THREATS:**	
ADJACENT LAND USE:		**OTHER FACTORS:**	
ALIEN SPP.:			
SUCCESS. STATUS:		**EST. SIZE COMM:**	**(ha)**
FRAGMENTATION OF ECOLOGICAL COMMUNITY			
❒ < 5% FRAGMENTED ❒ 5 - 25 % FRAGMENTED ❒ > 25% FRAGMENTED			
EVALUATION SUMMARY			
LANDSCAPE CONTEXT:	EXCELLENT ❒ GOOD ❒ FAIR ❒ POOR ❒		
ECOLOGICAL INTEGRITY:	EXCELLENT ❒ GOOD ❒ FAIR ❒ POOR ❒		
CONDITION:	EXCELLENT ❒ GOOD ❒ FAIR ❒ POOR ❒		
NOTES(AT-RISK SPECIES, WILDLIFE OBSV., ACCURACY INFO, ETC)			
OBSERVER	NAME:		
ADDRESS:			
EMAIL:		PHONE/FAX:	
SUBMIT DATA			
B.C. Conservation Data Centre **P.O. Box 9358, Stn. Prov. Gov't, Victoria, BC. V8W 9M2** Include: FS882 or GIF or VENUS file ❒ air photos with polygon marked ❒ map product(s) ❒ ground photos ❒			

Appendix D: Plant list

This plant list comes from the VENUS report. Therefore it includes only those plants entered with a percent cover. Plants without percent cover or those recorded in the notes section of field forms may not be included.

Species codes[11]	Latin Name	Common Name	Provincial Status
ABROLAT	Abronia latifolia	yellow sand-verbena	Blue
ACHIMIL	Achillea millefolium	yarrow	Yellow
AGROEXA	Agrostis exarata	spike bentgrass	Yellow
AGROSTI	Agrostis sp.	bentgrass	
AIRACAR	Aira caryophyllea	silver hairgrass	Exotic
AIRAPRA	Aira praecox	early hairgrass	Exotic
AMBRCHA	Ambrosia chamissonis	silver burweed	Yellow
ARMEMAR	Armeria maritime	thrift	Yellow
ARRHELA	Arrhenatherum elatius	tall oatgrass	Exotic
ATRIPAT	Atriplex patula	common orache	Exotic
BROMSTE	Bromus sterilis	barren brome	Exotic
BROMTEC	Bromus tectorum	cheatgrass	Exotic
CALACAN	Calamagrostis Canadensis	bluejoint reedgrass	Yellow
CAMALEI	Camassia leichtlinii	great camas	Yellow
CAREMAR	Carex macrocephala	large-headed sedge	Yellow
CHENALB	Chenopodium album	lamb's-quarters	Exotic
CIRSIUM	Cirsium sp.	thistle	Exotic
CONVSOL	Convolvulus soldanella	beach bindweed	Blue
DACTGLO	Dactylis glomerata	orchard-grass	Exotic
DESCCES	Deschampsia cespitosa	tufted hairgrass	Exotic
DICRANU	Dicranum sp.	heron's-bill moss	Yellow
DISTSPI	Distichlis spicata	seashore saltgrass	Yellow
ELYMGLA	Elymus glaucus	blue wildrye	Yellow
EPILOBI	Epilobium sp.	willowherb	
EQUISET	Equisetum sp.	horsetail	Yellow
ERIOLAN	Eriophyllum lanatum	woolly eriophyllum	Yellow
FESTRUB	Festuca rubra	red fescue	Yellow
FESTUCA	Festuca sp.	fescue	
GLEHLIT	Glehnia littoralis	American glehnia	Blue
GRININT	Grindelia integrifolia	Puget Sound gumweed	Yellow
HOLCLAN	Holcus lanatus	common velvet-grass	Exotic
HORDBRA	Hordeum brachyantherum	meadow barley	Yellow
HYPORAD	Hypochaeris radicata	hairy cat's-ear	Exotic
JAUMCAR	Jaumea carnosa	fleshy jaumea	Blue
JUNCARC	Juncus arcticus	arctic rush	Blue
LEPIDIU	Lepidium sp.	peppergrass species	
LEYMMOL	Leymus mollis	dune wildrye	Yellow
LOMANUD	Lomatium nudicaule	barestem desert-parsley	Yellow
OEMLCER	Oemleria cerasiformis	Indian-plum	Yellow

[11] Species codes are usually composed of the first 4 letters in the genus name followed by the first 3 letters in the species name. These codes are used on the field forms and in the VENUS file.

OENASAR	Oenanthe sarmentosa	Pacific water-parsley	Yellow
OROBCAL	Orobanche californica	California broomrape	Yellow
PLANLAN	Plantago lanceolata	ribwort plantain	Exotic
PLANMAR	Plantago maritima	sea plantain	Yellow
POLYPAR	Polygonum paronychia	black knotweed	Blue
POLYGLY	Polypodium glycyrrhiza	licorice fern	Yellow
POTEEGE	Potentilla egedii	coast silverweed	Yellow
PTERAQU	Pteridium aquilinum	bracken fern	Yellow
QUERGAR	Quercus garryana	Garry oak	Yellow
RACOCAN	Racomitrium canescens	grey rock-moss	Yellow Or Blue
RAMAMEN	Ramalina menziesii	the fishnet	
RANUOCC	Ranunculus occidentalis	western buttercup	Yellow
RHAMPUR	Rhamnus purshiana	cascara	Yellow
ROSANUT	Rosa nutkana	Nootka rose	Yellow
RUBULAC	Rubus laciniatus	cutleaf evergreen blackberry	Exotic
RUBUSPE	Rubus spectabilis	salmonberry	Yellow
RUBUURS	Rubus ursinus	trailing blackberry	Yellow
RUMEACT	Rumex acetosella	sheep sorrel	Exotic
RUMEX	Rumex sp.	sorrel species	
SALIVIR	Salicornia virginica	American glasswort	Yellow
SANICRA	Sanicula crassicaulis	Pacific sanicle	Yellow
SENECIO	Senecio sp.	groundsel species	
SONCASP	Sonchus asper	prickly sow-thistle	Exotic
SYMPALB	Symphoricarpos albus	common snowberry	Yellow
THUJPLI	Thuja plicata	western redcedar	Yellow
TIARTRI	Tiarella trifoliate	three-leaved foamflower	Yellow
TYPHLAT	Typha latifolia	common cattail	Yellow
VULPIA	Vulpia sp.	vulpia species	

Appendix E: Plant Lists compiled from Nancy Turner Lists

Plant Inventory for TIXEN, Tsawout

Original survey: May 6, 2007
Nancy Turner, Dan Claxton, Lisa, Tristan, Adam, Belinda, Richard, Susan, Glenn, Dennis

- * indicates introduced species
- species of particular importance and interest are in **boldface**

TREES [note the trees are quite stunted and there is evidence that quite a few have died recently, apparently from the summer drought]

Broadleaf maple (*Acer macrophyllum*)

Arbutus (*Arbutus menziesii*)

Wild crabapple (*Pyrus fusca*)

Douglas-fir (*Pseudotsuga menziesii*)

Cascara (*Rhamnus purshiana*) [one small, stunted tree]

* Mountain-ash or Rowan tree (*Sorbus aucuparia*)

Western red-cedar (*Thuja plicata*)

SHRUBS
Saskatoon berry (*Amelanchier alnifolia*) blooming

* Scotch broom (*Cytisus scoparius*) – a few flowering bushes

Oceanspray (*Holodiscus discolor*) [on landward end of spit]

Indian-plum (*Oemleria cerasiformis*) [on landward end of spit]

Black gooseberry (*Ribes divaricatum*)

Red-flowering currant (*Ribes sanguineum*)

Nootka rose (*Rosa nutkana*)

*Rugose rose (*Rosa rugosa*)

Trailing wild blackberry (*Rubus ursinus*)

* Himalayan blackberry (*Rubus discolor*)

* Cutleaf or evergreen blackberry (*Rubus laciniatus*)

Red elderberry (*Sambucus racemosa*) [on landward end of spit]

* Gorse (*Ulex europea*)

HERBACEOUS FLOWERING PLANTS

Sand verbena (*Abronia latifolia*)

Yarrow (*Achillea millefolium*)

* Hair grass (*Aira praecox*)

Hooker's onion (*Allium acuminatum*) – one patch seen; formerly eaten and pit-cooked (Belinda Claxton remembered from being with her mom, Elsie Claxton)

* Dunegrass (*Ammophila arenaria*)

* Sweet vernal grass (*Anthoxanthum odoratum*)

Orache (*Atriplex ?patula*)

* Cheatgrass (*Bromus tectorum*)

Beach wormwood (*Ambrosia chamissonis*; syn. *Franseria chamissonis*)

Sea rocket (*Cakile edentula*)

Bittercress (*Cardamine oligosperma*)

Large-headed sedge (*Carex macrocephala*)

Field chickweed (*Cerastium arvense*) – in bloom

Blue-eyed Mary (*Collinsia parviflora*)

* Wild carrot, or Queen Anne's Lace (*Daucus carota*)

? small mustard (?*Descurainea* sp.)

Saltgrass (*Distichlis spicata*)

?witlow grass (*Draba verna* ?)

American dune grass (*Elymus mollis*) - The tough leaves of this grass of the upper shoreline were used as ties for making basket traps and other kinds of fish traps,

according to Elsie Claxton. She said the fishermen used to take bundles of the leaves out in their canoes with them and spend their time waiting for the fish to come making basket traps with these grasses and other materials.

* Stork's bill geranium, or filaree (*Erodium cicutarium*)

?Fescue grass (*Festuca* sp.) – v. narrow leaved, non flowering

Chocolate lily (*Fritillaria lanceolata*) – small cluster; edible bulbs

* Common bedstraw (*Galium aparine*)

* Cranesbill (*Geranium molle*)

"Beach carrot" (*Glehnia littoralis*)

Gumweed (*Grindelia* sp.) - this yellow-flowered daisy-like plant grows on the rocks near the shoreline and has very gummy flowers.

* Velvet grass (*Holcus lanatus*)

* Cat's ear dandelion (*Hypochaeris radicata*)

* Dead nettle (*Lamium purpureum*)

Sea pea (*Lathyrus japonicus)* - grows along the beach and looks like a sweet-pea. Some people call it "canoe plant" because of the canoe-like seedpods.

Indian celery, Indian consumption plant (*Lomatium nudicaule*) - this plant is called qeXmín. It's highly aromatic seeds were an important incense, and were used for colds, sore throats and respiratory ailments. The smoke from burning them was said to be the food of the Salmon People. It is associated with the First Salmon Ceremony.

* Pineappleweed (*Matricaria matricarioides*)

Common miner's-lettuce (*Montia perfoliata*; syn. *Claytonia perfoliata*)

Bi-coloured forget-me-not (*Myosotis bicolor*)

Small owl's clover (*Orthocarpus pusillus*)

* Narrow-leaved plantain or ribwort (*Plantago lanceolata*)

Seaside plantain (*Plantago maritima*)

* Poa (*Poa viviparum*)

Beach knotweed (*Polygonum paronychia*)

* Sourgrass, or sheep sorrel (*Rumex acetosella*) - an introduced plant with sour-tasting leaves; in some places, children like to eat them

Glasswort (*Salicornia virginica* ?); need to check if it is a perennial – forming dense meadows at upper tide line

Sanicle (*Sanicula crassicaulis*)

stonecrop (*?Sedum divergens* – possibly * *S. acre*, an introduced species)

* Common groundsel (*Senecio vulgaris*)

Sand spurrey (*Spergularia rubra*)

Thrift (*Statice armeria*; syn. *Armeria maritima*)

* Common chickweed (*Stellaria media*)

* Dandelion (*Taraxacum officinale*)

* Common vetch (*Vicia sativa*)

Moss:
Rhacomitrium canescens
NOTE: list is very preliminary; many other mosses and lichens and grass species not yet documented.

Plant Notes from June 10, 2007:
Nancy Turner, Dan Claxton, Lisa, Tristan, Adam, Earl Claxton Jr., J. D. Williams

Sand verbena (*Abronia latifolia*) - in full bloom (need to photograph)

Yarrow (*Achillea millefolium*) – in full bloom (need to photograph)

Hooker's onion (*Allium acuminatum*) – in full bloom and common further out on spit (need to photograph)

Orache (*Atriplex patula*)

New plant: **Beach morning-glory (*Convolulus soldanella*)** NOT SEEN LAST TIME; - in full bloom (need to photograph); need to check if a listed species

"Beach carrot" (*Glehnia littoralis*) - in beginning bloom (need to photograph)

Indian celery, Indian consumption plant (*Lomatium nudicaule*) – qeXmín – in bloom and early fruiting stage; need to photograph

***Yellow bush lupine (*Lupinus arboreus*) –** native to California; some in bloom -escaped from cultivation to become an invasive species in many areas; potential noxious weed

New plant: **Unknown, low, silvery lupine like plant;** no flower; in fruit; possibly *Lupinus chamissonis,* Silver Dune Lupine; tolerates seaside conditions, salt and sand

Beach knotweed (*Polygonum paronychia*) – in beginning bloom (need to photograph)

Glasswort (*Salicornia virginica*) – growing up well to edible stage ("sea asparagus")

Thrift (*Statice armeria*; syn. *Armeria maritima*) – in full bloom (need to photograph)

Appendix F: A Selection of Resources on Introduced Plant Species Management

BC Biodiversity Webpage on Noxious Weeds
(**http://bcbiodiversity.homestead.com/noxiousweeds.html**)

BC Ministry of Agriculture and Lands Weed BC Identification and Management Website
http://www.weedsbc.ca/

BC Ministry of Agriculture and Lands Weed Management website
http://www.agf.gov.bc.ca/cropprot/weeds.htm

BC Ministry of Forests and Range Invasive Alien Plant Program website
http://www.for.gov.bc.ca/hra/Plants/application.htm

Canadian Wildlife Service On-line Publication, Invasive plants of natural habitats in Canada. An integrated review of wetland and upland species and legislation governing their control
http://www.cws-scf.ec.gc.ca/PUBLICATIONS/inv/cont_e.cfm

E-Flora BC Electronic Atlas of the Plants of British Columbia – Invasive plant species webpage
http://www.geog.ubc.ca/biodiversity/eflora/invasives.html

Garry Oak Ecosystem Recovery Team website
http://www.goert.ca/

Invasive Plant Council of BC webpage
http://www.invasiveplantcouncilbc.ca

Invasive Plants of Southwestern B.C. website
http://www.shim.bc.ca/invasivespecies/_private/index.htm

INVASIVE.ORG Centre for Invasive Species and Ecosystem Health website
http://www.invasive.org/

Appendix G: Terrestrial Ecosystem Map