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Integrated Stormwater Management Planning, Phase 2

(East Roberts Creek, Elphinstone, & West Howe Sound)

Watershed Assessments

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Prepared for:

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1.0 Introduction

The Sunshine Coast Regional District (SCRD) in cooperation with the Ministry of Transportation (MoT) has taken the initiative to identify and address existing stormwater management problems in three electoral areas within the Regional District, and to prepare an Integrated Stormwater Management Plan (ISMP) to guide future developments. Phase 1 of this study was completed during 2006 and various mitigation strategies were recommended in a technical memorandum prepared by Delcan on June 5, 2006. Phase 2 of the program was initiated in 2007 with the objective of carrying out the following tasks:

- Site investigations and feasibility assessments of improvements to sites within the three areas which were identified during the Phase 1 work, including recommendations for corrective actions; and

- Expansion and continuation of the stormwater planning carried out in Phase 1 to investigate environmental and engineering constraints to development within the three areas, to develop performance targets taking these constraints into account, and to identify required infrastructure requirements.

The first part of this assignment was completed in late 2007 and the results were documented in a Technical Memorandum dated December 4, 2007. Fourteen sites were identified; five in West Howe Sound, six in Elphinstone, and three in East Roberts Creek. After detailed site investigations were conducted at each site, engineering evaluations of potential solutions were carried out to establish feasibility and estimate capital costs. Recommendations for site improvements were provided.

This Technical Memorandum documents the results of Delcan's investigations and studies for the second part of the assignment. It discusses the reviews and assessments of the existing watershed conditions based on the principles of integrated stormwater management, develops and presents the recommended performance targets and proposed drainage infrastructure improvements, and provides as an appendix a revised policy and guidelines document for stormwater management in the three areas.

Public consultation was a key component in conducting the work associated with both Phase 1 and Phase 2. Input from all stakeholders was sought and obtained from stakeholders and the interested public at public open-house meetings organized by the SCRD and attended by Delcan staff. In addition, the meetings provided excellent opportunities to inform the public of how best to approach drainage issues associated with land development to avoid the negative impacts that have been experienced historically – and frequently described at the public meetings.

2.0 Application of Integrated Stormwater Management Principles

Based on the investigations carried out during Phase 1 and continued in this assignment, stormwater is of particular importance in the management of growth in the SCRD. In the first place, the natural geology, hydrology, topography, and climatic conditions point to a region sensitive to development. Prior to the arrival of non-native communities, the region was forested, a condition characterized by close to zero imperviousness and a thick canopy of largely coniferous trees. Direct runoff to streams from rainfall events was typically very low or zero. Stream flow was fed by shallow groundwater/interflow resulting in very clear, naturally filtered water in the channels. Secondly, effective stormwater management is of particular importance in controlling erosion and slumping of sensitive soil structures, and avoiding the negative impacts of cross-drainage between adjoining parcels. The above-mentioned impacts are prevalent in the areas being studied.

Integrated stormwater management can deal effectively with the issues arising out of land development in the SCRD. Subsurface geotechnical conditions and steep slopes pose significant stability issues for areas such as waterfront parcels. In such cases it is essential to understand the natural environment, assess the stability levels, and avoid or adequately mitigate for any modification that could exacerbate the problem, such as removal of vegetation or concentration of flows. In the Elphinstone benchland area, the complex surface and subsurface hydrology results in a high and seasonally variable water table within a bowl-like structure. Planning for developments in this area requires careful consideration of the impacts of changes, not only in the relatively flat area itself but also in the uplands within the "catchment" supplying it with surface and subsurface flows.

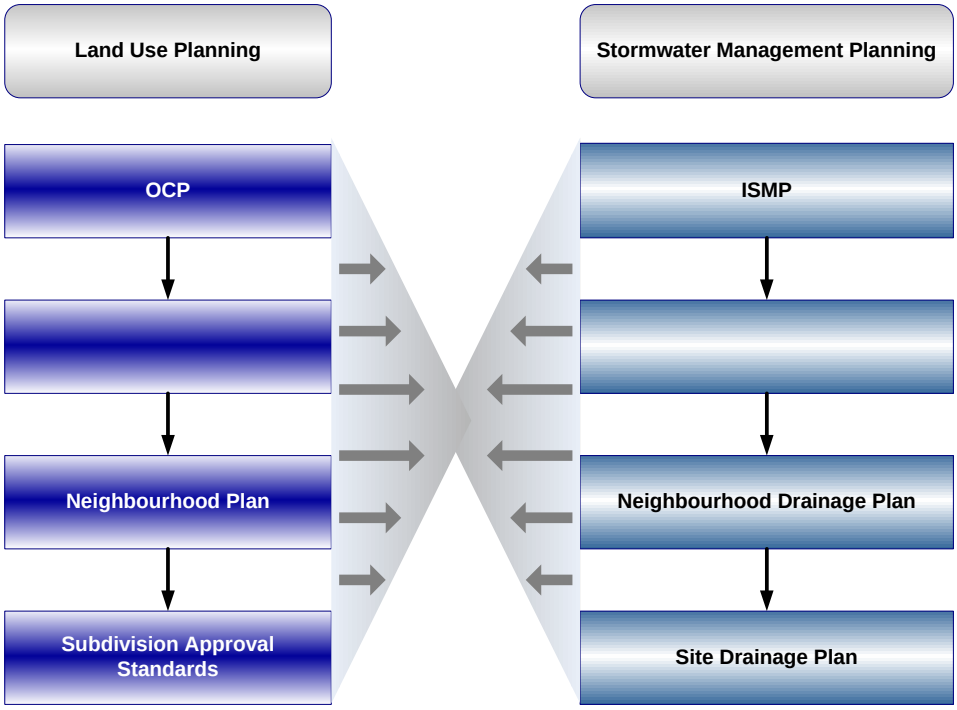
Integrated stormwater management has gained widespread acceptance by local governments, environmental agencies, and developers, and is now considered state-of-practice in most jurisdictions. It is a comprehensive approach to stormwater management planning which is meant to accommodate land development and population growth while protecting property and natural resources. The need for such an approach arose out of the obvious deficiencies inherent in the practices in the 1970s and 1980s. These past practices focused on the fast conveyance of extreme storms and often created substantial erosion, degradation, and flooding in receiving streams.

The following principles differentiate integrated stormwater management from the traditional approach, and guided Delcan's investigations, evaluations, and recommendations in the assignment.

- ***Land use planning and integrated stormwater management planning are interlinked***

  This principle is reflected in the official community planning documents which are prepared by local governments under the enabling provincial legislation. These documents lay out the philosophy and principles on which the policies and practices governing the future growth of the community are based.

In British Columbia, the move to a more integrated approach to stormwater management requires that a linkage be made between the land use planning documents and the watershed / stormwater planning documents at all levels. The figure below schematically depicts the proposed linkages and connections between planning documents at various detail levels. The document links will ensure that policies are consistent and implemented in a more holistic way to address urban development.



At the more detailed and advanced level, a site drainage plan (consistent with the ISMP) would be a condition for subdivision plan approval. The principle also highlights the need for an effective public consultation that results in buy-in for future plans on the part of the public and stakeholders.

- ***Stormwater is viewed as a resource***

  This principle requires the planning process to recognise the importance of stormwater for:

  - Fish, other aquatic life, and wildlife;
  - Groundwater recharge to maintain base flows in streams;
  - Water supply; and,
  - Aesthetic and recreational use by the community.

The main application of this principle is the requirement of the planning, engineering, and environmental disciplines to be cooperatively involved in developing the planning documents.

- ***It is essential to plan at all levels: watershed, subwatershed, neighbourhood, and site***

  This requires planning for stormwater management to be carried out first at the watershed level, and thereafter proceeding down in increasing detail to the individual site level. This is required to ensure that the policies and principles established and agreed in the ISMP are followed through down to the drainage systems installed at the individual lot level. This also ensures that upstream developments do not adversely impact downstream residences and all residences and other buildings and businesses have adequate levels of service against flooding.

- ***The full spectrum of rainfall events has to be designed for***

  This requires the total pattern of rainfall over a site or watershed to be considered. Runoff volumes and other hydrological characteristics (including peak flows) should be maintained as close as possible to original conditions.

- ***The importance of maintaining base flows in streams and rivers is recognised***

  This principle acknowledges the importance of base flows to the survival of fish and other aquatic life and their significance as a natural resource. In addition, maintaining base flows is an important feature in the aesthetic and recreational use of rivers and streams.

The above principles were presented and frequently discussed at the public meetings. It is felt the principles were understood and accepted by those present. However, continued education of the public and individual landowners is required in this regard, particularly in the perceived conflict between private property rights and implementing effective, safe, and adequate communal drainage systems.

3.0 Existing Watershed Conditions

A high-level assessment of the existing watershed conditions was made as part of this study. The major watersheds within each of the study areas were assessed in terms of the following parameters:

- Natural Habitat / Environment
- Land Use / Development Potential
- Geology / Soils
- Hydrology / Hydraulic Conveyance

A GIS-compatible data layer will be provided corresponding to each of the parameters listed above to assist in the spatial analysis of these parameters. Figures corresponding to the GIS-compatible data layers are provided in ***Appendix A***, which also includes a DVD-ROM of the data layers.

The three study areas share some commonality in terms of habitat types, land use, geology, soil conditions, hydrology, and climate. These parameters contribute to the overall drainage patterns within the study areas. The following sections will describe the overall conditions found within each of the study areas.

The West Howe Sound Study Area is located near the base of the southeast flank of Mount Elphinstone overlooking Shoal Channel and the southern end of Thornborough Channel. Except for the area around Williamson Landing about 2 km north of the Langdale Ferry Terminal, the study area is bounded between the northern edge of the Town of Gibsons and the northern end of the neighbourhood of Langdale. The areas of interest are located on either side of Marine Drive/Port Mellon Highway. With few exceptions the areas are generally less than 100 m above the shoreline of the channels. The average slope is about 20° down to the east, but locally slopes can be as steep as 50°, particularly where bedrock knobs are present, such as Soames Hill. Above the 100 m contour, the ground surface generally flattens to between 5 and 10°.

The major drainage systems include Soames Creek, Langdale Creek and Hutchinson Creek. Numerous smaller drainage courses occur within the area, and the majority are short, seasonal natural streams fed by groundwater and augmented by runoff collected into roadside ditches. Groundwater recharge occurs on the upland area and the middle slopes of the flank of Mount Elphinstone.

The Elphinstone Study Area is located between the west boundary of the Town of Gibsons and about Walker Creek to the west. The study area is bounded between the Strait of Georgia on the south and the Sunshine Coast Highway on the north. The coastal bluff bounding the southern edge of the study area rises between 18 and 25 m above the shoreline at 40 to 60° before beginning to flatten to between 10 and 15° and climbing a further 40 m. Between about 500 and 750 m from the shoreline, the upland flattens to between 2 and 5°, and is dissected by ravines incised by glacial meltwater to depths of 30 to 40 m and drainage by major conveyance systems such as Chaster Creek and its tributaries. Between the major ravines, the coastal bluff

is well-drained by numerous smaller drainage systems that are typically less than a kilometer in length. The upland between the ravines is generally poorly drained with numerous marshy areas developed in broad, shallow depressions that dimple the surface of the upland.

The East Roberts Creek Study Area extends from about Walker Creek on the east to about Crowe Road on the west, and from the shoreline of the Strait of Georgia on the south to the Sunshine Coast Highway on the north. The coastal bluff bounding the southern edge of the study area rises between 7 and 20 m above the shoreline at 40 to 60° before beginning to flatten to between 5 and 10° and climbing relatively uniformly to Elev. 150 m along the BC Hydro transmission line northeast of the Sunshine Coast Highway.

The upland is dissected by a parallel drainage pattern developed on the southwest flank of Mount Elphinstone. Numerous small streams rise about 2 to 3 km from the shoreline. Several are officially named, such as Joe Smith Creek, Molyneux Creek, Slater Creek, Clough Creek .and Robinson Creek, and many more have no official name. In general, the stream channels are less than 4 m deep until the stream crosses the coastal bluff. If bedrock is not encountered, the streams cut narrow steep-sided ravines through the coastal bluff. The natural drainage pattern has been altered by development, particularly roads crossing the slope, which divert flow from one watershed into another.

3.1 Natural Habitat / Environment

As part of the watershed assessment prepared for the three study areas, a literature review was conducted to identify the existence, or potential occurrence, of species at risk (e.g. plant and animal species) in the vicinity of, or within, the study areas.

Species at risk are identified in the context of both the provincial and national ranking systems. The provincial ranking system applies to species that have been assessed by the British Columbia (BC) Conservation Data Centre (CDC). The national ranking system applies to species that have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and in some instances, Schedule 1 of the Species At Risk Act (SARA). The Schedules in SARA are based on COSEWIC's assessments of the species.

The Federal and Provincial lists that were reviewed include the following:

- BC Conservation Data Centre: Conservation Data Centre Mapping Service [Web Application]. 2006. Victoria, BC, Canada;
- BC Conservation Data Centre. 2007. BC Species and Ecosystems Explorer. BC Minist. Of Environ. Victoria, BC, Canada;
- Ministry of Environment. 2007. Fisheries Inventory Data Queries Applications;
- Ministry of Environment. 2007. Sensitive Ecosystems Inventories for the Sunshine Coast;
- Sunshine Coast Regional District Habitat Atlas; and,
- Environment Canada, Canadian Wildlife Service. 2004. Species At Risk Mapping Application.

Species identified were grouped according to the following three habitat types:

- **Coastal**: includes marine and shoreline habitats, brackish, estuarine, sand dunes, and the immediate coastline (a legal definition of coastal habitat can be found in the Fisheries Act);

- **Riparian**: includes (but is not limited to) streams, wetlands, seeps, fens, ponds, lakes, and other freshwater habitats, as well as the riparian vegetation adjacent to the freshwater habitat (a legal definition of riparian habitat can be found in the Fisheries Act and in the Riparian Areas Regulation);

- **Upland**: includes forests (coniferous and deciduous, as well as mixed) rock outcrops, grasslands, meadows, etc. In the context of this study, the upland habitat type is used to identify habitat that is neither coastal nor riparian.

The sensitive species tables are provided in ***Appendix B***. Where a species may occur in more than one habitat type, the species is shown on each habitat table where it would likely occur. However, considering the dynamic nature of listing and delisting species, along with evolving information on species distribution and site specific environmental conditions, should a Species At Risk Assessment be required for the proposed watershed remediation activities, this list should be reviewed and revised by a qualified Professional Biologist.

The SCRD currently has habitat mapping depicting sensitive ecosystem inventory (SEI), fish species distributions, fish presence and stocking, eel grass beds, as well as streams, lakes and wetland areas. The natural habitat sensitive areas documented within the GIS-compatible layer provided are consistent with the sensitive ecosystem inventory areas.

3.2 Land Use

Land use within all three study areas are made up primarily of residential, agricultural land reserve (ALR) and resource rural areas. A small amount of commercial and industrial areas exist adjacent to the major roads within the SCRD. Waterfront and foreshore areas south of Highway 101 are predominantly residential. North of the highway within the bench area, there is a mix of residential subdivision and large agricultural lots. Large tracts of rural and resource rural lands lie further north of the Roberts Creek and Elphinstone areas and further west of the West Howe Sound area. The extent of urbanization within the study areas can be categorized as a mix of rural, undeveloped lands, large tracts of ALR and single-family residential housing with large lots.

Using available land use information found within the Official Community Plans for Roberts Creek, Elphinstone, and West Howe Sound community areas, we have identified areas of potential development or potential increases in densification. Further details on these areas and watersheds are given in ***Section 4.0 Potential Development Impacts to Watersheds***. In these areas, potential watershed impacts due to development or densification increases can be minimized through the use of on-site source control best management practices

(BMPs) or neighbour-scale stormwater management BMPs, such as retention ponds, infiltration galleries, and rain gardens.

3.3 Geology / Soil Conditions

This section presents summary descriptions of the principal geotechnical and soil conditions within each of the study areas included in this study. Generally, the lands in the three study areas slope towards the foreshore with moderate to steep grades. The majority of the older developed areas are confined to the lower elevations and concentrated along the shoreline. Newer developments are being constructed further from the shoreline within the upstream reaches of the many rivers and creeks, either along a bench area or the steep slopes of Mt. Elphinstone.

General information and maps regarding the surficial geological materials within the SCRD were prepared by the Ministry of Environment and the Ministry of Mines and Petroleum Resources in 1977. This information was supplemented by data collected in 1980 and 1981 by Luttmerding. The supplemental data provided a more specific indication of the composition and depth of surficial geological materials. Much of the study areas are made up of soils and geological material that are pervious and rapidly well drained. However, certain areas of poorly draining soil, typically overlying clayey or organic material, do exist within the study boundaries. Generally, overall subsurface drainage flow will be down slope towards the Strait of Georgia or Howe Sound, seeping out at the base of the waterfront slopes. The subsurface flow within specific parcels of lands is mainly determined by the in-situ soil conditions, geological materials, slope characteristics and vegetation. Perched watertables also occur during high rainfall periods in areas with Albion, Heron and Summer soils are located. In addition, there are several areas that have shallow bedrock depths. The shallowness of this impermeable stratum inhibits the infiltration capacity of the overlain soils and creates areas where subsurface flow takes place near the surface along the soil-rock interface.

A slope and terrain analysis was conducted by the SCRD during the preparation of the Official Community Plans for the three study areas. Generally, the slope characteristics within each study area can be divided into four categories:

1. **Waterfront Slopes:** escarpment areas with 10 – 30% slopes rising to approximately 100 metres in elevation along the foreshore and beach area;

2. **Bench Area:** 10 – 20% slopes rising gently northward from the top of the waterfront slope area to approximately 150 metres in elevation;

3. **Elphinstone Slopes:** varying slopes of 5 – 30% which become increasingly steep further north of the bench area; and,

4. **Watercourse Areas:** areas incised by creek channels cutting through the bench area with gradients and bank slopes generally between 10 – 40%.

West Howe Sound Study Area

The native soils are either glacio-marine sediments consisting of stoney glacial till or hard marine silt. Alluvial sands and gravels have accumulated along the bottoms of the major drainage systems, and isolated pockets of glacial outwash sand can be found at higher elevations. The glacio-marine sediments generally weather to a depth of 1 to 2 m developing a loosened soil profile, which is more permeable than the unweathered host, and is typically more prone to erosion and shallow sloughing than unweathered soil in slopes steeper than about 20°.

Where bedrock occurs at the surface, the rock is typically granite, which is generally massive, and is structurally sound, but is moderately to heavily fractured. The four principal sets of fractures and several sets of minor fractures and joints vary in orientation and spacing and control the topographic expression, form bluffs and contribute to rock fall.

On slopes steeper than about 20°, the combination of groundwater flow and the loosened structure of the weathered soil frequently result in soil creep or surface slides that can degenerate into mudflows. Deep-seated instability is not a common feature in the West Howe Sound Study Area.

Generally, within the West Howe Sound area, rock fall or rock slope stability is not a consideration. Although some plucking and dislodgement of rock fragments has occurred at the base of the shoreline bluff, the exposed bedrock is generally stable. Rock fall is a consideration around the base of Soames Hill.

Elphinstone Study Area

Pockets of glacial outwash sand and gravel are found on the surface of upland east of Chaster Creek and become more extensive west of Chaster Creek. At several locations, the deposits of sand and gravel have sufficient depth and extent to have been commercially developed as sources of construction materials. Underlying the sand and gravel is usually a thin layer of stoney glacial till and/or hard marine silt, which extends below sea level. On the coastal bluff and the slopes of the ravines, the glacio-marine sediments generally weather to a depth of 1 to 2 m developing a loosened soil profile that is typically prone to erosion and shallow sloughing in slopes steeper than about 20°.

Occurrences of bedrock are common only along the eastern edge of the study area and as shelves along the beach. The bedrock is granite, which is generally massive, and is structurally sound, but is moderately to heavily fractured. Dykes of basalt are also common.

Groundwater seepage occurs in the coastal bluff and along the sides of the ravines where sand and gravel overlying glacio-marine sediments is exposed.

In many places, the base of the coastal bluff is being actively eroded by wave action, resulting in near-vertical erosion scarps and surficial sliding. On slopes steeper than about

20°, the combination of groundwater seepage and the loosened structure of the weathered soil frequently result in soil creep or surface slides. In areas where existing runoff has been increased by development on the upland, large-scale erosion has occurred, such as at the south end of 15th Street and along the lower stretch of the creek discharging onto Secret Beach, where discharge from road drainage has greatly increased natural flow and has undercut native sand and gravel exposed in the bluff. Although signs of ancient deep-seated instability can be seen along the coastal bluff and lower Chaster Creek ravine, conditions giving rise to deep-seated instability no longer occur and deep slumping is not a common feature in the Elphinstone Study Area.

East Roberts Creek Study Area

Soil cover is generally shallow south of the Sunshine Coast Highway. A maximum thickness of less than 5 to 6 metres is not uncommon, and bedrock is frequently exposed. The soil overlying bedrock is usually glacio-marine sediments consisting of stoney glacial till or hard marine silt. The upper 1 to 2 metres weathers to a loose to medium dense silty sand with gravel, cobbles and some boulders. Pockets of alluvial sands and gravels as well as isolated pockets of glacial outwash sand can be found randomly scattered across the upland. Where soil is exposed along the shoreline, the base of the coastal bluff is being actively eroded by wave action, resulting in near-vertical erosion scarps and surficial sliding.

Granite bedrock is common along the shoreline and can also be seen at the base of many of the stream channels crossing the area. Low bedrock ridges and associated shallow, soil-filled depression define the undulating topography of the upland. Bedrock exposures are generally massive, and the rock is structurally sound, but is moderately to heavily fractured. In most cases, bedrock slopes and steps are not prominent enough to contribute to rock fall.

The unweathered soil or underlying bedrock forms an impervious barrier, and shallow groundwater flow is typical in the Roberts Creek area. Depressions in the ground surface, reflecting hummocks and swales in the underlying bedrock surface, collect and hold water forming seasonal marshy areas.

The major cause of retreat of the coastal bluff is wave attack at the base of the bluff. Storms over the past 5 years have caused retreat of the base of the bluff of as much as 5m in places. Fortunately, much of the shoreline of the study area consists of bedrock shelves and bedrock outcrop at the base of the bluff, which is resistant to erosion. On slopes steeper than about 20°, the combination of seepage and the loosened structure of the weathered soil frequently result in soil creep or surface slides. Deep-seated instability is not a feature in the East Roberts Creek Study Area.

In addition to the development permit areas already identified within the OCPs for the study areas, we have identified additional areas where geotechnical and / or hydrogeological assessments may be required as part of development applications.

3.4 Hydrology / Hydraulic Conveyance

In a typical forested undeveloped watershed, close to zero percent of rainfall is converted to direct runoff. The majority of rainfall is either infiltrated or evapotranspired through natural processes. With an increase in development, the amount of runoff increases due to the increase of impermeable land area. The extent of urbanization within the study area equates to a proportion of impermeable land area in the range of 20% to 25%. This relates to approximately 20% of rainfall being converted to surface runoff, which will need to be managed effectively. The biggest changes to the natural water balance within a watershed occurs when forested lands are first cleared, then ditched, and finally paved or roofed over.

Within the SCRD, surface water is drained predominantly within a system of roadside ditches and culverts which direct runoff to nearby creeks. The larger and more significant creeks originate from the slopes of Mt. Elphinstone. These creeks consist mainly of ravines that have been incised in the outwash gravels and glaciomarine deposits of the bench area. There is a tendency for these steep coastal watercourses to drain extremely quickly or "flash", which contributes to channel erosion and the release of destructive water, mud and debris flow within the downstream reaches. The major creek systems within each of the study areas are listed in ***Table 1.***

Based on information gathered through Phase 1 and Phase 2 of this study, the approximate watershed boundaries and flow patterns for each of these major creek systems have been updated and are provided in ***Appendix A.***

Table 1: Major Creek Systems within Study Areas

Study Area	Creek System
East Roberts Creek	Joe Smith Creek
	Molyneux Creek
	Slater Creek
	Leek Creek
	Cornwallis Creek
	Whittaker Creek
Elphinstone	Smales Creek
	Walker Creek
	Chaster Creek
	Seaward Creek
West Howe Sound	Gibsons Creek
	Soames Creek
	Langdale Creek
	Hutchinson Creek

Specific rainfall Intensity Duration Frequency (IDF) curves were developed in Phase 1 for each of the study areas based on rainfall and precipitation data collected at four

Environment Canada climate stations within or near the study limits. Data collected at the Gibsons Gower Point recording station were used as an estimate of the climatology for the Elphinstone study area. For the East Roberts Creek study area, an average of the Sechelt and Gibsons Gower Point data sets were used. Similarly, an average of the Gibsons and Port Mellon data sets were used to estimate the values for the West Howe Sound study area. The estimated rainfall and precipitation values show a definite increase in precipitation from west to east within the study area.

The existing catchment flows for each of the major creek systems listed in ***Table 1*** were estimated using the Rational Method for the 2-year, 10-year and 200-year return periods. These return periods span a complete range of rainfall events, from high frequency, low flow events (2-year) to low frequency, extreme events (200-year). Both the Ministry of Transportation and Ministry of Environment use the 200-year storm events as the upper bounds for design and construction. The runoff coefficients for each of the watersheds were estimated based on the land use within the watershed and existing developed areas visible on the orthophotos provided by the SCRD. ***Table 2*** provides a summary of the existing catchment flows for each of the watersheds. The detailed calculation worksheets are provided in ***Appendix C***.

Flooding hazards associated with watercourses within the SCRD are currently addressed through setback requirements under the SCRD's zoning bylaws. In addition, development permits are required in areas where the physical characteristics of the watercourse itself require detailed geotechnical review to assess hazard potential and environmental concerns. Increased urbanization and development is also seen as a significant contributing factor to larger creek flows due to increased impermeable land areas and surface runoff volumes.

Table 2: Existing Catchment Flows

Study Area and Watershed		Return Period (yrs)	Catchment Flows	
			Rainfall I (mm/hr)	Peak Flow Q (L/s)
West Howe Sound	Hutchinson Creek	2	11.5	7437.8
		10	15.4	10858.3
		200	26.2	21075.1
	Langdale Creek	2	10.1	12692.2
		10	13.5	18113.8
		200	22.9	33873.4
	Soames Creek	2	13.3	2964.6
		10	17.8	4444.6
		200	30.3	8917.6
	Gibsons Creek	2	11.1	6750.2
		10	14.8	9388.9
		200	25.2	17004.6

Table 2: Existing Catchment Flows (continued)

Study Area and Watershed		Return Period (yrs)	Catchment Flows	
			Rainfall	Peak Flow
			Int (mm/hr)	Q (L/s)
Elphinstone	Seaward Creek	2	10.3	2481.6
		10	15.7	4236.4
		200	26.7	8538.2
	Lower Chaster Creek	2	6.3	9086.8
		10	9.2	14290.8
		200	15.6	27667.5
	Walker Creek	2	8.0	3057.2
		10	12.0	5023.0
		200	20.4	9986.7
	Smales Creek	2	9.3	1370.3
		10	14.1	2305.4
		200	24.0	4595.4
East Roberts Creek	Whittaker Creek	2	14.4	638.8
		10	22.6	1103.1
		200	38.5	2290.5
	Cornwallis Creek	2	9.1	2055.7
		10	13.7	3332.8
		200	23.3	6346.5
	Leek Creek	2	9.3	1848.2
		10	14.0	3041.0
		200	23.8	5884.0
	Slater Creek	2	9.8	1522.5
		10	14.9	2593.0
		200	25.4	5180.1
	Molyneaux Creek	2	7.6	3555.7
		10	11.4	5620.3
		200	19.3	10467.1
	Joe Smith East	2	14.6	576.4
		10	22.9	1013.6
		200	38.9	2039.3
	Joe Smith	2	8.1	3192.5
		10	12.1	5124.3
		200	20.5	9998.6
	Clough Creek	2	7.9	3671.6
		10	11.8	5717.0
		200	20.0	10554.0
	Robinson Creek	2	8.8	1633.6
		10	13.2	2592.0
		200	22.4	4702.1

4.0 Potential Development Impacts to Watersheds

To estimate the potential impacts to each of the watersheds due to increased development and urbanization, projections based on the future land use, density, and potential growth areas were estimated and the corresponding future condition catchment flows were calculated. In addition, we also analyzed the foreshore areas within each of the three study areas.

The following two future development scenarios were analyzed:

1. 50% of agricultural lands were assumed to have been developed into greenhouse farming. The development of greenhouses within the ALR has been a relatively current issue in many agricultural communities. Although open crop farming still accounts for the majority of farms, more farms are looking to greenhouse technology to maximize their ability to produce goods. We have simulated this move to more greenhouse farming by assuming that 50% of the available agricultural lands will have an impervious area equal to residential land use.

2. 50% of residential areas were assumed to have been redeveloped into higher density residential communities to simulate the growing population and need for housing within the Sunshine Coast. We have simulated this increase in residential density by assuming that 50% of the existing residential lands will have an impervious area equal to commercial land use.

The future condition catchments flows and the percent change from the existing flows are summarized in ***Table 3***. Colour coded percent change in flows from the existing conditions are provided in ***Appendix A***. Green catchments indicate a change in flow between 0-5%, yellow between 5-10%, and red for changes greater than 10%.

From our analyses, only three of the seventeen watersheds show a potential increase in flows over 10% of the existing condition based on the future land use scenarios. These watercourses would be the most susceptible to increases in development and would benefit the most from the implementation stormwater best management practices related to volume reduction and detention. In addition, we would recommend that remedial works be undertaken to install volume reduction facilities outside of any planned development. The highest change, 14%, occurred in the Whittaker Creek watershed in Roberts Creek.

The majority of the watersheds, ten of seventeen, showed a potential increase in flows of 5%-10%, based on our future land use scenarios. Further development within these watercourses will have to incorporate both rate and volume control strategies to limit the potential impacts to the watershed.

The remaining four watersheds showed potential flow increases less than 5%. Although these watersheds may not be considered a “high-risk” or “high-priority” with respect to stormwater

management at a watershed-level, local and neighbourhood-level impacts due to development and redevelopment within these watersheds will have to be monitored.

Table 3: Future Condition Catchment Flows

Study Area and Watershed		Return Period (yrs)	Existing Flows Q (L/s)	Future Flows Q (L/s)	% Change
West Howe Sound	Hutchinson Creek	2	7437.8	7928.5	6.60%
		10	10858.3	11492.2	5.84%
		200	21075.1	22601.5	7.24%
	Langdale Creek	2	12692.2	13240.7	4.32%
		10	18113.8	18763.9	3.59%
		200	33873.4	34899.3	3.03%
	Soames Creek	2	2964.6	3250.4	9.64%
		10	4444.6	4798.6	7.96%
		200	8917.6	9742.5	9.25%
	Gibsons Creek	2	6750.2	6852.9	1.52%
		10	9388.9	9538.6	1.59%
		200	17004.6	17274.0	1.58%
Elphinstone	Seaward Creek	2	2481.6	2733.6	10.15%
		10	4236.4	4608.8	8.79%
		200	8538.2	9436.6	10.52%
	Lower Chaster Creek	2	9086.8	9719.2	6.96%
		10	14290.8	15233.9	6.60%
		200	27667.5	29485.6	6.57%
	Walker Creek	2	3057.2	3327.6	8.84%
		10	5023.0	5425.2	8.01%
		200	9986.7	10887.5	9.02%
	Smoles Creek	2	1370.3	1490.8	8.79%
		10	2305.4	2479.5	7.55%
		200	4595.4	5023.8	9.32%
Roberts Creek	Whittaker Creek	2	638.8	729.3	14.17%
		10	1103.1	1251.1	13.42%
		200	2290.5	2540.6	10.92%
	Cornwallis Creek	2	2055.7	2161.0	5.12%
		10	3332.8	3488.1	4.66%
		200	6346.5	6709.7	5.72%

Table 3: Future Condition Catchment Flows (continued)

Study Area and Watershed		Return Period (yrs)	Existing Flows Q (L/s)	Future Flows Q (L/s)	% Change
Roberts Creek (cont'd)	Leek Creek	2	1848.2	1974.3	6.82%
		10	3041.0	3216.7	5.78%
		200	5884.0	6242.8	6.10%
	Slater Creek	2	1522.5	1669.1	9.63%
		10	2593.0	2790.5	7.62%
		200	5180.1	5603.1	8.17%
	Molyneaux Creek	2	3555.7	3678.2	3.45%
		10	5620.3	5789.2	3.00%
		200	10467.1	10854.9	3.71%
	Joe Smith East	2	576.4	631.6	9.59%
		10	1013.6	1096.2	8.15%
		200	2039.3	2244.0	10.04%
	Joe Smith	2	3192.5	3434.8	7.59%
		10	5124.3	5506.4	7.46%
		200	9998.6	10742.9	7.44%
	Clough Creek	2	3671.6	3785.1	3.09%
		10	5717.0	5903.0	3.25%
		200	10554.0	10880.4	3.09%
	Robinson Creek	2	1633.6	1651.2	1.08%
		10	2592.0	2608.0	0.61%
		200	4702.1	4792.4	1.92%

A strategy to mitigate for increased development within these watersheds is to require on-site vegetation and tree canopy retention. The tree canopy is an important component of the water balance within a watershed. Rainfall interception by the tree canopy can account for up to 35% of the gross annual precipitation. Removing trees will generally decrease interception and therefore increase runoff. Vegetation also reduces the speed at which runoff is conveyed due to the timing and storage effects of the soil mass.

Several municipalities in BC have enacted Tree Protection Bylaws to prohibit the cutting of trees and promote the development of an urban forest. For example, the City of Nanaimo's Tree Protection Bylaw (No. 4695) states that during subdivision application review, a tree management plan shall be provided and that a minimum of 20% of the trees on the parcel of land exclusive of any area set aside for park dedication shall be protected when the land to be subdivided is greater than 0.5 hectare in size.

Currently, a Tree Canopy Research Project is being undertaken by the University of British Columbia in collaboration with the three North Shore municipalities, the Water Balance Model Partnership, Metro Vancouver, the Province of British Columbia and the Real Estate Foundation of British Columbia. The objectives of the research project are to explore the variables influencing the interception process and quantify the interception ability of trees and bushes within an urban environment. In particular, the effects of tree density, tree structure and species type.

The SCRD has developed a Tree Cutting Bylaw (No. 350, 1991), which regulates the application, approval, suspension or denial of Tree Cutting Permits in designated areas of the Sunshine Coast Regional District. Currently, this bylaw identifies two specific areas, Tree Cutting Permit Area A and Tree Cutting Permit Area B, which may be subject to flooding, erosion, avalanche or land slip. Therefore, the removal of trees from these areas have the potential of causing the above described land impacts. However, specific impacts to the hydrological system within watersheds due to tree and tree canopy removal have not been identified or quantified.

We recommend that the SCRD evaluate the results from the Tree Canopy Research Project and potentially revised their existing Tree Cutting Bylaw to address the potential watershed impacts related to tree removal.

5.0 Performance Targets and Design Guidelines

This section provides specific performance targets and guidelines for designing drainage systems that meet the SCRD's and MoT's performance targets for stormwater retention, detention and conveyance. The performance targets are also consistent with DFO's Urban Stormwater Guidelines and Best Management Practices for the Protection of Fish and Fish Habitat, as well as Green Shores Principles. A brief summary of the purpose of the BMPs described in DFO's Urban Stormwater Guidelines and the Guiding Principles for Green Shores is given below.

DFO's Urban Stormwater Guidelines

DFO's Urban Stormwater Guidelines provides a description of best management practices (BMPs) and guidelines for their design, which best protects fish and fish habitat from the impacts of stormwater runoff. The three main types of BMPs listed by DFO are:

- **Volume Reduction (VR):** the purpose of this BMP is to reduce and mitigate for the total runoff volume caused by increased urban development, as well as to maximize the amount of runoff returned to shallow groundwater via recharge;

- **Water Quality (WQ):** the purpose of this BMP is to mitigate water quality impacts to fish and fish habitat by collecting and treating "first flush" events of smaller storms and more frequent runoff events from impervious areas;

- **Detention or Rate Control (RC):** the purpose of this BMP is to restrict the post-development runoff flow rate to that of the pre-development peak runoff flow rate for selected design storms.

Guiding Principles for Green Shores

Green Shores Principles are designed to encourage sustainable use of coastal ecosystems through project planning and design that recognizes ecological features and functions of coastal systems. The Guiding Principles are:

- Preserve the integrity or connectivity of coastal processes.
- Maintain or enhance habitat diversity and function (on a local or regional scale).
- Minimize or reduce pollutants to the marine environment.
- Reduce cumulative impacts to the coastal environment.

Table 4 summarizes the proposed performance targets for the management of stormwater quantity and quality within the study area, which all new development projects in the SCRD must incorporate and meet as part of their proposed stormwater management system. ***Table 4***

also relates DFO's BMP types and Green Shore Principles to the proposed performance targets.

Table 4: Proposed Performance Targets

Performance Target	Related DFO BMP type	Related Green Shores Principle
Rainfall Capture (retention) Capture the volume equal to post-development 6-month/24-hour rainfall for all newly created impervious surfacesand restore it to natural hydrologic pathways by promoting infiltration, evapo-transpiration or rainwater reuse.	Volume Reduction	- Maintain or enhance habitat diversity and function (on a local or regional scale) - Preserve the integrity or connectivity of coastal processes.
Runoff Control (detention) Limit post-development runoff to match pre-development rates for 6-month/24-hour, 2-year/24-hour, and 5-year/24-hour rainfall events.	Detention Rate Control	- Maintain or enhance habitat diversity and function (on a local or regional scale) - Reduce cumulative impacts to the coastal environment
Flood Risk Management (conveyance) Ensure that the stormwater plan can safely convey storms with return periods between 25-year and 200-year	n/a	- Reduce cumulative impacts to the coastal environment
Water Quality Mitigation Mitigate for potential water quality impacts to downstream watercourses such as TSS, TP, oils and greases, and other deleterious substances through the use of water quality BMPs	Water Quality	- Minimize or reduce pollutants to the marine environment. - Preserve the integrity or connectivity of coastal processes

The performance targets outlined in ***Table 4*** are applicable for all developable areas within the study boundaries. It will be the responsibility of the Professional Engineer preparing the stormwater management and drainage plans for a particular development to determine the ultimate feasibility of implementing the performance targets based on pre-existing site condition, as well as site investigative studies (ie. geotechnical report, environmental report, etc.).

Specific design criteria for drainage systems are presented in ***Appendix D*** for:

- **Rainfall Capture and Runoff Control Criteria** – Guides developers through the process of designing the retention and detention components of drainage systems. This section includes a methodology for sizing infiltration facilities, and requirements for performance monitoring. This section consists mostly of new guidelines and criteria.

- **Peak Flow Conveyance Criteria** – Provides criteria for conveyance of peak flows within development sites, and for discharge of peak flows to existing drainage infrastructure.

As an interim measure the following is recommended:

- Developers ensure that pre-development runoff for different storms is not exceeded in the post development situation.
- "Major" drainage systems to safely convey the 1:200 year event are installed in all cases.
- "Minor" systems are designed for the 1:10 year event.

IDF curves contained in ***Appendix D*** can be used for design purposes until further data is collected and analyzed.

The following are additional recommended design guidelines:

1. The methodology used for designing infiltration and detention systems to meet the targets for rainfall capture and runoff control shall take into account the site-specific conditions at the site being developed.

2. Requirement that all developments, with the potential to increase runoff from the property to provide drainage systems that manage the majority of rainfall events within the development site (all but one per year, on average), and safely convey runoff from extreme storms to the outlet of the site. At a minimum, developments should provide for stormwater management facilities which limit runoff from extreme events to pre-development flows and mimic pre-development / natural runoff patterns when possible.

3. The SCRD's and Ministry's performance target for flood risk management is to ensure that runoff from extreme rainfall events, up to 200-year storm event, can escape to downstream watercourses without posing a threat to property or public safety. To achieve this objective, the following design conditions must be addressed:

    - All rainfall capture and runoff control facilities must incorporate 'escape routes' to allow extreme storms to be routed to downstream watercourses, either as overland flow or via a storm drainage system (i.e. whether ditched or piped).
    - Sites must be graded to ensure that any overflow resulting from extreme storms is dispersed away from areas where flooding problems could otherwise result (e.g. residential properties in low areas).
    - The downstream storm drainage systems must meet assessment criteria for both hydraulic adequacy and physical adequacy to handle the runoff from the upstream development area (refer to discussion below).

    The first two design conditions above refer to the conveyance of peak flows through on-site drainage systems, and the third refers to the routing of runoff from development sites through off-site drainage systems.

4. Through the process of developing catchment plans, the risk and adequacy of existing downstream drainage facilities to handle the increase in peak runoff generated by new development will be assessed by the SCRD and MoT, whichever may be applicable.

   The risk assessment will be based on:

   - Hydraulic Adequacy – A comparison of rated capacity versus design flow;
   - Physical Adequacy – A qualitative judgment regarding physical constraints (e.g. culvert blockage) that could adversely impact hydraulic adequacy.

   In order to ensure the ***hydraulic adequacy*** of stormwater conveyance systems, each system shall consist of the following components:

   - The Minor System shall consist of pipes, swales, and/or ditches, which convey overflows from on-site rainfall capture and runoff control facilities resulting from storms up to a 10-year return frequency. Driveway culverts that form part of the minor system shall be designed to a 10-year return frequency with the design headwater not to exceed the top of the culvert.

   - The Major System shall consist of overland flow paths, roadways and watercourses which convey peak flows resulting from storms up to a 100-year return frequency. Major flood path routing is required wherever surface overland flows in excess of 0.05m3 /s are anticipated. Roadway crossings shall be designed to accommodate the 200-year return frequency. Surcharge at the inlet for the 200-year flow is acceptable provided the headwater profile does not intersect habitable property or the roadway traffic area.

   Physical adequacy is typically the governing flood risk management criterion. Drainage system failure is most often the result of the sediment or debris transported from upstream development areas. All developments or works which will cause drainage discharge into existing drainage systems and/or natural watercourses must ensure that silt, gravel or debris entering is controlled.

Developments that occur in advance of the adoption of ISMPs will be required to provide an assessment of the impact on downstream drainage systems. Developers may be required to share in the cost of upgrading downstream drainage infrastructure, and/or provide additional detention in order that no impact to the downstream drainage systems will result from the new development.

6.0 Implementation Strategy

Currently, the SCRD does not have a formal drainage function and is not responsible for the regulation of stormwater or drainage from lands under their jurisdiction. In addition, the Ministry of Transporation (Ministry), which is the subdivision approving authority within the Sunshine Coast, is primarily responsible for the design and maintenance of drainage works within the road right-of-ways. Although the Ministry does review drainage plans for large, multi-lot development projects, they do not enforce or regulate runoff from one lot to the next once the development has been approved. Therefore, within the Sunshine Coast, there is a gap in the responsibility for the regulation of stormwater, which either the Ministry or the SCRD should fill. Currently, both the Ministry and the SCRD are working to bridge this gap and determine the specific stormwater-related planning and design review responsibilities each agency will take.

As part of addressing this gap in responsibility, the SCRD has drafted a revision to the Sunshine Coast Regional District Subdivision Servicing Bylaw No. 320, 1987. The revised bylaw could be amended to be Sunshine Coast Regional District Subdivision Servicing Bylaw No. 320, 2007. The revised bylaw could include a section related to stormwater management, specifically addressing:

- On-site Stormwater Requirements for Development Permits, Small Subdivisions and Associated Rezonings; and,

- Off-site Stormwater Requirements for Subdivisions, and Major Residential, Commercial, Industrial, and Institutional Developments.

The revised bylaw could require an On-site / Off-site Stormwater Management Plan to be prepared and sealed by a Professional Engineer with expertise in this type of work. The stormwater management plans will be site specific and provide details on both the pre-development and post-development conditions. Specific mitigation strategies and BMPs can then be designed and implemented based on the performance targets outlined in the previous section.

By implementing stormwater regulations at the subdivision level, there is an opportunity to clearly identify and integrate existing stormwater issues and impacts with other aspects of the proposed development prior to construction. This potentially alleviates any future retrofit works.

Stormwater requirements can be defined in the Subdivision and Servicing Bylaw and the subdivision approval process, which may deal with a number of specific requirements such as:

- Stormwater retention systems and requirements;
- Lot grading;
- Streamside setbacks;
- Landscaping requirements; and,
- Terracing, retaining walls, and natural slopes; and,
- Road design, including pavement widths, and other potential requirements such as “self mitigating” road design that sheds and disperses rainfall.

In addition, it is suggested that a "protocol" be established with the Approving Officer which sets out how the SCRD's requirements will be dealt with through the subdivision application review and approval process.

Environmental Considerations

Any works within watercourses or riparian areas will potentially fall under the statutory authority of several federal, provincial and local government bodies. These government bodies are empowered by regulations that require an application for development to be submitted to the respective agency. An official response from these agencies may be required prior to commencement of any works within watercources or riparian areas. A detailed list and descriptions of the regulations governing works within the watershed areas is provided in the environmental report prepared by Maddison Consultants, ***Appendix E***.

Financing

Financing of stormwater drainage infrastructure is one of the concerns of both the SCRD and MoT. For new developments, the installation of stormwater drainage works by a developer, both on and off site, may be a legitimate requirement of subdivision approval. Stormwater infrastructure repairs and retrofit works may be the responsibility of the individual landowner through either direct capital costs outlay or through a taxation scheme.

7.0 Recommendations / Next Steps

The objectives of Phase 2 of the Integrated Stormwater Management Plan for the SCRD were to:

- Expand on, and continue the stormwater management planning carried out in Phase 1;
- Investigate environmental and engineering constraints to development within the study areas;
- Develop performance targets consistent with the SCRD's planning and design policies; and,
- Identify required stormwater / drainage infrastructure improvements.

The watershed assessments conducted have identified several "high-risk" and "high-priority" watersheds, where increased development without implementation of adequate stormwater / drainage management strategies will result in a significant decrease in watershed health due to increased runoff flows and volumes, sediment deposition and bank erosion.

Based on the above objectives and the results of our watershed analyses, we recommend the following next steps to the planning and implementation processes:

- Detailed watercourse / watershed mapping program to identify existing creek alignments and recent creek ravine conditions;

- Detailed topographic survey of stormwater and drainage systems within the foreshore areas of the study area;

- Detailed watershed hydrology and conveyance system analysis for the Seaward Creek, Whittaker Creek and Joe Smith Creek watershed;

- Integrating detailed biophysical surveys of priority watersheds with watershed assessment;

- Additional discussions with the Ministry of Transportation and SCRD regarding implementation strategies; and,

- Identification of other funding sources for planning and implementation phases of this ISMP.

Appendix A

Figures Corresponding to GIS Data Layers
DVD-ROM Included

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Sensitive Ecosystems Inventory
West Howe Sound

May 2008

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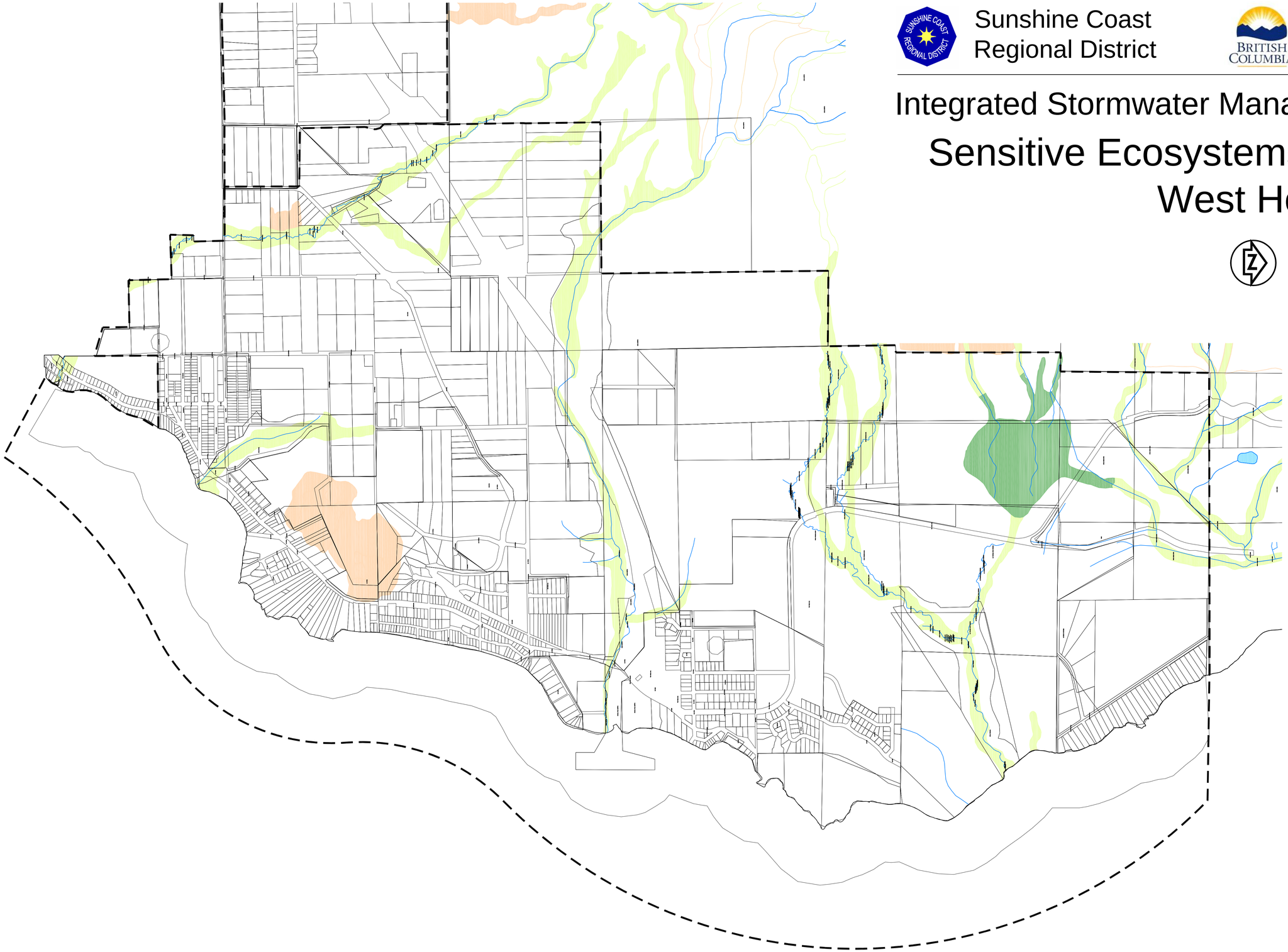

- Plan Area Boundary
- Herbacious (HB)
- (LA)
- Mature Forest (MF)
- Riparian (RI)
- Woodland (WD)
- Wetland (WN)

Delcan
TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

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Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Sensitive Ecosystems Inventory
Elphinstone

May 2008

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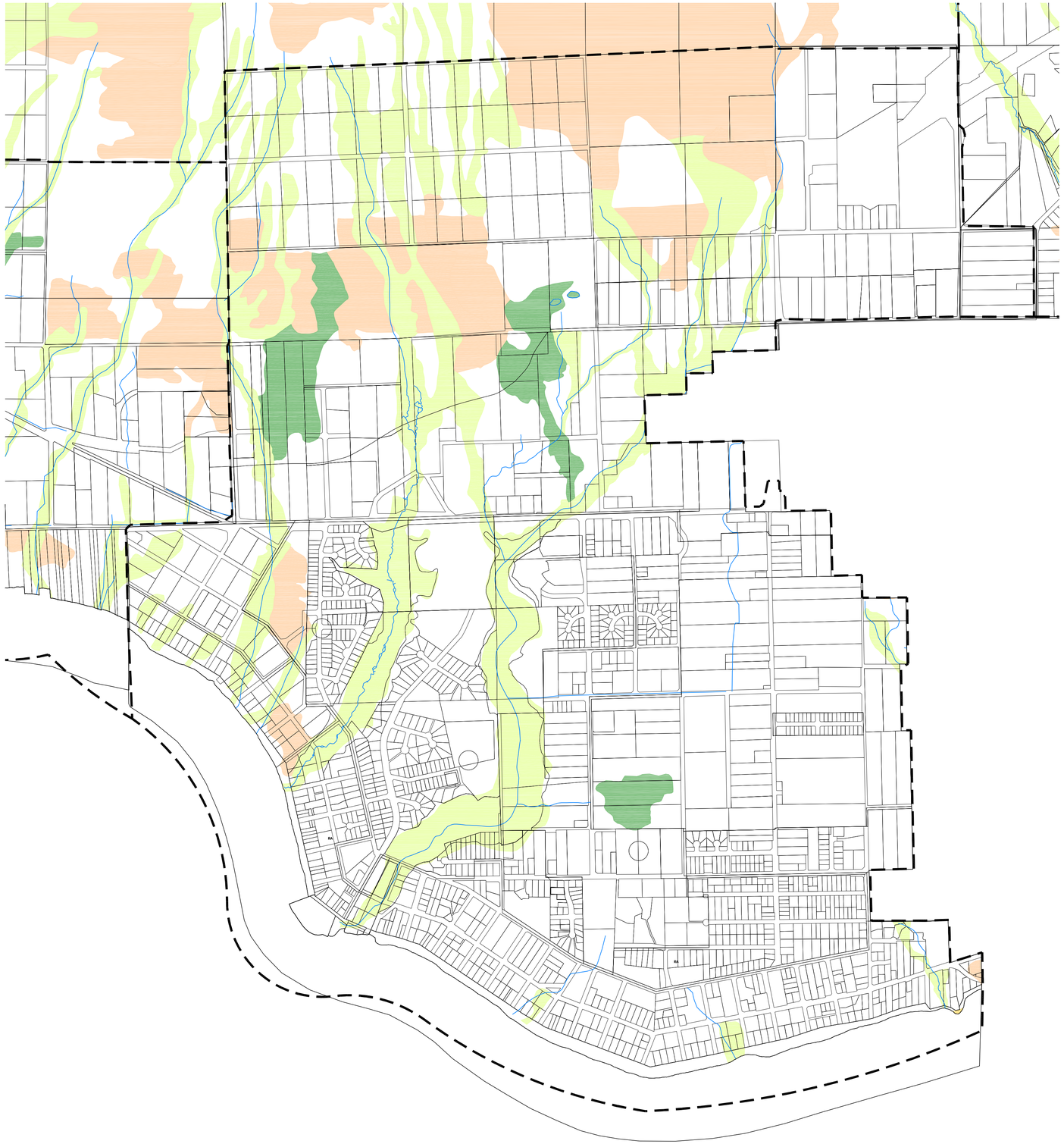

- Plan Area Boundary
- Herbacious (HB)
- (LA)
- Mature Forest (MF)
- Riparian (RI)
- Woodland (WD)
- Wetland (WN)

Delcan
TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Sensitive Ecosystems Inventory
Roberts Creek

May 2008

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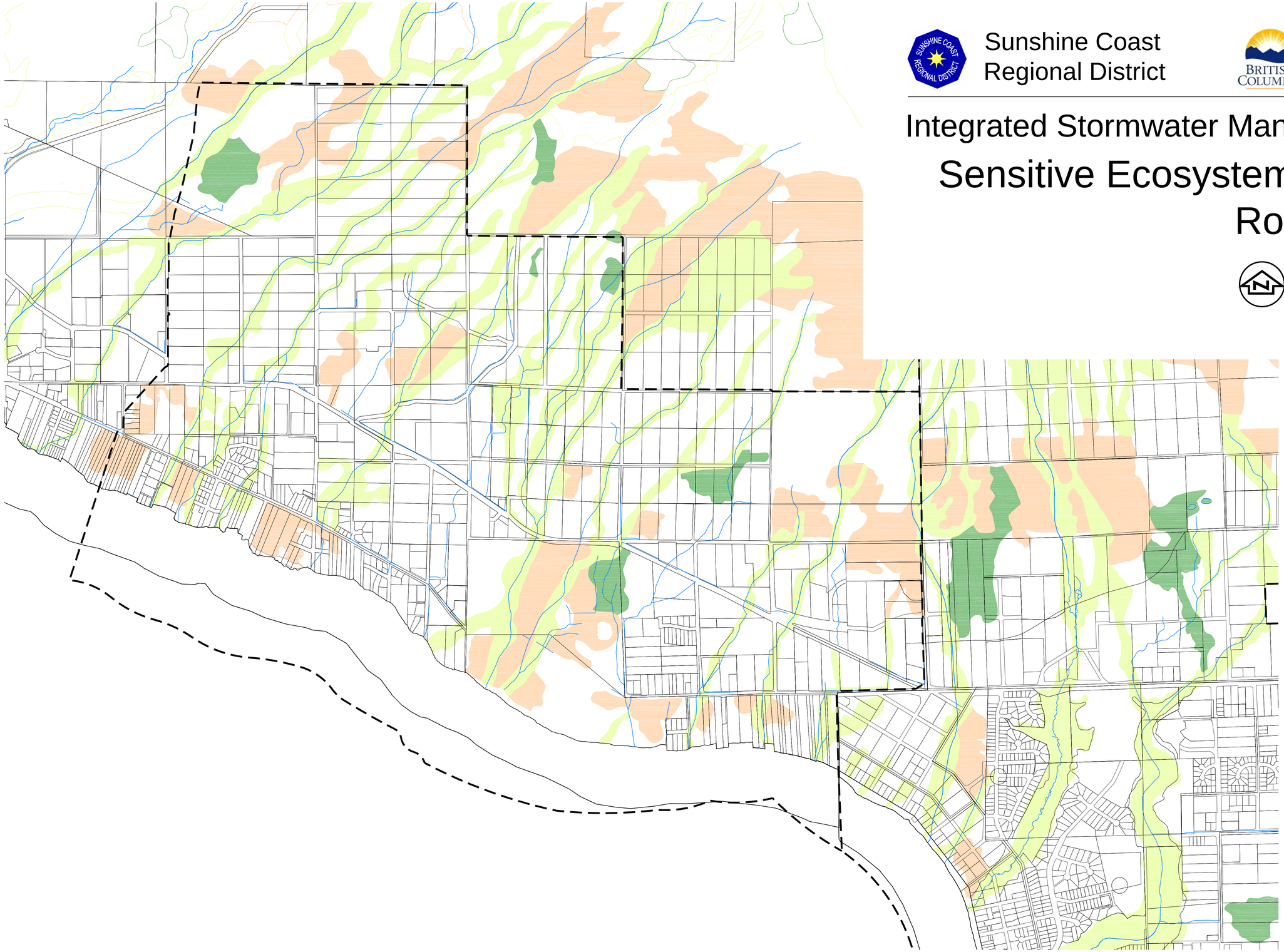

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TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Land Use - West Howe Sound

-

April 2008

0 40 120m

Delcan
TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Land Use - Elphinstone

-

April 2008

0 40 120m

Plan Area Boundary

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TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Land Use - Roberts Creek

-

April 2008

0 40 120m

Plan Area Boundary

Delcan
TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

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Sunshine Coast Regional District

Ministry of Transportation

Intergrated Stormwater Management Plan

Development Permit Areas
West Howe Sound

May 2008

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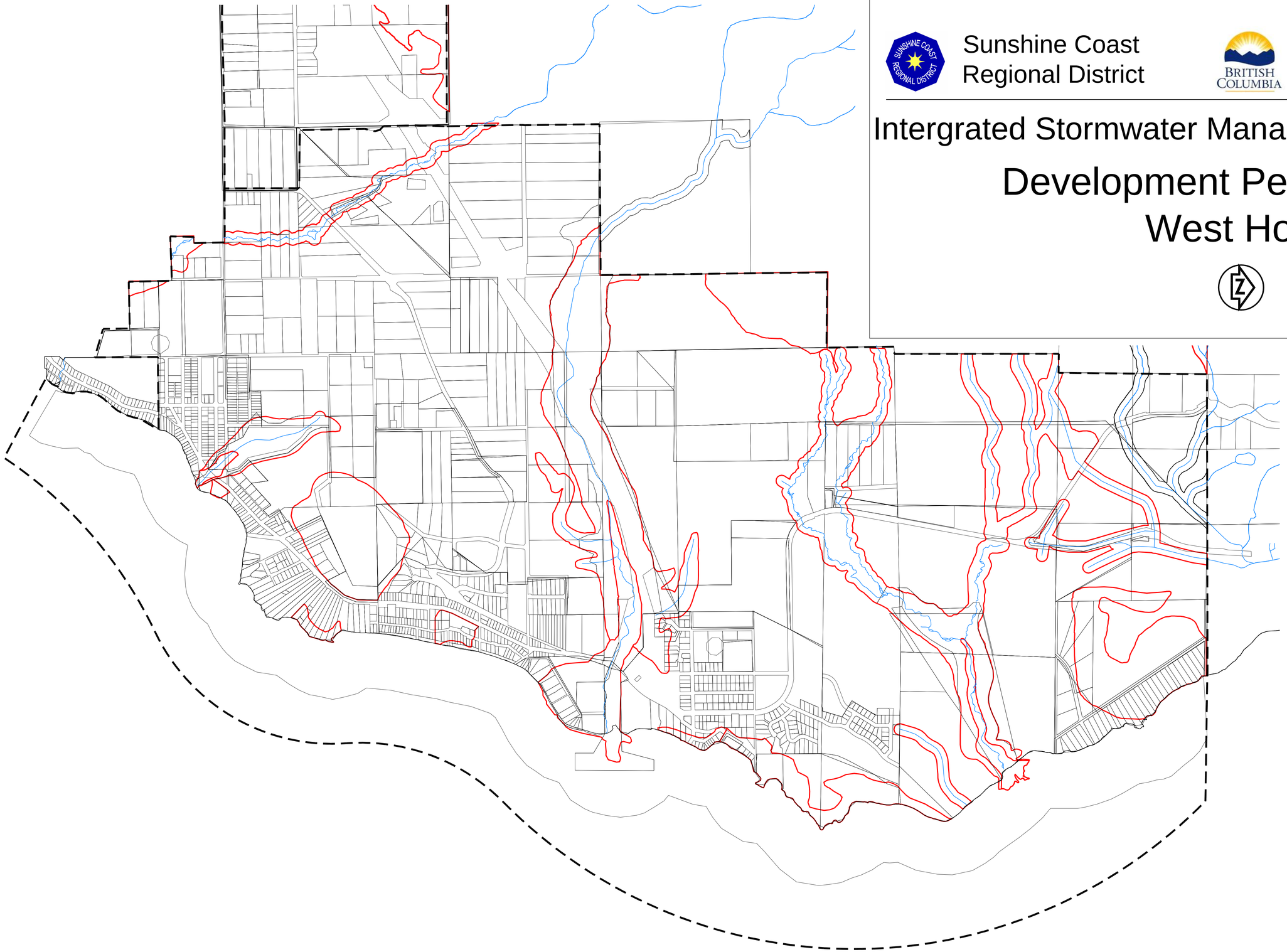

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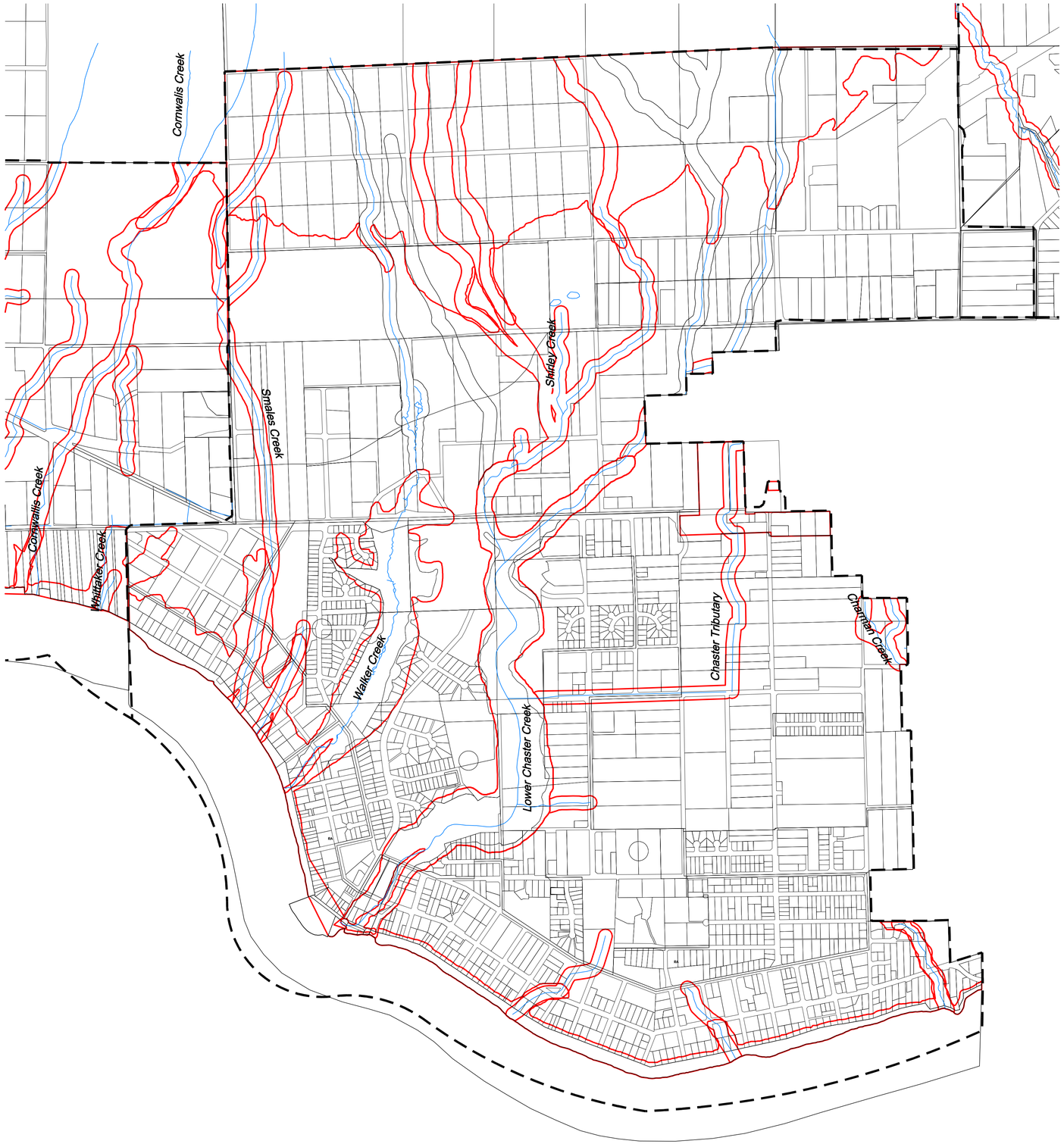

Sunshine Coast Regional District

Ministry of Transportation

Intergrated Stormwater Management Plan

Development Permit Areas
Elphinstone

May 2008

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Sunshine Coast Regional District

Ministry of Transportation

Intergrated Stormwater Management Plan

Development Permit Areas
Roberts Creek

May 2008

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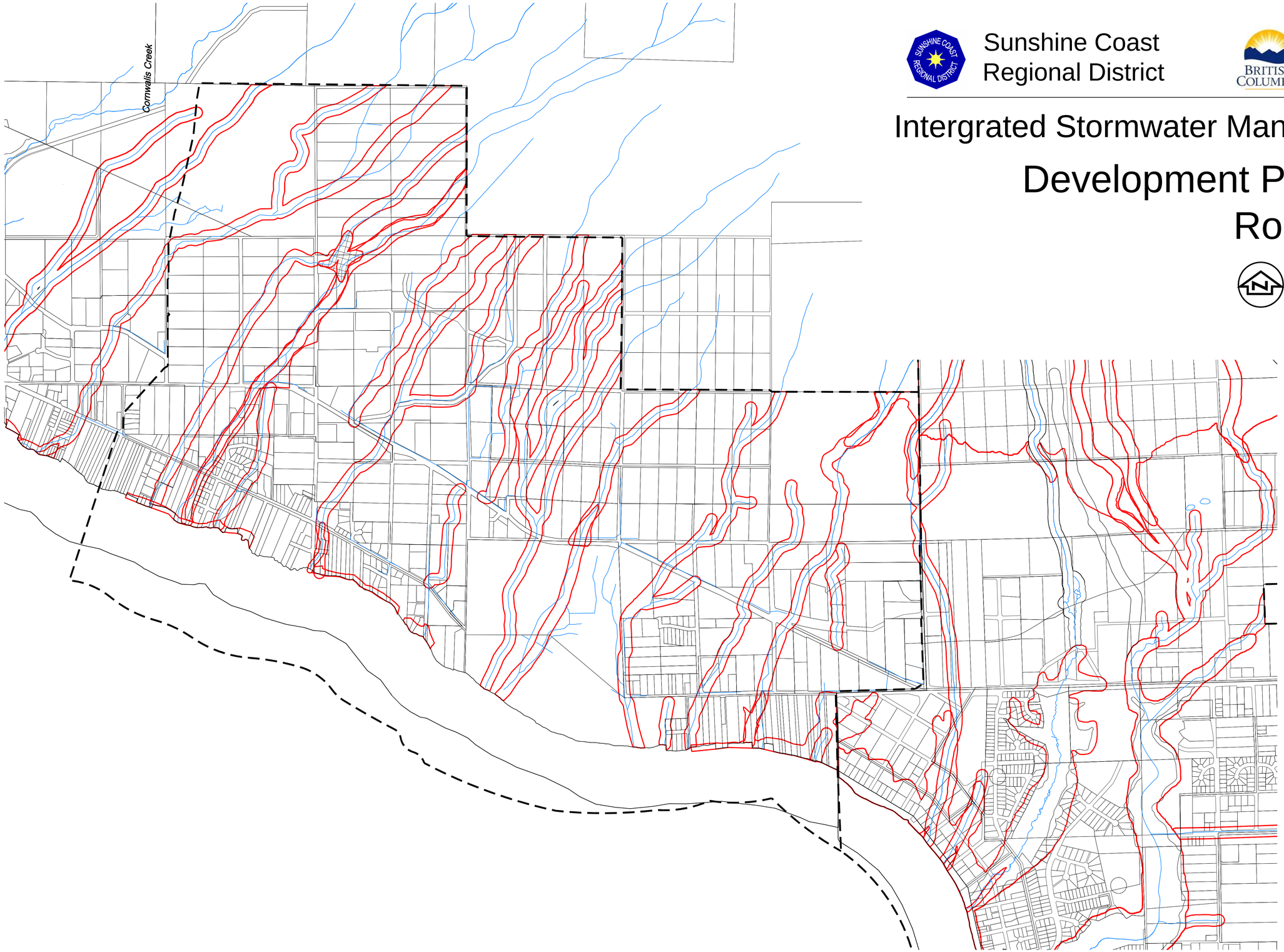

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Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Hydrology & Stormwater Facilities
West Howe Sound
Figure 7

April, 2008

0 200 600m

LEGEND:

- WATERSHED BOUNDARY
- STREAMS
- STUDY AREA BOUNDARY

REED ROAD
CEMETARY ROAD
GIBSONS WAY
NORTH ROAD
Creek
STEWART ROAD
Gibsons
CHAMBERLIN ROAD
Soames
Creek
Shoal
Channel
SUNSHINE COAST HIGHWAY
Creek
Langdale
PORT MELLON HIGHWAY
Hutchison Creek
POINT RD
MARINE DRIVE
LANGDALE FERRY TERMINAL
Howe Sound

ROBERTS CREEK
ELPHINSTONE
WEST HOWE SOUND

ACAD2006 2008/5/02 8:42 Q:\ER\3659 SCRD ISMP PHASE 2\EB\DWGS\TEMP WORKING DWGS\FROM EB3638\FIG_7-WEST HOWE SOUND.DWG PLOTTED ON 2008/5/02 13:11

Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Hydrology & Stormwater Facilities

Elphinstone

Figure 6

April, 2008

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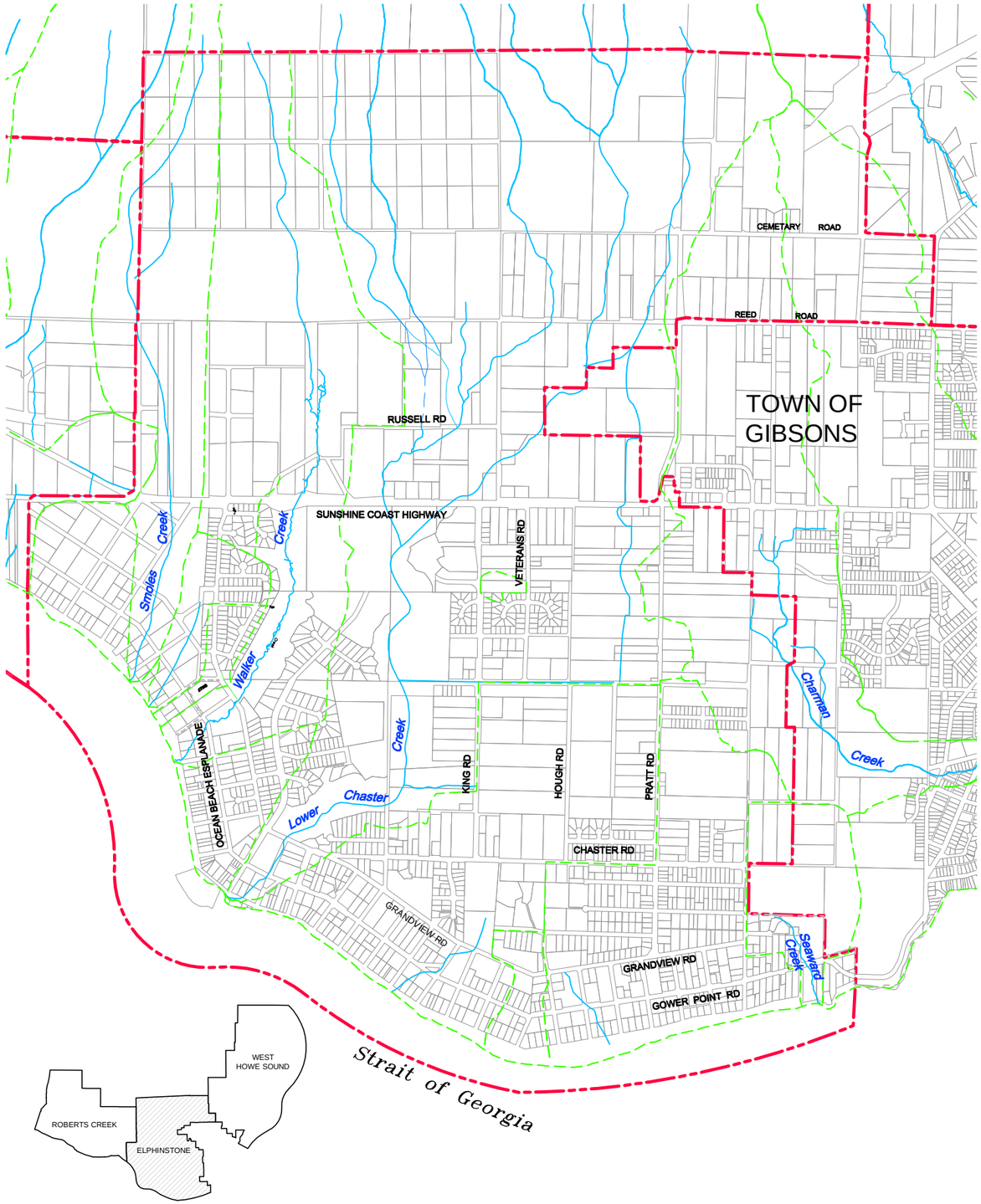

LEGEND:

- WATERSHED BOUNDARY
- STREAMS
- STUDY AREA BOUNDARY

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Sunshine Coast Regional District

Ministry of Transportation

Integrated Stormwater Management Plan

Hydrology & Stormwater Facilities

Roberts Creek

Figure 5

April, 2008

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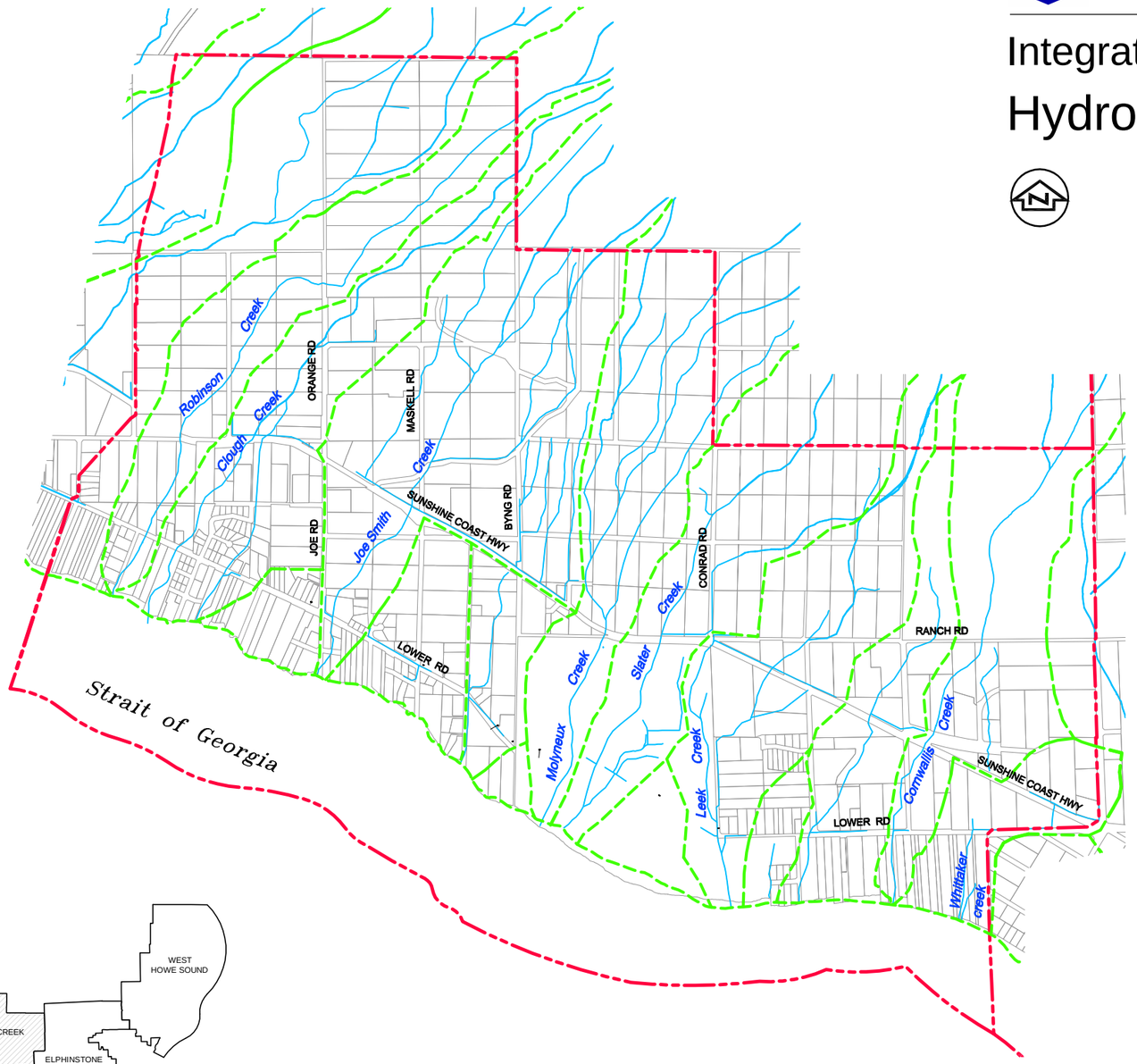

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- STREAMS
- STUDY AREA BOUNDARY

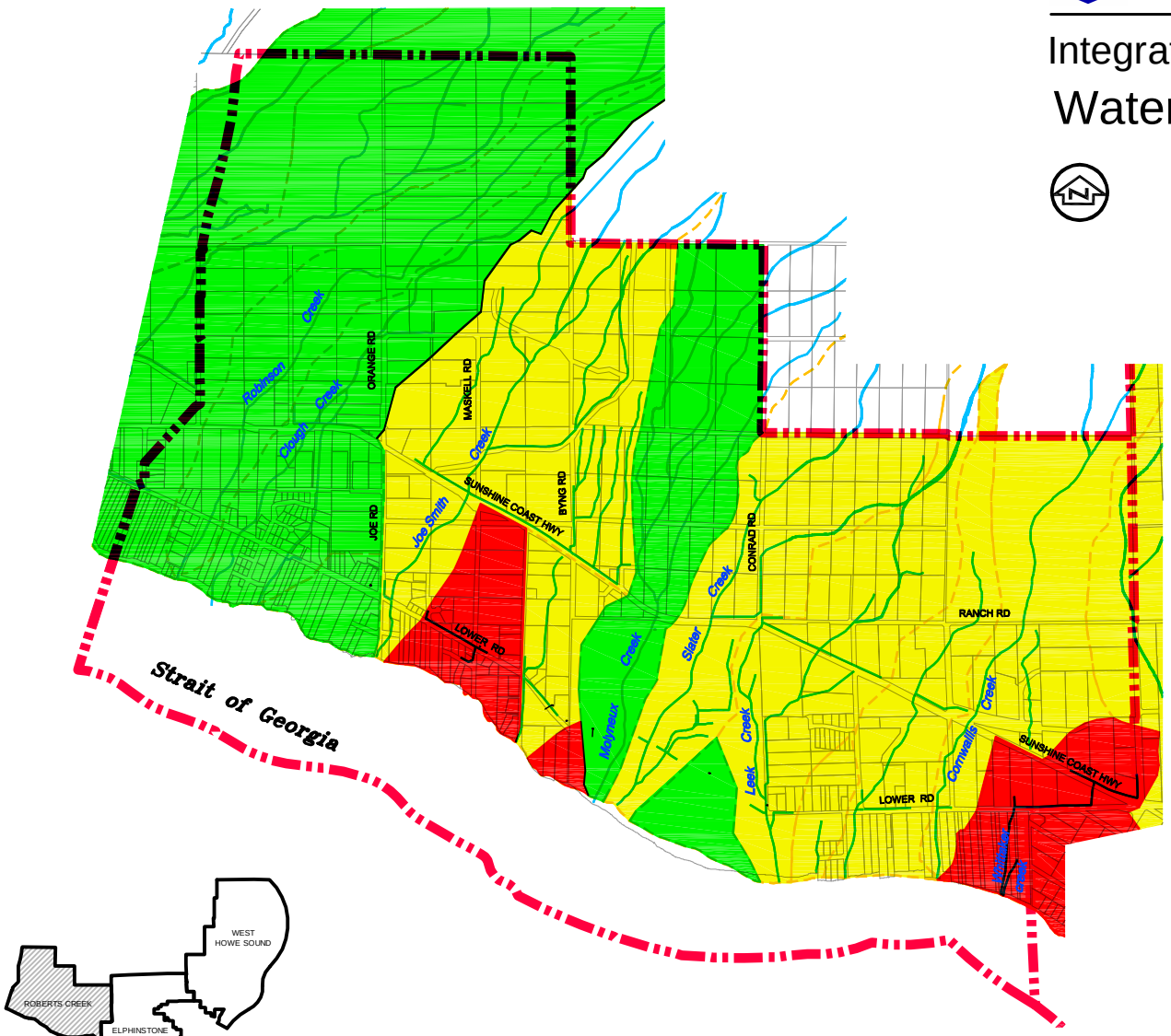
ACAD2006 2008/5/02 8:40 Q:\EB\3659 SCRD ISMP PHASE 2\EB\DWGS\TEMP WORKING DWGS\FROM EB3638\FIG_5-ROBERTS CREEK.DWG PLOTTED ON 2008/5/02 13:06

Sunshine Coast Regional District

Ministry of Transportation and Infrastructure

Integrated Stormwater Management Plan

Watershed Conveyance Capacity
East Roberts Creek



September, 2008

0 200 600m

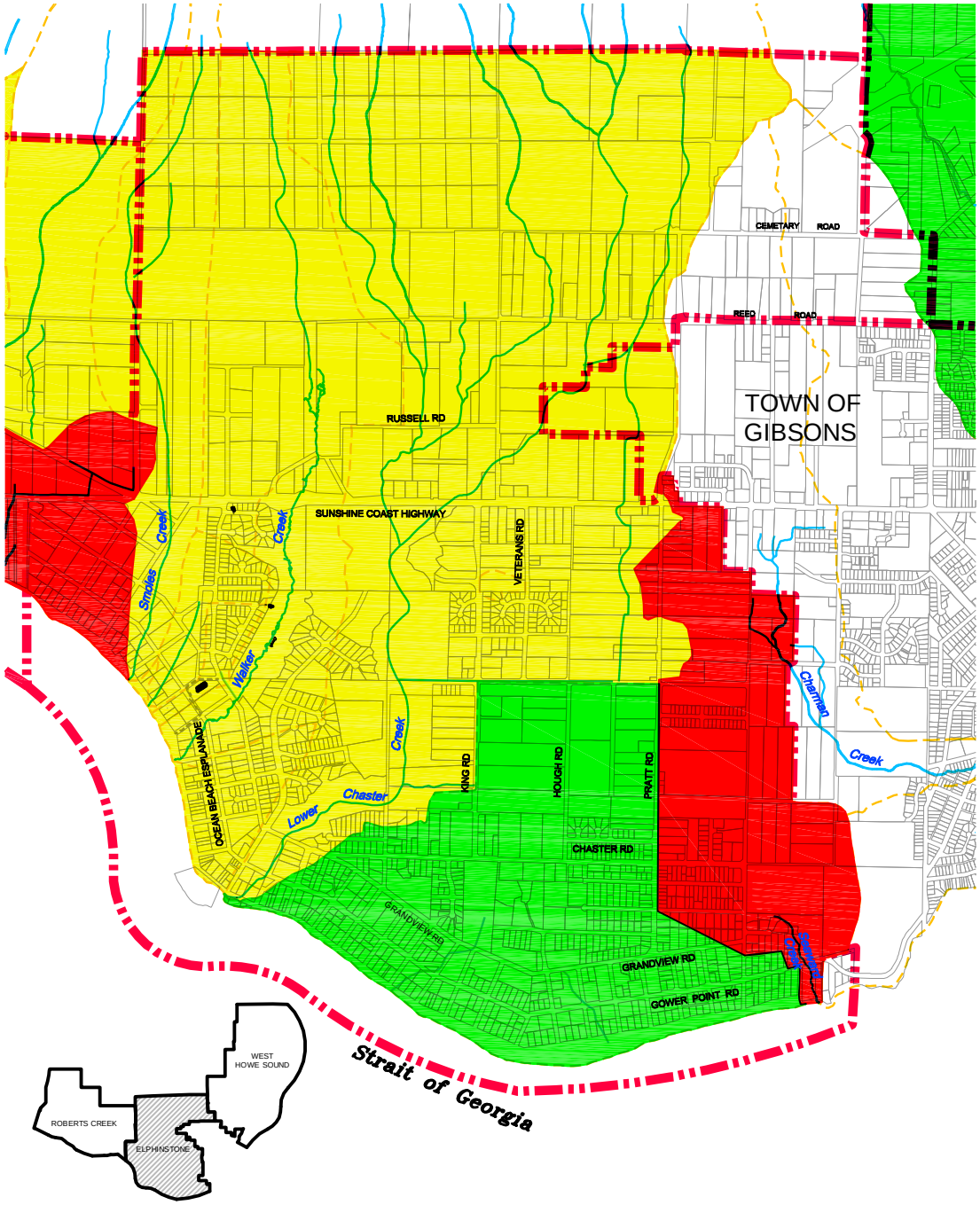
LEGEND:

- WATERSHED BOUNDARY
- STREAMS
- STUDY AREA BOUNDARY

POTENTIAL INCREASE IN RUNOFF (PEAK FLOWS)

- 0 - 5%
- 5 - 10%
- > 10%

ACAD2006 2008/9/17 9:53 G:\ER\3859 SCRD ISMP PHASE 2\ER\DWGS\SEPT-11- GR\FIG_5-ROBERTS CREEK.DWG PLOTTED ON 2008/12/11 8:42



Sunshine Coast Regional District

Ministry of Transportation and Infrastructure

Integrated Stormwater Management Plan

Watershed Conveyance Capacity Elphinstone

September, 2008

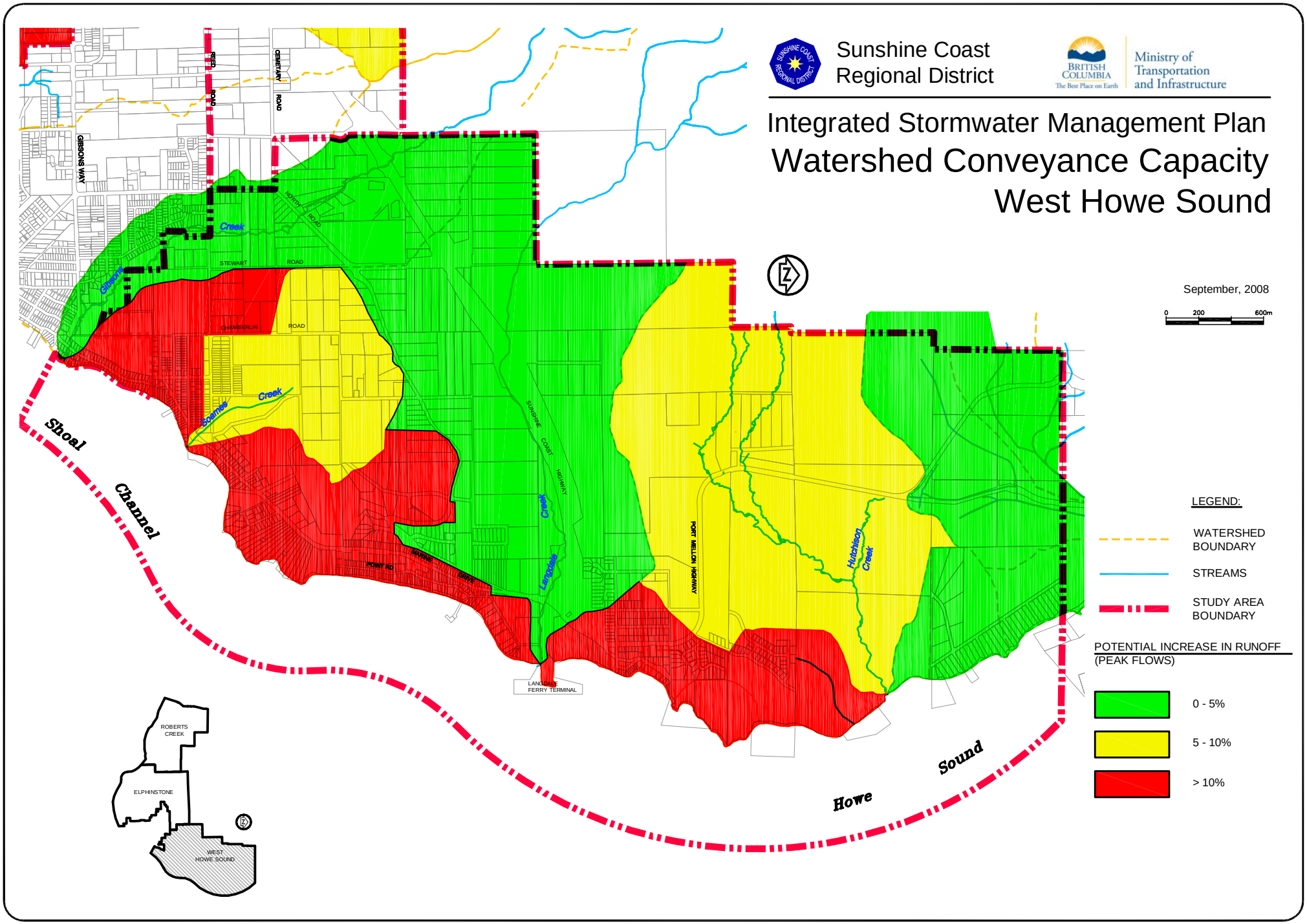
0 200 600m

LEGEND:

- WATERSHED BOUNDARY
- STREAMS
- STUDY AREA BOUNDARY

POTENTIAL INCREASE IN RUNOFF (PEAK FLOWS)

- 0 - 5%
- 5 - 10%
- > 10%


Sunshine Coast Regional District
Ministry of Transportation and Infrastructure
Integrated Stormwater Management Plan
Watershed Conveyance Capacity
West Howe Sound
September, 2008
0 200 600m
LEGEND:
WATERSHED BOUNDARY
STREAMS
STUDY AREA BOUNDARY
POTENTIAL INCREASE IN RUNOFF (PEAK FLOWS)
0 - 5%
5 - 10%
> 10%
Shoal Channel
Howe Sound
REED ROAD
CEMETERY ROAD
GIBSONS WAY
NORTH ROAD
STEWART ROAD
CHAMBERLIN ROAD
Soames Creek
Gibsons Creek
Langdale Creek
Hutchison Creek
SUNSHINE COAST HIGHWAY
FORT MELLON HIGHWAY
POWELL RD
MARINE DRIVE
LANGDALE FERRY TERMINAL
ROBERTS CREEK
ELPHINSTONE
WEST HOWE SOUND

Appendix B

Sensitive Species Tables

Sensitive Species Table – Coastal Habitat Type

SPECIES	HABITAT AND DISTRIBUTION	ACTIVITY / BLOOMING PERIOD	STATUS DESIGNATION	PROBABILITY OF OCCURRENCE
VASCULAR PLANTS				
Monocots				
dune bentgrass *Agrostis pallens*	Dry sand dunes, meadows, rock outcrops and rocky slopes in the lowland zone. 0 metres to 350 metres in elevation. Rare on Vancouver Island and the Queen Charlotte Islands; S to MT, ID, NV and CA.	June - august	CDC: blue COSEWIC: - SARA: -	
slimleaf onion *Allium amplectens*	Vernally moist rocky bluffs and meadows in lowland zone. Can occur in clay soils, including serpentine in either open or wooded places. Up to 1800 metres in elevation. From SE Vancouver Island, Gulf Islands and adjacent mainland (Powell River) south to California.	March - June	CDC: blue COSEWIC: SARA:	Documented in vicinity by CDC
Dicots				
chaffweed *Anagallis minima*	Moist to wet river banks, salt marshes, vernal pools and pond margins in the lowland zone. < 950 metres. Rare on S Vancouver Island and the Gulf Islands; S to MN, IL, CA, TX, FL and MX; South America, Europe.	March - May	CDC: blue COSEWIC: - SARA: -	
contorted-pod evening-primrose *Camissonia contorta*	Open, sandy areas in the lowland zone, often disturbed. 0–2300 m. Rare on S Vancouver Island; S to CA, NV and ID.	May - June	CDC: red COSEWIC: E SARA: -	
beach bindweed *Convolvulus soldanella*	Moist to mesic sand dunes in the lowland zone. < 50 metres. Infrequent along the coast; S to CA, also in the islands of the Pacific Ocean and Europe.	April - August	CDC: blue COSEWIC: - SARA: -	
smooth douglasia *Douglasia laevigata* var. *ciliolata*	Talus slopes and rocky alpine ledges, as well as moist coastal bluffs. On the west side of the Cascade range from Snohomish County to Mount Ranier and the Olympic Mountains. In addition, it occurs in the mountains of southwestern Washington and adjacent Oregon (Mount Hood and Saddle Mountain) and in the Columbia gorge.	March - August	CDC: blue COSEWIC: - SARA: -	
fleshy jaumea *Jaumea carnosa*	Moist tidal beaches and salt marshes in the lowland zone. Rre on S Vancouver Island; S to CA.	May - October	CDC: blue COSEWIC: - SARA: -	
grey beach peavine *Lathyrus littoralis*	Coastal dunes and sand beaches. <5 metres elevation. BC south to Monterey County, California.	April - July	CDC: red COSEWIC: - SARA: -	

Sensitive Species Table – Coastal Habitat Type

SPECIES	HABITAT AND DISTRIBUTION	ACTIVITY / BLOOMING PERIOD	STATUS DESIGNATION	PROBABILITY OF OCCURRENCE
FISH				
cutthroat trout *Oncorhynchus clarki clarki*	Small, low gradient, coastal streams and estuarine habitats that are well shaded with water temperatures optimally below 18 degrees Celsius, spawns in streams on clean, small gravel substrates. After emerging, fry move into larger rivers (or lakes). Young feed mostly on aquatic and drift insects, microcrustaceans, and occasionally smaller fish. Adults eat insects, crustaceans, and other fish. Occurs in small coastal streams from the Eel River in Humboldt County, California northward to the Prince William Sound area of Alaska, including numerous islands with suitable habitat off the coast of BC and southern Alaska. However, this species does not typically occur farther inland than 150km.	Year round	CDC: blue COSEWIC: - SARA: -	
Dolly Varden *Salvelinus malma*	Fresh and salt water. Anadromous forms occur in deep runs and pools of creeks and small to large rivers. Landlocked populations inhabit lakes and tributary streams. Feed on aquatic insects, sometimes fish eggs and smaller fisheastern Asia and western North America from just south of the Canadian border to Alaska. Their distribution does not extend far inland in the Skeena and Fraser River systems, although they are found in the headwaters of the Fraser Liard and Peace River systems.	Year round	CDC: blue COSEWIC: - SARA: -	
BIRDS				
fleshy jaumea *Jaumea carnosa*	Moist tidal beaches and salt marshes in the lowland zone. Rre on S Vancouver Island; S to CA.	May - October	CDC: blue COSEWIC: - SARA: -	
grey beach peavine *Lathyrus littoralis*	Coastal dunes and sand beaches. <5 metres elevation. BC south to Monterey County, California.	April - July	CDC: red COSEWIC: - SARA: -	
Canada goose *Branta canadensis occidentalis*	Breeds in freshwater marsh with tall shrub vegetative cover. Landscape level: herb graminoid and mixed tree/shrubs landcover classes. Nest site level: Interlevee basins were the most common site used for nesting, followed by levees. Low shrub cover or low height forb cover were important components of a nest site in high density nesting strata. Winters in farm fields and agricultural wetlands in Washington and Oregon.	Spring and summer; autumn migrant	CDC: blue COSEWIC: - SARA: -	

Sensitive Species Table – Coastal Habitat Type

Species	Habitat and Distribution	Activity/Blooming Period	Status Designation	Probability of Occurrence
marbled murrelet *Brachyramphus marmoratus*	Coastal areas, mainly in salt water within 2 km of shore, including bays and sounds; not uncommon up to 5 km offshore; occasionally also on rivers and lakes usually within 20 km of ocean (but up to 75 km), especially during breeding season. Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g., Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth. Nest sites generally have good overhead protection. Nesting or probable nesting has been recorded up to 56 km inland in California (USFWS 1994). On the British Columbia coast, nesting birds flew 12-102 kilometers (mean 39 kilometers) inland from foraging sites on the water. In British Columbia, adult diet during the breeding season is mostly fishes.	Year round; breeding from late March to late September	CDC: red COSEWIC: T SARA: T	
great blue heron *Ardea herodias herodias*	Salt, brackish, and freshwater environments including marshes, swamps, shores, and tidal flats. The diet of great blue herons is highly variable and adaptable and includes fish, frogs, salamanders, turtles, snakes, rodents, and birds. This species is very common in southern BC and is frequently observed. The Fraser River delta is the primary wintering area for the great blue heron in BC. Breeding colonies are typically associated with island or mainland sites adjacent to tidal mud flats and eelgrass meadows. Nesting colonies can be located adjacent to high-traffic areas, such as Stanley Park, Vancouver. The nest is in trees approximately 5 to 30 metres above the ground or water. Widely distributed along the coast including Vancouver Island and the Queen Charlotte Island and throughout the interior south of the 52 latitude.	Year round	CDC: blue COSEWIC: SC SARA: -	Heron nesting site documented in vicinity of project area by CDC

Sensitive Species Table – Coastal Habitat Type

Species	Habitat and Distribution	Activity/Blooming Period	Status Designation	Probability of Occurrence
double-crested cormorant *Phalacrocorax auritus*	Marine environments, such as bays, inlets, harbours, lagoons, and estuaries; however, this species is commonly associated with freshwater environments on southern Vancouver Island and within the Fraser River lowlands. The double-crested cormorant breeds throughout southern BC. Nesting colonies are typically situated on bare areas of rocky islands. Most widespread cormorant in North America, only cormorant likely to be seen inland in most areas. Breeds throughout BC and from western Alaska, central Alberta, James Bay, and Newfoundland, south to Mexico and the Bahamas. Winters along the Pacific Coast, on the Atlantic coast from New England to Florida and along the Gulf Coast to Central America.	Year round	CDC: red COSEWIC: NAR SARA: -	Documented on Texada Island by CDC
green heron *Butorides virescens*	Aquatic and terrestrial environments; fresh, marine, or brackish water with thickets, shrubs, and small trees nearby. Uses inland waters, including those in urban areas (e.g. golf courses, city parks, and sewage lagoons). Forages in shallow, still, and slow-moving water on fish but crayfish and other crustaceans, aquatic insects, frogs and tadpoles, grasshoppers, snakes, earthworms, snails and small rodents are also taken (Kaufman, 1996). Breeds in southwestern BC in deciduous trees and occasionally coniferous trees on nests near the end of branches of trees or tall shrubs over or far from fresh waters or brackish sloughs, slow-moving rivers, and lakes all with thickest or woodlands of willows and alders along the shore. Widely distributed and is found in almost every wetland in summer. Also breeds in Washington south to southern California, Arizona and New Mexico and from North Dakota, southern Ontario and New Brunswick south to the Gulf Coast and southern Florida. In winter this species withdraws from most of it's range except for the southern tier of the United States. Northern birds are known to migrate as far as Panama, northern South America. In addition, it is a permanent resident of Central America, West Indes.	Spring and Summer	CDC: blue COSEWIC: - SARA: -	

Sensitive Species Table – Coastal Habitat Type

Species	Habitat and Distribution	Activity/Blooming Period	Status Designation	Probability of Occurrence
grizzly bear *Ursus arctos horribilis*	Wide ranging species that requires large tracts of suitable habitat wherein individuals can move freely and establish home ranges. Omnivores that are opportunistic feeders, they eat vegetation such as roots and bulbs, feed on spawning salmon in stream class 1 streams. Riparian and wet forests are used throughout the range for berrying, foraging, and travel. Grizzly bears hibernate in winter months in high elevation excavated dens. The historical distribution of this species is from Mexico extending north, including Alaska and the Northwest Territories. The current range includes British Columbia, Alaska and the Northwest Territories with some small populations in the northern areas of the United States.	Spring, summer, fall; hibernate in winter	CDC: red COSEWIC: SC SARA: -	

Sensitive Species Table – Riparian Habitat Type

SPECIES	HABITAT AND DISTRIBUTION	ACTIVITY / BLOOMING PERIOD	STATUS DESIGNATION	PROBABILITY OF OCCURRENCE
VASCULAR PLANTS				
Monocots				
green-sheathed sedge *Carex feta*	Ditches, marshes, wet meadows, streambanks in the lowland and montane zones. 50 – 2400 metres. Rare in SW BC, S to CA.	May - August	CDC: red COSEWIC: - SARA: -	
pointed broom sedge *Carex scoparia*	Wet open places, including meadows, shores, springs, fens and swamps. BC east to Newfoundland, south to Florida, Kansas, new Mexico, and Oregon.	June - July	CDC: blue COSEWIC: - SARA: -	
small spike-rush *Eleocharis parvula*	Small perennial, occurs below 3500 metres asl along marshes and shallow water of lakes, ponds, and stream beds. Occurs in Europe, North America, and northern South America.	June - September	CDC: blue COSEWIC: - SARA: -	Documented in vicinity by CDC
white adder's-mouth orchid *Malaxis brachypoda*	Moist forests, mudflats, fens and streambanks in the lowland and montane zones. 390 – 2650 metres. Rare in coastal and N BC; N to AK, E to NF and S to ME, MA, PA, IN, IL, MN and disjunct in CO and CA; Japan.	July - August	CDC: blue COSEWIC: - SARA: -	
Dicots				
chaffweed *Anagallis minima*	Moist to wet river banks, salt marshes, vernal pools and pond margins in the lowland zone. < 950 metres. Rare on S Vancouver Island and the Gulf Islands; S to MN, IL, CA, TX, FL and MX; South America, Europe.	March - May	CDC: blue COSEWIC: - SARA: -	
upswept moonwort *Botrychium ascendens*	Lower montane coniferous forest (mesic). 1500 – 1800 metres. Occurs from Alaska south to California and Nevada, northeast to Montana and Wyoming; historic in Ontario.	May - September	CDC: red COSEWIC: - SARA:-	
smooth willowherb *Epilobium glaberrimum* ssp. *fastigiatum*	Moist streambanks, rocky slopes, and open forests in the montane to alpine zones. 1200 – 3800 metres. Rare in S BC; E to AB and S to MT, UT and CA.	July – August	CDC: blue COSEWIC: - SARA: -	
heterocodon *Heterocodon rariflora*	Moist open places in foothills and valleys below 2300 metres; also shady, damp, grassy places. Southern BC to California and east to Idaho and Nevada; Wyoming.	June - August	CDC: blue COSEWIC: - SARA: -	
western St. John's wort *Hypericum scouleri* ssp. *nortoniae*	Moist to wet streamsides, estuaries, marshes and open slopes in all zones except the alpine and steppe zones. 0 - 1525 metres. Infrequent in S BC; S to WY, CA and MX.	June - August	CDC: blue COSEWIC: - SARA: -	
Nuttall's quillwort *Isoetes nuttallii*	Vernal pools and ephemeral winter seepages in the lowland zone. <1500 metres. Infrequent on SE Vancouver Island and Gulf Islands; S to CA.	June - August	CDC: blue COSEWIC: - SARA: -	
woodland penstemon *Nothochelone nemorosa*	Moist forests and rocky slopes. 1000 – 1400 metres. Rare on S Vancouver Island and the adjacent mainland; S to NW CA.	June - August	CDC: blue COSEWIC: - SARA: -	

Sensitive Species Table – Riparian Habitat Type

northern adder's-tongue *Ophioglossum pusillum*	Moist streamside meadow. Periodically flooded wet meadows and lake margins, in the lowland and montane zones. From Nova Scotia west to North Dakota, south to Virginia, possibly North Carolina, Indiana, and Nebraska; and in the Pacific Northwest. 1000 – 2000 metres.	June - September	CDC: blue COSEWIC: SARA:
western pearlwort *Sagina decumbens* ssp. *occidentalis*	Annual herb that typically occurs from sea level to 900 metres asl in moist to mesic vernal pool habitats; also on dry hillsides, along streams edges, along roadsides and in openings in redwood and pinewood forests BC south into Baja California, Mexico	Spring to early summer	CDC: blue COSEWIC: - SARA: -
Menzies' burnet *Sanguisorba menziesii*	5 to 60 metres elevation asl in wet places, including, fens, bogs, marshes, wet meadows and in lowlands in montane zones. Historical range is documented from Alaska to Wisconsin, current range from Alaska to Washington.	August	CDC: blue COSEWIC: - SARA: -
poison oak *Toxicodendron diversilobum*	Dry to mesic rocky slopes (often climbing trees) in the lowland zone. Below 1550 metres, Rare in SW BC, known from SE Vancouver Island, the Gulf Islands and Howe Sound; S to MX.	April - May	CDC: blue COSEWIC: - SARA: -
Giant chain fern *Woodwardia fimbriata*	Wet forests and seepy, coastal cliffs in the lowland zone. 0 – 2300 metres. Infrequent in SW BC (SE Vancouver Island, Lasqueti and Texada Islands); S to CA, disjunct to AZ and NV.	Year round	CDC: blue COSEWIC: - SARA: -
DRAGONFLIES AND DAMSELFLIES			
black petaltail Tanypteryx hageni	Waterseeps with moss-covered rocks, spring-fed bogs, and seeps in old growth or riparian forests in the Coast Mountains where the larvae burrow in the mud. In Canada, this species is found in montane regions, specifically on British Columbia's mainland coast. Occur from mid to high elevations in the Cascade and southern Coast mountains and at sea level on the central coast. Known to breed in Cypress Provincial Park in West Vancouver (Kenner, 2000).	early July - early September	CDC: blue COSEWIC: - SARA: -
blue dasher *Pachydiplax longipennis*	Still waters of ponds, lakes, marshes and bogs and has been found at Killarney Lake on Bowen Island. Abundant in many areas of the southern half of North America. In BC, this species occurs in the lowlands of the south coast and at the end of Osoyoos Lake in the southern interior. Blue dasher is most common on southern Vancouver Island and in the Gulf Islands.	Early June – mid September	CDC: blue COSEWIC: - SARA: -
BUTTERFLIES AND MOTHS			
common woodnymph *Cercyonis pegala incana*	Grassy forest openings, clearcurs, roadsides, meadows and streambanks. Larval food source is grass, can feed on sedges. Adults feed on willow and poplar sap. Southern BC south to central California and Arizona and across the continent to the Atlantic. Subspecies *incana* only occurs from Vancouver island south to Willamette Valley, Oregon.	July - September	CDC: blue COSEWIC: - SARA: -

Sensitive Species Table – Riparian Habitat Type

dun skipper *Euphyes vestris*	Open, moist areas that have it's larval host plants, which are sedges (*Carex* sp.) and *Cyperus esculentus;* also in disturbed areas such as road edges, railroad right-of-ways, powerline right-of-ways, and roadside ditches. May be found in fairly dry conditions where spring floods or permanent springs provide moist conditions for the larval foodplant. From BC southward along the Cascade, Sierra Nevada, and Coast Mountains to Central California. In BC, this species occurs on Vancouver Island from Courtenay south to Thetis Lake Park, but is absent from the Saanich Peninsula. It is known from one location in Powell River, one location in Pemberton, Mission and five localities in the Fraser Canyon associated with small, moist areas at permanent springs, including Hope, Boston Bar, Lytton, North Lytton and Lillooet.	late June - mid-August	CDC: blue COSEWIC: T SARA: T
FISH			
cutthroat trout *Oncorhynchus clarki clarki*	Small, low gradient, coastal streams and estuarine habitats that are well shaded with water temperatures optimally below 18 degrees Celsius, spawns in streams on clean, small gravel substrates. After emerging, fry move into larger rivers (or lakes). Young feed mostly on aquatic and drift insects, microcrustaceans, and occasionally smaller fish. Adults eat insects, crustaceans, and other fish. Occurs in small coastal streams from the Eel River in Humboldt County, California northward to the Prince William Sound area of Alaska, including numerous islands with suitable habitat off the coast of BC and southern Alaska. However, this species does not typically occur farther inland than 150km.	Year round	CDC: blue COSEWIC: - SARA: -
Dolly Varden *Salvelinus malma*	Fresh and salt water. Anadromous forms occur in deep runs and pools of creeks and small to large rivers. Landlocked populations inhabit lakes and tributary streams. Feed on aquatic insects, sometimes fish eggs and smaller fisheastern Asia and western North America from just south of the Canadian border to Alaska. Their distribution does not extend far inland in the Skeena and Fraser River systems, although they are found in the headwaters of the Fraser Liard and Peace River systems.	Year round	CDC: blue COSEWIC: - SARA: -
REPTILES AND AMPHIBIANS			
red-legged frog *Rana aurora*	Streams, ponds, and marshes with slow-moving water and adjacent terrestrial environments; moist forest conditions far from open water characterized by mature vegetation, leaf litter, and large woody debris. Restricted to low elevations. Breeding in late winter/early spring in shallow water of permanent ponds or lakes, slow-moving streams, marshes, bogs, and swamps. During the summer, hatchlings typically occur within vegetation along streams,	March – October; hibernates from November until late February	CDC: red COSEWIC: SC SARA: SC

	in moist sedge or brush, on shaded pond edges, and/or under logs or debris. Due to predation and competition with introduced bullfrogs (*Rana catesbeiana*), the red-legged frog does not occur where this species is present. Occurs along the west coast of North America from Baja California to Canada and reaches the northern extent of its range in extreme southwestern BC. In BC, it occurs on Vancouver Island, the Gulf Islands, the mainland adjacent to the Straight of Georgia, and through the Fraser valley to Hope.		
tailed frog *Ascaphus truei*	Steep, cold mountain streams, with boulders or cobbles, approximately 0.5 to 15 meters in width in old-growth forests as breeding habitat, along with damp litter on the forest floor to survive as metamorphosed adults. Absent from creeks with either low or excessively steep gradients. Ice free in winter. They winter under rocks or at the stream surface. Eggs are attached to the underside of a boulder or large rock in the stream. Tadpoles feed on diatoms, and the adults consume a variety of items, including spiders, ticks, mites, collembolans (snow fleas), snails and various insects. Sensitive to stream disturbance such as siltation or algal growth. Adults are closely associated with their breeding creek throughout their lives, typically not moving more than 20 meters as adults need to stay moist as they are much less able to withstand drying than other frogs. Coastal mountain ranges in British Columbia, Washington, Oregon, Idaho, northwestern Montana and California from sea level to the timberline. In BC, this species occurs from Penticton north to the Portland Canal (north of Prince Rupert). It does not occur on Vancouver Island or the Queen Charlotte Islands.	Year round	CDC: blue COSEWIC: SC SARA: SC
western toad *Bufo boreas*	Three different types of habitat: breeding habitat, terrestrial summer range, and winter hibernation sites. Breeds in a variety of aquatic habitats with sandy substrates, including the shallow margins of lakes to roadside ditches. Outside the breeding season, adults spend most of their time on land and can be found in forested areas, wet shrublands, avalanche slopes, and meadows. Adults consume a wide variety of invertebrates including worms, spiders, bees, beetles, ants and grasshoppers. Tadpoles are highly gregarious and eat algae, as well as organic matter in the water, but will scavenge on carrion. Although they are capable of excavating their own burrows in loose soils, they shelter in small mammal burrows, beneath logs, and within rock crevices. Rocky Mountains to the pacific coast, from sea level to approximately 3 600 meters. The eastern portion of its range includes western Alberta, and parts of the	Adults are active from January until October; hibernates in burrows below the frostline up to six months of the year	CDC: yellow COSEWIC: SC SARA: SC

Sensitive Species Table – Riparian Habitat Type

	western United States; and the southern extent is Baja California.			
painted turtle *Chrysemys picta*	Lakes, ponds, slow moving streams with basking sites and aquatic vegetation. East of the Cascade Mountains in the Columbia drainage, eastern Washington, the north-central and northeastern portions of Oregon, interior southern BC, extreme northern Idaho and western Montana. Small scattered populations in the Puget Sound area.	Year round; breeding in late May	CDC: blue COSEWIC: - SARA: -	
BIRDS				
Canada goose *Branta canadensis occidentalis*	Breeds in freshwater marsh with tall shrub vegetative cover. Landscape level: herb graminoid and mixed tree/shrubs landcover classes. Nest site level: Interlevee basins were the most common site used for nesting, followed by levees. Low shrub cover or low height forb cover were important components of a nest site in high density nesting strata. Winters in farm fields and agricultural wetlands in Washington and Oregon.	Spring and summer; autumn migrant	CDC: blue COSEWIC: - SARA: -	
Barn swallow *Hirundo rustica*	Open situations, less frequently in partly open habitats, frequently near water. Nests in barns or other buildings, under bridges, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Usually returns to same nesting area in successive years; yearlings often return to within 30 km or closer to natal site. Flies over open land and water and forages on a wide variety of flying insects; rarely eats berries. South-coastal and southeastern Alaska, across much of Canada south through much of U.S. to central Mexico; also eastern Buenos Aires province, Argentina, in early 1980s (Ridgely and Tudor 1989); across Eurasia to Mediterranean region, northern Africa, China, Japan.	Late April through August	CDC: blue COSEWIC: - SARA: -	
great blue heron *Ardea herodias herodias*	Salt, brackish, and freshwater environments including marshes, swamps, shores, and tidal flats. The diet of great blue herons is highly variable and adaptable and includes fish, frogs, salamanders, turtles, snakes, rodents, and birds. This species is very common in southern BC and is frequently observed. The Fraser River delta is the primary wintering area for the great blue heron in BC. Breeding colonies are typically associated with island or mainland sites adjacent to tidal mud flats and eelgrass meadows. Nesting colonies can be located adjacent to high-traffic areas, such as Stanley Park, Vancouver. The nest is in trees approximately 5 to 30 metres above the ground or water. Widely distributed along the coast including Vancouver Island and the Queen Charlotte Island and throughout the interior south of the 52 latitude.	Year round	CDC: blue COSEWIC: SC SARA: -	Heron nesting site documented in vicinity of project area by CDC

Sensitive Species Table – Riparian Habitat Type

green heron *Butorides virescens*	Aquatic and terrestrial environments; fresh, marine, or brackish water with thickets, shrubs, and small trees nearby. Uses inland waters, including those in urban areas (e.g. golf courses, city parks, and sewage lagoons). Forages in shallow, still, and slow-moving water on fish but crayfish and other crustaceans, aquatic insects, frogs and tadpoles, grasshoppers, snakes, earthworms, snails and small rodents are also taken (Kaufman, 1996). Breeds in southwestern BC in deciduous trees and occasionally coniferous trees on nests near the end of branches of trees or tall shrubs over or far from fresh waters or brackish sloughs, slow-moving rivers, and lakes all with thickest or woodlands of willows and alders along the shore. Widely distributed and is found in almost every wetland in summer. Also breeds in Washington south to southern California, Arizona and New Mexico and from North Dakota, southern Ontario and New Brunswick south to the Gulf Coast and southern Florida. In winter this species withdraws from most of it's range except for the southern tier of the United States. Northern birds are known to migrate as far as Panama, northern South America. In addition, it is a permanent resident of Central America, West Indes.	Spring and Summer	CDC: blue COSEWIC: - SARA: -
western screech-owl (*kennicottii* subspecies) *Megascops kennicotti kennicottiii*	Mixed deciduous/coniferous forests on the edges of clearings, wooded canyons, riparian thickets, deserts, orchards, at low elevations often associated with riparian areas. May roost in either coniferous or deciduous tree cavities, patches of thick vegetation, nest boxes, buildings, trees, vines, and crevices in cliffs. Nesting habitats of this owl include large, natural cavities (e.g. in trees), abandoned pileated woodpecker (*Dryocopus pileatus)* and northern flicker holes, as well as, cavities in poles, and old magpie (*Pica pica)* nests. May occur in wooded suburban areas and city parks, if they are disturbed minimally by humans and their associated activities. Western screech-owl is nocturnal and becomes active at dusk feeding on small mammals, birds, reptiles, small fish, and insects, with large insects being primary source of food (Alsop, 2001). This species is sedentary in that it often stays in the same home range throughout the year. Western portion of the North American continent from southern Alaska to central Mexico (COSEWIC, 2002). It is generally common and widely distributed throughout its range. In BC, this subspecies is known along the coast,	Year round	CDC: blue COSEWIC: SC SARA: SC

Sensitive Species Table – Riparian Habitat Type

	including Vancouver Island, but excluding the Queen Charlotte Islands, relatively common in the lower mainland.		
MAMMALS			
grizzly bear *Ursus arctos horribilis*	Wide ranging species that requires large tracts of suitable habitat wherein individuals can move freely and establish home ranges. Omnivores that are opportunistic feeders, they eat vegetation such as roots and bulbs, feed on spawning salmon in stream class 1 streams. Riparian and wet forests are used throughout the range for berrying, foraging, and travel. Grizzly bears hibernate in winter months in high elevation excavated dens. The historical distribution of this species is from Mexico extending north, including Alaska and the Northwest Territories. The current range includes British Columbia, Alaska and the Northwest Territories with some small populations in the northern areas of the United States.	Spring, summer, fall; hibernate in winter	CDC: red COSEWIC: SC SARA: -
Roosevelt elk *Cervus canadensis roosevelti*	Habitat variable according to location. Uses open areas such as alpine pastures, marshy meadows, river flats, and aspen parkland, as well as coniferous forests, brushy clear cuts or forest edges. No special calving ground is used. Primarily a grazer, but much geographic and seasonal variation in diet. Holarctic; Eurasia and North America; Tunisia and northeastern Algeria; introduced in Morroco, South America, New Zealand, and Australia. Formerly widespread in North America, now mostly restricted to the West, with small reintroduced populations elsewhere.	Year round	CDC: blue COSEWIC: - SARA: -

Sensitive Species Table – Uplands Habitat Type

SPECIES	HABITAT AND DISTRIBUTION	ACTIVITY / BLOOMING PERIOD	STATUS DESIGNATION	PROBABILITY OF OCCURRENCE
NON VASCULAR PLANTS				
Homalothecium arenarium	Sandy soils		CDC: blue COSEWIC: SARA:	
VASCULAR PLANTS				
Monocots				
slimleaf onion *Allium amplectens*	Vernally moist rocky bluffs and meadows in lowland zone. Can occur in clay soils, including serpentine in either open or wooded places. Up to 1800 metres in elevation. From SE Vancouver Island, Gulf Islands and adjacent mainland (Powell River) south to California.	March - June	CDC: blue COSEWIC: SARA:	Documented in vicinity by CDC
white adder's-mouth orchid *Malaxis brachypoda*	Moist forests, mudflats, fens and streambanks in the lowland and montane zones. 390 – 2650 metres. Rare in coastal and N BC; N to AK, E to NF and S to ME, MA, PA, IN, IL, MN and disjunct in CO and CA; Japan.	July - August	CDC: blue COSEWIC: - SARA: -	
Dicots				
upswept moonwort *Botrychium ascendens*	Lower montane coniferous forest (mesic). 1500 – 1800 metres. Occurs from Alaska south to California and Nevada, northeast to Montana and Wyoming; historic in Ontario.	May - September	CDC: red COSEWIC: - SARA:-	
least moonwort *Botrychium simplex*	A wide variety of habits including meadows, barrens and woods, usually in subacid soils. 2200 – 3300 metres. High elevations from southern California to North Carolina and northward to Alaska and Newfoundland; also widespread in the Old World.	May - September	CDC: blue COSEWIC: - SARA: -	
field dodder *Cuscuta campestris*	On many hosts, especially Asteraceae. S to CA, east to Atlantic coast, W.Indies, S. America.	July - November	CDC: blue COSEWIC: - SARA: -	Documented in vicinity by CDC.
smooth douglasia *Douglasia laevigata* var. *ciliolata*	Talus slopes and rocky alpine ledges, as well as moist coastal bluffs. On the west side of the Cascade range from Snohomish County to Mount Ranier and the Olympic Mountains. In addition, it occurs in the mountains of southwestern Washington and adjacent Oregon (Mount Hood and Saddle Mountain) and in the Columbia gorge.	March - August	CDC: blue COSEWIC: - SARA: -	
smooth willowherb *Epilobium glaberrimum* ssp. *fastigiatum*	Moist streambanks, rocky slopes, and open forests in the montane to alpine zones. 1200 – 3800 metres. Rare in S BC; E to AB and S to MT, UT and CA.	July – August	CDC: blue COSEWIC: - SARA: -	

Sensitive Species Table – Uplands Habitat Type

hairy gumweed *Grindelia hirsutula var. hirsutula*	Dry sites in the lowland zone. < 900 metres. Rare on the Gulf Islands, known only from Lasqueti Island; disjunct S to CA.	April - July	CDC: red COSEWIC: - SARA: -	
heterocodon *Heterocodon rariflora*	Moist open places in foothills and valleys below 2300 metres; also shady, damp, grassy places. Southern BC to California and east to Idaho and Nevada; Wyoming.	June - August	CDC: blue COSEWIC: - SARA: -	
western St. John's wort *Hypericum scouleri* ssp. *nortoniae*	Moist to wet streamsides, estuaries, marshes and open slopes in all zones except the alpine and steppe zones. 0 - 1525 metres. Infrequent in S BC; S to WY, CA and MX.	June - August	CDC: blue COSEWIC: - SARA: -	
Nuttall's quillwort *Isoetes nuttallii*	Vernal pools and ephemeral winter seepages in the lowland zone. <1500 metres. Infrequent on SE Vancouver Island and Gulf Islands; S to CA.	June - August	CDC: blue COSEWIC: - SARA: -	
woodland penstemon *Nothochelone nemorosa*	Moist forests and rocky slopes. 1000 – 1400 metres. Rare on S Vancouver Island and the adjacent mainland; S to NW CA.	June - August	CDC: blue COSEWIC: - SARA: -	
elegant Jacob's ladder *Polemonium elegans*	Dry cliffs and scree slopes in the subalpine and alpine zones. 1675 – 2750 metres. Rare in S BC south of 56oN, mostly in the Coast-Cascade Mountains; S to N CA.	July - August	CDC: blue COSEWIC: - SARA: -	
snow bramble *Rubus nivalis*	Moist forests and glades in the montane zone. 500 – 1250 metres. Rare in S BC; S to CA and ID.	May - July	CDC: red COSEWIC: - SARA: -	Documented in vicinity by CDC.
western pearlwort *Sagina decumbens* ssp. *occidentalis*	Annual herb that typically occurs from sea level to 900 metres asl in moist to mesic vernal pool habitats; also on dry hillsides, along streams edges, along roadsides and in openings in redwood and pinewood forests BC south into Baja California, Mexico	Spring to early summer	CDC: blue COSEWIC: - SARA: -	
Macoun's groundsel *Senecio macounii*	Dry open forests, disturbed areas and rock outcrops or limestone quarries in the lowland zone, may occur in roadsides or clearings in coniferous forests. 400 – 900 metres. Rare on S Vancouver Island, Texada Island and adjacent mainland; S to OR.	June - July	CDC: blue COSEWIC: - SARA: -	
poison oak *Toxicodendron diversilobum*	Dry to mesic rocky slopes (often climbing trees) in the lowland zone. Below 1550 metres, Rare in SW BC, known from SE Vancouver Island, the Gulf Islands and Howe Sound; S to MX.	April - May	CDC: blue COSEWIC: - SARA: -	
Giant chain fern *Woodwardia fimbriata*	Wet forests and seepy, coastal cliffs in the lowland zone. 0 – 2300 metres. Infrequent in SW BC (SE Vancouver Island, Lasqueti and Texada Islands); S to CA, disjunct to AZ and NV.	Year round	CDC: blue COSEWIC: - SARA: -	
MOLLUSCS				
northern abalone *Haliotis kamtschatkana*	Mostly subtidal; adults are usually found at <10 m depth. The abalone prefer a firm substrate, usually rock, and are generally found in areas of moderate water exchange, such	Year round	CDC: red COSEWIC: T SARA: T	

	as occurs on exposed or semi-exposed coasts. Occurs along the pacific coast from Alaska to Turtle Bay, Baja California (Mexico).		
scarletback taildropper *Pprophyson vanattae*	Aboreal; lives on moss-covered trunks and shrub and tree branches in coastal mixed wood forests. Vancouver Island and Chilliwack Valley.	Year round	CDC: blue COSEWIC: - SARA: -
threaded vertigo *Nearctula* sp.	Lives in moist leaf litter in rich sites in deciduous and mixed forests. Southwestern BC to Monterey County, California.	Year round	CDC: red COSEWIC: - SARA: -
pacific sideband *Monadenia fidelis*	Deciduous, coniferous, or mixed forests; also in open woods and grassy areas. From Sitka, Alaska, to Cape Mendocino, California; west of the Coast and Cascade Mountains, in British Columbia.	Most common late spring	CDC: blue COSEWIC: - SARA: -
BUTTERFLIES AND MOTHS			
common woodnymph *Cercyonis pegala incana*	Grassy forest openings, clearcurs, roadsides, meadows and streambanks. Larval food source is grass, can feed on sedges. Adults feed on willow and poplar sap. Southern BC south to central California and Arizona and across the continent to the Atlantic. Subspecies *incana* only occurs from Vancouver island south to Willamette Valley, Oregon.	July - September	CDC: blue COSEWIC: - SARA: -
western pine elphin *Callophrys eryphon sheltonensis*	A variety of pine dominated or mixed pine forests. Adults take nectar from *Salix prolixa*. Larval foodplant is *Pinus contorta*. British Columbia east to Maine; south to southern California, Arizona, and New Mexico.	May - June	CDC: blue COSEWIC: - SARA: -
monarch *Danaus plexippus*	Open fields, roadsides, canyons and suburban areas. Main source of food is milkweed (*Asclepias* sp.), which is only native to the dry areas of the southern interior of BC. Therefore, migrants to the west coast cannot breed successfully. In tropical and subtropical areas of the world. Colonized New Zealand, Australia, and Canary Islands following the introduction of food plants to these areas. In BC, typically found in the interior, and infrequently in the lower Fraser valley, on Vancouver Island and the Rocky Mountain trench. Migrates in late summer and fall from BC to California to hibernate and overwinter along the central and southern California coast.	March – November	CDC: blue COSEWIC:SC SARA: SC
dun skipper *Euphyes vestris*	Open, moist areas that have it's larval host plants, which are sedges (*Carex* sp.) and *Cyperus esculentus;* also in disturbed areas such as road edges, railroad right-of-ways, powerline right-of-ways, and roadside ditches. May be found in fairly dry conditions where spring floods or permanent springs provide moist conditions for the larval foodplant. From BC southward along the Cascade, Sierra Nevada, and Coast Mountains to Central California. In BC, this species occurs on Vancouver Island from Courtenay south to Thetis Lake Park, but is absent from the Saanich Peninsula. It is known from one location in Powell River,	late June - mid-August	CDC: blue COSEWIC: T SARA: T

Sensitive Species Table – Uplands Habitat Type

	one location in Pemberton, Mission and five localities in the Fraser Canyon associated with small, moist areas at permanent springs, including Hope, Boston Bar, Lytton, North Lytton and Lillooet.		
REPTILES AND AMPHIBIANS			
red-legged frog *Rana aurora*	Streams, ponds, and marshes with slow-moving water and adjacent terrestrial environments; moist forest conditions far from open water characterized by mature vegetation, leaf litter, and large woody debris. Restricted to low elevations. Breeding in late winter/early spring in shallow water of permanent ponds or lakes, slow-moving streams, marshes, bogs, and swamps. During the summer, hatchlings typically occur within vegetation along streams, in moist sedge or brush, on shaded pond edges, and/or under logs or debris. Due to predation and competition with introduced bullfrogs (*Rana catesbeiana*), the red-legged frog does not occur where this species is present. Occurs along the west coast of North America from Baja California to Canada and reaches the northern extent of its range in extreme southwestern BC. In BC, it occurs on Vancouver Island, the Gulf Islands, the mainland adjacent to the Straight of Georgia, and through the Fraser valley to Hope.	March – October; hibernates from November until late February	CDC: red COSEWIC: SC SARA: SC
tailed frog *Ascaphus truei*	Steep, cold mountain streams, with boulders or cobbles, approximately 0.5 to 15 meters in width in old-growth forests as breeding habitat, along with damp litter on the forest floor to survive as metamorphosed adults. Absent from creeks with either low or excessively steep gradients. Ice free in winter. They winter under rocks or at the stream surface. Eggs are attached to the underside of a boulder or large rock in the stream. Tadpoles feed on diatoms, and the adults consume a variety of items, including spiders, ticks, mites, collembolans (snow fleas), snails and various insects. Sensitive to stream disturbance such as siltation or algal growth. Adults are closely associated with their breeding creek throughout their lives, typically not moving more than 20 meters as adults need to stay moist as they are much less able to withstand drying than other frogs. Coastal mountain ranges in British Columbia, Washington, Oregon, Idaho, northwestern Montana and California from sea level to the timberline. In BC, this species occurs from Penticton north to the Portland Canal (north of Prince Rupert). It does not occur on Vancouver Island or the Queen Charlotte Islands.	Year round	CDC: blue COSEWIC: SC SARA: SC
western toad *Bufo boreas*	Three different types of habitat: breeding habitat, terrestrial summer range, and winter hibernation sites. Breeds in a variety of aquatic habitats with sandy substrates, including the shallow margins of lakes to	Adults are active from January until October; hibernates in burrows below the frostline up	CDC: yellow COSEWIC: SC SARA: SC

Sensitive Species Table – Uplands Habitat Type

	roadside ditches. Outside the breeding season, adults spend most of their time on land and can be found in forested areas, wet shrublands, avalanche slopes, and meadows. Adults consume a wide variety of invertebrates including worms, spiders, bees, beetles, ants and grasshoppers. Tadpoles are highly gregarious and eat algae, as well as organic matter in the water, but will scavenge on carrion. Although they are capable of excavating their own burrows in loose soils, they shelter in small mammal burrows, beneath logs, and within rock crevices. Rocky Mountains to the pacific coast, from sea level to approximately 3 600 meters. The eastern portion of its range includes western Alberta, and parts of the western United States; and the southern extent is Baja California.	to six months of the year	
BIRDS			
Canada goose *Branta canadensis occidentalis*	Breeds in freshwater marsh with tall shrub vegetative cover. Landscape level: herb graminoid and mixed tree/shrubs landcover classes. Nest site level: Interlevee basins were the most common site used for nesting, followed by levees. Low shrub cover or low height forb cover were important components of a nest site in high density nesting strata. Winters in farm fields and agricultural wetlands in Washington and Oregon.	Spring and summer; autumn migrant	CDC: blue COSEWIC: - SARA: -
marbled murrelet *Brachyramphus marmoratus*	Coastal areas, mainly in salt water within 2 km of shore, including bays and sounds; not uncommon up to 5 km offshore; occasionally also on rivers and lakes usually within 20 km of ocean (but up to 75 km), especially during breeding season. Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g., Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth. Nest sites generally have good overhead protection. Nesting or probable nesting has been recorded up to 56 km inland in California (USFWS 1994). On the British Columbia coast, nesting birds flew 12-102 kilometers (mean 39 kilometers) inland from foraging sites on the water. In British Columbia, adult diet during the breeding season	Year round; breeding from late March to late September	CDC: red COSEWIC: T SARA: T

Sensitive Species Table – Uplands Habitat Type

	is mostly fishes.		
northern goshawk *Accipiter gentiles* ssp. *laingi*	Hunt inside the forest or along edge. Occur in coniferous or mixed forests and are restricted to wooded areas, may occur in open woods. Feed on birds and small mammals. In the Fraser basin, occurs near wooded skloughs, hedgrows, and woodlands along river banks with tall shrubs, and over cattail marsh. Nests in trees in major crotch of trunk. Throughout North America; range appears to be expanding. Breeds in the temperate and boreal regions of the northern hemisphere. Some confusion in the literature regarding the range of the subspecies: the American Ornithologists Union restrict this subspecies to the Queen Charlotte Islands and Vancouver Island, while Jewett *et al.* (1953) consider all coastal birds south to Oregon to be the *laingi* subspecies.	Year round	CDC: red COSEWIC: T SARA: T
Spotted owl *Strix occidentalis*	Preferentially selects old coniferous forests for foraging, roosting and nesting, with large overstorey trees (>75 cm dbh), multilayered canopy, large decaying fallen trees and large diameter standing dead trees; these stands are typically dominated by trees >200 years. Nest in tree cavities, deformities of large trees (e.g., depressions in the top of broken-topped trees, or platforms constructed by other birds or by natural accumulations of debris) located below the overhead canopy, thereby providing overhead cover and seclusion to the nest. Small mammals predominate in diet; also eats various birds and sometimes large insects. Sometimes stores food for future use. RESIDENT: southwestern British Columbia south through western Washington and western Oregon to southern California and northern Baja California (probably); in Rocky Mountain region from southern Utah and central Colorado south through the mountains of Arizona, New Mexico, extreme western Texas (Guadalupe Mountains), northern Sonora, Chihuahua, and Nuevo Leon to Jalisco, Michoacan, and Guanajato.	Year round; nocturnal	CDC: red COSEWIC: E SARA: E
Barn swallow *Hirundo rustica*	Open situations, less frequently in partly open habitats, frequently near water. Nests in barns or other buildings, under bridges, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Usually returns to same nesting area in successive years; yearlings often return to within 30 km or closer to natal site. Flies over open land and water and forages on a wide variety of flying insects; rarely eats berries. South-coastal and southeastern Alaska, across much of Canada south through much of U.S. to central Mexico; also eastern Buenos Aires province, Argentina, in early 1980s (Ridgely and Tudor 1989); across Eurasia to Mediterranean region,	Late April through August	CDC: blue COSEWIC: - SARA: -

Sensitive Species Table – Uplands Habitat Type

	northern Africa, China, Japan.			
great blue heron *Ardea herodias herodias*	Salt, brackish, and freshwater environments including marshes, swamps, shores, and tidal flats. The diet of great blue herons is highly variable and adaptable and includes fish, frogs, salamanders, turtles, snakes, rodents, and birds. This species is very common in southern BC and is frequently observed. The Fraser River delta is the primary wintering area for the great blue heron in BC. Breeding colonies are typically associated with island or mainland sites adjacent to tidal mud flats and eelgrass meadows. Nesting colonies can be located adjacent to high-traffic areas, such as Stanley Park, Vancouver. The nest is in trees approximately 5 to 30 metres above the ground or water. Widely distributed along the coast including Vancouver Island and the Queen Charlotte Island and throughout the interior south of the 52 latitude.	Year round	CDC: blue COSEWIC: SC SARA: -	Heron nesting site documented in vicinity of project area by CDC
pine grosbeak *Pinicola enucleator carlottae*	Open coniferous (less commonly mixed coniferous-deciduous) forest and forest edge; in migration and winter also in deciduous forest, woodland, second growth and shrubbery. Nests in trees or shrubs in open coniferous woods, 2-9 m above ground. Feeds on a wide variety of seeds; also eats fruits and insects. Forages in trees but also takes food from the ground. Breeds in North America, from western Alaska east across northern Canada to Newfoundland and south to central California, Arizona, northern New Mexico, northern Alberta, central Manitoba, northern Great Lakes region, central Maine and Nova Scotia. Overwinters in North America from western Alaska, southern Yukon, southern Mackenzie, and southern Canada south through breeding range.	Year round	CDC: blue COSEWIC: - SARA: -	
double-crested cormorant *Phalacrocorax auritus*	Marine environments, such as bays, inlets, harbours, lagoons, and estuaries; however, this species is commonly associated with freshwater environments on southern Vancouver Island and within the Fraser River lowlands. The double-crested cormorant breeds throughout southern BC. Nesting colonies are typically situated on bare areas of rocky islands. Most widespread cormorant in North America, only cormorant likely to be seen inland in most areas. Breeds throughout BC and from western Alaska, central Alberta, James Bay, and Newfoundland, south to Mexico and the Bahamas. Winters along the Pacific Coast, on the Atlantic coast from New England to Florida and along the Gulf Coast to Central America.	Year round	CDC: red COSEWIC: NAR SARA: -	Documented on Texada Island by CDC
green heron *Butorides virescens*	Aquatic and terrestrial environments; fresh, marine, or brackish water with thickets, shrubs, and small trees nearby. Uses inland waters, including those in urban areas (e.g. golf courses, city parks, and sewage lagoons).	Spring and Summer	CDC: blue COSEWIC: - SARA: -	

	Forages in shallow, still, and slow-moving water on fish but crayfish and other crustaceans, aquatic insects, frogs and tadpoles, grasshoppers, snakes, earthworms, snails and small rodents are also taken (Kaufman, 1996). Breeds in southwestern BC in deciduous trees and occasionally coniferous trees on nests near the end of branches of trees or tall shrubs over or far from fresh waters or brackish sloughs, slow-moving rivers, and lakes all with thickest or woodlands of willows and alders along the shore. Widely distributed and is found in almost every wetland in summer. Also breeds in Washington south to southern California, Arizona and New Mexico and from North Dakota, southern Ontario and New Brunswick south to the Gulf Coast and southern Florida. In winter this species withdraws from most of it's range except for the southern tier of the United States. Northern birds are known to migrate as far as Panama, northern South America. In addition, it is a permanent resident of Central America, West Indes.		
band-tailed pigeon *Columba fasciata*	Variety of habitats ranging from open wooded areas including mixed coniferous/deciduous trees with edges, city yards, parks, wooded groves, open bushland, mineral springs, and intertidal flats. Breeds in coniferous trees and deciduous trees. Forage for ripening fruits and grains in wooded areas; frequent rail lines, grain storage areas, and residential properties where grain is transferred and/or stored. Broadly distributed from southern Alaska to Central and South America. In North America, it is distributed along the coastal areas from about southern Alaska into Baja California; interior region from Colorado, where they extend mostly along the continental divide into South America. While present year-round in some northern urban areas where it is attracted to feeders and holly orchards, the species is described as a partial migrant where most from the northern pacific coast breeding range migrate to south of the upper third of California (Sonoma-Nevada Counties) and most from the interior region migrate beyond the U. S. and Mexico border.	Year round	CDC: blue COSEWIC: - SARA: -
peregrine falcon *Falco peregrinus anatum*	Habitat requirements can be divided into three components, including the nest site, the nesting territory and the home range. The nest site is a scrape made on cliff ledges on steep cliffs, typically near wetlands. The nesting territory is the area defended around the nest, which is related to food availability. The home range is the non-defended area in which peregrines forage for food. This	Year round	CDC: red COSEWIC: T SARA: T

	area can extend up to 27 kilometers from the nest. Peregrines often prefer open habitats such as wetlands, tundra, savanna, sea coasts, and open mountain meadows, but will hunt over open forest, can also occur near beaches, tidal flats, reefs, island, marshes, estuaries, lagoons, flooded farmland, airports, parks, golf courses, railway yards, and bridges. The main prey item for the peregrine falcon is birds; associated with habitats where there is an abundance of small-to-medium sized birds, including airports, bridges, and parks. Three subspecies of the peregrine falcon (*Falco peregrinus*) have distinct geographic distributions. The a*natum* subspecies, also known as the American peregrine, breeds south of the treeline in Alaska and Canada, throughout most of the United States of America, and from central to south Mexico.		
western screech-owl (*kennicottii* subspecies) *Megascops kennicotti kennicottiii*	Mixed deciduous/coniferous forests on the edges of clearings, wooded canyons, riparian thickets, deserts, orchards, at low elevations often associated with riparian areas. May roost in either coniferous or deciduous tree cavities, patches of thick vegetation, nest boxes, buildings, trees, vines, and crevices in cliffs. Nesting habitats of this owl include large, natural cavities (e.g. in trees), abandoned pileated woodpecker (*Dryocopus pileatus)* and northern flicker holes, as well as, cavities in poles, and old magpie (*Pica pica)* nests. May occur in wooded suburban areas and city parks, if they are disturbed minimally by humans and their associated activities. Western screech-owl is nocturnal and becomes active at dusk feeding on small mammals, birds, reptiles, small fish, and insects, with large insects being primary source of food (Alsop, 2001). This species is sedentary in that it often stays in the same home range throughout the year. Western portion of the North American continent from southern Alaska to central Mexico (COSEWIC, 2002). It is generally common and widely distributed throughout its range. In BC, this subspecies is known along the coast, including Vancouver Island, but excluding the Queen Charlotte Islands, relatively common in the lower mainland.	Year round	CDC: blue COSEWIC: SC SARA: SC

MAMMALS			
Townsend's big-eared bat *Corynorhinus townsendii*	Wide variety of habitats, its distribution strongly correlates with the availability of caves or cave-like roosts. Diet consists of small moths, lacewings, beetles, flies, and sawflies. Relatively sedentary and move only up to 10-65	Year round; nocturnal	CDC: blue COSEWIC: - SARA: -

Sensitive Species Table – Uplands Habitat Type

	km from the winter roost to the summer roost. Current range of this species is from Mexico into BC, along the western United States. In addition, there are a few isolated populations in the central and eastern United States.		
fisher *Martes pennanti*	Occurs primarily in dense coniferous or mixed forests, including early successional forest with dense overhead cover. Avoids open areas. When inactive, occupies den in tree hollow, under log, or in ground or rocky crevice, or rests in branches of conifer (warmer months). Diet consists primarily of mammals; also birds, other small animals, carrion, and fruit. Fishers range from Quebec, the Maritime Provinces, and New England west across boreal Canada to southeastern Alaska, south in the western mountains to Utah, Wyoming, Idaho, and California, and formerly south to Illinois, Indiana, Tennessee, and North Carolina.	Year round	CDC: blue COSEWIC: - SARA: -
wolverine *Gulo gulo*	Treed and treeless areas at all elevations including the northern forested wilderness, the alpine tundra of the western mountains and the arctic tundra. Habitat requirements are best defined in terms of an adequate year-round food supply in large, sparsely inhabited wilderness areas. Although they prefer pristine areas, their home range may overlap developed areas. In addition, they are not deterred by human presence as they have been known to investigate campsites, food caches and even cabins. Avoids using habitats within 100 meters of the TransCanada Highway and prefers areas greater than 1100 meters from the highway, will cross the Highway in the Kicking Horse Pass between Yoho and Banff National Parks. Occurs in low numbers throughout most of its remote habitat, is highly mobile, therefore it is extremely difficult to observe in the field. Holarctic species distributed across North America and Eurasia. In Canada, the western population of this species is distributed across the Boreal, Arctic, Northern Mountain, Southern Mountain and Pacific ecological regions. This species is non migratory and do not hibernate in the winter.	Year round	CDC: blue COSEWIC: - SARA: -

Sensitive Species Table – Uplands Habitat Type

grizzly bear *Ursus arctos horribilis*	Wide ranging species that requires large tracts of suitable habitat wherein individuals can move freely and establish home ranges. Omnivores that are opportunistic feeders, they eat vegetation such as roots and bulbs, feed on spawning salmon in stream class 1 streams. Riparian and wet forests are used throughout the range for berrying, foraging, and travel. Grizzly bears hibernate in winter months in high elevation excavated dens. The historical distribution of this species is from Mexico extending north, including Alaska and the Northwest Territories. The current range includes British Columbia, Alaska and the Northwest Territories with some small populations in the northern areas of the United States.	Spring, summer, fall; hibernate in winter	CDC: red COSEWIC: SC SARA: -
Roosevelt elk *Cervus canadensis roosevelti*	Habitat variable according to location. Uses open areas such as alpine pastures, marshy meadows, river flats, and aspen parkland, as well as coniferous forests, brushy clear cuts or forest edges. No special calving ground is used. Primarily a grazer, but much geographic and seasonal variation in diet. Holarctic; Eurasia and North America; Tunisia and northeastern Algeria; introduced in Morroco, South America, New Zealand, and Australia. Formerly widespread in North America, now mostly restricted to the West, with small reintroduced populations elsewhere.	Year round	CDC: blue COSEWIC: - SARA: -

Legend

CDC

red	candidates for legal designation as Threatened (TH) or Endangered (EN).
blue	considered to be vulnerable or sensitive to human activities or natural events, and could become candidates for the red-list.
yellow	indigenous and are not at risk in BC and include uncommon, declining, and increasing species.

SARA / COSEWIC

X	Extinct	a species that no longer exists
ET	Extirpated	a species that no longer exists in the wild in Canada, but occurs elsewhere
EN	Endangered	a species facing imminent extirpation or extinction
TH	Threatened	a species likely to become endangered if limiting factors are not reversed
SC	Special Concern	a species with characteristics that make it particularly sensitive to human activities or natural events
NAR	Not At Risk	have not been given status because populations are not in any peril; and,
DD	Data Deficient	a species for which there is insufficient scientific information to support status designation.
-	Not addressed	Not addressed by the COSEWIC or the SARA

Appendix C

Catchment Flow Calculations

Q = 2.78 AIR, where:

Q = peak flow in litres per second (L/s)

A = area in hectares (ha)

I = Rainfall intensity (mm/hr) I = a*Tc^b

R = runoff coefficient

R for grass = 0.3 (10 year), 0.37 (25 year), 0.45 (10 Impervious

R for Pavement = 0.8 (10 year), 0.85 (25 year), 0.9 Pervious

Note: 200-yr rainfall intensities determined by 1.7xI_10

IDF curve parameters

Return period (yrs)	west hound sound 2	10	100	robert creek 2	10	100	Elphinstone 2	10	100
a =	66.881	88.228	114.03	88.513	160.92	253.69	71.759	128.56	195.66
b =	0	0	0	0	0	0	0	0	0
c	0.382	0.3786	0.375	0.5253	0.566	0.5893	0.4864	0.5267	0.5445

ID	Location	Catchment Properties			Return Period	Runoff Coefficients												Runoff Summary			Time of Concentration				Catchment Flows	
						Forest			Agricultural-park lands			Residential			Commercial, industrial, Institutional			Total	Avg		BC method	BC	Bransby-Williams	Avg Time of	Rainfall	Peak Flow
		Area (ha)	Length (m)	Slope (m/m)	(yrs)	0.65	0.67	0.7	0.5	0.57	0.65	0.55	0.6	0.75	0.73	0.8	0.95	Area (ha)	C	2.78 AR	Area (km2)	tc (hrs)	tc (hrs)	Conc. (min)	Int(mm/hr)	Q (L/s)
	West Howe Sound																									
	Hutchinson Creek	417.00	4500.0	0.17	2	119.30			176.30			121.30			0.10			417.00	0.56	646.30	4.2	2.00	1.34	100.18	11.5	7437.8
					10		119.30			176.30			121.30			0.10		417.00	0.61	704.12	4.2	2.00	1.34	100.18	15.4	10858.3
					200			119.30			176.30			121.30			0.10	417.00	0.69	803.91	4.2	2.00	1.34	100.18	26.2	21075.1
	Langdale Creek	739.60	6840.0	0.16	2	425.60			165.60			78.00			70.40			739.60	0.61	1261.37	7.4	2.80	1.95	142.37	10.1	12692.2
					10		425.60			165.60			78.00			70.40		739.60	0.65	1341.81	7.4	2.80	1.95	142.37	13.5	18113.8
					200			425.60			165.60			78.00			70.40	739.60	0.72	1476.01	7.4	2.80	1.95	142.37	22.9	33873.4
	Soames Creek	155.20	2750.0	0.11	2				94.90			50.60			6.70			152.20	0.53	222.88	1.6	1.30	0.99	68.57	13.3	2964.6
					10					94.90			50.60			6.70		152.20	0.59	249.68	1.6	1.30	0.99	68.57	17.8	4444.6
					200						94.90			50.60			6.70	152.20	0.70	294.68	1.6	1.30	0.99	68.57	30.3	8917.6
	Gibsons Creek	344.60	5950.0	0.17	2	303.10			6.10			35.40						344.60	0.64	610.31	3.4	1.90	1.80	111.15	11.1	6750.2
					10		303.10			6.10			35.40					344.60	0.66	633.27	3.4	1.90	1.80	111.15	14.8	9388.9
					200			303.10			6.10			35.40				344.60	0.70	674.66	3.4	1.90	1.80	111.15	25.2	17004.6
	Drainage to Ocean	97.08	2050.0	0.11	2	4.70			40.61			51.77						97.08	0.53	144.10	1.0	1.02	0.77	53.70	14.6	2104.3
	Foreshore				10		4.70			40.61			51.77					97.08	0.59	159.46	1.0	1.02	0.77	53.70	19.5	3113.7
					200			4.70			40.61			51.77				97.08	0.71	190.47	1.0	1.02	0.77	53.70	33.2	6322.8
	Drainage to Ocean	139.58	960.0	0.19	2	35.19			17.14			87.25						139.58	0.57	220.82	1.4	1.10	0.31	42.37	16.0	3530.1
	Foreshore				10		35.19			17.14			87.25					139.58	0.61	238.24	1.4	1.10	0.31	42.37	21.4	5088.7
					200			35.19			17.14			87.25				139.58	0.73	281.37	1.4	1.10	0.31	42.37	36.3	10216.9
	Drainage to Ocean	95.41	660.0	0.12	2				21.18			71.84			2.40			95.42	0.54	144.15	1.0	1.02	0.24	37.92	16.7	2404.3
	Foreshore				10					21.18			71.84			2.40		95.42	0.60	158.73	1.0	1.02	0.24	37.92	22.3	3535.8
					200						21.18			71.84			2.40	95.42	0.73	194.40	1.0	1.02	0.24	37.92	37.9	7361.7
	Drainage to Ocean	66.52	510.0	0.35	2	28.00			23.52			15.00						66.52	0.57	106.22	0.7	0.87	0.16	30.84	18.1	1917.4
	Foreshore				10		28.00			23.52			15.00					66.52	0.62	114.44	0.7	0.87	0.16	30.84	24.1	2757.0
					200			28.00			23.52			15.00				66.52	0.69	128.26	0.7	0.87	0.16	30.84	41.0	5253.0
	South Ouillet Creek	182.26	2770.0	0.25	2	118.26			64.00									182.26	0.60	302.65	1.8	1.40	0.83	66.87	13.4	4064.5
					10		118.26			64.00								182.26	0.63	321.69	1.8	1.40	0.83	66.87	18.0	5781.0
					200			118.26			64.00							182.26	0.68	345.78	1.8	1.40	0.83	66.87	30.6	10563.8
	Elphinstone																									
	Seaward Creek	166.85	2330.0	0.07	2				100.11			66.74						166.85	0.52	241.20	1.7	0.90	0.91	54.23	10.3	2481.6
					10					100.11			66.74					166.85	0.58	269.96	1.7	0.90	0.91	54.23	15.7	4236.4
					200						100.11			66.74				166.85	0.69	320.05	1.7	0.90	0.91	54.23	26.7	8538.2
	Lower Chaster Creek	895.50	7000.0	0.14	2	351.80			204.70			316.90			22.10			895.50	0.58	1449.63	9.0	3.00	2.01	150.19	6.3	9086.8
					10		351.80			204.70			316.90			22.10		895.50	0.63	1557.37	9.0	3.00	2.01	150.19	9.2	14290.8
					200			351.80			204.70			316.90			22.10	895.50	0.71	1773.60	9.0	3.00	2.01	150.19	15.6	27667.5
	Walker Creek	251.90	4500.0	0.17	2	38.44			109.30			104.20						251.94	0.54	380.71	2.5	1.60	1.41	90.25	8.0	3057.2
					10		38.44			109.30			104.20					251.94	0.60	418.60	2.5	1.60	1.41	90.25	12.0	5023.0
					200			38.44			109.30			104.20				251.94	0.70	489.57	2.5	1.60	1.41	90.25	20.4	9986.7
	Smoles Creek	99.70	3500.0	0.17	2	7.30			56.60			35.80						99.70	0.53	146.60	1.0	1.00	1.20	66.06	9.3	1370.3
					10		7.30			56.60			35.80					99.70	0.59	163.00	1.0	1.00	1.20	66.06	14.1	2305.4
					200			7.30			56.60			35.80				99.70	0.69	191.13	1.0	1.00	1.20	66.06	24.0	4595.4
	Drainage to Ocean	24.39	610.0	0.21	2							24.39						24.39	0.55	37.29	0.2	0.56	0.23	23.73	15.4	573.5
	Foreshore				10								24.39					24.39	0.60	40.68	0.2	0.56	0.23	23.73	24.2	986.5
					200									24.39				24.39	0.75	50.85	0.2	0.56	0.23	23.73	41.2	2096.3
	Drainage to Ocean	185.86	1830.0	0.07	2	185.86												185.86	0.65	335.84	1.9	1.45	0.72	64.97	9.4	3164.5
	Foreshore				10		185.86											185.86	0.67	346.18	1.9	1.45	0.72	64.97	14.3	4939.2
					200			185.86										185.86	0.70	361.68	1.9	1.45	0.72	64.97	24.3	8772.6

Q = 2.78 AIR, where:

Q = peak flow in litres per second (L/s)

A = area in hectares (ha)

I = Rainfall intensity (mm/hr) I = a*Tc^b

R = runoff coefficient

R for grass = 0.3 (10 year), 0.37 (25 year), 0.45 (10 Impervious

R for Pavement = 0.8 (10 year), 0.85 (25 year), 0.9 Pervious

Note: 200-yr rainfall intensities determined by 1.7xI_10

IDF curve parameters

	west hound sound			robert creek			Elphinstone		
Return period (yrs)	2	10	100	2	10	100	2	10	100
a =	66.881	88.228	114.03	88.513	160.92	253.69	71.759	128.56	195.66
b =	0	0	0	0	0	0	0	0	0
c	0.382	0.3786	0.375	0.5253	0.566	0.5893	0.4864	0.5267	0.5445

ID	Location	Catchment Properties			Return Period	Runoff Coefficients												Runoff Summary			Time of Concentration				Catchment Flows	
						Forest			Agricultural-park lands			Residential			Commercial, industrial, Institutional			Total	Avg		BC method	BC	Bransby-Williams	Avg Time of	Rainfall	Peak Flow
		Area (ha)	Length (m)	Slope (m/m)	(yrs)	0.65	0.67	0.7	0.5	0.57	0.65	0.55	0.6	0.75	0.73	0.8	0.95	Area (ha)	C	2.78 AR	Area (km2)	tc (hrs)	tc (hrs)	Conc. (min)	Int(mm/hr)	Q (L/s)
	Roberts Creek																									
	Whittaker Creek	28.80	950.0	0.11	2				6.17			20.31			2.30			28.78	0.55	44.30	0.3	0.50	0.40	27.09	14.4	638.8
					10					6.17			20.31			2.30		28.78	0.61	48.77	0.3	0.50	0.40	27.09	22.6	1103.1
					200						6.17			20.31			2.30	28.78	0.74	59.57	0.3	0.50	0.40	27.09	38.5	2290.5
	Cornwallis Creek	140.60	3500.0	0.19	2	62.70			43.70			34.20						140.60	0.58	226.33	1.4	1.20	1.14	70.07	9.1	2055.7
					10		62.70			43.70			34.20					140.60	0.62	243.08	1.4	1.20	1.14	70.07	13.7	3332.8
					200			62.70			43.70			34.20				140.60	0.70	272.29	1.4	1.20	1.14	70.07	23.3	6346.5
	Leek Creek	125.40	3400.0	0.17	2	37.50			50.35			29.00			8.55			125.40	0.57	199.44	1.3	1.10	1.14	67.23	9.3	1848.2
					10		37.50			50.35			29.00			8.55		125.40	0.62	217.02	1.3	1.10	1.14	67.23	14.0	3041.0
					200			37.50			50.35			29.00			8.55	125.40	0.71	247.00	1.3	1.10	1.14	67.23	23.8	5884.0
	Slater Creek	103.70	2800.0	0.15	2				66.10			26.82			10.78			103.70	0.54	154.76	1.0	1.00	0.98	59.46	9.8	1522.5
					10					66.10			26.82			10.78		103.70	0.60	173.45	1.0	1.00	0.98	59.46	14.9	2593.0
					200						66.10			26.82			10.78	103.70	0.71	203.83	1.0	1.00	0.98	59.46	25.4	5180.1
	Molyneaux Creek	279.00	5300.0	0.17	2	166.60			69.30			37.63			5.47			279.00	0.60	466.01	2.8	1.70	1.64	100.26	7.6	3555.7
					10		166.60			69.30			37.63			5.47		279.00	0.64	495.05	2.8	1.70	1.64	100.26	11.4	5620.3
					200			166.60			69.30			37.63			5.47	279.00	0.70	542.33	2.8	1.70	1.64	100.26	19.3	10467.1
	Joe Smith East	27.40	880.0	0.10	2				16.95			10.44						27.39	0.52	39.52	0.3	0.50	0.38	26.47	14.6	576.4
					10					16.95			10.44					27.39	0.58	44.27	0.3	0.50	0.38	26.47	22.9	1013.6
					200						16.95			10.44				27.39	0.69	52.40	0.3	0.50	0.38	26.47	38.9	2039.3
	Joe Smith	246.50	4200.0	0.12	2	92.11			47.45			106.92						246.48	0.58	395.88	2.5	1.57	1.41	89.47	8.1	3192.5
					10		92.11			47.45			106.92					246.48	0.62	425.10	2.5	1.57	1.41	89.47	12.1	5124.3
					200			92.11			47.45			106.92				246.48	0.71	487.92	2.5	1.57	1.41	89.47	20.5	9998.6
	Drainage to Ocean	21.56	710.0	0.16	2				7.40			14.20						21.60	0.53	32.00	0.22	0.59	0.29	26.33	14.6	467.8
	Foreshore				10					7.40			14.20					21.60	0.59	35.41	0.22	0.59	0.29	26.33	23.0	813.0
					200						7.40			14.20				21.60	0.72	42.98	0.22	0.59	0.29	26.33	39.0	1677.5
	Unknown name	73.49	2,800.0	0.190	2	20.11			30.95			22.73						73.79	0.56	114.11	0.73	0.90	0.97	56.08	10.1	1155.0
					10		20.11			30.95			22.73					73.79	0.61	124.41	0.73	0.90	0.97	56.08	15.4	1918.0
					200			20.11			30.95			22.73				73.79	0.69	142.45	0.73	0.90	0.97	56.08	26.2	3733.5
	Drainage to Ocean	12.64	460.0	0.140	2	12.36			0.25									12.61	0.65	22.68	0.13	0.55	0.20	22.56	15.8	357.5
	Foreshore				10		12.36			0.25								12.61	0.67	23.42	0.13	0.55	0.20	22.56	24.9	583.3
					200			12.36			0.25							12.61	0.70	24.50	0.13	0.55	0.20	22.56	42.3	1037.6
	Drainage to Ocean	4.53	290.0	0.200	2							4.50						4.50	0.55	6.88	0.05	0.20	0.13	9.94	23.5	161.6
	Foreshore				10								4.50					4.50	0.60	7.51	0.05	0.20	0.13	9.94	38.4	287.9
					200									4.50				4.50	0.75	9.38	0.05	0.20	0.13	9.94	65.2	611.7
	Clough Creek	267.15	5,840.0	0.195	2	206.00			5.30			56.00						267.30	0.63	465.23	2.67	1.35	1.77	93.54	7.9	3671.6
					10		206.00			5.30			56.00					267.30	0.65	485.50	2.67	1.35	1.77	93.54	11.8	5717.0
					200			206.00			5.30			56.00				267.30	0.71	527.21	2.67	1.35	1.77	93.54	20.0	10554.0
	Malcolm Creek	391.34	6,330.0	0.180	2	330.00			5.30			56.00						391.30	0.63	689.30	3.91	2.00	1.87	116.23	7.1	4894.6
					10		330.00			5.30			56.00					391.30	0.66	716.46	3.91	2.00	1.87	116.23	10.5	7524.8
					200			330.00			5.30			56.00				391.30	0.71	768.52	3.91	2.00	1.87	116.23	17.9	13721.6
	Robinson Creek	110.24	4,030.0	0.119	2	81.00			29.00									110.00	0.61	186.68	1.10	1.05	1.47	75.64	8.8	1633.6
					10		81.00			29.00								110.00	0.64	196.82	1.10	1.05	1.47	75.64	13.2	2592.0
					200			81.00			29.00							110.00	0.69	210.03	1.10	1.05	1.47	75.64	22.4	4702.1
	Stephens Creek	390.46	7,110.0	0.160	2	340.46						50.00						390.46	0.64	691.66	3.90	2.00	2.16	124.68	6.9	4746.5
					10		340.46						50.00					390.46	0.66	717.54	3.90	2.00	2.16	124.68	10.1	7262.7
					200			340.46						50.00				390.46	0.71	766.79	3.90	2.00	2.16	124.68	17.2	13193.9

Q = 2.78 AIR, where:
Q = peak flow in litres per second (L/s)
A = area in hectares (ha)
I = Rainfall intensity (mm/hr) I = a*Tc^b
R = runoff coefficient

R for grass = 0.3 (10 year), 0.37 (25 year), 0.45 (100 ye Impervious
R for Pavement = 0.8 (10 year), 0.85 (25 year), 0.9 (100 Pervious

IDF curve parameters

Return period (yrs)	west hound sound 2	10	100	robert creek 2	10	100	Elphinstone 2	10	100
a =	66.881	88.228	114.03	88.513	160.92	253.69	71.759	128.56	195.66
b =	0	0	0	0	0	0	0	0	0
c	0.382	0.3786	0.375	0.5253	0.566	0.5893	0.4864	0.5267	0.5445

ID	Study Area and Watershed		Catchment Properties			Return Period	Runoff Coefficients												Runoff Summary			Time of Concentration				Catchment Flows		Existing	Future	
							Forest			Agricultural-park lands			Residential			Commercial, industrial, Institutional			Total	Avg		BC method	BC	Bransby-Williams	Avg Time of	Rainfall	Peak Flow	Flows	Flows	% Change
			Area (ha)	Length (m)	Slope (m/m)	(yrs)	0.65	0.67	0.7	0.53	0.59	0.70	0.640	0.700	0.850	0.85	0.9	0.95	Area (ha)	C	2.78 AR	Area (km2)	tc (hrs)	tc (hrs)	Conc. (min)	Int(mm/hr)	Q (L/s)	Q (L/s)	Q (L/s)	%
	West Howe Sound	Hutchinson Creek	417.0	4500.0	0.17	2	119.30			176.30			121.30			0.10			417.00	0.59	688.94	4.2	2.00	1.34	100.18	11.5	7928.5	7437.8	7928.5	6.60%
						10		119.30			176.30			121.30			0.10		417.00	0.64	745.22	4.2	2.00	1.34	100.18	15.4	11492.2	10858.3	11492.2	5.84%
						200			119.30			176.30			121.30			0.10	417.00	0.74	862.13	4.2	2.00	1.34	100.18	26.2	22601.5	21075.1	22601.5	7.24%
		Langdale Creek	739.6	6840.0	0.16	2	425.60			165.60			78.00			70.40			739.60	0.64	1315.89	7.4	2.80	1.95	142.37	10.1	13240.7	12692.2	13240.7	4.32%
						10		425.60			165.60			78.00			70.40		739.60	0.68	1389.97	7.4	2.80	1.95	142.37	13.5	18763.9	18113.8	18763.9	3.59%
						200			425.60			165.60			78.00			70.40	739.60	0.74	1520.72	7.4	2.80	1.95	142.37	22.9	34899.3	33873.4	34899.3	3.03%
		Soames Creek	155.2	2750.0	0.11	2				94.90			50.60			6.70			152.20	0.58	244.37	1.6	1.30	0.99	68.57	13.3	3250.4	2964.6	3250.4	9.64%
						10					94.90			50.60			6.70		152.20	0.64	269.57	1.6	1.30	0.99	68.57	17.8	4798.6	4444.6	4798.6	7.96%
						200						94.90			50.60			6.70	152.20	0.76	321.94	1.6	1.30	0.99	68.57	30.3	9742.5	8917.6	9742.5	9.25%
		Gibsons Creek	344.6	5950.0	0.17	2	303.10			6.10			35.40						344.60	0.65	619.59	3.4	1.90	1.80	111.15	11.1	6852.9	6750.2	6852.9	1.52%
						10		303.10			6.10			35.40					344.60	0.67	643.36	3.4	1.90	1.80	111.15	14.8	9538.6	9388.9	9538.6	1.59%
						200			303.10			6.10			35.40				344.60	0.72	685.35	3.4	1.90	1.80	111.15	25.2	17274.0	17004.6	17274.0	1.58%
		Drainage to Ocean	97.08	2050.0	0.11	2	4.70			40.61			51.77						97.08	0.59	159.87	1.0	1.02	0.77	53.70	14.6	2334.6	2104.3	2334.6	10.95%
						10		4.70			40.61			51.77					97.08	0.65	175.54	1.0	1.02	0.77	53.70	19.5	3427.8	3113.7	3427.8	10.09%
						200			4.70			40.61			51.77				97.08	0.78	210.51	1.0	1.02	0.77	53.70	33.2	6987.9	6322.8	6987.9	10.52%
		Drainage to Ocean	139.58	960.0	0.19	2	35.19			17.14			87.25						139.58	0.63	243.84	1.4	1.10	0.31	42.37	16.0	3898.1	3530.1	3898.1	10.43%
						10		35.19			17.14			87.25					139.58	0.68	263.21	1.4	1.10	0.31	42.37	21.4	5622.0	5088.7	5622.0	10.48%
						200			35.19			17.14			87.25				139.58	0.79	308.01	1.4	1.10	0.31	42.37	36.3	11184.1	10216.9	11184.1	9.47%
		Drainage to Ocean	95.41	660.0	0.12	2				21.18			71.84			2.40			95.42	0.62	164.40	1.0	1.02	0.24	37.92	16.7	2742.0	2404.3	2742.0	14.05%
						10					21.18			71.84			2.40		95.42	0.68	180.25	1.0	1.02	0.24	37.92	22.3	4015.3	3535.8	4015.3	13.56%
						200						21.18			71.84			2.40	95.42	0.82	217.31	1.0	1.02	0.24	37.92	37.9	8229.5	7361.7	8229.5	11.79%
		Drainage to Ocean	66.52	510.0	0.35	2	28.00			23.52			15.00						66.52	0.60	111.61	0.7	0.87	0.16	30.84	18.1	2014.6	1917.4	2014.6	5.07%
						10		28.00			23.52			15.00					66.52	0.65	119.59	0.7	0.87	0.16	30.84	24.1	2881.1	2757.0	2881.1	4.50%
						200			28.00			23.52			15.00				66.52	0.73	135.70	0.7	0.87	0.16	30.84	41.0	5557.7	5253.0	5557.7	5.80%
		South Ouillet Creek	182.26	2770.0	0.25	2	118.26			64.00									182.26	0.61	307.10	1.8	1.40	0.83	66.87	13.4	4124.2	4064.5	4124.2	1.47%
						10		118.26			64.00								182.26	0.64	324.35	1.8	1.40	0.83	66.87	18.0	5828.9	5781.0	5828.9	0.83%
						200			118.26			64.00							182.26	0.70	354.68	1.8	1.40	0.83	66.87	30.6	10835.6	10563.8	10835.6	2.57%
		Seaward Creek	166.9	2300.0	0.07	2				100.11			66.74						166.85	0.57	264.85	1.7	0.90	0.90	53.88	10.3	2733.6	2481.6	2733.6	10.15%
						10					100.11			66.74					166.85	0.63	292.68	1.7	0.90	0.90	53.88	15.7	4608.8	4236.4	4608.8	8.79%
						200						100.11			66.74				166.85	0.76	352.52	1.7	0.90	0.90	53.88	26.8	9436.6	8538.2	9436.6	10.52%
	Elphinstone	Lower Chaster Creek	895.5	7000.0	0.14	2	351.80			204.70			316.90			22.10			895.50	0.62	1550.51	9.0	3.00	2.01	150.19	6.3	9719.2	9086.8	9719.2	6.96%
						10		351.80			204.70			316.90			22.10		895.50	0.67	1660.15	9.0	3.00	2.01	150.19	9.2	15233.9	14290.8	15233.9	6.60%
						200			351.80			204.70			316.90			22.10	895.50	0.76	1890.15	9.0	3.00	2.01	150.19	15.6	29485.6	27667.5	29485.6	6.57%
		Walker Creek	251.9	4500.0	0.17	2	38.44			109.30			104.20						251.94	0.59	414.38	2.5	1.60	1.41	90.25	8.0	3327.6	3057.2	3327.6	8.84%
						10		38.44			109.30			104.20					251.94	0.65	452.13	2.5	1.60	1.41	90.25	12.0	5425.2	5023.0	5425.2	8.01%
						200			38.44			109.30			104.20				251.94	0.76	533.73	2.5	1.60	1.41	90.25	20.4	10887.5	9986.7	10887.5	9.02%
		Smoles Creek	99.7	3500.0	0.17	2	7.30			56.60			35.80						99.70	0.58	159.49	1.0	1.00	1.20	66.06	9.3	1490.8	1370.3	1490.8	8.79%
						10		7.30			56.60			35.80					99.70	0.63	175.31	1.0	1.00	1.20	66.06	14.1	2479.5	2305.4	2479.5	7.55%
						200			7.30			56.60			35.80				99.70	0.75	208.94	1.0	1.00	1.20	66.06	24.0	5023.8	4595.4	5023.8	9.32%
		Drainage to Ocean	24.39	610.0	0.21	2							24.39						24.39	0.64	43.39	0.2	0.56	0.23	23.73	15.4	667.3	573.5	667.3	16.36%
						10								24.39					24.39	0.70	47.46	0.2	0.56	0.23	23.73	24.2	1150.9	986.5	1150.9	16.67%
						200									24.39				24.39	0.85	57.63	0.2	0.56	0.23	23.73	41.2	2375.8	2096.3	2375.8	13.33%
		Drainage to Ocean	185.86	1830.0	0.07	2	185.86												185.86	0.65	335.84	1.9	1.45	0.72	64.97	9.4	3164.5	3164.5	3164.5	0.00%
						10		185.86											185.86	0.67	346.18	1.9	1.45	0.72	64.97	14.3	4939.2	4939.2	4939.2	0.00%
						200			185.86										185.86	0.70	361.68	1.9	1.45	0.72	64.97	24.3	8772.6	8772.6	8772.6	0.00%

Q = 2.78 AIR, where:

Q = peak flow in litres per second (L/s)

A = area in hectares (ha)

I = Rainfall intensity (mm/hr) I = a*Tc^b

R = runoff coefficient

R for grass = 0.3 (10 year), 0.37 (25 year), 0.45 (100 ye Impervious

R for Pavement = 0.8 (10 year), 0.85 (25 year), 0.9 (100 Pervious

IDF curve parameters

Return period (yrs)	west hound sound			robert creek			Elphinstone		
	2	10	100	2	10	100	2	10	100
a =	66.881	88.228	114.03	88.513	160.92	253.69	71.759	128.56	195.66
b =	0	0	0	0	0	0	0	0	0
c	0.382	0.3786	0.375	0.5253	0.566	0.5893	0.4864	0.5267	0.5445

ID	Study Area and Watershed		Catchment Properties			Return Period	Runoff Coefficients												Runoff Summary			Time of Concentration				Catchment Flows		Existing	Future	
							Forest			Agricultural-park lands			Residential			Commercial, industrial, Institutional			Total	Avg		BC method	BC	Bransby-Williams	Avg Time of	Rainfall	Peak Flow	Flows	Flows	% Change
			Area (ha)	Length (m)	Slope (m/m)	(yrs)	0.65	0.67	0.7	0.53	0.59	0.70	0.640	0.700	0.850	0.85	0.9	0.95	Area (ha)	C	2.78 AR	Area (km2)	tc (hrs)	tc (hrs)	Conc. (min)	Int(mm/hr)	Q (L/s)	Q (L/s)	Q (L/s)	%
	Roberts Creek	Whittaker Creek	28.8	950.0	0.11	2				6.17			20.31			2.30			28.78	0.63	50.58	0.3	0.50	0.40	27.09	14.4	729.3	638.8	729.3	14.17%
						10					6.17			20.31			2.30		28.78	0.69	55.31	0.3	0.50	0.40	27.09	22.6	1251.1	1103.1	1251.1	13.42%
						200						6.17			20.31			2.30	28.78	0.83	66.07	0.3	0.50	0.40	27.09	38.5	2540.6	2290.5	2540.6	10.92%
		Cornwallis Creek	140.6	3500.0	0.19	2	62.70			43.70			34.20						140.60	0.61	237.93	1.4	1.20	1.14	70.07	9.1	2161.0	2055.7	2161.0	5.12%
						10		62.70			43.70			34.20					140.60	0.65	254.41	1.4	1.20	1.14	70.07	13.7	3488.1	3332.8	3488.1	4.66%
						200			62.70			43.70			34.20				140.60	0.74	287.87	1.4	1.20	1.14	70.07	23.3	6709.7	6346.5	6709.7	5.72%
		Leek Creek	125.4	3400.0	0.17	2	37.50			50.35			29.00			8.55			125.40	0.61	213.05	1.3	1.10	1.14	67.23	9.3	1974.3	1848.2	1974.3	6.82%
						10		37.50			50.35			29.00			8.55		125.40	0.66	229.56	1.3	1.10	1.14	67.23	14.0	3216.7	3041.0	3216.7	5.78%
						200			37.50			50.35			29.00			8.55	125.40	0.75	262.06	1.3	1.10	1.14	67.23	23.8	6242.8	5884.0	6242.8	6.10%
		Slater Creek	103.7	2800.0	0.15	2				66.10			26.82			10.78			103.70	0.59	169.66	1.0	1.00	0.98	59.46	9.8	1669.1	1522.5	1669.1	9.63%
						10					66.10			26.82			10.78		103.70	0.65	186.66	1.0	1.00	0.98	59.46	14.9	2790.5	2593.0	2790.5	7.62%
						200						66.10			26.82			10.78	103.70	0.76	220.48	1.0	1.00	0.98	59.46	25.4	5603.1	5180.1	5603.1	8.17%
		Molyneaux Creek	279.0	5300.0	0.17	2	166.60			69.30			37.63			5.47			279.00	0.62	482.07	2.8	1.70	1.64	100.26	7.6	3678.2	3555.7	3678.2	3.45%
						10		166.60			69.30			37.63			5.47		279.00	0.66	509.93	2.8	1.70	1.64	100.26	11.4	5789.2	5620.3	5789.2	3.00%
						200			166.60			69.30			37.63			5.47	279.00	0.73	562.43	2.8	1.70	1.64	100.26	19.3	10854.9	10467.1	10854.9	3.71%
		Joe Smith East	27.4	880.0	0.10	2				16.95			10.44						27.39	0.57	43.31	0.3	0.50	0.38	26.47	14.6	631.6	576.4	631.6	9.59%
						10					16.95			10.44					27.39	0.63	47.88	0.3	0.50	0.38	26.47	22.9	1096.2	1013.6	1096.2	8.15%
						200						16.95			10.44				27.39	0.76	57.65	0.3	0.50	0.38	26.47	38.9	2244.0	2039.3	2244.0	10.04%
		Joe Smith	246.5	4200.0	0.12	2	92.11			47.45			106.92						246.48	0.62	425.93	2.5	1.57	1.41	89.47	8.1	3434.8	3192.5	3434.8	7.59%
						10		92.11			47.45			106.92					246.48	0.67	456.80	2.5	1.57	1.41	89.47	12.1	5506.4	5124.3	5506.4	7.46%
						200			92.11			47.45			106.92				246.48	0.77	524.24	2.5	1.57	1.41	89.47	20.5	10742.9	9998.6	10742.9	7.44%
		Drainage to Ocean	21.56	710.0	0.16	2				7.40			14.20						21.60	0.60	36.06	0.22	0.59	0.29	26.33	14.6	527.3	467.8	527.3	12.71%
						10					7.40			14.20					21.60	0.66	39.67	0.22	0.59	0.29	26.33	23.0	910.8	813.0	910.8	12.02%
						200						7.40			14.20				21.60	0.80	47.96	0.22	0.59	0.29	26.33	39.0	1871.7	1677.5	1871.7	11.58%
		Unknown	73.49	2,800.0	0.190	2	20.11			30.95			22.73						73.79	0.59	121.95	0.73	0.90	0.97	56.08	10.1	1234.3	1155.0	1234.3	6.87%
						10		20.11			30.95			22.73					73.79	0.64	132.02	0.73	0.90	0.97	56.08	15.4	2035.4	1918.0	2035.4	6.12%
						200			20.11			30.95			22.73				73.79	0.75	153.07	0.73	0.90	0.97	56.08	26.2	4011.8	3733.5	4011.8	7.46%
		Drainage to Ocean	12.64	460.0	0.140	2	12.36			0.25									12.61	0.65	22.70	0.13	0.55	0.20	22.56	15.8	357.8	357.5	357.8	0.08%
						10		12.36			0.25								12.61	0.67	23.43	0.13	0.55	0.20	22.56	24.9	583.5	583.3	583.5	0.04%
						200			12.36			0.25							12.61	0.70	24.54	0.13	0.55	0.20	22.56	42.3	1039.1	1037.6	1039.1	0.14%
		Drainage to Ocean	4.53	290.0	0.200	2							4.50						4.50	0.64	8.01	0.05	0.20	0.13	9.94	23.5	188.0	161.6	188.0	16.36%
						10								4.50					4.50	0.70	8.76	0.05	0.20	0.13	9.94	38.4	335.8	287.9	335.8	16.67%
						200									4.50				4.50	0.85	10.63	0.05	0.20	0.13	9.94	65.2	693.3	611.7	693.3	13.33%
		Clough Creek	267.15	5,840.0	0.195	2	206.00			5.30			56.00						267.30	0.65	479.61	2.67	1.35	1.77	93.54	7.9	3785.1	3671.6	3785.1	3.09%
						10		206.00			5.30			56.00					267.30	0.67	501.29	2.67	1.35	1.77	93.54	11.8	5903.0	5717.0	5903.0	3.25%
						200			206.00			5.30			56.00				267.30	0.73	543.52	2.67	1.35	1.77	93.54	20.0	10880.4	10554.0	10880.4	3.09%
		Malcolm Creek	391.34	6,330.0	0.180	2	330.00			5.30			56.00						391.30	0.65	703.68	3.91	2.00	1.87	116.23	7.1	4996.7	4894.6	4996.7	2.09%
						10		330.00			5.30			56.00					391.30	0.67	732.25	3.91	2.00	1.87	116.23	10.5	7690.7	7524.8	7690.7	2.20%
						200			330.00			5.30			56.00				391.30	0.72	784.82	3.91	2.00	1.87	116.23	17.9	14012.7	13721.6	14012.7	2.12%
		Robinson Creek	110.24	4,030.0	0.119	2	81.00			29.00									110.00	0.62	188.69	1.10	1.05	1.47	75.64	8.8	1651.2	1633.6	1651.2	1.08%
						10		81.00			29.00								110.00	0.65	198.03	1.10	1.05	1.47	75.64	13.2	2608.0	2592.0	2608.0	0.61%
						200			81.00			29.00							110.00	0.70	214.06	1.10	1.05	1.47	75.64	22.4	4792.4	4702.1	4792.4	1.92%
		Stephens Creek	390.46	7,110.0	0.160	2	340.46						50.00						390.46	0.65	704.17	3.90	2.00	2.16	124.68	6.9	4832.4	4746.5	4832.4	1.81%
						10		340.46						50.00					390.46	0.67	731.44	3.90	2.00	2.16	124.68	10.1	7403.4	7262.7	7403.4	1.94%
						200			340.46						50.00				390.46	0.72	780.69	3.90	2.00	2.16	124.68	17.2	13433.1	13193.9	13433.1	1.81%

Runoff coefficients updated for future flows assuming that 50% of the agricultural area will have an impervious area equal to residential (ie: greenhouses) and that 50% of the residential area will have an impervious area equal to commercial (ie: dense development, multiple homes and pavement on a single lot)

Return Period (yrs)	Weight Ag	Ag Coeff	Weight Res	Res Coeff
2	0.500	0.53	0.500	0.640
10	0.500	0.59	0.500	0.700
100	0.500	0.70	0.500	0.850

Appendix D

Stormwater System Design

A.1.1 General

The Rational Formula can be used to generate conservative peak flow estimates for the design of conveyance systems within development sites that are less than 10 hectares. Use of the Rational Formula is described on the following pages.

The OTTHYMO computer model shall be used to generate peak flow estimates for the design conveyance systems within development sites that are greater than 10 hectares.

To determine design flows by computer modelling, the peak flow rate resulting from 10-year and/or 200-year storms with durations of 1, 2, 6, 12 and 24 hours shall be determined. The maximum peak flow rate shall govern the design of minor and major systems. This task will be performed by Developers to evaluate conveyance systems within development sites, as well as by the applicable approving agency to evaluate off-site conveyance systems.

As part of the catchment planning process, peak flow estimates will be generated by the applicable approving agency for drainage facilities downstream of development sites.

The Developer shall provide the applicable approving agency with all calculations pertinent to the design of the proposed conveyance system at the time design drawings are submitted. All designs shall determine and include post-development upstream flows based on the highest land use as per the OCP for the upstream lands.

Use of the Rational Formula

The Rational Formula to use for design on site conveyance systems is, **Q = RAIN**, where:

- Q = Flow in m^3/s
- R = Runoff coefficient
- A = Drainage area in ha
- I = Rainfall Intensity in mm/hr
- N = 0.00278

Runoff Coefficients

The following runoff coefficient (R values) shall be used in the calculation for the Rational Formula:

Type of Area	Coefficient		
	Low	High	Standard
Low density housing	0.45	0.55	0.50
Medium density housing	0.55	0.65	0.60
High density housing	0.60	0.80	0.70
Commercial, Industrial	0.80	1.00	0.85
Institutional	0.70	1.00	0.80
Park or golf course	0.15	0.25	0.20
Churches or schools	0.60	0.85	0.75

Type of Area	Coefficient		
	Low	High	Standard
Grassland	0.15	0.30	0.20
Cultivated	0.30	0.50	0.40
Woodland	0.10	0.40	0.25
Roofs or pavements	0.90	1.00	0.95

Low values are applicable to areas with high soil permeability and gentle slopes (5% or less).

High values are applicable to areas with low soil permeability and steeper slopes (greater than 5%).

Standard values are for general application. The Designer/Consultant should verify the coefficient applicable for the area involved. A soils report may be required to verify the coefficient/s to be used.

The SCRD shall be the final authority on the coefficient to be utilized.

Drainage Areas

The entire tributary drainage area for the conveyance system under design shall be determined based on the natural contours of the land. While contour maps provided through Property Information and Mapping Services can be expected to be reasonably indicative of the actual condition, designers are cautioned not to interpret them to be exact and correct.

It is the Designer's responsibility to ensure that they obtain true and accurate elevations for the development site.

Rainfall Intensities

Rainfall intensities can be determined from the SCRD Rainfall Intensity/Duration/Frequency (IDF) curves.

The following parameters are needed to obtain intensity values from the IDF curves:

- **Time of Concentration (Duration)** – The time of concentration shall be calculate using the formula, $\mathbf{T_c = [Ct*L*n]/[12*S^{0.5}]}$, where:
  - T_C = Time of concentration in minutes
  - C_t = Concentration coefficient depending on the type of flow
    = 0.5 for natural watercourses or ditches
    = 1.4 for overland flow
    = 0.5 for storm sewer flow
  - L = Length of watercourse, conduit or overland flow in metres, along the drainage path from the furthest point in the basin to the outlet (maximum length = 300 m)

- n = Channel friction factor

  = 0.050 Natural Channels
  = 0.030 Excavated ditches
  = 0.016 Overland flow on smooth paving
  = 0.400 Overland flow on natural areas
  = 0.013 Concrete pipe
  = 0.011 PVC

- s = Basin slope in metre/metre

  Actual flow velocities in storm sewers shall be used. A composite value for T_C shall be calculated in cases where the type of flow along the longest path varies or the slope changes.

- **Rainfall Return Period (Frequency)** - As discussed previously, the 10 year return for design Minor Systems - and the 200 year return period shall be used for Major Systems.

Calculating Flow Capacities

Manning's formula shall be used to calculate flow capacities for storm sewers and open channels, $\mathbf{Q = [A*R^{0.667} *S^{0.5}] / n}$, where:

- Q = Design flow in m^3/s
- A = Cross sectional area of pipe or channel, in m^2
- R = Hydraulic radius (area divided by wetted perimeter)
- S = Slope of hydraulic grade line in m/m
- n = Roughness coefficient

  = 0.024 for corrugated steel pipe
  = 0.020 for gravel lined channels
  = 0.013 for concrete or asphalt lined channels
  = 0.050 for natural streams and grassed channels

  = 0.013 for concrete
  = 0.011 for P.V.C.

To calculate the flow capacity for culverts, the Designer is advised to use the inlet control and outlet control methods referred to in:

- Handbook of Steel Drainage and Highway Construction Products, by American Iron and Steel Institute.
- Handbook of Concrete Culvert Pipe Hydraulics, by Portland Cement Association.

These methods can be used to estimate the hydraulic adequacy of culverts; however, it is the physical adequacy (i.e. vulnerability to blockage) that generally governs the performance of culverts.

A.1.2 Physical Adequacy of Stormwater Conveyance Systems

Assessment of physical adequacy is a key input for any flood risk analysis. Drainage problems often occur in small tributaries where stream crossings, such as culvert installations, are vulnerable to blockage (i.e. physically inadequate). Flooding may be a common occurrence at tributary stream crossings even though conventional hydraulic analysis indicates that the conveyance capacity (i.e. hydraulic adequacy) is adequate.

All watercourse crossings (including culverts) shall conform to the following guidelines:

1 Maintain line and grade of creek channel
2 Maintain the waterway opening by "bridging" the creek channel
3 Construct inlet structure to provide direct entry and accelerated velocity
4 Ensure that it can pass trash, small debris and bedload material
5 Install debris interceptor upstream to provide protection from large debris
6 Provide scour protection to prevent undermining of the outlet structure
7 Incorporate provision for an overflow route in the event of a worst-case scenario
8 Provide equipment access for ease of maintenance (debris removal)
9 Consider environmental issues, such as fish passage

A.1.3 Site and Lot Grading

Developments in the SCRD shall incorporate proper site and lot grading techniques. The following criteria shall be used:

- Each lot should be graded to drain to an approved drainage system, or natural watercourse, independent of adjacent lots where possible. Minimum lot grades to be 1.0 percent and are to be shown draining away from building areas.
- Areas around buildings (or proposed building sites) shall be graded away from the (proposed) foundations to prevent flooding.
- Lots lower than adjacent roadways should be avoided, where possible, or acceptable stormwater management techniques must be incorporated to direct drainage to an existing or proposed drainage system.

Minimum Building Elevations (M.B.E.)

The M.B.E. means the top of slab (crawl space, basement or slab on grade). The M.B.E. shall be set by a Professional Engineer as part of an approved Comprehensive Drainage Plan (see Section 5), or by the Manager of Engineering Services where no stormwater management plan exists.

The purpose of setting a M.B.E. is to ensure that the means of draining a building is provided in accordance with the B.C. Building Code. M.B.E.'s set by a Professional Engineer as part of an approved Comprehensive Drainage Plan may not be revised without referral to the Sunshine Coast Regional District.

A gravity connection to the public storm drainage system may be made only where the habitable portion of a dwelling is above the Major System hydraulic grade line.

A.1.4 Rainfall Capture and Runoff Control Design Details

Infiltration Facilities

The design of infiltration facilities must be supported by site-specific soils report, including percolation tests. Based on site-specific soils information, infiltration facilities shall be sized according to the methodology presented in this Section. The final design of infiltration facilities requires certification from a Professional Engineer.

All infiltration facilities shall be designed with overflow pathways (can be pipes, channels, or overland flow) that connect to the conveyance system.

All pipes leading into infiltration facilities (e.g. roof leaders) shall be fitted with debris catchers and cleanouts, to minimize the movement of sediment and debris into the facilities.

Infiltration facility sites shall be protected during construction from either compaction or sedimentation, by pre-identification and fencing or other means. Inadvertent compaction shall be removed by ripping or scarifying the site prior to installation of infiltration facilities. Piezometers shall be installed for post-construction groundwater monitoring these facilities.

Adequate sediment and erosion control during construction is essential to prevent clogging of infiltration facilities and their underlying soils.

The following types of infiltration facilities can be used to meet rainfall capture (and runoff control) targets:

- **Retention Ponds (Dry Ponds) –** Unlined ponds that retain runoff and allow it to infiltrate through the pond bottom.
- **Bioretention Areas** - Shallow landscaped basins that retain runoff in a thick layer of absorbent soil and on the surface (shallow ponding). The low points of should be planted with plants that tolerate flooding – higher areas should be planted with streamside or upland species.
- **Soakaway Trenches or Pits –** Trenches or pits filled with drain gravel. Absorbent landscaping can be installed over the surface, and with proper engineering, pavement (with light vehicle traffic) may be allowed on the surface (e.g. a soakaway under a driveway).
- **Infiltrator Chambers** - Inverted plastic half pipes can be installed in infiltration trenches to increase retention storage capacity and improve infiltration performance.
- **French Drains –** Runoff exfiltrates from a perforated pipe into an infiltration trench and then into the surrounding soil. Refer to Standard Drawing DD-8.
- **Soakaway Wells** – Runoff exfiltrates from screened wells into the surrounding soil. Refer to Standard Drawings.
- **Infiltration Swales** - Consists of a surface swale on top of a gravel filled infiltration trench.

Standard detail drawings for these facility types will be created (or updated) as part an overall Drainage 5-year Action Plan.

Other Source Controls

Other source controls (rainwater reuse or green roofs) may be applied, without or in combination with infiltration facilities, provided it can be shown that the SCRD's and MoT's rainfall capture criteria are met.

The design of a rainwater reuse system must be supported by a detailed water use and rainfall collection report. Low flow release to ensure adequate stream baseflow may be required in some cases. Designers shall consult with applicable approving agency staff.

The design of green roofs must be supported by a drainage plan for the building envelope. Standard drawings will also be created for Green Roofs will be created as part of the SCRD's 5-year Action Plan.

The final design of all source control facilities requires certification from a Professional Engineer.

Detention Facilities

Detention facilities shall be provided on all development sites where the SCRD's and MoT's runoff control targets are not met through source control. Detention facilities shall be sized according to the methodology presented in currently accepted local and provincial guidelines (ie. Stormwater Source Control Guide, Metro Vanvouver, 2005 and BMP Guide for Stormwater, Metro Vancouver, 1999, etc.)

Designers shall obtain approval of all proposals for detention systems from the SCRD's Infrastructure Services Department and/or MoT prior to detailed design.

Detention facilities shall be designed with bottom drainage to ensure the facility is dry when not in use, except where slope stability concerns require ponds to be lined.

A.1.5 Conveyance System Design Details

Conveyance systems may consist of ditches, swales and/or storm sewer pipes. Runoff may be collected into the conveyance system via overflow connections from rainfall capture facilities (e.g infiltration facilities) and/or overland flow pathways.

Swales

Conveyance swales shall be a maximum 150 mm deep and shall conform to Standard Drawing. All swales are to be lined with turf on a minimum 300 mm layer of absorbent soil. Swales that drain adjacent lots shall be located within a 3.0 m easements. Swales for Major Flood Path routing shall be designed to accommodate the anticipated flows and the easement established accordingly. Swales shall have a minimum 1.0% grade.

Swales can be designed as combined infiltration and conveyance facilities (i.e. infiltration swales).

Ditches

Ditches adjacent to roadways shall conform to the following criteria:

- maximum depth = 1.0 m
- minimum grade = 0.5 %
- maximum velocity* = 1.0 m/s (*Unlined ditch)

Where soil conditions are suitable or where erosion protection is provided, higher velocities may be permitted. If grades are excessive, erosion control structures or ditch enclosure may be required.

The minimum right-of-way width for a ditch shall be 6.0 m where the ditch crosses private property. The ditch shall be offset in the right-of-way to permit a 4.0m wide access for maintenance vehicles. Additional right-of-way may be required.

Where a new ditch is proposed to be located adjacent to an existing property line or where a new property line is proposed to located adjacent to an existing ditch, no portion of the ditch cross-section shall lie closer than 0.5m to that property line.

Storm Sewer Location/Corridors

On roads with storm sewers, the utility shall be located within the road right-of-way as noted in the applicable Standard Drawing Typical Cross-section for that road.

When the utility is required to cross private land(s), refer to the SCRD's Design Standards for Water Systems for minimum right-of-way width standards.

Where there are manholes, oil and silt interceptor facilities, or other appurtenances which require maintenance located within the right-of-way, the Developer may be required to provide for and construct an access from a Ministry of Transportation road to enable access by maintenance vehicles. The maintenance access shall be constructed in such a manner and to a paved standard that is adequate to support the maintenance vehicles for which the access is intended. The Developer shall ensure that the maintenance access will not present a nuisance to adjoining properties, and that hardened impervious surfaces are kept to a minimum.

Utility Separation

The minimum separation between storm sewers and watermains shall be 3.0 m horizontally (center line to center line) and 0.5 m vertically (from the water pipe invert to the top of the storm sewer).In situations where the minimum separations cannot be attained, protection of the watermain may be considered subject to the acceptance of such proposals by the Ministry of Health and the SCRD. Where storm and sanitary are installed in a common trench, the clearance between pipes shall be minimum 1.0 m invert-to-invert.

Minimum Pipe Sizes

The minimum size of storm sewer pipes shall be 250 mm diameter, except where a terminal section is within a short cul-de-sac. In this case the size may be reduced to 200 mm diameter where there are no catch basin connections. Catch basin leads shall be a minimum 150 mm diameter for single lead and 200mm for double.

Service connections shall be a minimum 100 mm diameter (residential) and 150 mm diameter (industrial/commercial), and in addition shall be sized and designed to satisfy runoff requirements for the ultimate development of the property being served.

Driveway culverts shall be sized and designed to accept the design flows of the upstream tributary area and in no case shall be less than 300 mm in diameter.

Minimum Depth of Cover

The minimum depth of cover shall be 1.0 m for storm sewer pipes and culverts up to 600 mm under roads, and 0.3 m for culverts under driveways, subject to the correct pipe loading criteria. For pipe sizes larger than 600 mm, an engineering design for cover will be required. Where minimum cover is not attainable, a design for concrete encasement should be discussed with the SCRD.

The elevation of storm sewers at the upstream tributary points must be of sufficient depth to service all of the tributary lands.

Storm Service Connections

For development sites that are served by storm sewer conveyance systems, storm service connections shall:

- be installed to all lands fronting the storm sewers, so that the lands may be provided with a 'gravity-flow' connection for overflow from rainfall capture facilities to enter the storm sewer system.
- have a diameter of a minimum 100 mm for residential and 150mm for industrial/commercial.
- have a slope of not less than 2.0%. At the property line, the minimum depth shall be 1.0 m and the maximum depth shall be 1.2 m.
- be installed at the lower (downstream) portion of the lot for larger lots or parcels of land. In urban developments connections shall be as noted on Standard Drawing DC-1 and DC-2.
- establish the Minimum Building Elevation (M.B.E.) at not less than 0.6 m above the storm service connection invert at the front property line of the lot/s adjacent.
- connect all existing storm service connections to the proposed storm sewer, when the design proposes to infill an existing ditch.

Minimum/Maximum Velocity

The minimum velocity for pipes flowing full, or half full, shall be 0.75 m/s.

There is no maximum velocity, however, where grades exceed 15%, scour protection may be required and anchor blocks will be required.

Where drainage discharge enters a natural watercourse, the Ministry of Water, Land and Air Protection generally requires adequate erosion protection and maximum velocities under 1.0 m/s.

Curvilinear Sewers

Curvilinear sewers are not recommended. Where no other acceptable alternative exists and the Municipal Engineer has granted approval, the minimum radius should not be less than 60 m and the maximum joint deflection should be one half the pipe manufacturer's recommended maximum pipe deflection.

Manholes

Storm drain manholes require a 600 mm deep sump unless approved otherwise by the Municipal Engineer.

Manholes are required at:

- all changes in grade
- every intersecting sewer
- all changes in pipe size
- all changes in direction
- every 150 m

Hydraulic Losses in Manholes

The following criteria shall be used:

- Generally the crown of the downstream pipe shall not be higher than the crown of the upstream pipe.
- Minimum drop in invert levels across manholes:
  - straight run - no drop required
  - deflections up to 45^{o} - 20 mm drop
  - deflection 45^{o} to 90^{o} - 30 mm drop
- Outside drop connections shall be provided wherever the drop exceeds 0.6 metres.

Temporary Clean-outs

Temporary clean-outs may be provided at terminal sections of a storm sewer provided that all the following criteria can be met:

- future extension of the main is proposed or anticipated.
- the length of sewer to the downstream manhole does not exceed 45.0m.
- the depth of the pipe does not exceed 2.0 m at the terminal point.

Note that clean-outs shall not be considered permanent structures, and that mid-block clean-outs are not permitted.

Catch Basins

On roads with storm sewers, catch basins shall be provided at regular intervals along roadways, at intersections, and at low points.

Catch basin spacing shall be designed to drain a maximum area of 500 m^2 on road grades up to 5%. On steeper grades, side entry catch basin grates are to be installed.

Catch basin leads shall be a minimum of 150 mm in diameter for single C.B.'s and 200 mm for double C.B.'s. Where possible, C.B. leads should be taken into manholes.

Inlet and Outlet Structures

The Standard Drawings for inlet and outlet structures shall be used in the design of these facilities.

Outlets shall be designed with adequate rip rap protection and/or an accepted energy dissipating structure to control erosion.

A safety grillage shall be required at the outlets of all storm sewers over 600 mm in diameter and which exceed 30 m in length. Trash racks at the inlets shall be required on all storm sewers which utilize safety grillages.

A.1.6 Standard Detail Drawings

Over time, the standard drawings will be modified or replaced as needed to achieve stormwater management objectives. As noted previously, under its implementation plan the SCRD and Ministry will be creating standards that provide direction for meeting rainfall capture targets and Low Impact Development objectives. It is anticipated that some of these drawings may result from experience gained with the first Demonstration Projects.

A.1.7 Sediment and Erosion Control

All building sites during construction shall employ the following sediment and erosion control strategies:

- **Source Erosion Control -** Maintain vegetation and preventing soil from being displaced until necessary.
- **Erosive Runoff Control** - Reduce the erosive energy of runoff and use non-erodable surfaces for conveyance of runoff.
- **Sediment Control -** Trap runoff and reduce velocity to allow sediment to settle.

Prior to construction, a *Sediment and Erosion Control Plan* shall be submitted to the SCRD. The Plan must incorporate Best Management Practices. All construction work must be undertaken and completed in such a manner as to:

- Prevent the release of silt, raw concrete and concrete leachate, and other deleterious substances into any ditch, storm sewer, watercourse or ravine.
- Prevent silt, raw concrete and concrete leachate, and other deleterious substances from entering any infiltration facilities (or areas proposed for infiltration).

Proposed sediment control structures must be maintained and be functional throughout the development process. Changes in the design and the structure will be required if the proposed structure is found not to be adequate.

Construction and excavation wastes, overburden, soil, or other substances deleterious to aquatic life shall be disposed of or placed in such a manner as to prevent their entry into any watercourse, ravine, storm sewer system, or restrictive covenant area.

The location of all sediment control devices shall be placed as close as possible to the area they are required to protect, at the downstream ends of all development, and before entrance into the existing drainage system.

All stockpiles located within 3.0 metres of a public road and/or drainage system shall have the perimeter silt fenced and the pile covered.

The proposed location of sediment control ponds shall be situated to provide ready access for cleaning and maintenance, and shall be sited and designed to prevent property damage in the event of structural failure.

Soil Removal and Deposit

All locations within the development site on which spoil material is to be placed must be identified by the Design Engineer. Any off-site property or location to which material is to be trucked is to be identified and is to receive prior approval by the SCRD as a designated "deposit" site under a permit issued in accordance with the SCRD's existing bylaws.

Proposed truck haul routes not located wholly within designated MoT "truck routes" are subject to application to and approval by the MoT. Proposed routes are to be shown on a plan, and the means by which the haul route will be kept clean and free of dust and soils is

to be identified.

A.1.8 Water Quality Protection

New storm drainage systems which are located on land that is zoned CD, industrial, multi-family or commercial according to the Zoning Bylaw, shall not be connected to a storm sewer or infiltration system connection unless equipped with an oil and grit interceptor. The oil and grit interceptor shall:

- meet the technical specifications set out in the SCRD's and/or MoT's Standard Drawings;
- be suitable for the sampling and inspection of the stormwater which is discharged from the storm drainage system to the storm sewer connection; and
- be suitable for the interception, retention, and removal of deleterious substances in that discharge.

A property owner that is served with written notice from the applicable approving agency advising that an oil and grit interceptor is required on an existing or new storm drainage system located on that owner's property shall install an oil and grit interceptor on that storm drainage system.

- within one year of the notice being served for an existing storm drainage system; or
- prior to connection to the storm sewer connection in the case of a new storm drainage system; or
- as ordered by the applicable approving agency.

Responsibility for Installation and Maintenance

An owner of a parcel of land, or person on behalf of the owner, who installs an oil and grit interceptor shall install the oil and grit interceptor on the storm drainage system at or near the property line within the bounds of the owner's parcel of land. All costs associated with the installation and maintenance thereof shall be the responsibility of the owner.

Maintenance Requirements

- All oil and grit interceptors shall be cleaned by a waste contractor holding a valid SCRD's business licence as frequently as necessary to ensure that deleterious substances in the discharge from the storm drainage system are intercepted and retained for removal;
- The owner of the property on which an oil and grit interceptor has been installed shall maintain records of the cleaning for inspection by the Director and shall

forward, to the Director, by May 1 of each year, a copy of the record of inspections for the previous 12 months;

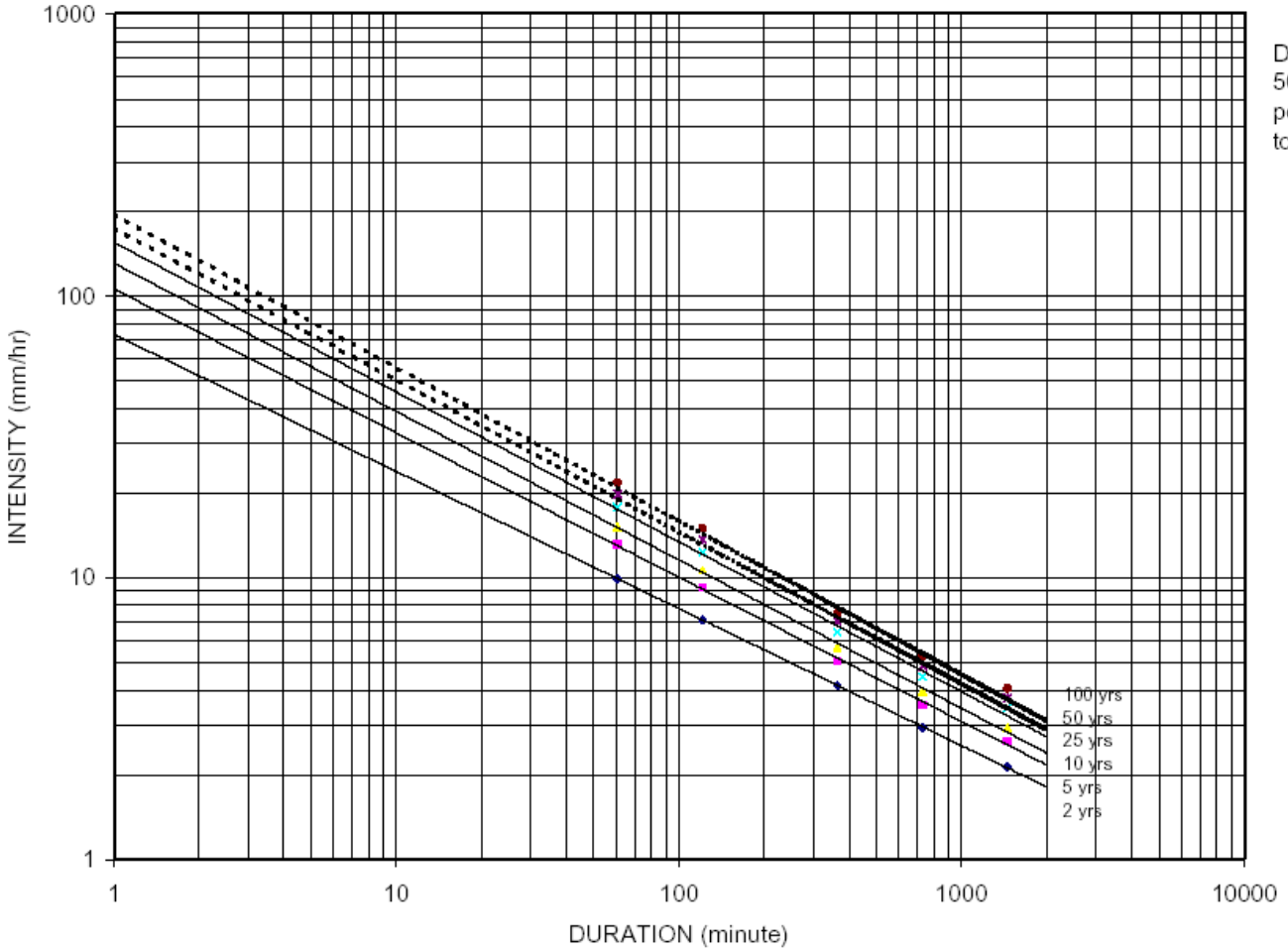
- Such records are to be maintained on the premises on which the oil and grit interceptor is located and are to be retained for not less than six years;

- The applicable approving agency may order the owner of an oil and grit interceptor to undertake more frequent cleaning if there is evidence that inadequate or lack of cleaning of the oil and grit interceptor has impaired its ability to intercept, and retain for removal, the deleterious substances in the discharge from the storm drainage system.

Exceptions

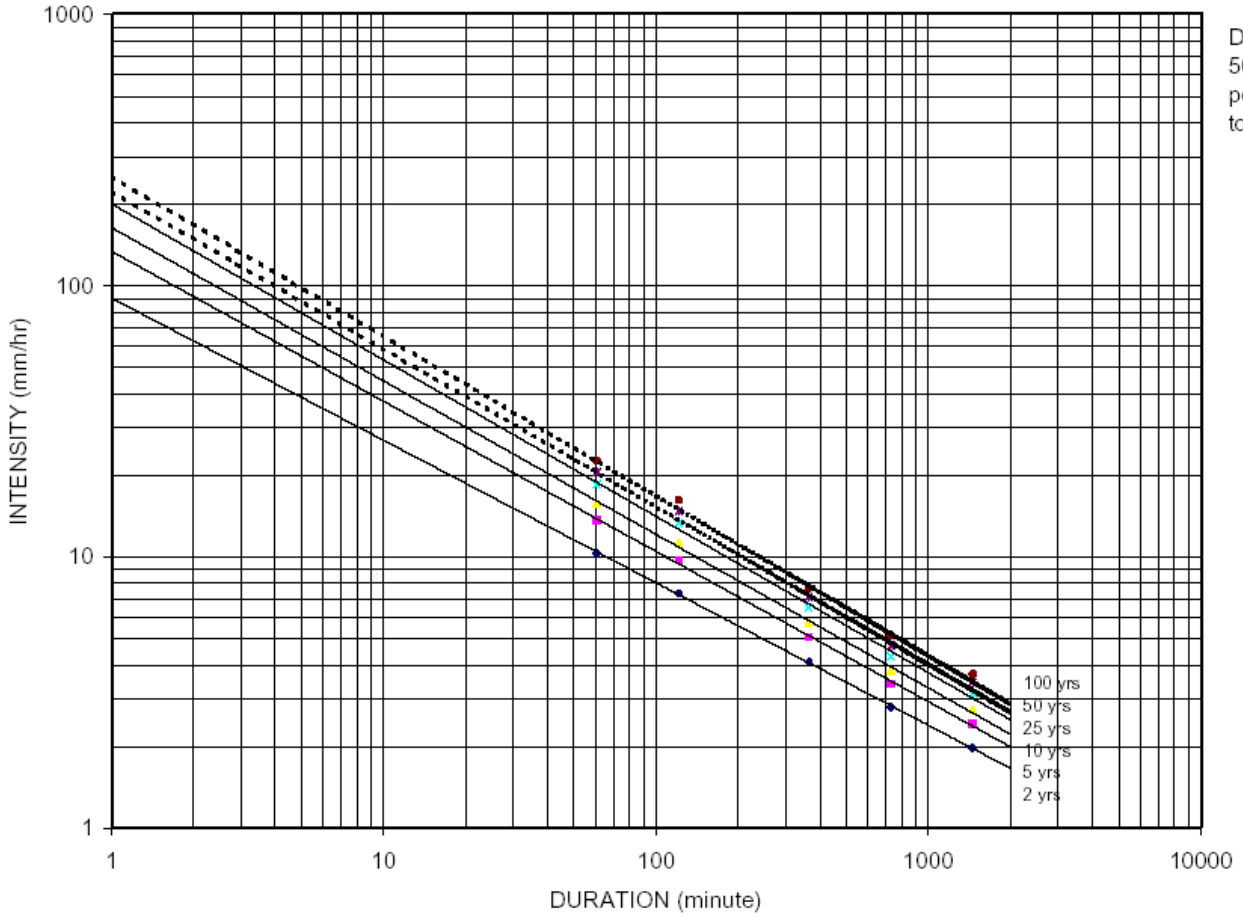
The requirements of this section may be waived where the property owner has submitted a report from a Professional Engineer certifying that the intended use of the property including any construction or remodeling work, will not introduce deleterious substances to the storm sewer system.

INTENSITY-DURATION-FREQUENCY DATA FOR ELPHINSTONE



Disclaimer:
50 and 100 year return period are unreliable due to limited data.

INTENSITY-DURATION-FREQUENCY DATA FOR ROBERTS CREEK



Disclaimer:
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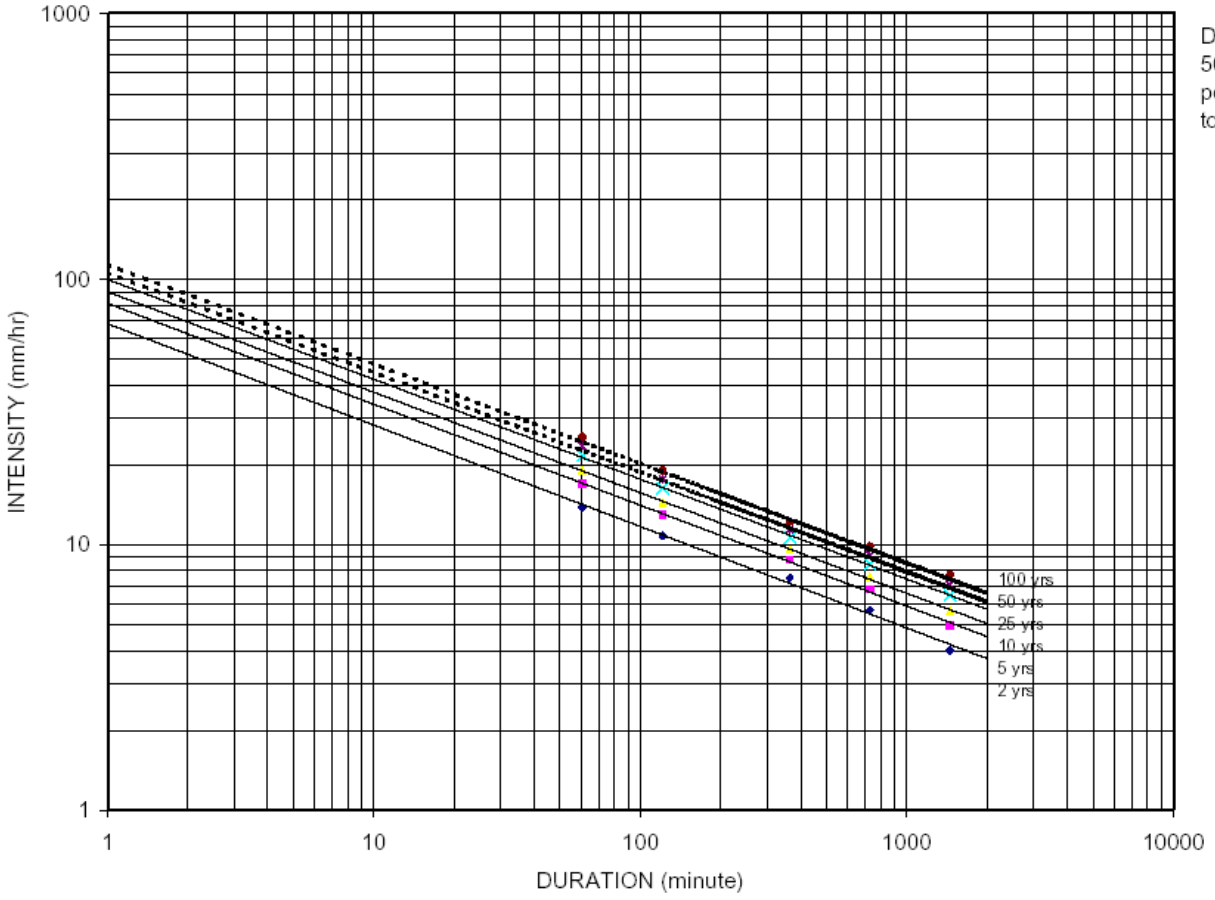
INTENSITY-DURATION-FREQUENCY DATA FOR WEST HOWE SOUND



Disclaimer:
50 and 100 year return period are unreliable due to limited data.

Appendix E

Environmental Consultation Report

ENVIRONMENTAL CONSULTATION

SUNSHINE COAST REGIONAL DISTRICT INTEGRATED STORMWATER MANAGEMENT PLAN 14 WATERSHED REMEDIATION AREAS

ENVIRONMENTAL CONSULTATION

SUNSHINE COAST REGIONAL DISTRICT INTEGRATED STORMWATER MANAGEMENT PLAN

Submitted to:

Delcan Corporation
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Prepared by:

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Maddison Consultants Project No. M29

June 23, 2008

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APPENDICES

INTRODUCTION

Maddison Consultants, Ltd. (Maddison Consultants) was retained by Delcan Corporation (Delcan) to provide environmental consultation for the Phase II Integrated Stormwater Management Plan (ISMP) so that the Plan addresses protection of stormwater as a resource for fish, other aquatic species and wildlife. The Plan area includes East Roberts Creek, Elphinstone, and West Howe Sound Communities in the Sunshine Coast Regional District (SCRD). Delcan completed Phase I of the ISMP in 2006 that identified existing watershed conditions and concerns along with potential engineering and planning solutions to address the identified concerns. Fourteen sites were identified during Phase I, five in West Howe Sound, six in Elphinstone and three in East Roberts Creek. Phase II (the current phase) of the ISMP will provide a watershed based implementation program for the remediation of the existing problems.

METHODS

Literature Review

A literature review was conducted to identify the existence, or potential occurrence, of species at risk (e.g. plant and animal species) in the vicinity of, or within, the study area. Species at risk are identified in the context of both the provincial and national ranking systems. The provincial ranking system applies to species that have been assessed by the British Columbia (BC) Conservation Data Centre (CDC). The national ranking system applies to species that have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and in some instances, Schedule 1 of the *Species At Risk Act* (SARA). The Schedules in SARA are based on COSEWIC's assessments of the species.

The Federal and Provincial lists that were reviewed by Maddison Consultants include the following:

- BC Conservation Data Centre: Conservation Data Centre Mapping Service [Web Application]. 2006. Victoria, BC, Canada. Available: http://maps.gov.bc.ca/imf50/imf.jsp?site=cdc (March 22, 2007 and September 10, 2007);
- BC Conservation Data Centre. 2007. BC Species and Ecosystems Explorer. BC Minist. Of Environ. Victoria, BC, Available: hhtp://srmapps.gov.bc.ca/apps/eswp/(accessed: September 10, 2007);
- Ministry of Environment. 2007. Fisheries Inventory Data Queries Applications (http://srmapps.gov.bc.ca/apps/fidq/) accessed on September 26, 2007;
- Ministry of Environment. 2007. Sensitive Ecosystems Inventories for the Sunshine Coast (http://www.env.gov.bc.ca/sei/sunshine/index.html);
- Sunshine Coast Regional District Habitat Atlas available at http://habitat.scrd.bc.ca/; and,
- Environment Canada, Canadian Wildlife Service. 2004. Species At Risk Mapping Application (http://www.sis.ec.gc.ca/ec_species/ec_species_e.phtml) accessed on October 9, 2007.

The table that summarizes the results of the literature review to identify sensitive species that have a potential of occurring within the plan area is attached in Appendix A. However, considering the dynamic nature of listing and delisting species, along with evolving

information on species distribution and site specific environmental conditions, should a Species At Risk assessment be required for the proposed watershed remediation activities, this list should be reviewed and revised by a qualified biologist.

Maddison Consultants reviewed the Sunshine Coast Regional District Habitat Atlas to identify Riparian Assessment Area Development Permit Areas and potential fish presence within the proposed watershed remediation areas. The pertinent areas are attached in Appendix B.

Consultation

In addition to compiling information from the above sources, Maddison Consultants contacted interested stakeholders. The persons contacted include:

By telephone:

- Tom Blackbird, BC Conservation Data Centre on September 12, 2007.
- Carmen Cadrin, BC Conservation Data Centre, left message on October 15, 2007.
- Bruce Clark, Department of Fisheries and Oceans on October 16, 2007.
- Kevin Fort, Canadian Wildlife Service on October 3, 2007.
- Tony Greenfield, Sunshine Coast Natural History Society, left message on October 15, 2007.
- Dave Nanson, Department of Fisheries and Oceans on October 4, 2007.
- Erin Prescott, BC Conservation Data Centre, left messages October 19 and 24, 2007.
- Dale Reynolds, Ministry of Environment, left message on October 3, 2007.

By electronic mail (e-mail):

- Andrew Allen, Sunshine Coast Regional District on September 28, 2007.
- David Cunnington, Environment Canada on October 3, 2007 – no response.
- Matt Fairbarns, Aruncus Consulting, on June 20, 2007.
- Phil Henderson, Strix Environmental Consulting on June 19, 2007.
- Sylvia Letay, Ministry of Environment on October 3, 2007 – no response.
- Nick Page, on June 20, 2007.
- Erin Prescott, BC Conservation Data Centre, on September 10, 2007.
- Lucy Reiss, Ministry of Environment on October 3, 2007.
  Forwarded my e-mail to: Jan Kirkby, Environment Canada.
  Andrew Robinson, Environment Canada – no response.
  Dan Shervill, Environment Canada – no response.
  Kathleen Moore, Environment Canada – no response.

ENVIRONMENTAL CONSIDERATIONS

The remediation of the watershed areas will potentially fall under the statutory authority of several federal, provincial and local government bodies. These government bodies are empowered by regulations that require an application for development to be submitted to the respective agency. An official response from these agencies may be required prior to commencement of the watershed remediation.

Federal Regulations

Fisheries Act

The Fisheries Act provides for the management of fisheries resources and the protection of fish and fish habitats. Fish are defined by the Act as "fish, shellfish, crustaceans, and marine animals" as well as the "eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals." Further, fish habitats are defined by the Act as "spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly in order to carry out their life processes." Clarification of these definitions was provided in the Habitat Conservation and Protection Guidelines (1998) which state that "fish habitat therefore refers to: freshwater, estuarine and marine environments that directly or indirectly support fish stocks or fish populations that sustain, or have the potential to sustain, subsistence, commercial, or recreational fishing activities". The Fisheries Act is administered by Fisheries and Oceans Canada (DFO).

Subsection 35(1) of the Act prohibits the harmful alteration, disruption, or destruction (HADD) of fish habitat unless authorized by the Minister. Subsection 35(2) provides the mechanism for an authorization of a HADD, which is contingent on compliance with the National Habitat Policy, specifically the Fish Habitat Conservation Goal and it's guiding "no net loss of the productive capacity of habitats" policy.

Impacts to instream and riparian areas, as well as ocean shoreline, would be considered a HADD by DFO. In cases where the productive capacity of fish habitat is high, DFO will typically not authorize a HADD. In those instances where the productive capacity of fish habitat is not high, an authorization of a HADD may be considered by DFO. The authorization may be granted contingent upon the implementation of various measures, including those to restore or develop fish habitat so that a "no net loss" is achieved.

Guidelines issued by DFO indicate a minimum setback of impacts, including direct or indirect, of 30 metres from top of bank of streams and 15 metres from either higher high tide or the shoreline of the ocean, depending on the situation (Bruce Clark, DFO, Personal Communication).

Although the proposed watershed remediation activities should reduce erosion sediment runoff to existing waterways, all of the proposed watershed remediation construction activities will involve direct impacts to fish habitat and may cause indirect impacts to fish habitat with the increase surface flows to existing watercourses. In addition, some of the watershed remediation activities will involve improvements within 15 metres of the ocean, which may be measured from either higher high tide or shoreline, depending on the situation. The proposed watershed remediation activities that currently identify improvements within 15 metres of the ocean are: S1- Twin Isle Drive, S2 – Forbes Road/Smith Road, S3-Burns Road/Hopkins Road/Langdale Creek, S5-Williamson's Landing, S6-Area west of Ocean Beach Esplanade and east of Gulf Road, S7-Byng Road/Geddes Road/Maskell Road, S9-Wood Creek Park/Ocean Beach Esplanade, S12-15th Street/Ocean Beach Esplanade. However, other proposed watershed remediation activities may encroach into this setback. Therefore, during the design stage of each watershed remediation activity, obtain advice from a qualified environmental professional to assess potential impacts and develop mitigative measures as well as secure the necessary approvals for meeting applicable regulatory requirements.

In addition, Mr. Clark stressed the importance of maintaining predevelopment water quality and rates of flow and expressed concerns about replacing culverts with new culverts. He identified the preferred method is to discharge the water to ground to reduce the volume. Furthermore, it is important to consider where ditches are connected to fish habitat they are considered streams and, as such, the installation of ditches and connecting them to existing ditches (that flow into fish habitat) increase the DFO jurisdiction within an area.

Canadian Environmental Assessment Act

The Canadian Environmental Assessment Act (CEAA) was established in 1994 to ensure that the environmental effects of federal projects are fully considered, to promote sustainable development, and to ensure public participation in the environmental assessment process. The Environmental Protection Branch of Environment Canada is responsible for administering CEAA. The project review process pursuant to the requirements of CEAA is triggered when a federal authority 1. proposes a project, 2. grants money to a project, 3. grants an interest in land to a project and/or, 4. exercises a regulatory duty in relation to a project.

The CEAA process is administered by the regulatory agency that exercises its legislative authority in relation to the project. The regulatory agency administering the process is responsible for the decision as to whether or not the project proceeds as proposed. As such, this agency is referred to as the Responsible Agency. The proponent is typically responsible for addressing the information needs of the CEAA regulatory agency. It is anticipated for the purposes of the watershed remediation activities that DFO would be the Responsible Agency. DFO will screen the project pursuant to requirements of CEAA in conjunction with its review of the project pursuant to the requirements of the Fisheries Act and associated policies.

The CEAA was harmonized with the Provincial Environmental Assessment Act project review process through the “1997 Canada-British Columbia Agreement for Environmental Assessment Cooperation. The agreement was applied to projects subject to environmental legislation of both governments. The 1997 agreement between British Columbia and Canada expired on April 16, 2002 and an interim extension was confirmed in October 2002. The *Canada-British Columbia Agreement on Environmental Assessment Cooperation* will replace the interim extension. This agreement was amended and signed in 2004. Under which, projects that require a review under both federal and provincial environmental assessment legislation will undergo a single, cooperative assessment, meeting the legal requirements of both governments while maintaining their respective existing roles and responsibilities. The agreement provides for periodic review of its implementation and effectiveness, and a thorough evaluation within five years.

Species At Risk Act

The Species At Risk Act provides protection to plant and animal species listed under Schedule 1 of SARA. Listing of species by Schedule 1 imposes statutory requirements for the management of listed species, which includes monitoring, assessment, response, recovery, and program evaluation of each species. Species addressed by COSEWIC but not addressed by Schedule 1 of SARA are not legally recognized. Federal Ministers that participate in the implementation of SARA consist of the:

- Minister of Fisheries and Oceans Canada for aquatic species at risk;
- Minister of Canadian Heritage (through the Parks Canada Agency) for individuals of species at risk found in national parks, national historic sites or other protected heritage areas; and
- Minister of the Environment Canada for all other species at risk, and is also responsible for the administration of the Act.

SARA refers to these three ministers as "competent ministers" and gives them the authority to make decisions in their areas of responsibility and requires them to consult with each other on specific SARA-related matters.

Sections 32 and 33 of SARA make it an offence to:

- Kill, harm, harass, capture or take an individual of a listed species that is extirpated, endangered, or threatened;
- Possess, collect, buy, sell, or trade an individual of a listed species that is extirpated, endangered, or threatened, or its part or derivative; or,
- Damage or destroy the residence of one or more individuals of a listed endangered or threatened species or of a listed extirpated species if a recovery strategy has recommended its reintroduction.

For other listed species, the provinces and territories are given the first opportunity to protect them through their laws. If the province or territory does not act, SARA has a 'safety net'. The Governor in Council, on the recommendation of the Minister of the Environment, may order that the prohibitions in sections 32 and 33 apply for a given species in a province or territory. The Minister must make a recommendation if, after consultation with the provincial or territorial minister, the Minister finds that the species or its residence is not effectively protected.

Projects that require an environmental assessment under an Act of Parliament will have to take into account the project's effects on listed wildlife species and their critical habitats. The assessment must include recommendations for measures to avoid or reduce adverse effects and plans to monitor the impact of the project, if it goes ahead. The project plan must respect recovery strategies and action plans and SARA prohibitions still apply.

The applicability of SARA to proposed watershed remediation activities is associated with the CEAA review of development triggered by a Subsection 35(2) Fisheries Act Authorization for anticipated impacts to creeks and shoreline. DFO, as part of the assessment of impacts to environmental resources, may require the project to identify impacts to Schedule 1 species, and how these impacts will be mitigated through the design, construction and operation of the project.

A compilation of species that have the potential to occur within the Plan area is attached in Appendix A. However, considering the dynamic nature of listing and delisting species, along with evolving information on species distribution and site specific environmental conditions, this list should be reviewed and revised by a qualified biologist prior to conducting a Species At Risk assessment within the watershed plan area, if required.

Migratory Bird Treaty Act

The Migratory Birds Convention Act provides for the protection of migratory birds and migratory bird habitat. A migratory bird is defined as "a migratory bird referred to in the Convention, and includes sperm, eggs, embryos, tissue cultures, and parts of the bird." The Act is administered by the Canadian Wildlife Service (CWS) of Environment Canada.

CWS rarely issues formal approvals of relatively small development projects such as the proposed watershed remediation activities. However, DFO, in fulfilling its obligations under the CEAA, may refer the application for works in and about creeks to CWS for comment. DFO will incorporate CWS's response in its formal response to the applicant.

However, the Migratory Birds Convention Act provides protection for migratory birds regardless of whether or not formal approval is required. Therefore, any vegetation clearing or ground disturbance activities associated with the proposed watershed remediation activities should be conducted outside the bird-nesting season. If the nesting season cannot be avoided, a qualified biologist should conduct a survey to determine the presence of nesting birds and provide avoidance and minimization measures, if necessary.

Navigable Waters Protection Act

Section 5 of the Navigable Waters Protection Act provides for the protection of navigable waters by regulating any activity that may impact the navigability of a waterbody. Navigable waters are defined as "any body of water capable of being navigated by any type of floating vessel for the purpose of transportation, recreation or commerce." Projects affecting navigable water must be approved by the Navigable Waters Protection Division of the Canadian Coast Guard.

It is unlikely that the Navigable Waters Protection Division would consider the creeks within the study area navigable waters. However, an application for works in and about the creeks would have to be submitted to the Division for a decision statement to be rendered regarding the navigability of the creek.

Provincial Regulations

Environmental Assessment Act

The Environmental Assessment Act provides a single review process to assess certain major projects and activities in British Columbia. The Act addresses reviewable projects as designated by regulation, the executive Director of the Environmental Assessment Office (EAO), or the Minister of Sustainable Resource Management. Reviewable project categories are industrial, energy, mining, water, waste, food processing, transportation and tourism. An environmental assessment certificate is granted a reviewable project upon acceptance of potential effects identified by the assessment and conditions thereof, as required, that reduce the severity of such effects. As mentioned previously, constitutional responsibility for management of the environment is shared by the federal and provincial governments. As a

result, projects subject to the Provincial Environmental Assessment Act may be subject to the federal Canadian Environmental Assessment Act. Each government retains autonomy over their respective decisions regarding approval of the project; each government retains its decision-making role. The decisions are made on the basis of shared information and are analyzed through a single process facilitated through the EAO.

Fish Protection Act

The Fish Protection Act was passed to help ensure fish have sufficient water and habitat as BC continues to grown and develop. Section 12 of the Act authorizes the Province to establish "policy directives regarding the protection and enhancement of riparian areas that the Lieutenant Governor in Council considered may be subject to residential, commercial or industrial development." These policy directives are intended for local governments (municipalities and regional districts), which are the primary bodies responsible for planning and regulating these forms of development. The Riparian Areas Regulation outlined below provides direction needed by local governments to achieve improved fish and fish habitat protection.

Riparian Areas Regulation

The Riparian Areas Regulation (RAR), enabled by the *Fish Protection Act*, provides legislated direction needed by local governments to achieve improved fish and fish habitat protection. The regulation, administered by the Ministry of Environment, applies to riparian fish habitat affected by new residential, commercial and industrial development on land under local government jurisdiction.

Under the regulation, local governments may allow development within 30 metres of the high water mark of a stream or top of a ravine bank, provided the prescribed riparian assessment methods have been followed. The riparian assessment method requires a Qualified Environmental Professional (QEP) to provide an opinion, in an assessment report, that the development will not result in a HADD of riparian fish habitat.

Per guidance from Andrew Allen, the Sunshine Coast Regional District include roadside ditches in their interpretation of the RAR only if they flow into a stream, not if they are directed to the ocean on road allowances or through private property. However, ditches that flow to the ocean are considered fish habitat and are subject to both the federal fisheries act and the Fish Protection Act.

Where ditches are connected to fish habitat they are considered streams under the Riparian Areas Regulation and require an assessment and SPEA determination. Therefore, each of the proposed watershed remediation activities will involve activities within the riparian assessment areas as identified in the riparian assessment regulation and, as such, each watershed remediation activity will require a riparian areas assessment in accordance with the regulation.

It is important to note that with the consideration of ditches being streams under the Riparian Areas Regulation, that the installation and connection of ditches to existing ditches or streams increase the DFO and MoE jurisdiction within an area.

Wildlife Act

The Wildlife Act provides for the protection of wildlife and wildlife habitat. Although not all provincially listed species (i.e. red- and blue- listed by the CDC) are directly addressed by the Wildlife Act, the Act protects almost all vertebrate animals, legally designated or not, from direct harm, except as allowed by regulation (i.e. hunting and trapping).

Section 34 of the Wildlife Act prohibits the possession, take, injury, molestation or destruction of a bird or its egg; the nest of an eagle, peregrine falcon, gyrfalcon, osprey, heron or burrowing owl; or, the nest of a bird when the nest is occupied by a bird or its egg.

Section 75 prohibits killing or wounding wildlife, other than prescribed wildlife, by accident or for the protection of life or property if the killing or wounding, along with the location of the wildlife, is not reported promptly to an officer.

Although there are no formal approvals or authorizations, Sections 34 and 75 of the Act will apply to the construction phase of the proposed activities, at which point the construction must be phased to avoid the active nesting period for birds, and implement measures to remove wildlife to avoid the killing or wounding of wildlife. The most common measures include the use of temporary fencing to limit access to adjacent habitats and to have a qualified biologist on site to monitor construction activities and to remove individuals should they “wander” onto the site.

Waste Management Act

The Waste Management Act regulates the discharge of solid waste, effluent and emissions to the environment. Wastes may only be discharged in accordance with permits or approvals issued by the Environmental Protection Division of the Ministry of Environment, a Liquid Waste Management Plan or the Municipal Sewage Regulation of the Act. Part 4 of the Act, “Contaminated Site Remediation”, sets out rules for the identification, remediation and liability associated with contaminated sites. A number of conditions can trigger the initial “site profile” requirements under this section, such as subdivision, rezoning or development permit applications for land that the applicant “knows or reasonably should know is or was used for industrial or commercial activity”.

Heritage Conservation Act

The Archaeology Branch of the Ministry of Tourism, Sport and the Arts reviews applications for works that may impact sites that are of archaeological and/or historical significance. Many low-lying coastal areas may sustain relics of settlements of both First Nations peoples and early European settlers that are of archaeological and/or historical significance. In those instances where proposed development may damage archaeological sites protected under the Act, the Branch will advise the applicant that and archaeological impact assessment is required. The Ministry administrates the activities of independent government bodies that may facilitate and/or participate in the review and/or approval of proposed uses within shoreline environments. Three of the more relevant of these bodies include:

1. Land and Water British Columbia Inc.
2. Environmental Assessment Office, and,
3. Land Reserve Commission.

Water Act

The Water Act addresses activities associated with the modification of the morphology of a watercourse. Land and Water Inc. of the BC Ministry of Sustainable Resource Management reviews applications to conduct "changes in and about a stream" in accordance with Section 9 of the Act. An approval must be obtained from Land and Water Inc. prior to implementation of any such changes.

The Environmental Stewardship Division of the BC Ministry of Environment recommends standards and best management practices for works and related activities in and about streams. These recommendations are considered terms and conditions as provided by a Habitat Officer pursuant to:

- Sections 40 and 42 of Part 7 of the Water Act;
- Regulation for a Notification pursuant to Section 44 of the Act; and
- Advice for applications pursuant to Section 9 of the Act.

All of the proposed watershed remediation construction activities will involve direct impacts to existing watercourses. Therefore, during the design stage obtain advice from a qualified environmental professional to assess potential impacts and secure necessary approval for those that require a Section 9 approval.

Local Government Regulations

In urbanized areas, Municipalities and Regional Districts, as mandated under the Provincial Local Government Act conduct project reviews to assess compliance with municipal zoning bylaws. Proposals for the maintenance or repair of existing facilities often fall under the jurisdiction of municipalities.

Municipalities and Regional Districts formulate Official Community Plans to set out land use zoning and other development requirements. For shoreline developments, leave strips may be required, the width of which are dependent on the environmental sensitivity of the area. Neighbourhood community plans further define land use zoning and other development requirements for specific areas within the municipality.

Official Community Plans provide the basic direction for land use decisions in a community. The establish policies for the "preservation, protection, restoration, and enhancement of the natural environment, it's ecosystems and biological diversity". An OCP can acknowledge streams and riparian areas and establish policies for their protection and future planning or development approvals. These OCP policies then guide land use decisions made under local area plans and other land use bylaws.

Development permit areas allow a local government to regulate a wide range of development activities that involves any form of site disturbance; but has limited enforcement measures. All three OCP's identify stream riparian assessment areas as a development permit area. The text of each OCP states that all streams, mapped or unmapped, are included in this development permit area. While the Elphinstone and West Howe Sound identify streams that are fish habitat or streams that flow into a waterbody that provides fish habitat, the Robert's Creek OCP only identifies streams that are fish habitat. However, in accordance with the Fisheries Act, streams that contribute flows to fish habitat are protected, including those that flow directly to the ocean and constructed ditches.

The following proposed watershed remediation activities are within riparian assessment areas development permit areas:

- S4 – Reed Road/Soames Creek,
- S6 – Wood Creek Park/Ocean Beach Esplanade,
- S7 – Secret Beach,
- S9 – 15th Street/Ocean Beach Esplanade,
- S11 – Burton Road/Russell Road/Reed Road,
- S12 – Area west of Ocean Beach Esplanade and east of Gulf Road, and
- S13 – Byng Road/Geddes Road/Maskell Road

Sunshine Coast Regional District Bylaw Number 310 states that no building may be placed within 7.5 metres of the natural boundary of the ocean. This bylaw defines buildings as a "roofed structure supporting, enclosing or protecting persons or property but does not include motor vehicle or recreational vehicles". The natural boundary of the ocean is defined in the bylaw as "the visible high water mark". As none of the proposed watershed remediation activities identified previously as occurring within the setback of the ocean involve buildings, per se, this bylaw will not apply to the proposed activities. However, in accordance with the Fisheries Act, any ground disturbance, either direct, or indirect (such as erosion runoff resulting from ground disturbance outside the setback) will require advice from a qualified environmental professional to assess potential impacts and develop mitigative measures as well as secure the necessary approvals for meeting applicable regulatory requirements.

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APPENDIX A

Species At Risk Table

SPECIES	HABITAT AND DISTRIBUTION	ACTIVITY / BLOOMING PERIOD	STATUS DESIGNATION	PROBABILITY OF OCCURRENCE
NON VASCULAR PLANTS				
Homalothecium arenarium	Sandy soils		CDC: blue COSEWIC: SARA:	
VASCULAR PLANTS				
Monocots				
dune bentgrass *Agrostis pallens*	Dry sand dunes, meadows, rock outcrops and rocky slopes in the lowland zone. 0 metres to 350 metres in elevation. Rare on Vancouver Island and the Queen Charlotte Islands; S to MT, ID, NV and CA.	June - august	CDC: blue COSEWIC: - SARA: -	
slimleaf onion *Allium amplectens*	Vernally moist rocky bluffs and meadows in lowland zone. Can occur in clay soils, including serpentine in either open or wooded places. Up to 1800 metres in elevation. From SE Vancouver Island, Gulf Islands and adjacent mainland (Powell River) south to California.	March - June	CDC: blue COSEWIC: SARA:	Documented in vicinity by CDC
green-sheathed sedge *Carex feta*	Ditches, marshes, wet meadows, streambanks in the lowland and montane zones. 50 – 2400 metres. Rare in SW BC, S to CA.	May - August	CDC: red COSEWIC: - SARA: -	
pointed broom sedge *Carex scoparia*	Wet open places, including meadows, shores, springs, fens and swamps. BC east to Newfoundland, south to Florida, Kansas, new Mexico, and Oregon.	June - July	CDC: blue COSEWIC: - SARA: -	
small spike-rush *Eleocharis parvula*	Small perennial, occurs below 3500 metres asl along marshes and shallow water of lakes, ponds, and stream beds. Occurs in Europe, North America, and northern South America.	June - September	CDC: blue COSEWIC: - SARA: -	Documented in vicinity by CDC
white adder's-mouth orchid *Malaxis brachypoda*	Moist forests, mudflats, fens and streambanks in the lowland and montane zones. 390 – 2650 metres. Rare in coastal and N BC; N to AK, E to NF and S to ME, MA, PA, IN, IL, MN and disjunct in CO and CA; Japan.	July - August	CDC: blue COSEWIC: - SARA: -	
Dicots				
chaffweed *Anagallis minima*	Moist to wet river banks, salt marshes, vernal pools and pond margins in the lowland zone. < 950 metres. Rare on S Vancouver Island and the Gulf Islands; S to MN, IL, CA, TX, FL and MX; South America, Europe.	March - May	CDC: blue COSEWIC: - SARA: -	
upswept moonwort *Botrychium ascendens*	Lower montane coniferous forest (mesic). 1500 – 1800 metres. Occurs from Alaska south to California and Nevada, northeast to Montana and Wyoming; historic in Ontario.	May - September	CDC: red COSEWIC: - SARA:-	

least moonwort *Botrychium simplex*	A wide variety of habits including meadows, barrens and woods, usually in subacid soils. 2200 – 3300 metres. High elevations from southern California to North Carolina and northward to Alaska and Newfoundland; also widespread in the Old World.	May - September	CDC: blue COSEWIC: - SARA: -	
contorted-pod evening-primrose *Camissonia contorta*	Open, sandy areas in the lowland zone, often disturbed. 0–2300 m. Rare on S Vancouver Island; S to CA, NV and ID.	May - June	CDC: red COSEWIC: E SARA: -	
beach bindweed *Convolvulus soldanella*	Moist to mesic sand dunes in the lowland zone. < 50 metres. Infrequent along the coast; S to CA, also in the islands of the Pacific Ocean and Europe.	April - August	CDC: blue COSEWIC: - SARA: -	
field dodder *Cuscuta campestris*	On many hosts, especially Asteraceae. S to CA, east to Atlantic coast, W.Indies, S. America.	July - November	CDC: blue COSEWIC: - SARA: -	Documented in vicinity by CDC.
smooth douglasia *Douglasia laevigata* var. *ciliolata*	Talus slopes and rocky alpine ledges, as well as moist coastal bluffs. On the west side of the Cascade range from Snohomish County to Mount Ranier and the Olympic Mountains. In addition, it occurs in the mountains of southwestern Washington and adjacent Oregon (Mount Hood and Saddle Mountain) and in the Columbia gorge.	March - August	CDC: blue COSEWIC: - SARA: -	
smooth willowherb *Epilobium glaberrimum* ssp. *fastigiatum*	Moist streambanks, rocky slopes, and open forests in the montane to alpine zones. 1200 – 3800 metres. Rare in S BC; E to AB and S to MT, UT and CA.	July – August	CDC: blue COSEWIC: - SARA: -	

hairy gumweed *Grindelia hirsutula var. hirsutula*	Dry sites in the lowland zone. < 900 metres. Rare on the Gulf Islands, known only from Lasqueti Island; disjunct S to CA.	April - July	CDC: red COSEWIC: - SARA: -	
heterocodon *Heterocodon rariflora*	Moist open places in foothills and valleys below 2300 metres; also shady, damp, grassy places. Southern BC to California and east to Idaho and Nevada; Wyoming.	June - August	CDC: blue COSEWIC: - SARA: -	
western St. John's wort *Hypericum scouleri* ssp. *nortoniae*	Moist to wet streamsides, estuaries, marshes and open slopes in all zones except the alpine and steppe zones. 0 - 1525 metres. Infrequent in S BC; S to WY, CA and MX.	June - August	CDC: blue COSEWIC: - SARA: -	
Nuttall's quillwort *Isoetes nuttallii*	Vernal pools and ephemeral winter seepages in the lowland zone. <1500 metres. Infrequent on SE Vancouver Island and Gulf Islands; S to CA.	June - August	CDC: blue COSEWIC: - SARA: -	
fleshy jaumea *Jaumea carnosa*	Moist tidal beaches and salt marshes in the lowland zone. Rre on S Vancouver Island; S to CA.	May - October	CDC: blue COSEWIC: - SARA: -	
grey beach peavine *Lathyrus littoralis*	Coastal dunes and sand beaches. <5 metres elevation. BC south to Monterey County, California.	April - July	CDC: red COSEWIC: - SARA: -	
woodland penstemon *Nothochelone nemorosa*	Moist forests and rocky slopes. 1000 – 1400 metres. Rare on S Vancouver Island and the adjacent mainland; S to NW CA.	June - August	CDC: blue COSEWIC: - SARA: -	
northern adder's-tongue *Ophioglossum pusillum*	Moist streamside meadow. Periodically flooded wet meadows and lake margins, in the lowland and montane zones. From Nova Scotia west to North Dakota, south to Virginia, possibly North Carolina, Indiana, and Nebraska; and in the Pacific Northwest. 1000 – 2000 metres.	June - September	CDC: blue COSEWIC: SARA:	
elegant Jacob's ladder *Polemonium elegans*	Dry cliffs and scree slopes in the subalpine and alpine zones. 1675 – 2750 metres. Rare in S BC south of 56oN, mostly in the Coast-Cascade Mountains; S to N CA.	July - August	CDC: blue COSEWIC: - SARA: -	
snow bramble *Rubus nivalis*	Moist forests and glades in the montane zone. 500 – 1250 metres. Rare in S BC; S to CA and ID.	May - July	CDC: red COSEWIC: - SARA: -	Documented in vicinity by CDC.
western pearlwort *Sagina decumbens* ssp. *occidentalis*	Annual herb that typically occurs from sea level to 900 metres asl in moist to mesic vernal pool habitats; also on dry hillsides, along streams edges, along roadsides and in openings in redwood and pinewood forests BC south into Baja California, Mexico	Spring to early summer	CDC: blue COSEWIC: - SARA: -	
Menzies' burnet *Sanguisorba menziesii*	5 to 60 metres elevation asl in wet places, including, fens, bogs, marshes, wet meadows and in lowlands in montane zones. Historical range is documented from Alaska to Wisconsin, current range from Alaska to Washington.	August	CDC: blue COSEWIC: - SARA: -	

Macoun's groundsel *Senecio macounii*	Dry open forests, disturbed areas and rock outcrops or limestone quarries in the lowland zone, may occur in roadsides or clearings in coniferous forests. 400 – 900 metres. Rare on S Vancouver Island, Texada Island and adjacent mainland; S to OR.	June - July	CDC: blue COSEWIC: - SARA: -
poison oak *Toxicodendron diversilobum*	Dry to mesic rocky slopes (often climbing trees) in the lowland zone. Below 1550 metres, Rare in SW BC, known from SE Vancouver Island, the Gulf Islands and Howe Sound; S to MX.	April - May	CDC: blue COSEWIC: - SARA: -
Giant chain fern *Woodwardia fimbriata*	Wet forests and seepy, coastal cliffs in the lowland zone. 0 – 2300 metres. Infrequent in SW BC (SE Vancouver Island, Lasqueti and Texada Islands); S to CA, disjunct to AZ and NV.	Year round	CDC: blue COSEWIC: - SARA: -
MOLLUSCS			
northern abalone *Haliotis kamtschatkana*	Mostly subtidal; adults are usually found at <10 m depth. The abalone prefer a firm substrate, usually rock, and are generally found in areas of moderate water exchange, such as occurs on exposed or semi-exposed coasts. Occurs along the pacific coast from Alaska to Turtle Bay, Baja California (Mexico).	Year round	CDC: red COSEWIC: T SARA: T
scarletback taildropper *Pprophyson vanattae*	Aboreal; lives on moss-covered trunks and shrub and tree branches in coastal mixed wood forests. Vancouver Island and Chilliwack Valley.	Year round	CDC: blue COSEWIC: - SARA: -
threaded vertigo *Nearctula* sp.	Lives in moist leaf litter in rich sites in deciduous and mixed forests. Southwestern BC to Monterey County, California.	Year round	CDC: red COSEWIC: - SARA: -
pacific sideband *Monadenia fidelis*	Deciduous, coniferous, or mixed forests; also in open woods and grassy areas.From Sitka, Alaska, to Cape Mendocino, California; west of the Coast and Cascade Mountains, in British Columbia.	Most common late spring	CDC: blue COSEWIC: - SARA: -
DRAGONFLIES AND DAMSELFLIES			
black petaltail Tanypteryx hageni	Waterseeps with moss-covered rocks, spring-fed bogs, and seeps in old growth or riparian forests in the Coast Mountains where the larvae burrow in the mud. In Canada, this species is found in montane regions, specifically on British Columbia's mainland coast. Occur from mid to high elevations in the Cascade and southern Coast mountains and at sea level on the central coast. Known to breed in Cypress Provincial Park in West Vancouver (Kenner, 2000).	early July - early September	CDC: blue COSEWIC: - SARA: -
blue dasher *Pachydiplax longipennis*	Still waters of ponds, lakes, marshes and bogs and has been found at Killarney Lake on Bowen Island. Abundant in many areas of the southern half of North America. In BC, this species occurs in the lowlands of the south coast and at the end of Osoyoos Lake in the southern interior. Blue dasher is most common on southern Vancouver Island and in the Gulf Islands.	Early June – mid September	CDC: blue COSEWIC: - SARA: -

BUTTERFLIES AND MOTHS			
common woodnymph *Cercyonis pegala incana*	Grassy forest openings, clearcurs, roadsides, meadows and streambanks. Larval food source is grass, can feed on sedges. Adults feed on willow and poplar sap. Southern BC south to central California and Arizona and across the continent to the Atlantic. Subspecies *incana* only occurs from Vancouver island south to Willamette Valley, Oregon.	July - September	CDC: blue COSEWIC: - SARA: -
western pine elphin *Callophrys eryphon sheltonensis*	A variety of pine dominated or mixed pine forests. Adults take nectar from *Salix prolixa*. Larval foodplant is *Pinus contorta*. British Columbia east to Maine; south to southern California, Arizona, and New Mexico.	May - June	CDC: blue COSEWIC: - SARA: -
monarch *Danaus plexippus*	Open fields, roadsides, canyons and suburban areas. Main source of food is milkweed (*Asclepias* sp.), which is only native to the dry areas of the southern interior of BC. Therefore, migrants to the west coast cannot breed successfully. In tropical and subtropical areas of the world. Colonized New Zealand, Australia, and Canary Islands following the introduction of food plants to these areas. In BC, typically found in the interior, and infrequently in the lower Fraser valley, on Vancouver Island and the Rocky Mountain trench. Migrates in late summer and fall from BC to California to hibernate and overwinter along the central and southern California coast.	March – November	CDC: blue COSEWIC:SC SARA: SC
dun skipper *Euphyes vestris*	Open, moist areas that have it's larval host plants, which are sedges (*Carex* sp.) and *Cyperus esculentus;* also in disturbed areas such as road edges, railroad right-of-ways, powerline right-of-ways, and roadside ditches. May be found in fairly dry conditions where spring floods or permanent springs provide moist conditions for the larval foodplant. From BC southward along the Cascade, Sierra Nevada, and Coast Mountains to Central California. In BC, this species occurs on Vancouver Island from Courtenay south to Thetis Lake Park, but is absent from the Saanich Peninsula. It is known from one location in Powell River, one location in Pemberton, Mission and five localities in the Fraser Canyon associated with small, moist areas at permanent springs, including Hope, Boston Bar, Lytton, North Lytton and Lillooet.	late June - mid-August	CDC: blue COSEWIC: T SARA: T
FISH			
cutthroat trout *Oncorhynchus clarki clarki*	Small, low gradient, coastal streams and estuarine habitats that are well shaded with water temperatures optimally below 18 degrees Celsius, spawns in streams on clean, small gravel substrates. After emerging, fry move into larger rivers (or lakes). Young feed mostly on aquatic and drift insects, microcrustaceans, and occasionally smaller fish. Adults eat insects, crustaceans, and other fish. Occurs in small coastal streams from the Eel River in Humboldt	Year round	CDC: blue COSEWIC: - SARA: -

	County, California northward to the Prince William Sound area of Alaska, including numerous islands with suitable habitat off the coast of BC and southern Alaska. However, this species does not typically occur farther inland than 150km.		
Dolly Varden *Salvelinus malma*	Fresh and salt water. Anadromous forms occur in deep runs and pools of creeks and small to large rivers. Landlocked populations inhabit lakes and tributary streams. Feed on aquatic insects, sometimes fish eggs and smaller fisheastern Asia and western North America from just south of the Canadian border to Alaska. Their distribution does not extend far inland in the Skeena and Fraser River systems, although they are found in the headwaters of the Fraser Liard and Peace River systems.	Year round	CDC: blue COSEWIC: - SARA: -
REPTILES AND AMPHIBIANS			
red-legged frog *Rana aurora*	Streams, ponds, and marshes with slow-moving water and adjacent terrestrial environments; moist forest conditions far from open water characterized by mature vegetation, leaf litter, and large woody debris. Restricted to low elevations. Breeding in late winter/early spring in shallow water of permanent ponds or lakes, slow-moving streams, marshes, bogs, and swamps. During the summer, hatchlings typically occur within vegetation along streams, in moist sedge or brush, on shaded pond edges, and/or under logs or debris. Due to predation and competition with introduced bullfrogs (*Rana catesbeiana*), the red-legged frog does not occur where this species is present. Occurs along the west coast of North America from Baja California to Canada and reaches the northern extent of its range in extreme southwestern BC. In BC, it occurs on Vancouver Island, the Gulf Islands, the mainland adjacent to the Straight of Georgia, and through the Fraser valley to Hope.	March – October; hibernates from November until late February	CDC: red COSEWIC: SC SARA: SC
tailed frog *Ascaphus truei*	Steep, cold mountain streams, with boulders or cobbles, approximately 0.5 to 15 meters in width in old-growth forests as breeding habitat, along with damp litter on the forest floor to survive as metamorphosed adults. Absent from creeks with either low or excessively steep gradients. Ice free in winter. They winter under rocks or at the stream surface. Eggs are attached to the underside of a boulder or large rock in the stream. Tadpoles feed on diatoms, and the adults consume a variety of items, including spiders, ticks, mites, collembolans (snow fleas), snails and various insects. Sensitive to stream disturbance such as siltation or algal growth. Adults are closely associated with their breeding creek throughout their lives, typically not moving more than 20 meters as adults need to stay moist as they are much less able to withstand drying than other frogs.	Year round	CDC: blue COSEWIC: SC SARA: SC

	Coastal mountain ranges in British Columbia, Washington, Oregon, Idaho, northwestern Montana and California from sea level to the timberline. In BC, this species occurs from Penticton north to the Portland Canal (north of Prince Rupert). It does not occur on Vancouver Island or the Queen Charlotte Islands.		
western toad *Bufo boreas*	Three different types of habitat: breeding habitat, terrestrial summer range, and winter hibernation sites. Breeds in a variety of aquatic habitats with sandy substrates, including the shallow margins of lakes to roadside ditches. Outside the breeding season, adults spend most of their time on land and can be found in forested areas, wet shrublands, avalanche slopes, and meadows. Adults consume a wide variety of invertebrates including worms, spiders, bees, beetles, ants and grasshoppers. Tadpoles are highly gregarious and eat algae, as well as organic matter in the water, but will scavenge on carrion. Although they are capable of excavating their own burrows in loose soils, they shelter in small mammal burrows, beneath logs, and within rock crevices. Rocky Mountains to the pacific coast, from sea level to approximately 3 600 meters. The eastern portion of its range includes western Alberta, and parts of the western United States; and the southern extent is Baja California.	Adults are active from January until October; hibernates in burrows below the frostline up to six months of the year	CDC: yellow COSEWIC: SC SARA: SC
painted turtle *Chrysemys picta*	Lakes, ponds, slow moving streams with basking sites and aquatic vegetation. East of the Cascade Mountains in the Columbia drainage, eastern Washington, the north-central and northeastern portions of Oregon, interior southern BC, extreme northern Idaho and western Montana. Small scattered populations in the Puget Sound area.	Year round; breeding in late May	CDC: blue COSEWIC: - SARA: -
BIRDS			
Canada goose *Branta canadensis occidentalis*	Breeds in freshwater marsh with tall shrub vegetative cover. Landscape level: herb graminoid and mixed tree/shrubs landcover classes. Nest site level: Interlevee basins were the most common site used for nesting, followed by levees. Low shrub cover or low height forb cover were important components of a nest site in high density nesting strata. Winters in farm fields and agricultural wetlands in Washington and Oregon.	Spring and summer; autumn migrant	CDC: blue COSEWIC: - SARA: -
marbled murrelet *Brachyramphus marmoratus*	Coastal areas, mainly in salt water within 2 km of shore, including bays and sounds; not uncommon up to 5 km offshore; occasionally also on rivers and lakes usually within 20 km of ocean (but up to 75 km), especially during breeding season.	Year round; breeding from late March to late September	CDC: red COSEWIC: T SARA: T

	Nests often are in mature/old growth coniferous forest near the coast: on large mossy horizontal branch, mistletoe infection, witches broom, or other structure providing a platform high in mature conifer (e.g., Douglas-fir, mountain hemlock). Most nesting occurs in large stands of old growth. Nest sites generally have good overhead protection. Nesting or probable nesting has been recorded up to 56 km inland in California (USFWS 1994). On the British Columbia coast, nesting birds flew 12-102 kilometers (mean 39 kilometers) inland from foraging sites on the water. In British Columbia, adult diet during the breeding season is mostly fishes.		
northern goshawk *Accipiter gentiles* ssp. *laingi*	Hunt inside the forest or along edge. Occur in coniferous or mixed forests and are restricted to wooded areas, may occur in open woods. Feed on birds and small mammals. In the Fraser basin, occurs near wooded skloughs, hedgrows, and woodlands along river banks with tall shrubs, and over cattail marsh. Nests in trees in major crotch of trunk. Throughout North America; range appears to be expanding. Breeds in the temperate and boreal regions of the northern hemisphere. Some confusion in the literature regarding the range of the subspecies: the American Ornithologists Union restrict this subspecies to the Queen Charlotte Islands and Vancouver Island, while Jewett *et al.* (1953) consider all coastal birds south to Oregon to be the *laingi* subspecies.	Year round	CDC: red COSEWIC: T SARA: T
Spotted owl *Strix occidentalis*	Preferentially selects old coniferous forests for foraging, roosting and nesting, with large overstorey trees (>75 cm dbh), multilayered canopy, large decaying fallen trees and large diameter standing dead trees; these stands are typically dominated by trees >200 years. Nest in tree cavities, deformities of large trees (e.g., depressions in the top of broken-topped trees, or platforms constructed by other birds or by natural accumulations of debris) located below the overhead canopy, thereby providing overhead cover and seclusion to the nest. Small mammals predominate in diet; also eats various birds and sometimes large insects. Sometimes stores food for future use. RESIDENT: southwestern British Columbia south through western Washington and western Oregon to southern California and northern Baja California (probably); in Rocky Mountain region from southern Utah and central Colorado	Year round; nocturnal	CDC: red COSEWIC: E SARA: E

	south through the mountains of Arizona, New Mexico, extreme western Texas (Guadalupe Mountains), northern Sonora, Chihuahua, and Nuevo Leon to Jalisco, Michoacan, and Guanajato.			
Barn swallow *Hirundo rustica*	Open situations, less frequently in partly open habitats, frequently near water. Nests in barns or other buildings, under bridges, in caves or cliff crevices, usually on vertical surface close to ceiling. Commonly reuses old nests. Usually returns to same nesting area in successive years; yearlings often return to within 30 km or closer to natal site. Flies over open land and water and forages on a wide variety of flying insects; rarely eats berries. South-coastal and southeastern Alaska, across much of Canada south through much of U.S. to central Mexico; also eastern Buenos Aires province, Argentina, in early 1980s (Ridgely and Tudor 1989); across Eurasia to Mediterranean region, northern Africa, China, Japan.	Late April through August	CDC: blue COSEWIC: - SARA: -	
great blue heron *Ardea herodias herodias*	Salt, brackish, and freshwater environments including marshes, swamps, shores, and tidal flats. The diet of great blue herons is highly variable and adaptable and includes fish, frogs, salamanders, turtles, snakes, rodents, and birds. This species is very common in southern BC and is frequently observed. The Fraser River delta is the primary wintering area for the great blue heron in BC. Breeding colonies are typically associated with island or mainland sites adjacent to tidal mud flats and eelgrass meadows. Nesting colonies can be located adjacent to high-traffic areas, such as Stanley Park, Vancouver. The nest is in trees approximately 5 to 30 metres above the ground or water. Widely distributed along the coast including Vancouver Island and the Queen Charlotte Island and throughout the interior south of the 52 latitude.	Year round	CDC: blue COSEWIC: SC SARA: -	Heron nesting site documented in vicinity of project area by CDC
pine grosbeak *Pinicola enucleator carlottae*	Open coniferous (less commonly mixed coniferous-deciduous) forest and forest edge; in migration and winter also in deciduous forest, woodland, second growth and shrubbery. Nests in trees or shrubs in open coniferous woods, 2-9 m above ground. Feeds on a wide variety of seeds; also eats fruits and insects. Forages in trees but also takes food from the ground. Breeds in North America, from western Alaska east across northern Canada to Newfoundland and south to central California, Arizona, northern New Mexico, northern Alberta, central Manitoba, northern Great Lakes region, central Maine and Nova Scotia. Overwinters in North America from western Alaska, southern Yukon, southern Mackenzie, and southern Canada south through breeding range.	Year round	CDC: blue COSEWIC: - SARA: -	

double-crested cormorant *Phalacrocorax auritus*	Marine environments, such as bays, inlets, harbours, lagoons, and estuaries; however, this species is commonly associated with freshwater environments on southern Vancouver Island and within the Fraser River lowlands. The double-crested cormorant breeds throughout southern BC. Nesting colonies are typically situated on bare areas of rocky islands. Most widespread cormorant in North America, only cormorant likely to be seen inland in most areas. Breeds throughout BC and from western Alaska, central Alberta, James Bay, and Newfoundland, south to Mexico and the Bahamas. Winters along the Pacific Coast, on the Atlantic coast from New England to Florida and along the Gulf Coast to Central America.	Year round	CDC: red COSEWIC: NAR SARA: -	Documented on Texada Island by CDC
green heron *Butorides virescens*	Aquatic and terrestrial environments; fresh, marine, or brackish water with thickets, shrubs, and small trees nearby. Uses inland waters, including those in urban areas (e.g. golf courses, city parks, and sewage lagoons). Forages in shallow, still, and slow-moving water on fish but crayfish and other crustaceans, aquatic insects, frogs and tadpoles, grasshoppers, snakes, earthworms, snails and small rodents are also taken (Kaufman, 1996). Breeds in southwestern BC in deciduous trees and occasionally coniferous trees on nests near the end of branches of trees or tall shrubs over or far from fresh waters or brackish sloughs, slow-moving rivers, and lakes all with thickest or woodlands of willows and alders along the shore. Widely distributed and is found in almost every wetland in summer. Also breeds in Washington south to southern California, Arizona and New Mexico and from North Dakota, southern Ontario and New Brunswick south to the Gulf Coast and southern Florida. In winter this species withdraws from most of it's range except for the southern tier of the United States. Northern birds are known to migrate as far as Panama, northern South America. In addition, it is a permanent resident of Central America, West Indes.	Spring and Summer	CDC: blue COSEWIC: - SARA: -	
band-tailed pigeon *Columba fasciata*	Variety of habitats ranging from open wooded areas including mixed coniferous/deciduous trees with edges, city yards, parks, wooded groves, open bushland, mineral springs, and intertidal flats. Breeds in coniferous trees and deciduous trees. Forage for ripening fruits and grains in wooded areas; frequent rail lines, grain storage areas, and residential properties where grain is transferred and/or stored. Broadly distributed from southern Alaska to Central and South America. In North America, it is distributed	Year round	CDC: blue COSEWIC: - SARA: -	

	along the coastal areas from about southern Alaska into Baja California; interior region from Colorado, where they extend mostly along the continental divide into South America. While present year-round in some northern urban areas where it is attracted to feeders and holly orchards, the species is described as a partial migrant where most from the northern pacific coast breeding range migrate to south of the upper third of California (Sonoma-Nevada Counties) and most from the interior region migrate beyond the U. S. and Mexico border.		
peregrine falcon *Falco peregrinus anatum*	Habitat requirements can be divided into three components, including the nest site, the nesting territory and the home range. The nest site is a scrape made on cliff ledges on steep cliffs, typically near wetlands. The nesting territory is the area defended around the nest, which is related to food availability. The home range is the non-defended area in which peregrines forage for food. This area can extend up to 27 kilometers from the nest. Peregrines often prefer open habitats such as wetlands, tundra, savanna, sea coasts, and open mountain meadows, but will hunt over open forest, can also occur near beaches, tidal flats, reefs, island, marshes, estuaries, lagoons, flooded farmland, airports, parks, golf courses, railway yards, and bridges. The main prey item for the peregrine falcon is birds; associated with habitats where there is an abundance of small-to-medium sized birds, including airports, bridges, and parks. Three subspecies of the peregrine falcon (*Falco peregrinus*) have distinct geographic distributions. The a*natum* subspecies, also known as the American peregrine, breeds south of the treeline in Alaska and Canada, throughout most of the United States of America, and from central to south Mexico.	Year round	CDC: red COSEWIC: T SARA: T
western screech-owl (*kennicottii* subspecies) *Megascops kennicotti kennicottiii*	Mixed deciduous/coniferous forests on the edges of clearings, wooded canyons, riparian thickets, deserts, orchards, at low elevations often associated with riparian areas. May roost in either coniferous or deciduous tree cavities, patches of thick vegetation, nest boxes, buildings, trees, vines, and crevices in cliffs. Nesting habitats of this owl include large, natural cavities (e.g. in trees), abandoned pileated woodpecker (*Dryocopus pileatus)* and northern flicker holes, as well as, cavities in poles, and old magpie (*Pica pica)* nests. May occur in wooded suburban areas and city parks, if they are disturbed minimally by humans and their associated activities.	Year round	CDC: blue COSEWIC: SC SARA: SC

	Western screech-owl is nocturnal and becomes active at dusk feeding on small mammals, birds, reptiles, small fish, and insects, with large insects being primary source of food (Alsop, 2001). This species is sedentary in that it often stays in the same home range throughout the year. Western portion of the North American continent from southern Alaska to central Mexico (COSEWIC, 2002). It is generally common and widely distributed throughout its range. In BC, this subspecies is known along the coast, including Vancouver Island, but excluding the Queen Charlotte Islands, relatively common in the lower mainland.		
MAMMALS			
Townsend's big-eared bat *Corynorhinus townsendii*	Wide variety of habitats, its distribution strongly correlates with the availability of caves or cave-like roosts. Diet consists of small moths, lacewings, beetles, flies, and sawflies. Relatively sedentary and move only up to 10-65 km from the winter roost to the summer roost. Current range of this species is from Mexico into BC, along the western United States. In addition, there are a few isolated populations in the central and eastern United States.	Year round; nocturnal	CDC: blue COSEWIC: - SARA: -
fisher *Martes pennanti*	Occurs primarily in dense coniferous or mixed forests, including early successional forest with dense overhead cover. Avoids open areas. When inactive, occupies den in tree hollow, under log, or in ground or rocky crevice, or rests in branches of conifer (warmer months). Diet consists primarily of mammals; also birds, other small animals, carrion, and fruit. Fishers range from Quebec, the Maritime Provinces, and New England west across boreal Canada to southeastern Alaska, south in the western mountains to Utah, Wyoming, Idaho, and California, and formerly south to Illinois, Indiana, Tennessee, and North Carolina.	Year round	CDC: blue COSEWIC: - SARA: -

wolverine *Gulo gulo*	Treed and treeless areas at all elevations including the northern forested wilderness, the alpine tundra of the western mountains and the arctic tundra. Habitat requirements are best defined in terms of an adequate year-round food supply in large, sparsely inhabited wilderness areas. Although they prefer pristine areas, their home range may overlap developed areas. In addition, they are not deterred by human presence as they have been known to investigate campsites, food caches and even cabins. Avoids using habitats within 100 meters of the TransCanada Highway and prefers areas greater than 1100 meters from the highway, will cross the Highway in the Kicking Horse Pass between Yoho and Banff National Parks. Occurs in low numbers throughout most of its remote habitat, is highly mobile, therefore it is extremely difficult to observe in the field. Holarctic species distributed across North America and Eurasia. In Canada, the western population of this species is distributed across the Boreal, Arctic, Northern Mountain, Southern Mountain and Pacific ecological regions. This species is non migratory and do not hibernate in the winter.	Year round	CDC: blue COSEWIC: - SARA: -
grizzly bear *Ursus arctos horribilis*	Wide ranging species that requires large tracts of suitable habitat wherein individuals can move freely and establish home ranges. Omnivores that are opportunistic feeders, they eat vegetation such as roots and bulbs, feed on spawning salmon in stream class 1 streams. Riparian and wet forests are used throughout the range for berrying, foraging, and travel. Grizzly bears hibernate in winter months in high elevation excavated dens. The historical distribution of this species is from Mexico extending north, including Alaska and the Northwest Territories. The current range includes British Columbia, Alaska and the Northwest Territories with some small populations in the northern areas of the United States.	Spring, summer, fall; hibernate in winter	CDC: red COSEWIC: SC SARA: -
Roosevelt elk *Cervus canadensis roosevelti*	Habitat variable according to location. Uses open areas such as alpine pastures, marshy meadows, river flats, and aspen parkland, as well as coniferous forests, brushy clear cuts or forest edges. No special calving ground is used. Primarily a grazer, but much geographic and seasonal variation in diet. Holarctic; Eurasia and North America; Tunisia and northeastern Algeria; introduced in Morroco, South America, New Zealand, and Australia. Formerly widespread in North America, now mostly restricted to the West, with small reintroduced populations elsewhere.	Year round	CDC: blue COSEWIC: - SARA: -

Legend

CDC

red	candidates for legal designation as Threatened (TH) or Endangered (EN).
blue	considered to be vulnerable or sensitive to human activities or natural events, and could become candidates for the red-list.
yellow	indigenous and are not at risk in BC and include uncommon, declining, and increasing species.

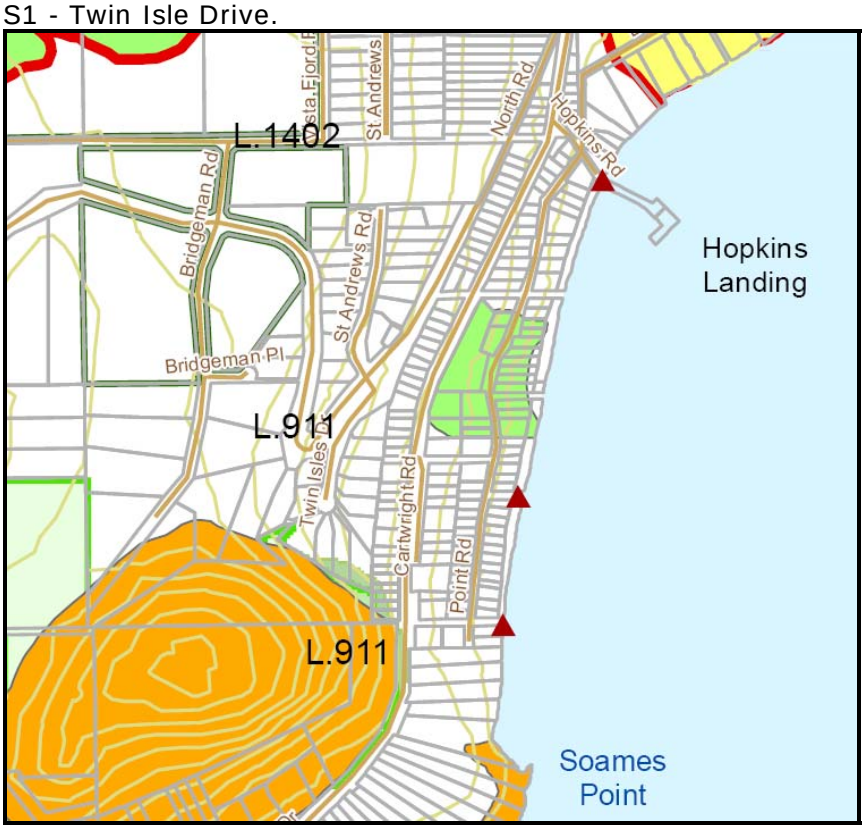
SARA / COSEWIC

X	Extinct	a species that no longer exists
ET	Extirpated	a species that no longer exists in the wild in Canada, but occurs elsewhere
EN	Endangered	a species facing imminent extirpation or extinction
TH	Threatened	a species likely to become endangered if limiting factors are not reversed
SC	Special Concern	a species with characteristics that make it particularly sensitive to human activities or natural events
NAR	Not At Risk	have not been given status because populations are not in any peril; and,
DD	Data Deficient	a species for which there is insufficient scientific information to support status designation.
-	Not addressed	Not addressed by the COSEWIC or the SARA

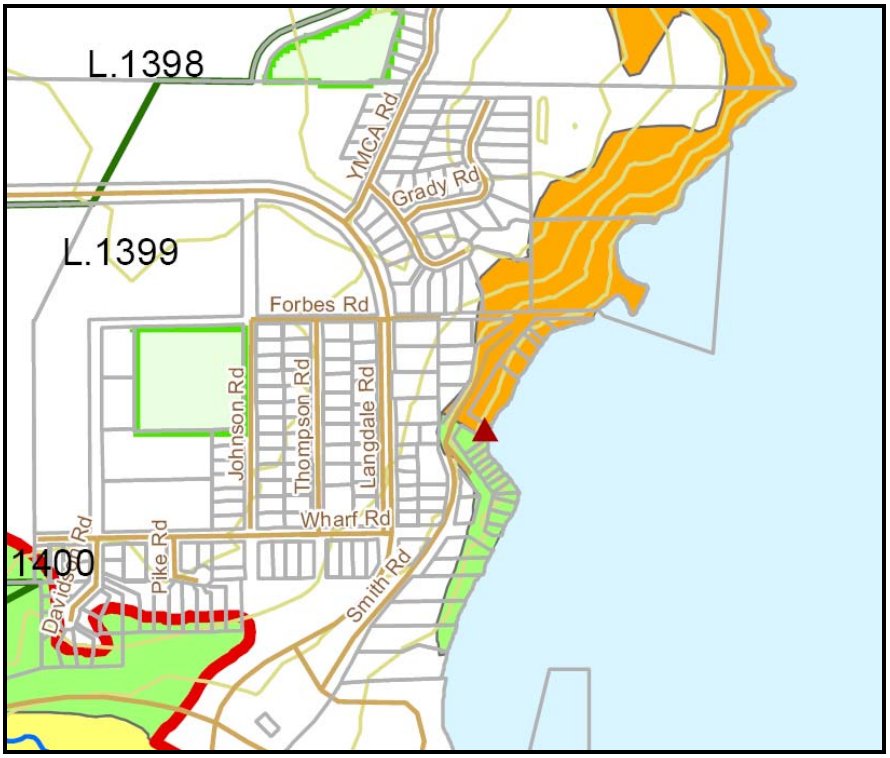
APPENDIX B

Sunshine Coast Regional District Habitat Atlas

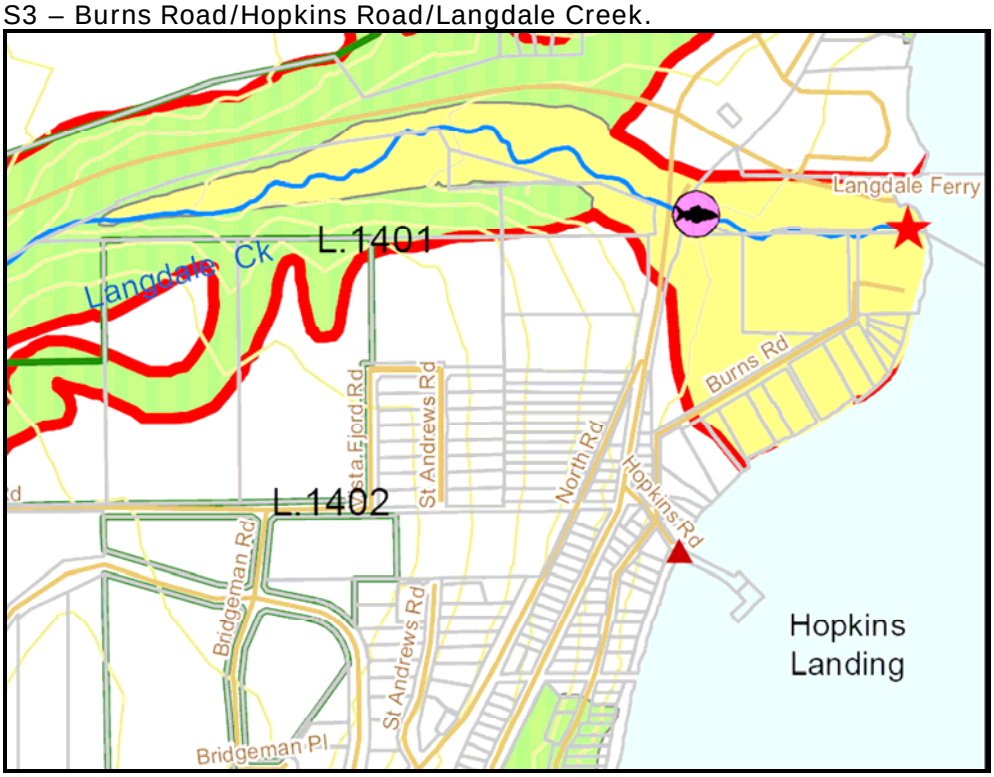
S1 - Twin Isle Drive.



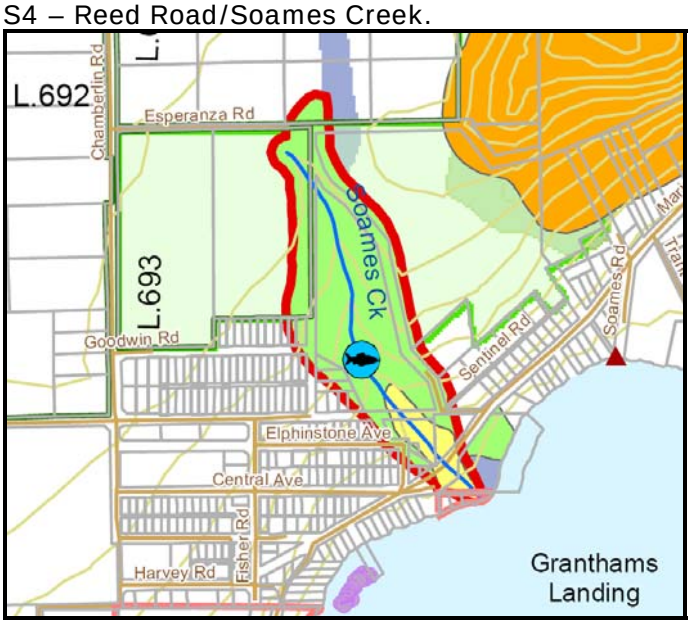
S2 – Forbes Road/Smith Road.



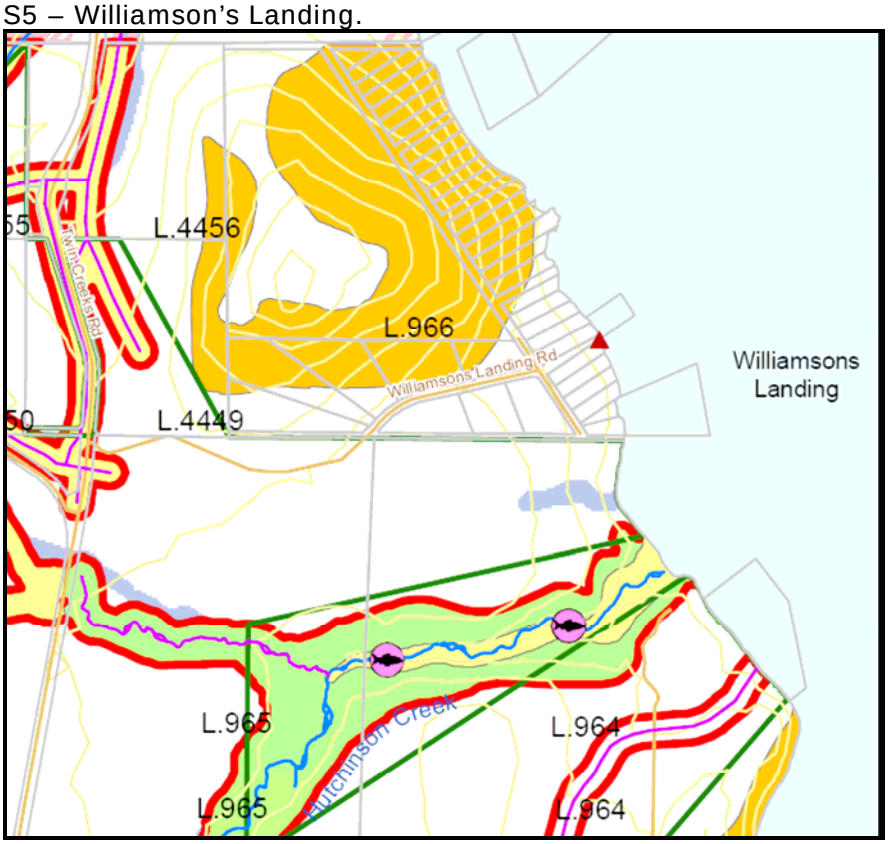
S3 – Burns Road/Hopkins Road/Langdale Creek.



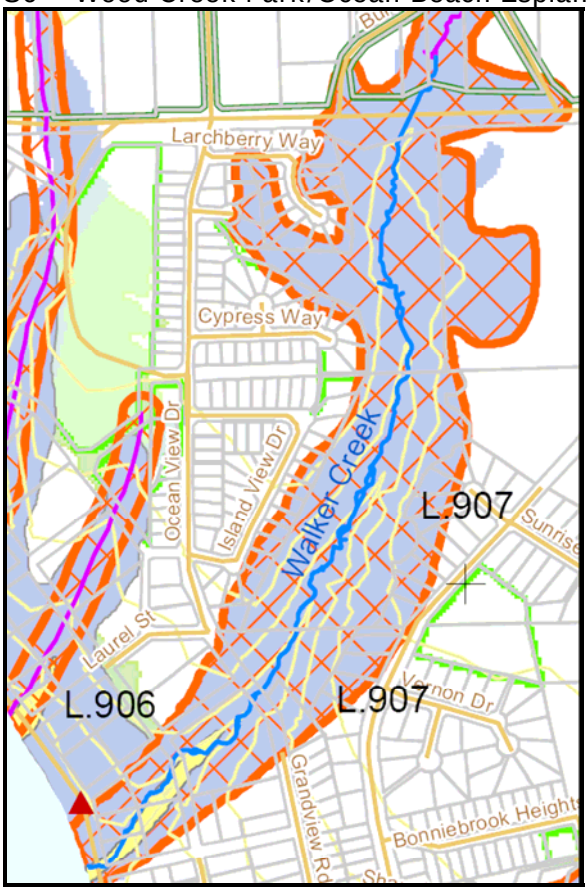
S4 – Reed Road/Soames Creek.



S5 – Williamson's Landing.

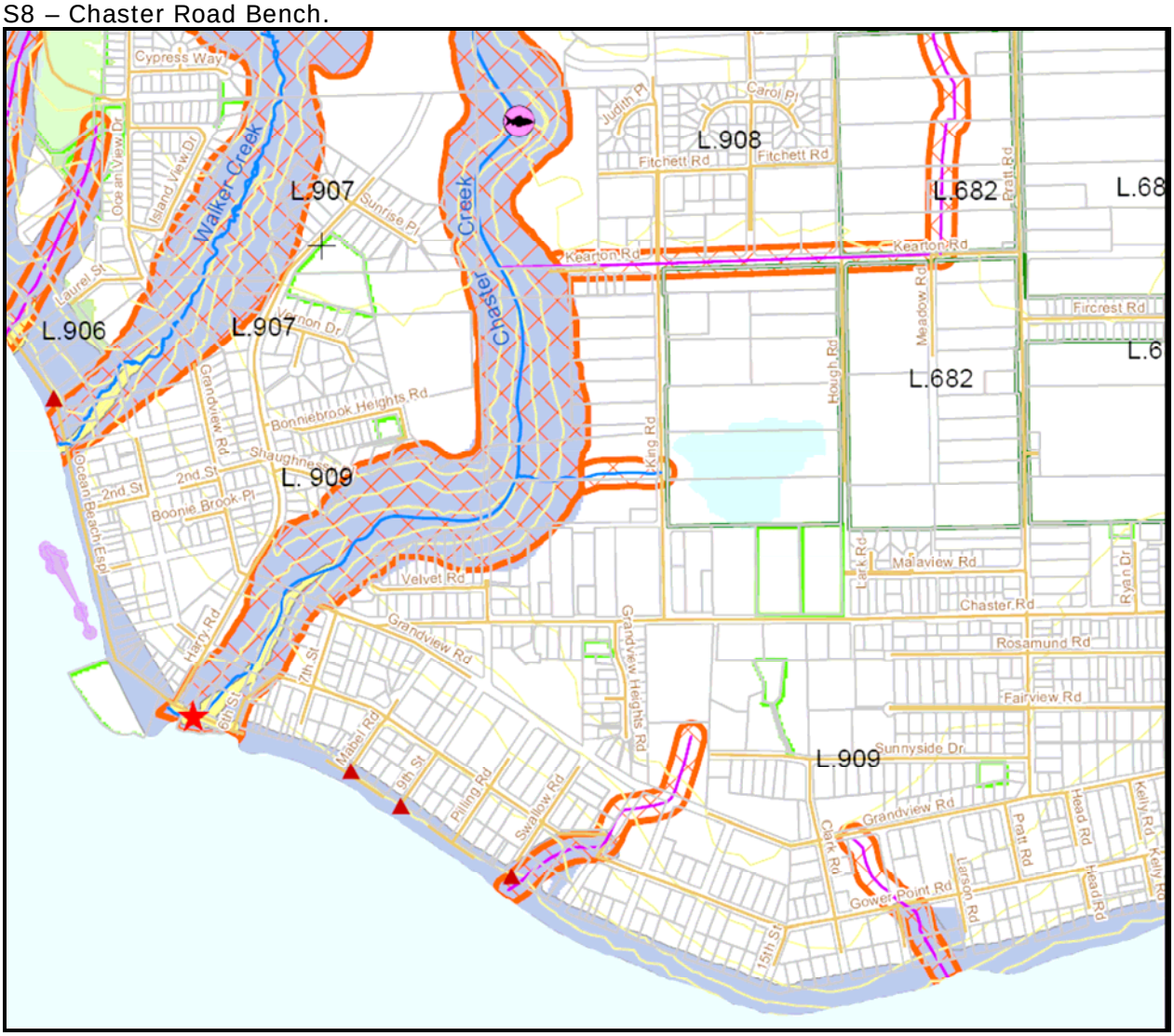


S6 – Wood Creek Park/Ocean Beach Esplanade.

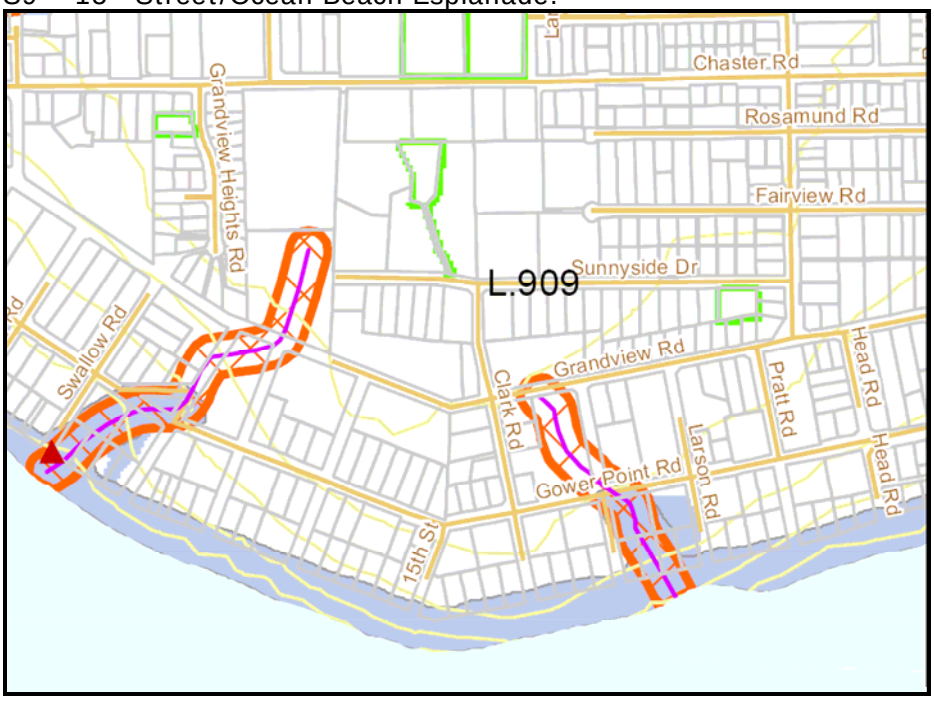


S7 – Secret Beach.

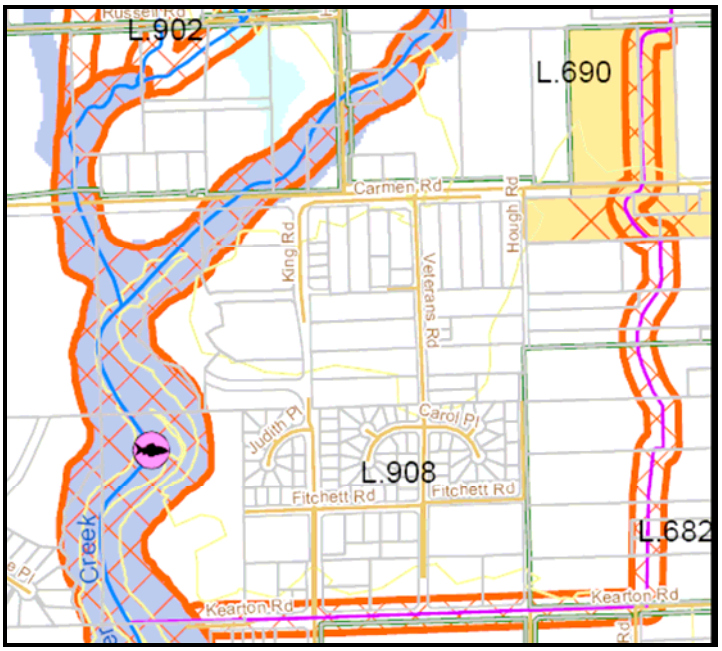
S8 – Chaster Road Bench.



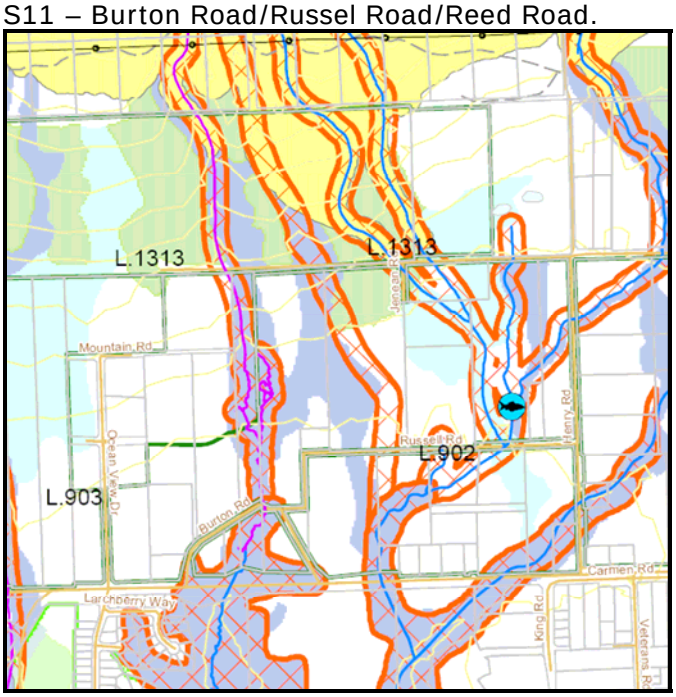
S9 – 15th Street/Ocean Beach Esplanade.



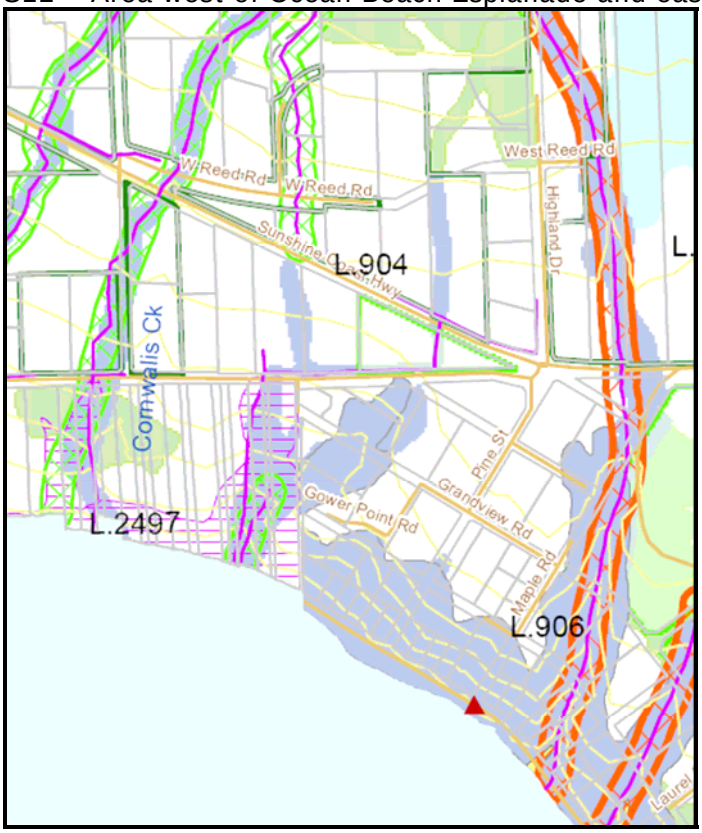
S10 – Veterans Road.



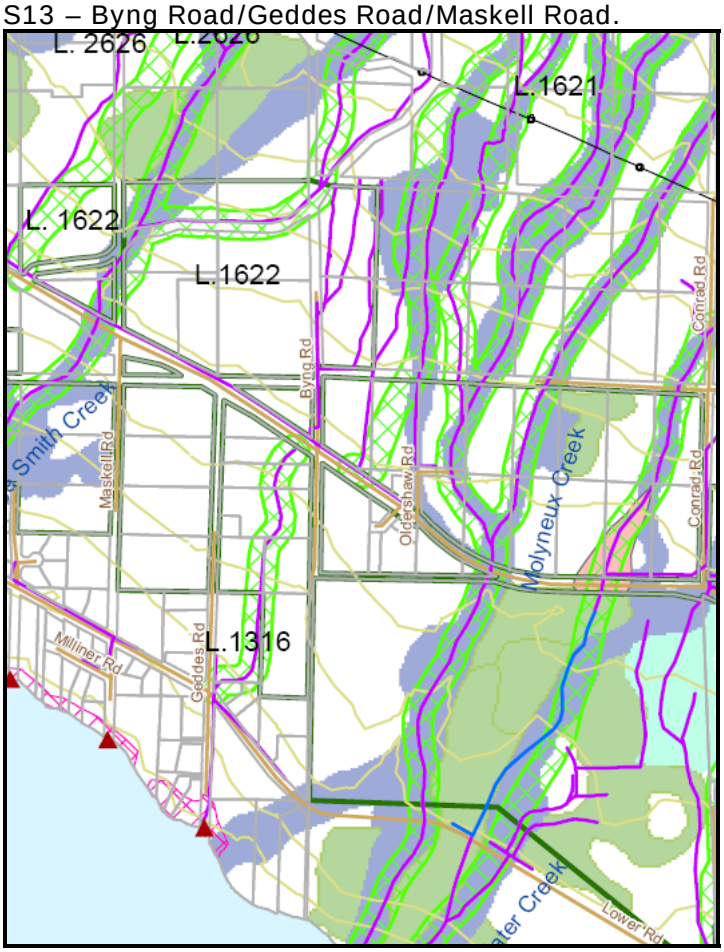
S11 – Burton Road/Russel Road/Reed Road.



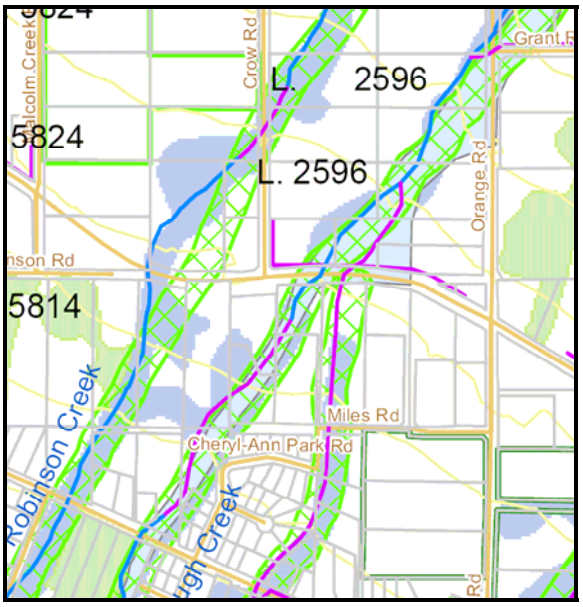
S12 – Area west of Ocean Beach Esplanade and east of Gulf Road.

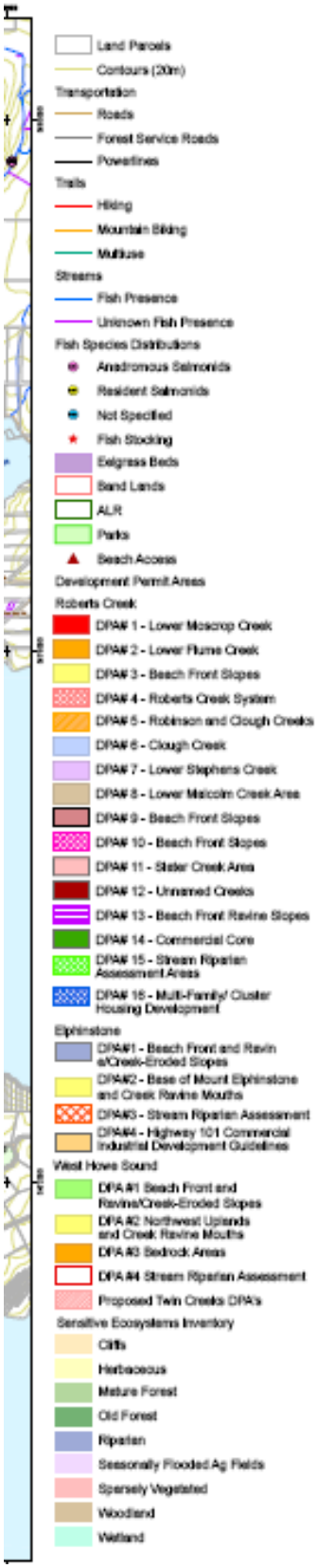


S13 – Byng Road/Geddes Road/Maskell Road.



S14 - Crowe Road.





Source – Sunshine Coast Regional District Habitat Atlas Map 11. Available at http://habitat.scrd.bc.ca/. Accessed February, 2008.